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Promotion of a Market for Hourly Energy Certificates

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Promotion of a Market for Hourly Energy Certificates

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Abstract

GHG emissions play a key role in the escalating extreme weather crisis. Commercial and industrial sectors consume almost two-thirds of global end-use electricity; therefore, they have played and will continue to play an important role in driving clean energy in the near term, particularly renewables.

Electricity lies at the heart of these global challenges. It is both a significant source of global carbon emissions and is also key to decarbonizing large sectors of the economy, including buildings, transport, and industry. Access to affordable and clean electricity is also essential for economic growth, quality healthcare and education, and many other development goals. To achieve net-zero emissions across the global economy by 2050, electricity must decarbonize even faster, while becoming the core of a just and accessible energy system.

Carbon Neutral is where organizations offset their emissions by purchasing carbon offsets intended to reduce or prevent global emissions. 100% Renewable Energy is where organizations purchase renewable energy to match their annual electricity use. 24/7 RE (Renewable Energy) means that rather than emitting and compensating, organizations don't emit in the first place. Every kilowatt-hour of electricity consumption is met with renewable energy electricity sources. It means reneweble energy for all.

The thesis evaluates two main needs for reaching 24/7 for all: metering production and consumption data access and a granular certificate scheme. In addition, a business case for a granular certificate issuer is presented in order to show the opportunities and challenges that these entities will have with the coming 24/7 renewable energy approach.

For metering data access, the thesis shows that although Europe is at the forefront of the process, only 3 countries out of the 18 analysed meet all the criteria required to allow consumers and their partners easy and cost-efficient access to relevant, granular metering data. 8 of these countries present some kind of obstacle, 7 do not have a system in place, although data is available in some way, and 1 has no smart rollout plan in place at all.

Guarantees of origin schemes analysed shows that systems are not customer centred, in most of the countries it is not possible to assign the GO certificate to a specific consumption point and the process of getting information about cancelled GOs for corporate consumers is tedious and time-consuming.

With the identified barriers, in both, metering data exchange infrastructures and guarantees of origin systems, a proposed system have been developed, which links metering data exchange infrastructures with the certification scheme, by providing metering consumption and production data with hourly granularity to support the 24/7 matching of renewable energy.

Finally, in the business case proposed, it can be observed that being a granular certificate issuer, a 1.3 M revenue can be obtained in the first year, only with the Spanish market. Then, after 5

years, by also targeting Netherlands and Denmark, a 3.24 M revenue can be obtained. Several business opportunities appear, in addition to the business of being a granular certificate issuer.

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List of abbreviations

GHG	Green House Gases
RE	Renewable Energy
RES	Renewable Energy Sources
RES-E	Electricity from Renewable Energy Sources
EAC	Energy Attribute Certificate
REC	Renewable Energy Certificate
GO	Guarantee of Origin
CO_2	Carbon Dioxide
CO_4	Methane
MWh	Megawatt-hour
TWh	Terawatt-hour
kWh	Kilowatt-hour
CBA	Cost-Benefit analysis
CDP	Carbon Disclosure Project
EECS	European Energy Certificate System
GHGP	Green House Gas Protocol
API	Application Programming Interface

Glossary

As in any sector, there are many ways of saying the same thing in the renewable energy and power markets sector. This often creates confusion. In the table below, we have specified a set of words and phrases which we have tried to use consistently throughout this master thesis, what we mean by them, and alternative words/phrases that can be used.

Issuing body – A competent body responsible for the issuance and tracking of EACs. Issuing bodies manage with the registration of Production Devices.

Corporation – Public or privately owned company.

Disclosure – Disclosure is the provision of information to a final customer about the specific attributes of each unit of energy supplied to them. A disclosure period is a period within which a unit of energy is generated, its attributes are certified through the issuance of an EAC, and those certified attributes are consumed by cancelling the related EAC.

Granular metering data - Electricity production and consumption settlement metering data with at least an hourly frequency.

1. Introduction

1.1. Electricity usage by corporations and impact in CO_2 emissions

The largest driver of global warming is the emission of GHG, of which over 90% is CO_2 and CH_4. The majority of anthropogenic CO_2 is caused by the combustion of fossil fuels, such as coal, oil, and natural gas. In Figure 1, a breakdown by sector of the global GHG emissions for the year 2016 is shown. Almost three-quarters of emissions come from energy use; almost one-fifth from agriculture and land and the remaining 8% from industry and waste.

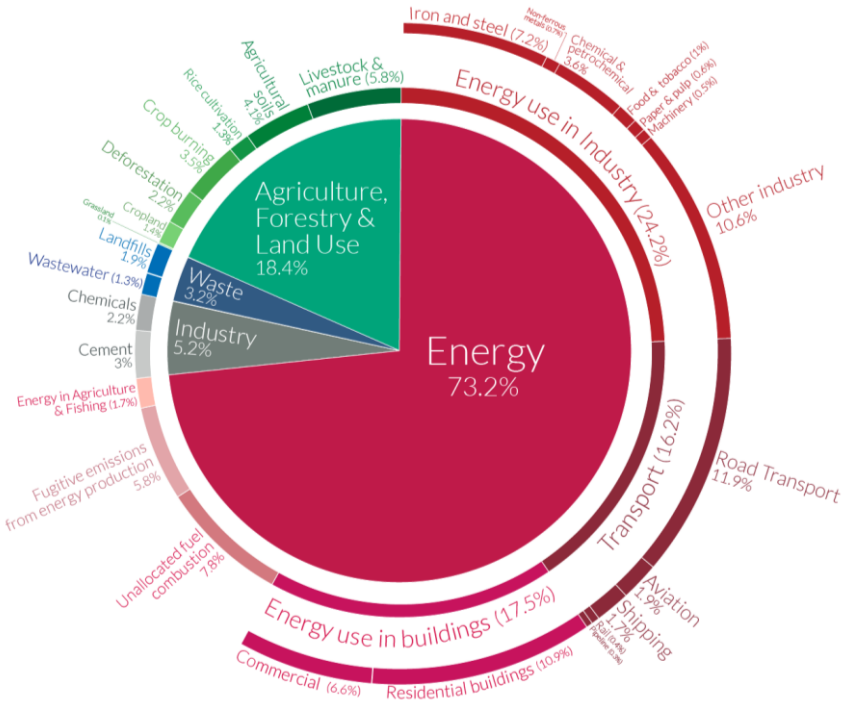

Figure 1. Global greenhouse gas emission by sector [1]

Large energy buyers -including corporates, cities, and institutional customers- are great contributors to the global GHG emissions, due to the fact of its electricity consumption. As a result, they need to make significant progress towards the reductions of emissions. Commercial and industrial sectors consume almost two-thirds of global end-use electricity; therefore, they have played and will continue to play an important role in driving clean energy in the near term, particularly renewables. More than 500 companies have established science-based targets to reduce their emissions and more than 1,100 companies have committed to take climate action [2]. Further, over 280 companies have joined RE100 and committed to purchasing renewable electricity in an amount equal to their annual electricity consumption, which collectively represents more than 300 TWh per year [3]. Globally, nearly 10,000 cities and local governments have adopted GHG emissions reduction targets, while more than 250 cities have announced 100 percent RE targets at the city-wide level [3].

Even though corporates have made significant progress towards the reduction of emissions, they will need to take additional actions to play a leading role in accelerating the transition to a carbon-free grid. Where and how corporates source their electricity will be a decisive factor in the world's pursuit of a sustainable future. The following sections will present the state of the art of today renewable energy procurement models available on the market, with their related certification and emissions reporting. A number of limitations of current reporting systems will be presented, with the aim of presenting a potential solution and its related needs to implement it.

1.2. Available models for corporate sourcing of renewable electricity

Corporations that want to buy renewable energy to cover their electricity consumption have several options available on the market, each of them having diverse features, advantages, drawbacks and environmental impact. A brief of the available models can be observed in Figure 2. Corporations are on their way to meeting or have already met their total electricity consumption with renewables on an average annual basis through a combination of electricity bundled with Guarantees of Origins (GOs) -green power-, power purchase agreements (PPAs) bundled with Guarantees of Origin (GOs), on-site generation (behind-the-meter), and unbundled GO purchases separately from electricity.

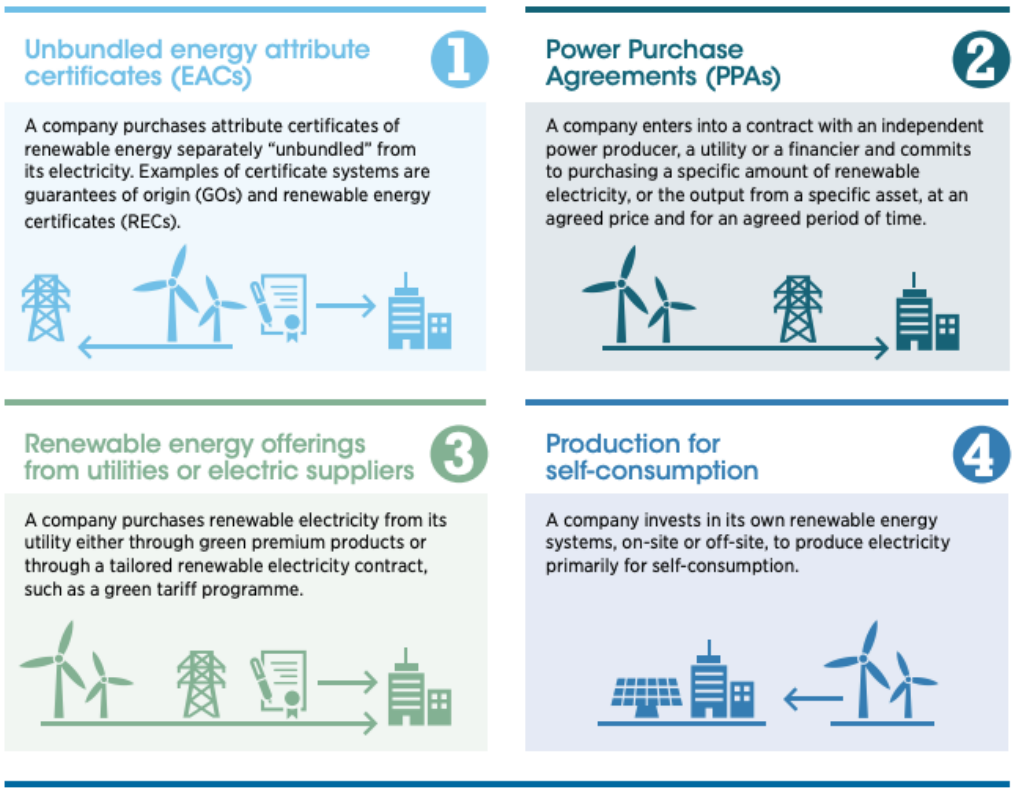

Figure 2. Models for corporate sourcing of renewable electricity [4]

As shown in Figure 3, renewable electricity sourced by corporations reached 465 TWh in 2017, representing approximately 3.5% of total electricity demand in the Commercial and Industrial

sectors. Production for self-consumption is the most common model, followed by the purchase of unbundled energy attribute certificates and power purchase agreements. The overall share of renewables in total electricity use would need to reach at least 85% by 2050 to achieve objectives set in the Paris Agreement, which translates into 19,000 TWh of renewable energy consumption for the Commercial and Industrial sector.

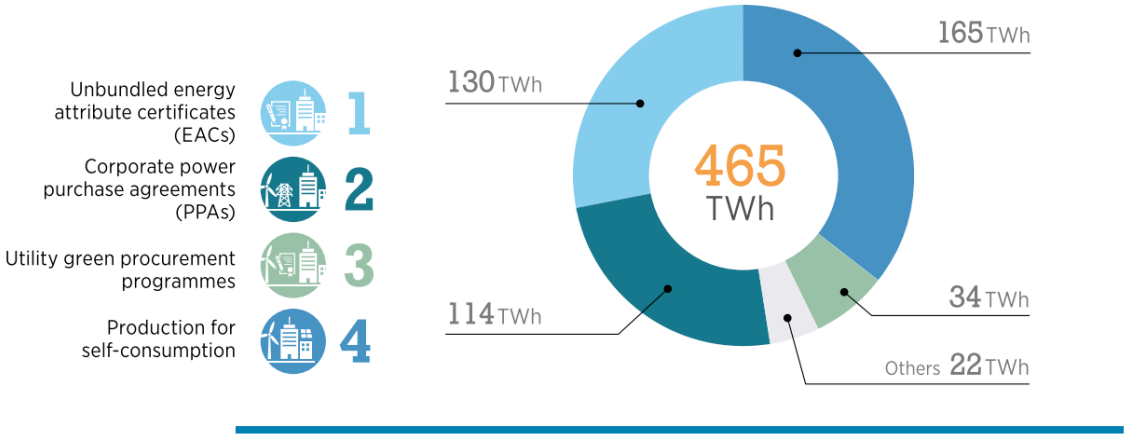

Figure 3. Global corporate sourcing of renewable by sourcing model [4]

1.2.1. Unbundled energy attribute certificates (EACs)

An Energy Attribute Certificate (EAC) is a market instrument that represents 1 MWh of electricity generated by a renewable energy power plant [5]. The owner of a renewable generator, whether its technology, can sell their EAC bundled with the electricity they generate, a product known as "green power", or the EAC can be stripped from the underlying electricity and sold "unbundled". Each unbundled EAC grants its owner the marketing right to call a MWh of electricity that they purchased from a non-renewable source "renewable".

Through the use of EACs, corporations around the world can make reliable claims about their energy usage such as: "my facility runs on 100% renewable energy", "our products are made with 100% wind energy", and "our electricity consumption causes zero CO_2 emissions". Electricity is not a tangible product that can be boxed and sent from the producer to the consumer. Instead, a producer injects an electrical charge into the grid in one place and somewhere else, a consumer takes the same amount of charge off the grid. When electricity is generated -either from a renewable or non-renewable power plant- the electrons added to the grid are indistinguishable. Therefore, the only reliable mechanism for making claims about the electricity consumed is a system that books all injected electricity as unique units (1 MWh). These booked unique units can be traded independently from the underlying electricity and the only entity that 'cancels' this unique unit can claim the usage of that specific MWh. This mechanism is called a book-and-claim system and is the cornerstone of EACs worldwide.

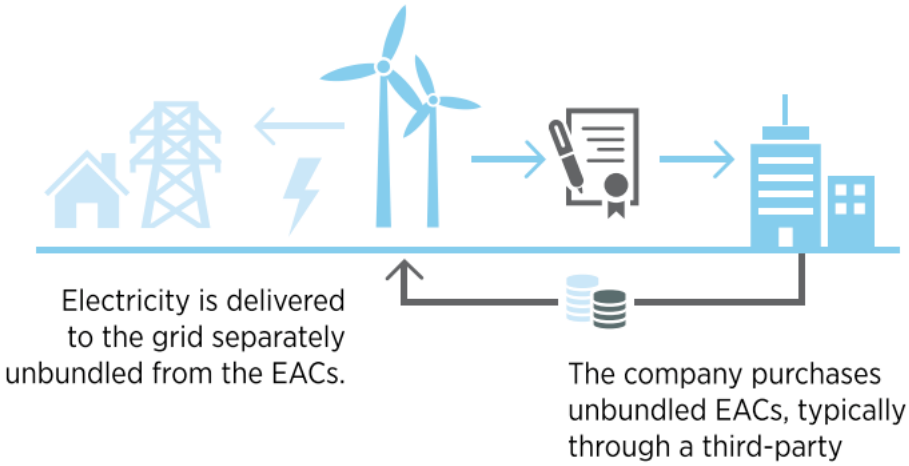

Figure 4. Unbundled energy certificate model [4]

In the United States, EACs are known as Renewable Energy Certificates (RECs). US REC schemes are governed at both the federal and state level, and they are used for compliance reporting as well as voluntary consumption purposes. In Europe, EACs are known as Guarantees of Origin (GO) and are unquestionably the largest standardized and legally enforceable market for EACs in the world [6], and there will be the scope of this thesis. Same as in North America, European GO schemes are mandatory for disclosure purposes as well as voluntaries, used by businesses, public institutions and households. I-REC is a global standard introduced in a growing number of countries where no market mechanism was previously in place. I-REC builds on best practices from the North American REC market and Europe's GOs and has strong stakeholder support. Figure 5 shows the distributions of EACs throughout the world.

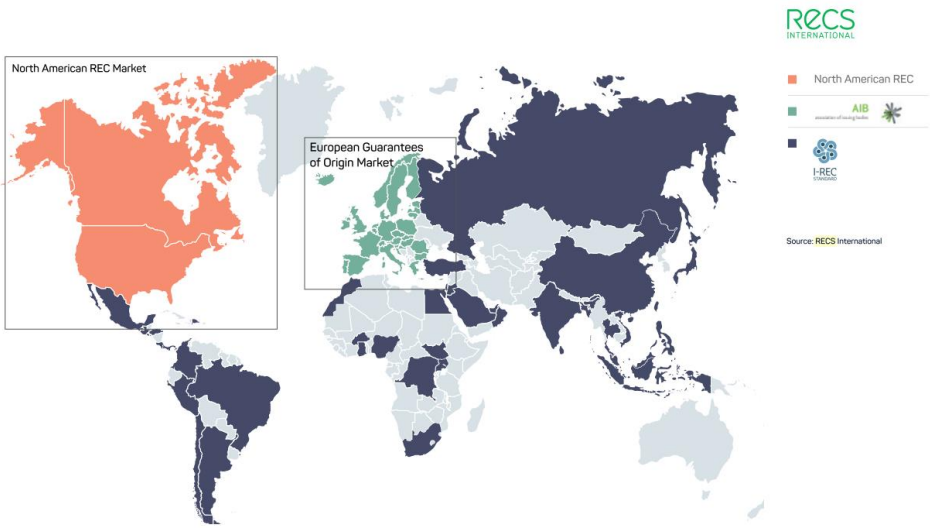

Figure 5. Map of the three main EAC schemes: I-REC, GO and REC [7]

Many countries with established EACs markets have two trading schemes: one for compliance markets, where utilities and energy suppliers trade certificates to comply with quota obligations; and one for its voluntary market. The latter is crucial for companies wanting to source renewable electricity. In markets without certificate tracking systems, it has been proven to be more difficult

for corporations to substantiate their claims of renewable energy usage, which in turn discourages further corporate sourcing.

Corporate consumers are interested in GOs as they can use them for carbon accounting purposes or for marketing communication. The purchase of unbundled renewable EACs is a popular form of corporate sourcing of renewable electricity that is available in many markets where an energy attribute tracking mechanism is in place, as shown in Figure 5. Prices for EACs (and their variants) vary depending on local supply and demand, technology, locational attributes and contract length. They differ significantly from country to country. As for today, the average prices of a Guarantee of origin (EAC scheme in Europe) is 0.5€/MWh [8], whereas the average wholesale electricity price is 40 €/MWh [9].

1.2.2. Power Purchase Agreements (PPAs)

Power Purchase Agreements allow corporates to purchase renewable energy directly from a producer. A contract with an independent power producer is signed for several years. The typical duration for a newly built project is ten years or longer. A decision for signing such a contract needs a lot of preparation and planning, and it allows to avoid the risk and price volatility and helps in future budgeting since the customer knows in advance exactly how much will pay for their electricity consumption. Companies like Google, Facebook, Microsoft, Adobe, IKEA are examples of big corporates that have signed a PPA in recent years. Two main models of PPA can be distinguished:

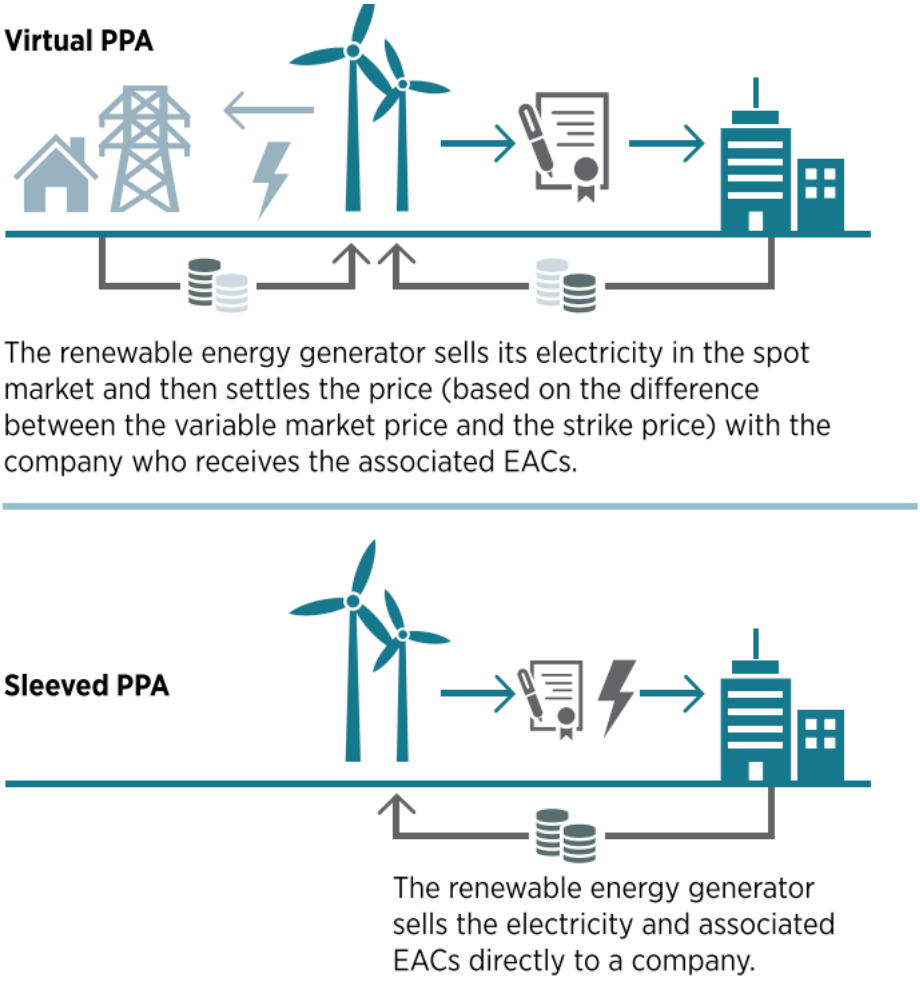

Figure 6. PPA available models [4]

The global cumulative market for corporate PPAs amounted to roughly 114 TWh in 2017 [4]. The sleeved PPA usually covers large amounts of energy and possesses customers before the power plant is created in order to secure the financing of the project. Sleeved PPAs are an important part of nowadays market and with every year their popularity increases. In 2020 a record of 3 GW of renewable PPA has been contracted in Europe, which adds up to cumulative 11.1 GW. The majority, 75% of the European PPAs are photovoltaic projects, while the other 25% are wind projects.

1.2.3. Renewable energy offerings from utilities or electric suppliers

Utility green tariffs allow the corporate buyer to purchase renewable electricity either through green premium products or through a tailored renewable electricity contract, such as green tariff programs offered by certain utilities. It allows customers to buy renewable electricity bundled with an energy attribute certificate. Either a supplier promises to match a customer's electricity usage with the generation from renewable energy sources or will contribute towards environmental schemes on the customer's behalf. Green tariffs work just like standard tariffs that energy retailers offer, but in addition, a Guarantee of Origin is bundled with each MWh of procured electricity. In most cases, the price paid for a green tariff is higher than the one paid for a standard tariff. The price per MWh varies a lot depending on the amount of electricity

purchased. The details of an offer and the electricity price depend on the agreement made with the retailer.

Green premium products enable corporate buyers to conveniently purchase renewable electricity directly from the utility without a long-term commitment. In contrast, utility green tariffs (also known as utility renewable contracts) are longer-term agreements whereby customers purchase renewable electricity bundled to a specific renewable energy asset, usually from a new system, but this may vary between markets and programmes. Renewable energy offerings from utilities or electric suppliers were 34 TWh in 2017 [4].

1.2.4. Production for self-consumption

Deploying renewable energy systems, on-site or off-site, to generate power for their own use have become an important option for corporate consumers. The company becomes responsible for the entire life cycle, from commissioning to decommissioning, assuming the associated risks and financing responsibilities. It is estimated that the market for production for self-consumption was 165 TWh in 2017 [4].

In comparison to other sourcing models, corporate direct investment has gained traction in developing countries, with a range of innovative policy and financing mechanisms in place.

1.3. Emission reporting market

In order to meet the goals dictated by the directives, a certain level of control over the industry and domestic users is needed. The attention focuses especially on the Industrial and Commercial sector since accounts for two-thirds of the global end-use electricity. Detailed instructions and restrictions are defined by each country's government individually. In most countries, the companies have to report their energy use and related CO_2 emissions in their annual reports. While all corporates need to follow the mandatory regulations, many companies are voluntarily setting ambitious targets for themselves and are joining initiatives such as RE100 [3].

In 2004, the first important position, called the Corporate Standard, has been published by the Greenhouse Gas Protocol – an organization established in 1998. It was a result of the cooperation of various businesses, non-governmental organizations, and other stakeholders associated with the World Resources Institute and World Business Council for Sustainable Development. The International Organization of Standardization introduced its ISO 14064 two years later, in the year 2006, and it was updated in 2018 [10]. Like all the other standards issued by ISO, the ISO 14064 is protected by copyrights and in order to be used has to be purchased by the company. Unlike ISO 14064, the Corporate Standard has been released to the companies' use free of charge. Currently, more than 90% of the Fortune 500 companies are using Greenhouse Gas Protocol standards [11] according to the CDP reports. It is the most widely used standard in the world, recognized by many authorities as an independent standard for reporting greenhouse gases.

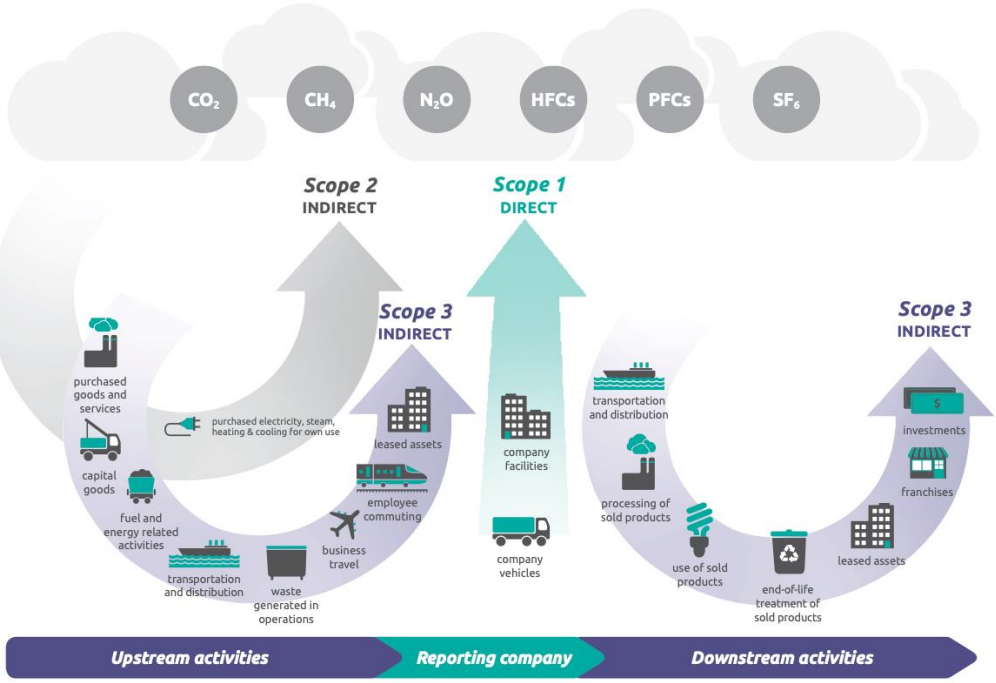

Figure 7. Overview of GHG Protocol scopes and emissions across the value chain [11]

As Figure 7 shows, the Corporate Standard categorized the emissions into three main categories, based on their origin:

- Scope 1: All emissions released directly from the activities of an organisation or a party under their control. They represent emissions such as fuel combustion on-site (gas boilers, furnaces, vehicles), chemical production or air-conditioning leaks.
- Scope 2: This term describes indirect emissions from the purchase or acquired electricity, steam, heating and cooling. Those emissions are a consequence of an organization's activities that occur at the sources it does not own or control. For most of the companies, Scope 2 emissions represent the majority of emission sources and operational costs.
- Scope 3: All the other indirect emissions from activities of the organization, which occur from sources that are out of the company's control. They represent emissions such as business travels, waste, water or procurement.

Scope 2 category incorporates two reporting ways, the first one is called the "location-based" method, and it quantifies emissions based on average energy generation emission factors for defined locations, including local, subnational, or national boundaries. The second one is called the "market-based" method, and it quantifies emissions based of GHG emissions emitted by the generators from which the reporter contractually purchases electricity bundled with instruments or unbundled instruments on their own.

1.3.1. Limitations

However, there exists an important problem with the way that the CO_2 accounting system works, which has not been addressed yet by the protocol. In both cases of location-based and market-

based methods, values used in calculations are yearly averages. This means that insight on what exactly happens during the whole year of electricity consumption is not included.

The current way of calculating emissions of both methods relies on yearly average grid carbon intensity, which does not account for any patterns in users' electricity consumption and does not take into consideration the time of consumption. In reality, the grid carbon intensity changes every hour, depending on the electricity generation mix in a given location, the import of electricity between countries and the demand on the market. Without accounting for those changes a good representation of reality cannot be achieved, which is how the current reporting system works. For example, a company that owns an on-site photovoltaic installation that generates 10 MWh per year of electricity - the company's yearly amount of electricity consumption - can claim to be '100% renewable' and report their market-based yearly emissions as zero. But in reality, if this company happens to consume electricity at night, when no solar irradiation occurs, it is impossible for the photovoltaic installation to produce any electricity. Therefore, the company is physically consuming electricity coming from the grid, which in many cases comes from the local fossil fuel power plant, and then it returns to the grid the amount of electricity produced by the PV installation at different times. But by consuming their electricity at night, the company contributes to the increased demand in the time when the emission intensity of the grid is high and should be responsible for the related emissions.

A model analysis for the electricity delivered to the Spanish grid in 2012 [12] reveals that, for companies operating during the day, GHG emissions calculated by the real-time method are estimated to be up to 5% higher (and in some special cases up to 9% higher) than the emissions calculated by the conventional method in which a national grid EF is applied.

A paper published by Jacques A. de Chalendar [13], a doctoral candidate in energy resources engineering at Stanford University demonstrates in one example that using annualized data, “overestimated the carbon reductions from purchasing solar by over 50%”

1.4. “24/7” matching in corporate RES-E

The challenge of achieving a 100 % renewable electricity grid is not only a question of how much renewable energy is built, but rather whether renewables can supply electricity when it is needed. One emerging approach to address this challenge is “24/7" renewable energy, which requires matching a corporation’s hourly energy demand with renewable energy produced in the same region and hour [14]. Some companies such as Google or Microsoft are already implementing “24/7” procurement in their strategy, as they see the importance of such practice on the energy market.

When a corporation says that it is “100 % renewable” it generally means that it has purchased the same volume of renewable electricity as the electricity it consumes in a year, but not necessarily at the same time as it is consumed. Because electricity is delivered instantly and cannot be directly stored, operating the power grid reliably re-quires supply to equal demand, every second of every day. This means that the main challenge of achieving a 100 % renewable electricity grid is not only a question of how much renewable energy is built but rather whether renewables can supply electricity when society can use it.

Procuring mismatched renewable energy allows the buyer to benefit from cheap, fixed prices while passing the costs and volatility on to other ratepayers. Each renewable energy buyer has the best knowledge of, and control over, its internal costs and operational flexibility, and thus is the best-informed market participant to invest in cost-effective, load-matched supply (or supply-matched demand flexibility). Given the 20-25-year contract length of many existing corporate PPAs, the mismatched PPAs that corporations are signing today could end up being a liability as the grid continues to transform. In addition to concerns about impact, this evolving risk profile is a further incentive for corporations to rethink their strategy. Shape risk, also known as covariance risk, is the primary concern, as it is exacerbated when project output does not correlate with the buyer's consumption.

In addition, if there is not enough systemwide load to absorb this solar energy, solar operators may be forced to curtail their production, reducing the overall quantity of RECs that the off-taker can retire and use to make progress toward their renewable energy goals.

The accounting guidance for "scope 2 emissions," or emissions from purchased electricity, allows for market instruments such as GOs to be counted as a zero-emissions attribute for any electricity consumed in the same reporting year, thus allowing companies to report zero market-based scope 2 emissions if the quantity of GOs they retire equals the annual quantity of electricity consumed. Previous research [13] has found that using annual emissions data for a constant load would overestimate the emissions reductions from purchasing solar power by over 50 %. Updating the protocols to include guidance on, if not preferred, hourly accounting of scope 2 emissions would help make corporate sustainability teams more familiar with this concept and allow them to quantitatively measure the benefits of load-matched renewable energy procurement in their reporting.

The following case given by Google [15] illustrated in Table 1 provides an example of the impact in market-based Scope 2 emission by using two different procurement approaches. Company A, which consumes 1,000 MWh of electricity at a factory in Kentucky, purchases 1,000 MWh of renewable electricity certificates (EACs) generated by existing solar PV projects in California. By doing so, it calculates and reports that its market-based Scope 2 emissions are zero following the Scope 2 Guidance. Now consider Company B, which also consumes 1,000 MWh of electricity in Kentucky, but decides to target a 90% hourly of renewable energy by purchasing renewable energy from new generation projects deployed on the local grid, as well as shifting demand to times of the day when renewable energy mix is higher. This approach by Company B, despite requiring greater investment and having a demonstrably higher impact in terms of avoided carbon emissions, would not be recognized as higher-impact based on the market-based Scope 2 accounting methodology.

Table 1. Comparison example between two different renewable energy procurement strategies [15]

	Electricity demand (Location)	Procurement approach	Grade-level emissions impact	Market-based scope 2 emissions
Company A	1,000 MWh (Kentucky)	1,000 MWh of unbundled RECs from existing PV	Negligible (projects have already been built, emissions on	Zero

		projects in California equivalent to 100% of annual consumption	CA grid lower than KY)	
Company B	1,000 MWh (Kentucky)	Achieve 90% CFE on an hourly basis over the course of a year on electricity grid where consumptions occur	Significant (CFE purchases from new projects avoid carbon-intensive generation on grid where electricity is consumed)	Greater than zero

Other examples of this problem, can be observed in Figure 8, in where the company procured wind energy is 100% volumetrically-marched to their demand, but only 80% matched on an hourly basis since the wind production profile does not match the demand profile of their consumption.

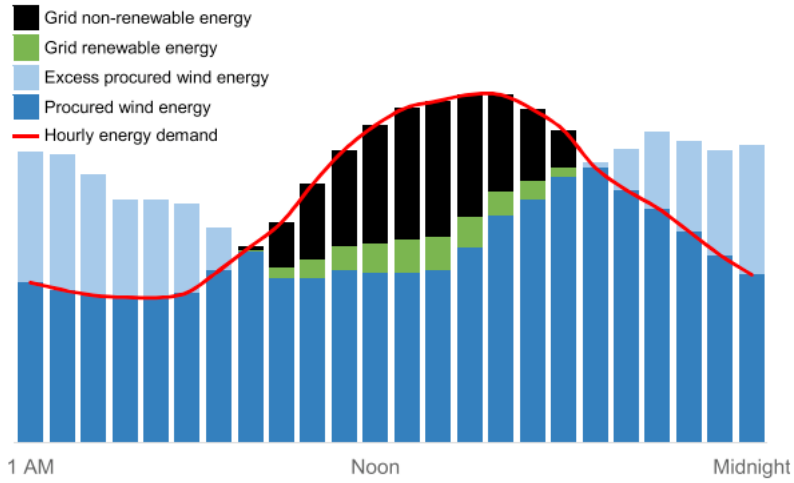

Figure 8. Hypothetical day hourly-matched renewables [14]

As corporate energy procurement practices evolve toward approaches targeting greater impact on electricity system decarbonization, the guidance for emissions accounting will need to be revised to recognize and differentiate the emissions impact of different approaches.

In Table 2, 5 examples of 24/7 procurement strategies can be observed. Achieving a 24/7 renewable target will require five main approaches: understanding a company's demand patterns throughout the year, procuring a diverse portfolio of renewable technologies whose output match a company's demand profile in each region, shaping and shifting the timing of loads to match the availability of these local renewables, investing in local energy storage to balance the difference, and prioritizing action in regions where they will displace the dirtiest fuels first.

Table 2. 24/7 Renewable Energy uses cases

Company	Description	Reference
Google	By 2030 Google intends to match its operational electricity (on the same regional grid) carbon-free energy sources in every hour of every year.	[16]

Iron Mountain	By 2040 Iron Mountain will use 100% clean electricity, 100% of the time in their data centers. They are going beyond their RE100 commitment. They will use Google methodology for matching site by site electricity consumption with local clean power generation every hour, every day to achieve 24/7 clean power.	[17]
Microsoft	Microsoft announced a goal to match 100 percent of its electricity consumption 100 percent of the time with zero carbon energy purchases.	[18][19]
Des Moines, Iowa	In January 2021, the Des Moines City Council unanimously voted to pass a resolution to achieve net-zero emissions by 2050 and reach 24/7 carbon-free electricity by 2035	[20]
Palo Alto	Carbon Neutral Plan Accounting Update: Change the annual carbon accounting methodology used in the Carbon Neutral Plan to a more accurate hourly emissions factor.	[21]
US Federal Government	In the American Jobs Plan and in the Executive Order on Tackling the Climate Crisis, the Biden administration specifically outlines a goal to use the federal government's purchasing power to purchase 24/7 clean power for federal buildings and a carbon pollution-free electricity sector no later than 2035	[22], [23]
Peninsula Clean Energy	Design a power portfolio that is sourced by 100% carbon-free energy by 2025 that aligns supply and consumer demand a 24/7 basis	[24]

The core concept of 24/7 RES-E sourcing is: "Matching a given volume of electricity demand with an equivalent volume of RES-E that is generated (injected) at the same time, validated by meter/grid data and energy attribute certificates with a time stamp of one hour or less, where possible"

1.4.1. Needs

Several "building blocks" are needed for this enhanced procurement strategy, and this thesis will focus on two that have been identified as key in the short term:

- *Hourly certificates:*
  - Development and issuance of hourly certificates for hourly accounting, as well as interactions among hourly certificates and existing EACs schemes. Implementation of hourly energy attribute certificates would need to be led by the various renewable energy tracking schemes or registries who are responsible for creating GOs. Since these granular certificates would need to be retired against load occurring in a specific hour, there might be a need for a complementary certificate system for tracking and verifying hourly load.
  - Harmonise the granular certificate scheme across Internal Energy Market countries to provide a clear and unambiguous foundation for voluntary 24/7 matching schemes. Update existing rules so that GOs are time-stamped. Retain the volumetric measure of a GO as 1 MWh and consider the implication of splitting or combining GOs to reflect the required volume of consumption for a given period of time.
  - Providing clear evidence of 24/7 matching: Issuing energy certificates with information that evidences the time when the energy was produced. A GO specifies the geographic location of the electricity generation asset, the type and

capacity of the installation, but issuing bodies are free to define the production period. Most of the issuing bodies use monthly periods, labeling GOs with the first and last day of that month, but not the day, hour, or 15 minute balancing period.

- A requirement for 24/7 matching is for issuing bodies to "time-stamp" the GOs they issue to energy producers, stating the precise moment that the underlying unity of energy was produced. This level of precision is allowed but not required under current EU law, although the matter is under review.
- Accurate and reliable smart meters at both the point of production and consumption can provide the data required to time-stamp GOs. A confirmation framework to ensure accuracy and veracity must be developed, which should avoid double-counting. In the meantime, a voluntary system of Granular Certificates is emerging within the existing scheme, drawing from experience with existing Non-Governmental Certificates – voluntary certificate schemes operated on a commercial and non-legislative basis.
- Grid-level energy storage can support 24/7 matching by taking variable renewable power generation and making it dispatchable. As with other points on 24/7 matching, once the relevant GOs are time-stamped, the underlying EAC scheme should govern the certification of power that goes through storage.
- Accounting systems that recognise and value moving towards 24/7: A fundamental question of volume or time. There is a clear benefit to having a standard volumetric unit of energy, set in Europe and all major EAC schemes at 1 MWh. The volumetric unit of GOs allows them to be easily traded in bundles of 100 GOs or more, reducing transaction and handling costs. The adoption of 24/7 matching poses a challenge to volumetric units by counting temporal units of less than one hour. A unit of energy generated by a given production site in an hour or less will contain a different kWh or MWh quantity of energy depending on the size and productivity of the production device at that specific moment. This difference could add to the challenge of 24/7 matching as those seeking to match their renewable energy consumption in every hour will have to find the specific GOs that cover their consumption for each hour of each day. This contrasts starkly with annual or even monthly matching where a consumer simply has to calculate their MWh of consumption over the relevant period and buy the same number of GOs - one for one. This is a fundamental issue which needs a lot more analysis and discussion.
- A key part of supporting the development of 24/7 matching that is being explored in various EnergyTag demonstration projects [6] will be finding a reliable way to use the volumetric units of GOs to match a specific time period. This could include splitting or combining GOs to reflect the required volume of consumption for a given period of time. A GO may only be split into several GOs for whole numbers of watt-hours. It is possible that two markets will emerge,

one for 1MWh GOs and a separate market in sub-MWh GOs, with some form of clearing mechanism between the two.

- *Metering data:*
    - Access to metering data is a fundamental need for companies wanting to get started on the 24/7 RES-E journey. Metering data will be defined as electricity production and consumption settlement metering data. Metering data is essential for companies to make informed decisions around 24/7 RES-E. As the adage goes: "If you can't measure it, you can't manage it." Transparent, accessible metering data (e.g., with limited or no additional investment in hardware devices or complex interfaces for consumers) will accelerate the uptake of 24/7 RES-E by providing the data points needed to plan, purchase, adapt, match, certify and report RES-E production and consumption on an hourly basis.
    - Accelerate grid digitalisation and metering data access, alongside a framework to ensure all interested parties can access data with at least hourly granularity in a standardised format and as soon as possible after physical energy flow. Availability and credibility of hourly metering data (production and consumption certified data). Hourly data will help users ensure that each hour of their operations is matched to actual renewable energy produced at the same time.
    - A fundamental need is for regulated and non-discriminatory access to metering data through transparent, secure and digital consent mechanisms. These systems should be harmonised, and ultimately standardised, across Europe to allow market participants to share their metering data with any secure and trusted service provider they wish. All metering data would need to have at least hourly granularity to support hourly matching of electricity production and consumption, be available as soon as possible after physical energy flow (a maximum of one month after physical energy flow) and without geographical limitations within Europe. Hourly matching will be a journey from the current annual matching periods used in most European countries, but hourly metering data must be available and accessible now to support this transition.

1.4.2. Potential benefits

The potential benefits of moving towards 24/7 matching are:

- Increasing transparency of corporate sustainability claims and potential granularity of carbon accounting
- Increasing renewable energy investment
- Accelerating electricity decarbonisation by supporting the development of renewable energy assets to better reflect when and where RES-E generation is most needed
- Facilitating new business models and innovative technologies
- More closely aligning markets with the physics and economics of the grid and the variability of supply and demand.

2. Problem statement and scope of the thesis

2.1. Problem statement

When a corporation says that it is "100% renewable" -claiming that they are emitting zero CO_2 from their electricity consumption- it means that it has purchased the same volume of renewable electricity as the electricity it consumes in a year, but not necessarily at the same time as it is consumed. The real-time availability and intermittent character of the renewable energy sources are completely hidden in the "100% renewable" statement, meaning that corporations are claiming zero emissions when their emissions from electricity consumption are greater than zero.

The main challenge of achieving a 100% renewable electricity grid is not only a question of **how much** renewable energy is built, but rather whether renewables can supply electricity **when** corporations can use it.

One emerging approach to address this challenge is "24/7" renewable energy procurement, which requires matching the corporation's hourly energy demand with renewable energy produced in the same region and hour. In order to achieve the hourly matching, access to -at least- hourly production and consumption certified metering data is needed, in addition to a scheme for granular energy certificates.

2.2. Scope of the thesis

Based on the need for hourly metering production and consumption data and a granular energy certificate scheme to support the "24/7" renewable energy procurement, the thesis aims to propose a model for having available for all market participants:

- Hourly metering production and consumption data
- A granular certificate scheme

Related to hourly metering data, an in-depth investigation of the key characteristics of European data exchange infrastructures will be developed with the aim of identifying the current status of certified metering data access in Europe. As a result, by identifying the existing barriers and challenges, a model for having a standardized model of a data exchange infrastructure will be proposed.

Related to the certification scheme, an in-depth investigation of the key characteristics of today's annual certification scheme in Europe, called guarantees of origin, will be developed with the aim of identifying the current status, the existing barriers and challenges. More specifically, the cancellation process will be studied in more detail. As a result, a model for the granular certificates scheme and its integration with the existing scheme will be proposed.

In addition to the proposed models for hourly metering data and granular certificates, a business case will be presented, in order to understand challenges and opportunities for the granular

certificates issuing bodies. The business case will be based on an issuing body for granular energy certificates.

Scope:

- Focus on electricity (not energy/hydrogen)
- Focus on Europe (not global)
- Focus on corporates and third-party service providers (not all consumers)

3. Literature review

3.1. Granular metering data

To begin with, granular metering data is defined as electricity production and consumption settlement metering data with at least an hourly frequency.

Electricity metering data is the new "gold" of the energy transition. Gathering granular metering data (i.e., at least hourly production and consumption settlement metering data) is key for corporate consumers to achieve cost reductions, mitigate both short and long-term risks and prioritise strategies that maximise emission reductions and make a real positive impact. Data is also extremely important for service providers and consultants to be able to support companies on their renewable energy journey.

However, obtaining access to such data is not easy: expensive investments and high maintenance costs for hardware devices, data interfaces with O&Ms and producers as well as tedious negotiations with electricity suppliers are some of the traditional barriers.

3.1.1. Smart meters

A smart meter can, indifference to a regular meter requiring manual readings on a monthly basis [25], measure the real time energy consumption in a household and both transmit and receive information remotely [26]. The definition of a smart meter varies globally, according to the European Commission, a smart meter should:

- Provide the consumer with meter readings
- Be able to update readings frequently enough for energy savings and for network planning
- Allow remote readings for meter operators and remote ON/OFF control of supply by grid operators
- Provide a secure two-way communication flow with external networks
- Support advanced and dynamic electricity tariffs
- Prevent and detect data frauds
- Provide functions allowing distributed generation

One of the main purposes of smart meters is to acquire data about the customer as well as the producers. This leads to a large collection of data that can provide parties with full information about electricity production, consumption, and behavioral patterns.

In order to have access to granular metering data, data must be digital, thus requiring a wide-scale[1] smart meter penetration. Without smart meters, the tools available to reach a 24/7 RES-E procurement are limited. According to national targets, 223 million smart meters will be installed in Europe by 2024 [27], corresponding to a 77% penetration rate. This rollout is generating valuable data for all energy market participants and has the potential to unlock several monetary and environmental benefits for consumers. However, this potential still

[1] More than 80% of metering points covered by smart-meters

remains largely unexpressed, and very few companies in the world have incorporated granular metering data in their operations as a means of gaining a detailed, global understanding of their demand's hourly or even daily profile and the characteristics of their loads.

Table 3. Key figures for different electricity smart meters deployment state of play scenarios [27]

Smart metering deployment for electricity			
	Number of electricity smart meters installed (in million)	Penetration at EU level (%)	Induced overall investment (€ billion)
2020 original target in households (ref. COM (2014)156)	~200	~72% in households	€45 billion based on original costing
Estimated 2020 State of play (households & SMEs)	123	43	21
Estimated 2024 State of play (households & SMEs)	223	77	38
Estimated 2030 State of play (households & SMEs)	266	92	46

Smart meters have been set to replace conventional electricity meters throughout Europe. European Member States will have until the 31st of December 2020 to transpose the Electricity Directive (2019/944) [28] into national law, which provides consumers clear rights to request smart metering devices and dynamic pricing contracts to be able to profit from the digitalisation of the energy system. The Electricity Directive (2009/72/EC) [29] called for Member States to conduct a Cost-Benefit Analysis (CBA), and subject to a positive outcome, Member States were required to define implementation timetables over a period of up to ten years and reach a smart meter penetration rate target of at least 80% by 2020.

Aiming to increase a wide-scale deployment of smart meters in Europe, the Electricity Directive (2019/944/EC) [28] mandates every Member State to update the CBA at least every four years, and subject to a positive outcome, 80% of final customers must be equipped with smart metering devices within seven years or by 2024.

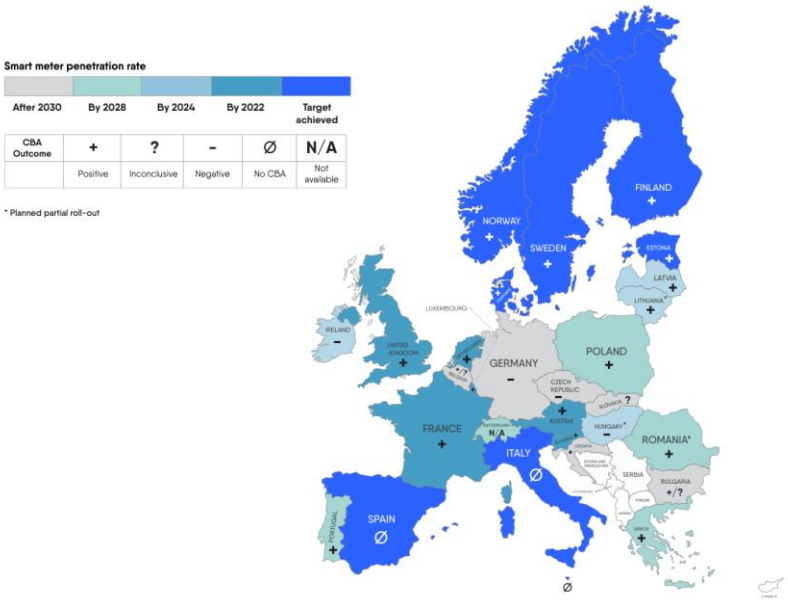

Figure 9. Smart penetration rate and CBA Outcome [30]

Figure 9 shows that only 7 countries (25%) have achieved the wide-scale smart meter rollout plan, 6 countries (21%) will achieve the plan by 2022, 4 countries (14%) will achieve the plan by 2024, 5 countries (18%) by 2028 and finally, 6 countries after 2030 (21%). Coincidently countries with positive cost-benefit analyses and clear mandatory regulatory frameworks are on their way to reach their targets according to national plans. Whereas, countries without mandatory smart meter roll-out programs and clear legal frameworks, are facing considerable delays in their roll-out programs. €41 bn is needed to achieve a smart meter penetration rate of 92% by 2030 [27].

3.1.2. Data exchange infrastructures

Efficient management of metering data is the key to unleashing the potential of smart meters. Data must be also protected against cyber-attacks, while still being easily accessible for market actors. With smart meters being rolled out in Europe, valuable data is generated that can benefit all energy market participants: consumers, network operators, DSOs, TSOs, suppliers, and new energy providers. For this to happen, data need to be accessed in an efficient, non-discriminatory way and free of charge for all authorized energy market participants.

Data management has become important in today's society and the electricity sector is not an exception. Countries, both within and outside Europe, are working on new solutions to increase usage and efficiency. National data platforms to store and process electricity data are seen as key players to coordinate this work.

While the topic of metering data processing has been addressed and regulated, this is not the case with access and sharing (including across borders) of metering data. The situation regarding collecting and processing metering data varies across states in terms of regulation and across energy providers in terms of advancement in the adoption of information technology. This thesis aims to propose a single homogenous model to fill all.

A data exchange infrastructure is a communication platform of which main functionalities are:

- To secure metering data transfer (routing) from data providers (e.g., data hubs, TSOs, DSOs) to the data users (TSOs, DSOs, consumers, suppliers, energy service providers and other third parties).
- Store and make available measurements (e.g., metering data) and associated master data.
- Sourcing, validating, storing, protecting, processing and distributing or providing access to data.

In terms of defining data exchange infrastructures, it is common to attempt to distinguish between centralised, partially centralised and decentralised models of data management.

- Centralised model – Data exchange infrastructure where all metering data of the country is retrieved, validated, stored, protected, processed, distributed and accessed. This model is essentially a 'one stop shop' for metering data, where market actors only have one actor, which they relate to in order to obtain data.
- Partially centralised model – Involves centralisation of one of the key aspects of data management, typically distribution and access to data. A typically centralised model would not include sourcing, storage, validation and protection of data, but rather be a communication hub that provides a common access point for metering data that could be stored in several databases, at DSOs or at metering point (i.e., the model could enable centralised access to data stored at decentralised locations).
- Decentralised model – In decentralised models, all the key aspects of data management are under the responsibility of DSOs. A typical decentralised model would be a standardised message exchange system or another cruder way of connecting market actors with DSOs, such as the use of PDF files for updated network tariffs. The customer does not typically have access to data in a decentralised model, but will have to contact the DSO for access to data.

Existing data exchange interfaces are currently not homogenously structured, and this thesis focuses on the differences and similarities in governance, their barriers and a potential solution for a harmonized and standardised model.

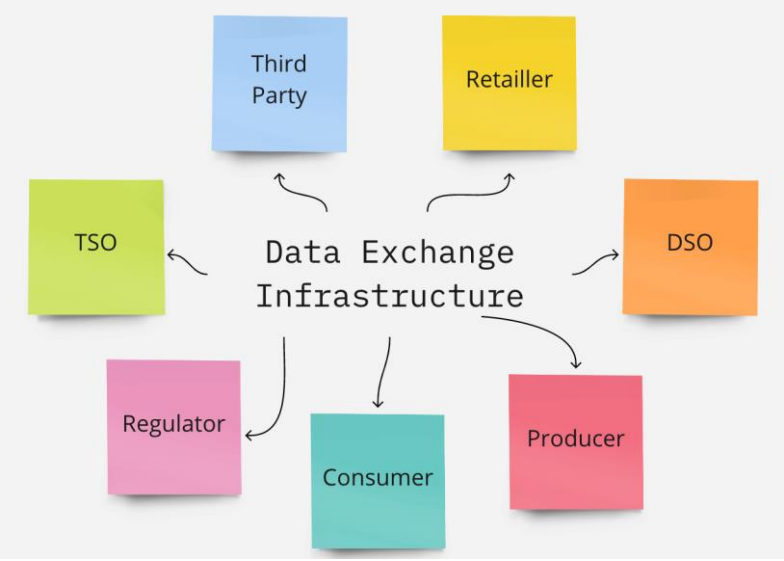

Figure 10. Data exchange infrastructures market actors.

Figure 10 shows the energy market communication structure, with all the stakeholders -market actors- that are implied. Third-party is defined as energy service providers, such as innovative technology companies that offer energy services to customers.

3.1.3. Data access

Based on the Electricity Market Directive (2019/944/EU) [28], validated historical consumption data shall be made available to final customers on request, easily and securely, and at no additional cost. Final customers should be able to retrieve their own metering data and to give another party access, acting on their behalf. In order to promote competition in the retail market and to avoid excessive administrative costs for the eligible market participants, European Member States must facilitate interoperability and non-discriminatory and transparent procedures for data access.

3.2. Guarantees of Origin

In order to help the renewable energy industry to boost financial viability to support renewable energy projects, a market-based system, known as Guarantees of Origin, was implemented through regulative directives. Guarantees of origin allow energy to be tracked and ensure that the renewable sector receives more investments.

Guarantees of Origin (GO) are a tracking system that was defined in article 15 of the [31]. The directive has described GOs as "an electronic document which has the sole function of providing proof to a final customer that a given share or quantity of energy was produced from renewable sources" [31].

The GO system aims to give transparency and disclosure to the electricity market. Thanks to European energy legislation, the electricity market has become deregulated. This allowed EU countries to transport and consume energy that is produced within other EU countries. The GO system is the most reliable and safe way to give consumers the possibility to choose the origin

of the electricity produced. The primary aim of such a market-based system is to boost financial viability to support renewable energy projects.

Due to its unique attributes, electricity is not traceable [32]. Once it has left the power plant, guarantees of origin come into play to give customers the possibility to decide what source of energy they have used or want to use in the future.

Guarantees of origin are issued as certificates. One certificate corresponds to 1 MWh of electricity produced. An end-consumer can acquire certificates to prove that the electricity produced comes from a renewable energy source. Each certificate contains detailed information about the origin, the source, and attributes of the energy that was delivered. All certificates are listed in an electronic certificate registry and are only issued electronically. As a result, if a final user decides to purchase guarantees of origin for documenting how much renewable energy they have consumed or will consume, the certificate gets cancelled from the registry. When it comes to the actual use of the GOs, the cancellation takes an important part. Only after the GO certificate is cancelled from the registry, the attributes of a certificate will become effective. This allows for certificates not to be given, used, traded, or sold by another end-consumer. Moreover, the standardized system allows ownership to be tracked, and consequently, certificates are only sold once and that no double-counting can happen [31].

To better understand the guarantees of origin for renewable energy, it must be understood how electricity travels from a producer to a consumer. For the electricity to reach the end customer, the electricity producer must feed the energy produced onto a grid, which in this case, is referred to as the electricity market. Only if the plant is connected to the electricity market, it will be able to deliver the energy to the end customer.

3.2.1. Governance

The European Energy Certificate System (EECS) is a standardization system for the European Guarantees of Origin, which was established by the Association of Issuing Bodies (AIB). The main function of the EECS is to standardize and regulate all activities that are involved with use, trading, and cancellation of Guarantees of Origin. Countries become members of the AIB to facilitate the trade of GOs across borders. When an electricity producer generates energy, it can receive 1 certificate for each MWh produced, which are issued by the national GO issuing bodies. For a country to be able to issue GOs for its national electricity producers, it must establish a national GO issuing body that must be a member of the AIB. Only countries that are members of the EECS system are allowed to receive Guarantees of origin that can be traded on an open market. This allows the certificate system to be consistent and regulated to avoid fraudulent activities to take place. Also, the AIB established within Europe an electronic Hub to allow for a more efficient way to transfer GOs across the European market. In particular, the electronic Hub allows for full transparency and traceability in order to make sure that GOs are only sold only once and that there is no double-counting [33]. Figure 11 contain all the Issuing bodies within Europe, both EECCS countries and non-EECS countries.

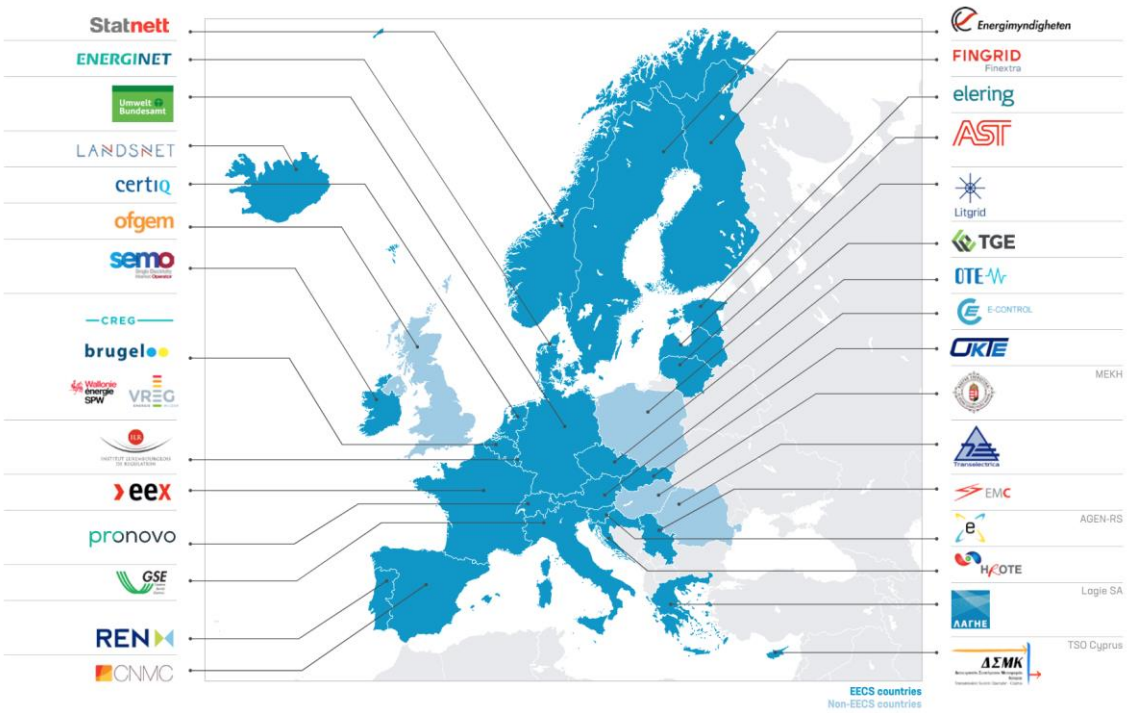

Figure 11. European Guarantees of Origin Issuing Bodies [7]

While the commercial trade in GOs is executed between market participants, cancellations and statistical transfers are made technically under the EECS, through a common IT communication hub, operated by the Association of Issuing Bodies (AIB), an association of the national registries/issuing bodies in 28[2] European countries.

3.2.2. Uses of certificates

Disclosure of the origin of electricity towards consumers – Currently, each electricity supplier is obliged to disclose to its customers the energy origin of all electricity sold (2019/944/EU, Annex 1.5) [28]. In most countries typically this information is only based on cancelled GOs for the share of electricity that is exactly sold as originating from renewable sources. The origin of the remaining supply is covered by residual mix. The need for a residual mix stem from the fact that electricity disclosure is mandatory for all electricity sold, but GOs are typically only for part of the volume, namely the renewable part. The power supplier may only disclose renewable electricity on the electricity bills and for advertisement if they have cancelled GOs for the delivered amount of energy in the register. The registry system makes it possible to track ownership, verify claims and prevents electricity suppliers from double selling renewable energy.

Renewable energy claims – Private consumers purchase guarantees of origin from suppliers/producers/traders to express environmental and use it to "green" their energy mix

[2] 22 *EU 27* countries: Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Portugal, Slovakia, Spain, Sweden; 3 *EEA* countries: Norway, Iceland, Switzerland; 2 *EU 27 candidates* countries: Montenegro, Serbia

(e.g., labelling, adding value to secondary products, meeting environmental standards, carbon accounting)

Guarantees of Origin make it possible to make credible renewable energy claims in Europe. They are ideal for companies that seek a simple solution to reduce their carbon footprint and meet renewable energy targets. It complies with the Greenhouse gas protocol Scope 2 Guidance and is an effective and recognised tool to reduce the greenhouse gas emissions and improve sustainability ratings, such as the CDP score.

The key difference between fuel disclosure and renewable energy claims is that in the former the purchase of certificates is based on obligation whereas in the latter on a voluntary choice.

3.2.3. GO Lifecycle

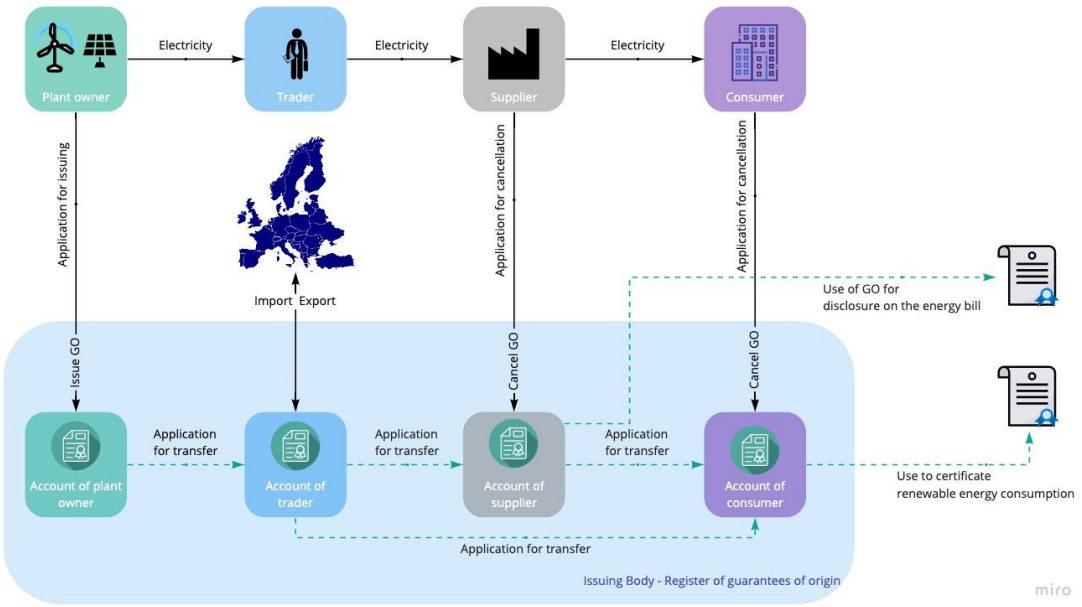

Figure 12. GO Lifecycle

In order to issue, transfer or cancel a GO you need to be registered as an account-holder in the issuing body register. Power plants issuing GOs need to be registered as well.

Issuing – The Issuing Body issues 1 energy certificate for each MWh of electricity production from a verified production plant and deposits the certificate into the account of the plant owner in the electronic registry. Certificates are issued in the nominated account against verified meter readings of registered production devices, e.g., deriving from imbalance settlement calculation of the TSO. Production power plants that receive some form of support from the local government (e.g., Feed-in Tariffs) are not entitled to receive a GO. Such practice takes place in Croatia, France, Germany, Ireland and Portugal.

Transfer – Energy certificate, representing the generation attributes of the produce MWh can be traded in the certificate markets separately from the trade of electricity. In practice transfers are made in electronic registries over the internet using a standard web browser in similar manner to making payments using internet banking. If the country is a member of AIB (Association of

Issuing Body), its account-holders can import and export guarantees of origin electronically from and to other EECS participants.

Cancellation – Electricity consumers or suppliers on their behalf purchase energy certificates and cancel them to comply with the fuel disclosure and/or to prove that consumed or sold electricity is generated by renewable sources.

Expiration - Guarantees of origin issued or imported in the month m of production will be considered automatically expired in month m+12, if they were not cancelled.

3.2.4. GOs market development

Figure 13 below compares production and consumption. On the left bar renewable production is broken down into 3 categories: volume issued, volume available for certification and volumes that are not entitled to a GO; the remaining in grey bar represents fossil and nuclear generation according to ENTSO-E's figures. On the right bar, the graph shows consumption volumes also according to ENTSO-E data but it distinguishes between the consumption that is certified (cancelled) and the remaining that is uncertified. It is easy to see that renewable generation levels are much higher than renewable consumption by means of certificates. The share of cancelled GOs in total electricity production had grown from 8% in 2009 until 21% in 2018.

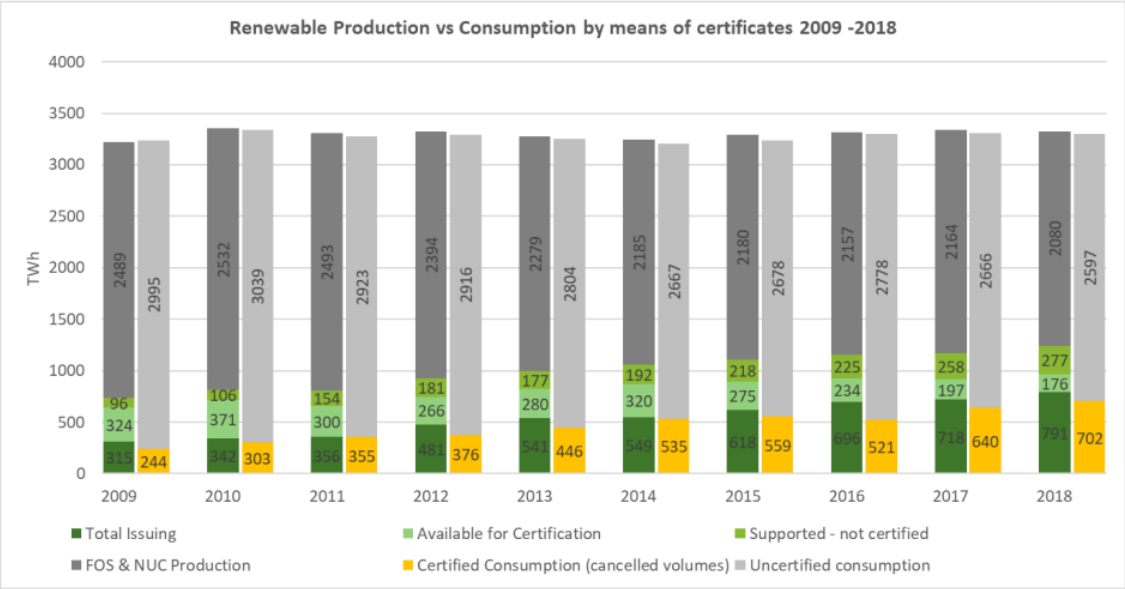

Figure 13. Renewable Production vs Consumption by means of certificates 2009 -2018 [34][35]

Total Issuing – GOs are issued electronically for each MWh of electricity produced from renewable sources. Issuing volumes in this report contain both EECS-GOs and national GOs.

Supported - not certified – In some EU Member States, the electricity disclosure system to consumers already takes into account production that receives some form of support from the local government (e.g., Feed-in Tariffs). As a result, this volume is not entitled to a GO. Such practice takes place in Croatia, France, Germany, Ireland and Portugal.

Available for certification – This is the residual electricity that is not yet certified or under a support system that prevents certification.

Cancellation – This refers to the process of allocating the electricity attributes carried by a GO to a consumer by removing the GO from the market to avoid use by another end-consumer. Cancellation volumes are an indication of the market's appetite for renewable electricity.

FOS & NUC Production – Fossil and nuclear generation according to ENTSO-E's figures.

Electricity consumption – Consumption volumes according to ENTSO-E's figures.

3.2.5. Residual mix

The residual mix is a key tool for avoiding double-counting of the same amount of electricity from a certain energy source. It refers to a set of electricity which remain after certified attributes are taken out of the mix as a result of cancelling a GO.

The residual mix is a pool of available generation attributes, which are not explicitly tracked through guarantees of origin. Residual mix is an implicit disclosure mechanism in which volumes and shares of energy sources and environmental impacts of untracked electricity consumption are determined by the statistical mix of a country's yearly generation attributes, available after explicit tracking. It complements the disclosure done with explicit tracking instruments by determining the origin of the rest of electricity consumption. Residual mix is defined on a country level and calculated based on a calendar year.

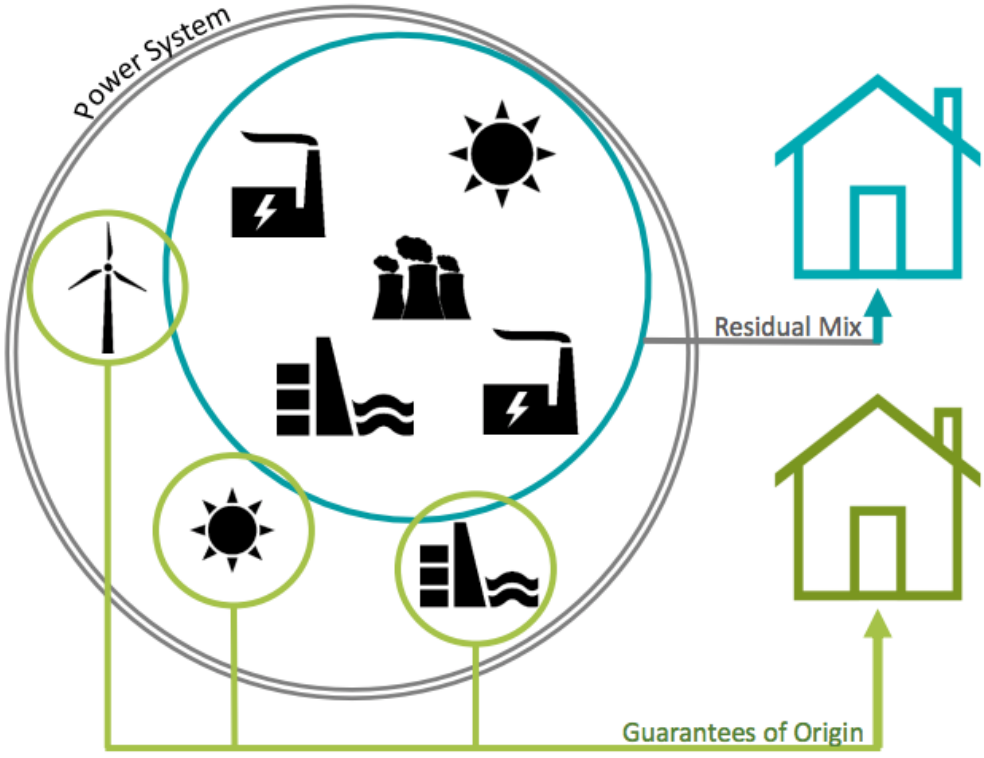

Figure 14. Residual mix scheme [36]

Figure 14 shows an explanation of the residual mix. Physically, electricity production and consumption in Europe equal each other in volume as long as electricity transfers to and from outside Europe are considered. International trading of GOs and electricity within Europe distort the equilibrium of available generation attributes and electricity consumption volumes on a

national level, but on a European level the balance remains. The coordinated residual mix calculation, returns this balance at the domestic level. Countries which have a surplus of generation attributes compared to their consumption (typically GO net importers and/or electricity net exporters), give attributes to the common pool and vice versa. Because of the physical balance, the total surplus equals in volume with the total deficit. The coordinated residual mix calculation is a simple yet powerful tool to allow international trading of generation attributes whilst avoiding double-counting.

3.2.6. GOs Limitations

Purchasing electricity and/or contractual claims Guarantees of Origin (GO). These contractual rights enable contract holders to claim a zero-footprint of their electricity consumption, and were introduced in order to serve as a financing mechanism to install more renewable generation assets.

Various shortcomings appear when these contractual claims are allowed to be used in the attributional framework:

- The hourly granularity is not taken into account, and doesn't fit the physical reality that it is more difficult to reach zero emissions during hours without wind or sun.
- The regional granularity is taken into account, as one can buy certificates from e.g., Iceland to claim as low-carbon the electricity consumption of a factory in continental Europe.
- Energy providers can buy certificates from RE plants that have existed for years, effectively stifling the need to make investments of their own renewable sources. Instead of increasing the fraction of RE in the overall mix, EACs can be used to reassign green energy to ecologically aware consumers on the expense of the fraction of green energy sold to non-ecologically aware users.

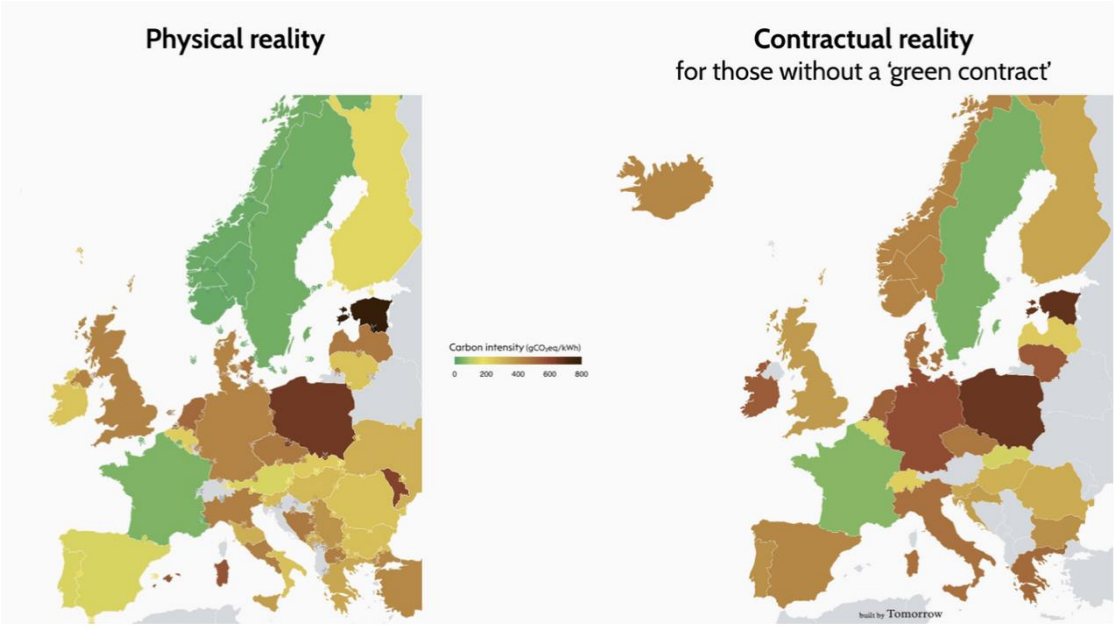

Figure 15. Carbon intensity: Physical reality vs Contractual reality [37]

- From a physical standpoint, Norway has a fully decarbonised electricity system (left). However, after having accounted for the sale of certificates (to avoid double-counting), a Norwegian company that hasn't bought a certificate will not be able to claim a low electricity footprint, even though the electricity physically is low-carbon (right). Note the case of Iceland where its inhabitants might wonder how their greenness could have been sold even though no transport cable to the continent exists.
- As the use of contractual instruments in attributional accounting currently does not follow the underlying physical constraints of electricity delivery (by e.g., disallowing trades between disconnected regions), this method is currently suboptimal in the attribution of emissions.
- EACs cast doubt on the extent to which trading them will help to support existing or create new additional capacity. The question of whether Guarantees of Origin have a positive environmental effect is a topic of many discussions in the academic literature. A little price premium of 0.5 €/MWh (1.25% of electricity price) can provide corporations with the basis to offset their CO_2 emissions, which cannot possibly stimulate the development of renewable energy.
- Another issue related with GOs, is that allow for buying certificates from sources that are completely detached from the consumer's location. In 2020, 43% of the Guarantees of origin export was coming from Norway. Nordic Hydro are the most competitive certificates because of their extremely low price, which attracts energy managers as they see the possibility of offsetting their company's emissions for a very small amount of money. However, electricity produced in Norway cannot be transferred to the corporate's arbitrary location. Because electricity usage in a corporate's physical location causes an increased demand for electricity at plants located in its proximity, supporting the national renewable generation is a much better practice and the big scale European Guarantees of Origin trade should be limited to the countries which are at least connected through the grid, meaning importing electricity from each other.

4. Methodology

This research is explanatory and has been conducted using a qualitative methodology. Information was gathered from company reports, academic papers and other various online sources and specific information about the market was collected via semi-structured interviews with market players in order to gain practical insights into the functioning of existing and planned metering data exchange infrastructures and the functioning of the GO market and its integration with metering data. Discussions in the interviews were not strictly bound to the agenda and can lead to unexpected findings.

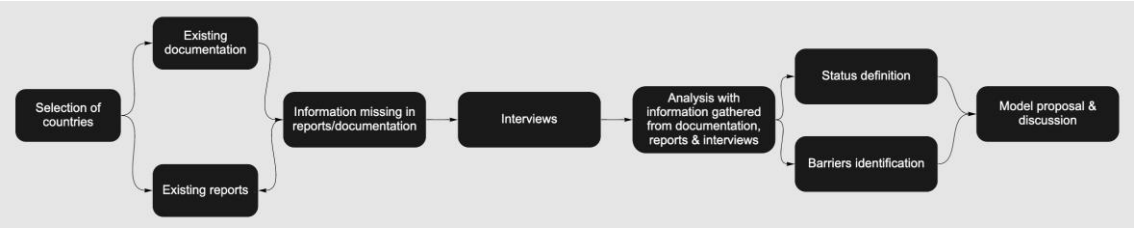

Figure 16. MSc Thesis Research Process.

Both, metering data exchange infrastructures and Energy Attribute Certificates schemes were focused in several EU countries (not global).

4.1. Metering data collection

In order to study the status of metering data exchange infrastructures in Europe, crucial variables were taken into account (see Table 4). As a result, relevant facts, barriers and challenges were found, and they serve as parameters to build a proposal for a harmonized and standardized model for data exchange infrastructures in Europe.

Table 4. Crucial considered variables for metering data exchange infrastructures

Category 1	Category 2	Description
Smart meter rollout	Metering points | % Smart meters	Regulated smart meter rollout is not always happening at a fast enough pace, at a low enough cost, or with suitable technology/interfacing/access that would enable the majority of products and services.
	Wide-scale plan	The current status of the smart meter roll-out is stated in this variable. By wide-scale plan, we refer to a plan to cover at least 80% of consumers, both retail and corporate.
Data exchange infrastructure	Unique access point	Unique access point means that all the country's metering data can be accessed through one single market participant. In centralised models (e.g., Estonia) there is one single data provider. In decentralised models (e.g., the Netherlands) several market participants have this role. In countries without a unique access point, country's metering data is not grouped together and its access, if possible, is managed by several DSOs (e.g., Sweden), depending on the area of the country they have been assigned.

	Data provider	A data provider is an entity in charge of the management of the data exchange infrastructure. In some countries, such as Norway or Denmark, there is only one centralised data provider. In some cases, in countries like the UK and the Netherlands, there is more than one data provider, among which are private companies.
	Interoperability	Interoperability refers to the capability of two or more systems to connect without complications and their ability to share information securely and effortlessly. This is essential in order to allow third parties and end-consumers to combine and change different technologies and still trust the operations to work (U.S. Department of Energy, 2014). For example, in absence of interoperability a new energy supplier might be unable to operate the existing smart meter in smart mode upon a switch of the supplier (DECC, 2015f).
Data characteristics	Settlement data	We define settlement metering data as the ex-post data rectified and validated by grid operators. This data can be used for final settlements and billing.
	Customer type	Indicates the customer type for which data is available; the main customer types being, Residential, Corporate, and Industry.
	Data granularity	All metering data should have at least hourly granularity to support hourly matching of electricity production and consumption.
	Data availability	All metering data should be available as soon as possible after physical energy flow (max. one day after physical energy flow) and without geographical limitations within the EU.
	Consumption data	Settlement consumption data measured at the consumption metering point.
	Production data	Settlement consumption data measured at the production metering point.
Data access processes	Customer access	Based on the Electricity Market Directive (Directive (EU) 2019/944), validated historical metering data should be made available to end-customers on request, easily and securely, and at no additional cost. This variable indicates if the customer has access to their own data.
	Third-party access	According to European regulations, corporate consumers can allow access to eligible third parties by giving them an explicit consent to access their data.
	Customer consent process	Standardisation and digitalisation of the customer consent process is required in order to simplify the administrative process and make it secure. The customer should be able to allow or disallow specific parties access to metering data available from smart meters. Customers should be able to

		modify and terminate the data privacy options they have chosen.
	Free price	This column specifies if third parties have to pay a fee in order to access corporate customers metering data.

4.1.1. Dimension of comparison

5. The following key variables will be analysed per country, and after the data collection, a comparison will be developed. Data was collected from several interviews with data providers, documentation and from FlexiDAO's business operations (See Future research and next steps

The conclusions of this report are only high-level, and there is still significant work to do. The definition of a new granular certification scheme will make more reflective the physical availability of clean energy. Public perceptions of clean energy claims may improve and it could support new carbon accounting methodologies.

Future research using the coming granular hourly certificates in new carbon accounting methodologies is needed. A comparison between the real impact, both economical and environmental, of existing and new proposed carbon accounting methodologies is needed in order to serve as scientific demonstrations to help change in carbon accounting regulations.

As shown in this study, current carbon accounting methodologies do not show the real impact in GHG emissions. The real impact of new carbon accounting methodologies using the proposed granular certification scheme need to be reasearched with real use cases, in countries in where the renewable penetration is significant.

In countries with relatively high renewable penetration, the difference between yearly and hourly accounting is non-negiligible and will become increasingly significant as more renewable generation is added into the system and the carbon intentisty varitations during the year and the hour of the day become more important.

Among the many topics that need to be addressed as next steps, the following ones are identified as a priority.

- The market effect – The market effect of 24/7 certification at scale is not yet known, and will depend on the varied individual preferences and load shapes of the number of companies that will pursued this strategy. It is needed future research in how this 24/7 certification scheme will affect prices and whether those pricing changes will be enough

to affect new renewable energy projects and new development of storage systems to support the need of renewable energy in periods where renewable is not available

In conclusion, in addition to the new carbon accounting methologies impact reasearch, an indepth market modelization of the granular certification scheme is needed. This reseach could answer the following questions which are not yet answered:

- What is the amount of demand for renewable energy in low carbon-free energy hours that would be needed locally in a region to create a high local market price for renewable energy in that hour? And then who can react to that price to create new generation in that hour?
- When and at what level will hourly procurement send sufficient demand or price signals for different technologies in a region?

The market and decarbonization effect of 24/7 certification is not yet known, we need more analysis of the market effective of 24/7 certification in different regions and its real impact on decarbonization. The 24/7 certification impact in demand response is not yet known it need to be analysed as next step for this coming granular certification scheme.

Another importan topic to be analysed and reasearched is the unit of energy of the coming granular certificates. There is a clear benefit to having a standard volumetric unit of energy, set in Europe and all major EAC schemes at 1 MWh. The volumetric unit of GOs allows them to be easily traded in bundles hundred GOs or more, reducing transaction and handling costs. The adoption of 24/7 matching poses a challenge to volumetric units by counting temporal units of less than one hour. A unit of energy generated by a given production site in an hour or less will contain a different generation quantity of energy depending on the size and productivity of the production device at that specific moment. This difference could add to the challenge of 24/7 matching as those seeking to match their renewable energy consumption in every hour will have to find the specific GCs that cover their consumption for each hour of each day. This contrasts starkly with annual or even monthly matching where a consumer simply has to calculate their MWh of consumption over the relevant period and buy the same number of GOs - one for one. This is a fundamental issue which needs a lot more analysis and discussion.

to review name and features of people and organization interviewed for this section). The reason why those variables were selected for the comparison are explained in the methodology section.

Smart meter roll-out

- % Smart meters – What is the status of the smart meter roll-out in terms of the percentage of metering points covered by smart meters?
- Wide-scale plan – Does the country have a wide-scale plan (> 80%) of smart meter roll-out?

Data exchange infrastructure

- Data provider/s – Who owns and who operates the data exchange infrastructure? There are more than one data provider offering access to metering data?
- Type – Is the data exchange infrastructure centralised, partly centralised or decentralised?
- Implemented, Planned or not Planned – Is the data exchange infrastructure already implemented, planned or not yet planned?

Data characteristics

- Settlement data – Is the metering data, validated data?
- Customer types covered – For which type of customers is data available? Residential customers, business customers or all customers?
- Data Granularity – What is the granularity of available data?
- Data Availability – What is the data availability of the metering data?
- Production and Consumption data availability – Are production and consumption data available in the data exchange infrastructure?

Data access and rights

- Customer access – Does the customer have access to their meter values?
- Third-party access – Do third parties, such as suppliers, have access to metering values with customer consent? If so, how is the customer consent process?
- Third-party country registration – It is mandatory to register the company within the country to access data?

Technical information

- Data interfaces – Does the data exchange infrastructure have data interfaces for reading and exchanging metering values? (e.g., API, STFP)
- Test user – Does the data exchange infrastructure provide a test environment to test the interaction with metering data?

Costs

- Access price – Does the access to metering data values have a price? It is different depending on the stakeholder that wants to use the data?

5.1. Guarantees of Origin

In order to study the status of Guarantees of origin schemes in Europe, crucial variables were taken into account (see Table 5). As a result, relevant facts, barriers, and challenges were found, and they serve as parameters to build a proposal for a harmonized and standardized model for granular certificates scheme and its integration with the actual Guarantees of origin scheme.

Table 5. Crucial considered variables for guarantees of origin schemes

Country	It specifies the country of analysis.
Interoperability	This variable specifies how is the level of interoperability of the national scheme.

	Interoperability is a characteristic of the national GO scheme, whose interfaces are completely understood, to work with other products or systems, at present or in the future, in either implementation or access, without any restrictions.
Issuing body	This variable specifies which is the Issuing Body of the country. An Issuing Body is a competent body responsible for the issuance and tracking of GOs.
Type of issuing body	An issuing body could be a public or private entity. This variable specifies the current type of the issuing body of the country.
Privacy of certificate	A Guarantee of Origin is a certificate that specifies the attributes of the electricity produced. The status and the owner of each GO could be public, in which everyone can access to the information or could be private, in where only the account-holder of the GO can access to the information.
Issuing period	It describes the frequency of the issuance of Guarantees of origins. The guarantees of origin are mainly issued once a month for the production period of the calendar month in question. Guarantees of origin can also be issued in periods of 3 or 6 months instead of 1 – this choice can be made individually for each power plant.
Disclosure period	The period of time used as the accounting period for electricity consumption. Directive 2009/72/EC stipulates that disclosure of electricity consumed in a calendar year should be based on the fuel mix of the supplier in the previous calendar year. However, Directive 2009/28/EC stipulates that guarantees of origin have a validity of one year as from the date of issuance. This implies, that at present valid guarantees of origin might be used for authentication of information disclosed in (one of) two successive calendar years.
Timestamp	It specifies if the issued guarantee of origin possess or not a timestamp of the related produced electricity. And if it is specified, the level of granularity is shown.
Claim entity	It specifies which kind of entities can made a cancellation claim. Depending on the country, the type of entities allowed to make a cancellation claim.

Beneficiary consumption point assignation	It specifies if it is possible to assign a specific consumption point of the beneficiary to a GO cancellation statement.
API Integration	Besides web portal user interfaces, it specifies if the national scheme have available an API for automatic data exchange.
End-consumer access	It specifies if the end-consumer (the entity that consumes the electricity) have access to their guarantees of origin associated with their consumption and those who were cancelled in their name.
Third-party access	It specifies if third parties, such as service providers, have access to the guarantee of origin registry, by considering a previous consent given by the account-holder of the guarantee of origin.

5.1.1. Dimension of comparison

6. The following key variables will be analysed per country, and after the data collection a comparison will be developed. Data was collected from several interviews with issuing bodies, documentation and from FlexiDAO's business operations (See Future research and next steps

The conclusions of this report are only high-level, and there is still significant work to do. The definition of a new granular certification scheme will make more reflective the physical availability of clean energy. Public perceptions of clean energy claims may improve and it could support new carbon accounting methodologies.

Future research using the coming granular hourly certificates in new carbon accounting methodologies is needed. A comparison between the real impact, both economical and environmental, of existing and new proposed carbon accounting methodologies is needed in order to serve as scientific demonstrations to help change in carbon accounting regulations.

As shown in this study, current carbon accounting methodologies do not show the real impact in GHG emissions. The real impact of new carbon accounting methodologies using the proposed granular certification scheme need to be reasearched with real use cases, in countries in where the renewable penetration is significant.

In countries with relatively high renewable penetration, the difference between yearly and hourly accounting is non-negiligible and will become increasingly significant as more renewable generation is added into the system and the carbon intentisty varitations during the year and the hour of the day become more important.

Among the many topics that need to be addressed as next steps, the following ones are identified as a priority.

- The market effect – The market effect of 24/7 certification at scale is not yet known, and will depend on the varied individual preferences and load shapes of the number of companies that will pursued this strategy. It is needed future research in how this 24/7 certification scheme will affect prices and whether those pricing changes will be enough to affect new renewable energy projects and new development of storage systems to support the need of renewable energy in periods where renewable is not available

In conclusion, in addition to the new carbon accounting methologies impact reasearch, an indepth market modelization of the granular certification scheme is needed. This reseach could answer the following questions which are not yet answered:

- What is the amount of demand for renewable energy in low carbon-free energy hours that would be needed locally in a region to create a high local market price for renewable energy in that hour? And then who can react to that price to create new generation in that hour?
- When and at what level will hourly procurement send sufficient demand or price signals for different technologies in a region?

The market and decarbonization effect of 24/7 certification is not yet known, we need more analysis of the market effective of 24/7 certification in different regions and its real impact on decarbonization. The 24/7 certification impact in demand response is not yet known it need to be analysed as next step for this coming granular certification scheme.

Another importan topic to be analysed and reasearched is the unit of energy of the coming granular certificates. There is a clear benefit to having a standard volumetric unit of energy, set in Europe and all major EAC schemes at 1 MWh. The volumetric unit of GOs allows them to be easily traded in bundles hundred GOs or more, reducing transaction and handling costs. The adoption of 24/7 matching poses a challenge to volumetric units by counting temporal units of less than one hour. A unit of energy generated by a given production site in an hour or less will contain a different generation quantity of energy depending on the size and productivity of the production device at that specific moment. This difference could add to the challenge of 24/7 matching as those seeking to match their renewable energy consumption in every hour will have to find the specific GCs that cover their consumption for each hour of each day. This contrasts starkly with annual or even monthly matching where a consumer simply has to calculate their MWh of consumption over the relevant period and buy the same number of GOs - one for one. This is a fundamental issue which needs a lot more analysis and discussion.

). The reason why those variables were selected for the comparison are explained in the methodology section. As this thesis targets corporate customers, only the cancellation process will be analised, without taking into account the issuing and transfer process of a guarantee of origin in countries analised. Corporate electricity customers only participate in the cancellation process. Below, a list of questions are shown and they will be the scope of the comparison of different guarantees of origin systems.

Issuing body

- Is it a public or private entity?
- Which was the participation in the GO market on the last 3 years in terms of GOs cancellation?

Privacy of the certificate

- Is the certificate public or private?

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)
- If so, does the customer can authorize a third-party to access their data?
- If third parties can access data, how is the process where the customer gives consent to access their data?
- If third parties can access data, does the third-party need to be registered in the country?

6.1. Country selection

Countries analysed in this report are chosen to cover all the possible existing types of schemes and systems, both for metering data collection and guarantees of origin, making them interesting and desirable to evaluate for the purpose of this report.

For the metering data collection countries, countries selected are based on their status of the smart meter roll out, covering ranges from countries that have a clear regulatory status and a clear strategy for the implementation from countries that they do not have a strategy at all. Also, both centralised, partly centralised and fully decentralised data exchange infrastructures are covered with chosen countries.

For the guarantees of origin countries, countries were selected based on the difference of the Guarantees of Origin cancellation processes, and its accessibility for end-consumers to access to their claim renewable energy. Covering a range of countries in where accessibility of end-consumers it is not possible at all, from countries in where cancelled Guarantees of Origin are publicly, and can be accessed by everyone.

7. Results of the research

7.1. Metering data: Case studies

The purpose of this section is to compare 18 data exchange infrastructures, covering a wide range of different models for data exchange in order to identify existing barriers and challenges to propose and discuss a standardised model to support the 24/7 Renewable Energy approach.

7.1.1. Case studies

Estonia

Smart meter roll-out

Estonia is one of the most advanced European countries concerning smart metering infrastructure. It reached 100% penetration in January 2017 [27], with 707,900 smart meters installed.

- % Smart meters – 100% (2017).
- Wide scale plan – After a positive result in their CBA (2013), Estonia have already finished their large-scale smart meter roll out in 2017.

Data Exchange Infrastructure

The Estonian Data Exchange Infrastructure system is a software/hardware solution that manages the exchange of electricity metering data between market participants, supports the process of changing electricity suppliers in the market, and archives the metering data of electricity consumption and production.

Estfeed is Elering's Data Exchange Infrastructure, which enables secure message exchange in the energy sector. It is a platform managed by Elering as a TSO, through which its electricity metering data is made available to the consumer and to a third-party on the consumer's authorization in accordance with law. Different data sources and applications that want to use this data can interface with the platform. The software network platform can be used by the energy service provider, the owner of the application and the end-consumer to exchange messages and manage data through the Consumer Portal.

- Data provider/s – Elering (Estonian TSO)
- Type – Fully centralised
- Implemented, Planned or not Planned – Already Implemented (2017)

Data characteristics

- Settlement data – Validated DSO/TSO data, used for imbalance settlement and billing.
- Customer types covered – All types of customers are covered by the Estonian Data Exchange infrastructure.
- Data Granularity – Hourly data is available.
- Data Availability – Data is available the following day after the event occurs.

- Production and Consumption data availability – Production and consumption data can be accessed.

Data access and rights

- Customer access – Through e-elering's web portal end-consumers can access data related to their electricity consumption and production. The customers can log into the portal using an ID card, Mobile-ID, smart-ID, or online bank links.
- Third-party access – In order to use the Estonian Data Exchange Infrastructure, third-parties must sign an Estonian Data Hub User Agreement with the system operator, setting out the rights and obligations related to submitting and requesting data in accordance with the law.
- Consent process – Customers can consent to share their metering data with eligible service providers. The consent process begins on the website of the customer energy supplier, and continues at e-elering, the data exchange infrastructure. List of metering points, name of service provider, the purpose of processing data and validity period are specified in the consent process. Users can revoke consent on the data provider's website. The list of given consents can be viewed from e-elering portal.
- Third-party country registration – Registration in Estonia of third-party service provider is not mandatory.

Technical information

- Data interface/s – The metering data can be accessed through an API. A software needs to be installed before running the API. More information about the different queries can be found in the documentation section below.
- Test user – The platform has a test environment and a live environment. Before having a customer consent, by having a signed contract with Elering, a third-party can perform a test of the data interface.

Costs

- Access price – Access to metering data in Estonia is free for customers and other market participants.

Spain

Smart meter roll-out

Spain is at the forefront of smart meter roll-out for households, SMEs and commercial customers in the EU having reached a 100% in 2018 [27]. Since the roll-out in Spain began more than ten years ago, smart meters already installed do not need to comply with all the requirements established in the EU Directive 2019/944/EU on common rules for the internal electricity market. However, new functionalities are expected to be introduced once older smart meters finish their lifetime, in order to adapt smart metering systems to incoming changes in the internal market for electricity. No CBA was performed for Spain, and the roll-out was done it with the aim of increasing efficiency in energy consumption.

- % Smart meters – 100% for households, and 40% for SMEs and commercial customers.

- Wide-scale plan – 26 million of 28 million of metering points are already covered with smart meters.

Data exchange infrastructure

Datadis is a digital solution that allows free, safe and neutral access for each consumer to their electricity consumption data. Datadis aggregates consumption data for more than 29 million Spanish consumers, including households, SMEs and commercial customers. All five types of Spanish meters are included, ranging from <10kW contracted power up to >10MW contracted power.

The solution works as a data gateway that accesses the databases of the Spanish DSOs showing the information stored in them, avoiding duplication of data and complying with the requirements of the regulation. This joint initiative of all the country's distribution companies aims to open a digital channel, in addition to the one currently offered by companies, so that customers can have access to their data, both on electricity consumption and contracted power, from a simple, safe way and without additional costs.

Datadis also enables consumers to grant authorization to trusted third parties to let them have access to their consumption data in just a few clicks.

- Data provider/s – Datadis is the Spanish metering data provider, created by all the Spanish electricity distribution companies, integrated in the associations Aelec, Aseme and Cide.
- Type – The data exchange infrastructure is partly centralised, as the metering data is stored in DSO's databases and accessed all in one single point, which is Datadis.
- Implemented, Planned or not Planned – The data exchange infrastructure is already implemented, since 2020.

Data characteristics

- Settlement data – Validated DSO/TSO data, used for imbalance settlement and billing.
- Customer types covered – All types of customers are covered by the Spanish Data Exchange infrastructure.
- Data Granularity – Hourly metering consumption data is available.
- Data Availability – Data is available the following day after the event occurs.
- Production and Consumption data availability – At the time, only consumption data is available.

Data access and rights

- Customer access – The customer can have access to their consumption data at all supply points.
- Third-party access – Customers can authorize access to marketers and other market agents, with prior and duly accredited consent, to view their consumption data, facilitating new business models.
- Third-party country registration – It is mandatory to be registered in Spain in order to have access to Spanish metering data.

Technical information

- Data interfaces – In addition to the customer portal, metering consumption data can be accessed through API.
- Test user – It is not possible to access the platform in a test environment.

Costs

- Access price – Access to metering data in Spain is free for customers and other market participants.

Italy

Smart meter roll-out

Italy was a pioneer in smart meter deployment but is now facing the challenges of outdated infrastructure in need of a second-generation roll-out. Italy was one of the first countries to start with smart meter installations across the EU beginning in the early 2000s. They reached 100% coverage well before 2017.

- % Smart meters – 100% of metering points are covered with smart-meters. Enel Distribuzione initiated a new roll-out in 2016 with the installation of modern second-generation smart meters with the necessary functionalities required by the new EU Regulation.
- Wide-scale plan – In July 2019 the target was set by the Italian regulator, ARERA, to equip all metering points with second-generation smart meters by the end of 2026, an estimated 41 million units.

Data exchange infrastructure

The Italian data exchange infrastructure, named SII (Integrated Information System) is operated by Acquirente Unico (AU) which is a public company fully owned by the GSE (Energy Services Manager), a company of the Ministry of Economy. The SII collects metering data for all types of customers.

- Data provider/s – The SII (Integrated Information System) is operated by Acquirente Unico, an Italian public company and is independent of both DSOs and other energy companies. In addition, Enel -Italian DSO with almost 90% of Italian customers-, offers to its registered customers access to metering consumption and production data.
- Type – The data exchange infrastructure is fully centralised. The SII collects metering data from all the DSOs and manages the exchange of these data with the TSO (for balancing) and with retailers (for invoicing purposes).
- Implemented, Planned or not Planned – The data exchange infrastructure SII has been operational since 2016.

Data characteristics

- Settlement data – Validated DSO/TSO data, used for imbalance settlement and billing.

- Customer types covered – All types of customers are covered by the Italian Data Exchange infrastructure.
- Data Granularity – 15-min granularity
- Data Availability – Data is available one day after the physical flow.
- Production and Consumption data availability – Production and consumption data is available.

Data access and rights

- Customer access – Currently only TSOs and retailers can access SII metering data. Through Enel platform, registered customers can access to their metering values, by logging in to the web portal using a Public Digital Identity System (SPID).
- Third-party access – Acquirente Unico (AU) is working to allow customers to authorise third parties to access smart metering data, but it is not possible yet. Third-party access through Enel is possible, by having express customer consent. The customer consent is given in the customer portal.
- Third-party country registration – It is not mandatory to register the company within the country to access data. Both with SII and Enel.

Technical information

- Data interfaces – Both, SII and Enel do not have any data interface implemented yet.
- Test user – A test environment is not available at SII neither at Enel.

Costs

- Access price – Access to metering data values are for free for all type of market participants in Italy.

Finland

Smart meter roll-out

When it comes to smart meters, Finland is one of Europe's most advanced countries with 100% penetration of the market, since 2019. The meters supply hourly readings, while households' smart meters can be easily changed into 15-minute measurements. A CBA was performed for the roll-out.

- % Smart meters – 100% of penetration.
- Wide-scale plan – In 2013, the wide-scale plan was reached in Finland.

Data exchange infrastructure

- Data provider/s – Fingrid, the Finnish TSO, is in charge of the Data Exchange Infrastructure.
- Type – The data exchange infrastructure is fully centralised.
- Implemented, Planned or not Planned – Finnish Data Exchange Infrastructure will go live on 21 February 2022.

Data characteristics

- Settlement data – Available data is validated metering data, used for billing purposes.

- Customer types covered – All customers types are covered by the data exchange infrastructure.
- Data Granularity – Hourly metering data is available.
- Data Availability – Metering data is available after one day of the physical flow.
- Production and Consumption data availability – Metering consumption data is available, and production data is only available at small-scale installed power.

Data access and rights

- Customer access – Customers will have access to their own data through Fingrid Web Portal.
- Third-party access – Third parties can access customer information with customer consent. An authorised third-party must submit the end's customer authorisation to Datahub. The customer will submit the authorisation using Datahub's customer portal. Authorisations are valid only for fixed-term period, max 2 years.
- Third-party country registration – It is not mandatory for a third-party to be registered in Finland.

Technical information

- Data interfaces – The B2B interface will be designed with SOAP protocol. SOAP is a lightweight protocol intended for exchanging structured information in a decentralised, distributed environment.
- Test user – The data exchange infrastructure will have a test environment.

Costs

- Access price – Access will be free for customers, but it will have a cost for third parties, which will include a basic monthly fee, and a variable cost depending on the amount of metering points that third parties have access to.

Sweden

Smart meter roll-out

Infrastructure in Sweden is quite advanced. First generation smart meters cover Sweden's entire customer base but are only able to provide hourly measurements. The second-generation roll-out started in 2019 with a plan to complete it by 2025. The CBA performed for both rollouts was in compliance with the European Commission's recommendations (2012/148/EU).

- % Smart meters – 100% of penetration of first-generation smart meters. Second generation will be finished by 2025.
- Wide-scale plan – Wide-scale plan of first-generation smart meters finished; second generation smart meters wide-scale plan will be finished by 2025.

Data exchange infrastructure

- Data provider/s – The national TSO, Svenska Kraftnät (Svk), is responsible for developing, building, implementing and running Sweden's data exchange infrastructure. Energimarknadsinspektionen (Ei), the Swedish regulator, is responsible for producing the overall regulatory framework that is required for giving the data hub a place in the

electricity market. Currently, each DSO manages metering data depending on the area they operate, there exist 170 DSOs in Sweden.

- Type – The data exchange infrastructure will be fully centralised. Currently, the access to metering data is decentralised and depends on each DSO.
- Implemented, Planned or not Planned – The development of the data exchange infrastructure for metering data is underway, with planned launch in 2022 or 2023, depending on the legislative package, which is delayed. The Swedish Ministry expects that the legislative package will be implemented by the beginning of 2021.

Data characteristics

- Settlement data – Validated DSO/TSO data, used for imbalance settlement and billing.
- Customer types covered – All customers types will be covered by the national data exchange infrastructure.
- Data Granularity – Hourly metering values are available.
- Data Availability – Data will be available the day after the physical flow. Currently, it depends on each DSO.
- Production and Consumption data availability – Production and consumption data will be available. Currently, it depends on each DSO.

Data access and rights

- Customer access – Customers will have access to the data exchange infrastructure web portal. Currently, it depends on each DSO.
- Third-party access – Yes, it will be possible for third parties to access to metering data with a given customer consent. The consent process is not defined yet. Currently, third-party access depends on each DSO.
- Third-party country registration – It will a requirement for the third-party to be registered as an actor in the Swedish market and have passed the needed certification for EDI messaging and have a signed a so-called EDIEL agreement for the Swedish Market.

Technical information

- Data interfaces – Data interfaces are not yet defined for the coming data exchange infrastructure. Currently, not standardized ways of communication exist. Depends on each specific DSO to make an API available for this purpose.
- Test user – It is not defined yet for the coming data exchange infrastructure.

Costs

- Access price – Same as other Nordic countries, access to metering data will be for free for end customers, and it will include a fee for third parties, which will be a basic monthly fee plus a variable fee depending on the metering points that the third-party have access to.

Norway

Smart meter roll-out

Since January 2019 Norway has completed its smart meter roll-out with a 100% penetration across all customer types. The smart meters installed provide 15-minute measurements.

- % Smart meters – 100% of penetration, since 2019.
- Wide-scale plan – The wide-scale plan is completed.

Data exchange infrastructure

- Data provider/s – The data exchange infrastructure is owned and operated by a wholly owned subsidiary of Statnett (Norwegian TSO), known as Elhub.
- Type – The data exchange infrastructure is fully centralised.
- Implemented, Planned or not Planned – The system went in operation in February 2019.

Data characteristics

- Settlement data – Validated DSO/TSO metering data is available for access.
- Customer types covered – All customers types are covered by the Norwegian data exchange infrastructure.
- Data Granularity – Hourly metering values are available.
- Data Availability – The grid companies have the task of submitting all metering values for electricity consumption, electricity production and exchange to Elhub by 7:00 am, the following morning. Elhub forwards the metering values to relevant balance suppliers, third parties and end-consumers by 9:00 am, the same morning.
- Production and Consumption data availability – Production and consumption data is available.

Data access and rights

- Customer access – Customers have access to their metering data through elhub web portal.
- Third-party access – Third parties can retrieve measurement settlement value data that they need to perform a service or service to their end-consumers. Elhub requires that third parties must enter into a direct legal agreement with the end-consumer in order to gain access to the end-consumer's measured values. Elhub has its own web interface where third parties can retrieve consumption data for those customers who have authorised it. In Elhub, this role is registered as a Third Party (AG). In the consent process the end customer must log in via the Elhub web plugin to approve the access request.
- Third-party country registration – It is mandatory to register the company in Norway to have access to metering data. A foreign number in Norway is needed. The process of registering the company is time consuming.

Technical information

- Data interfaces – Elhub data interface is based on SOAP 1.1 web services and uses WS-Security and WS-Policy technologies.
- Test user – A test environment is available for third parties.

Costs

- Access price – Access is for free for end customers, and it have a cost for third parties. Monthly fee: 4,250 NOK + 0.28 NOK/metering point.

Denmark

Smart meter roll-out

Denmark has achieved a high percentage of smart meter roll-out, with over 80% of households being equipped with smart meters, being one of the highest rates across the EU. All industrial customers (customers with an annual consumption of more than 100 000 kWh) already have smart meters installed.

- % Smart meters – 100% reached at 2020.
- Wide-scale plan – The country has already reached the wide-scale plan.

Data exchange infrastructure

- Data provider/s – Energinet.dk (the Danish TSO) administrates the data exchange infrastructure, responsible of storing, metering, collecting and to secure the validation of data.
- Type – The data exchange infrastructure is fully centralised.
- Implemented, Planned or not Planned – Energinet.dk's data exchange infrastructure has been up and running since 2013.

Data characteristics

- Settlement data – Validated DSO/TSO data is available for access.
- Customer types covered – All type of customers are covered by the Danish data exchange infrastructure.
- Data Granularity – 15-minute measurements are available.
- Data Availability – Metering data is available at the data exchange infrastructure one day after the physical flow.
- Production and Consumption data availability – Consumption and production data is available.

Data access and rights

- Customer access – The customer is able to view its own metering data, either through the data exchange infrastructure web portal of its electricity supplier or the Eloverblick's website.
- Third-party access – Third-party access is possible with a given customer consent. Third parties must first request authorisation from one or more customers to access their data, after registering as an actor in the data exchange infrastructure.
- Third-party country registration – It is mandatory register the company for VAT in Denmark to access metering data. In addition, a NemID is required.

Technical information

- Data interfaces – An API is available for customers and third parties
- Test user – The data exchange infrastructure counts with a test environment.

Costs

- Access price – Access to metering data is for free for all market participants.

France

Smart meter roll-out

France has committed itself to a 95% smart meter deployment and so far, has installed over 19 million smart meters until May 2019. All customers connected to a power level above 36 kVa already have smart meters. France smart meter is called Linky. Linky is not just an electricity meter. As well as providing accurate meter readings, it can perform remote operations, such as measuring the consumption and production of electricity, or resolving accidental outages. Linky also helps to control electricity consumption. More than 29 million linky meters are installed out of a total of 35 million metering points (80% of metering points are equipped with smart meters).

- % Smart meters – Smart meters penetration rate is 80 (2020)
- Wide-scale plan – They are planning to finish the smart meter roll out in December 2021.

Data exchange infrastructure

- Data provider/s – Enedis, the mayor DSO in France, is the data provider in the country. They offer two data exchange infrastructures, depending on the power contracted. For customers with a power level below 36 kVa, the service is called Data Connect, and for customers with a power level above 36 kVa the service is called SGE Tiers.
- Type – The Enedis data exchange infrastructures are fully centralised.
- Implemented, Planned or not Planned – Since 2018, they allow citizens and companies to securely transfer their consumption and production data.

Data characteristics

- Settlement data – Data accessed through Enedis data exchange infrastructures is validated by TSO/DSO, used for billing purposes.
- Customer types covered – As mentioned, all customer types are covered. Customers with a power level below 36 kVa can access to their metering data through Data Connect service, and customers with a power level above 36 kVa can access to their metering data through SGE Tiers service.
- Data Granularity – Hourly measurements are available.
- Data Availability – Data is available after one day of the physical flow.
- Production and Consumption data availability – Production and consumption data is available at both Enedis' services.

Data access and rights

- Customer access – End customer functionalities are accessible, such as monitoring consumption, comparison of consumption, monitoring of production, management of access to consumption / hourly production, personal data, etc. In order to access, the customer needs to have an account and a PRM (metering point ID). They can access also through a Mobile application.

- Third-party access – Depending on the service the third-party want to access it is the process they need to follow. Registration at Enedis Web Portal, which includes signing a contract, is required. After that, customers have to complete an agreement digital form, signed, to grant access to a third-party. In accordance with the Energy Code, a customer can authorize a third-party to access all or part of the data concerning him held by the electricity distribution network operators. The customer consent can be obtained in several forms: Orally, writing, digitally.
- Third-party country registration – It is not required to register the company in France in order to be a Third Party.

Technical information

- Data interfaces – Data connect: APIs are based on the OAuth2.0 standard to facilitate their integration into services.; SGE Tiers: Third parties can access to the measurement data via a Web Portal (sge.enedis.fr) or via a SOAP API library (Web services)
- Test user – The data exchange infrastructure does not provide any test environment.

Costs

- Access price – Access to metering data is for free for all market participants.

Netherlands

Smart meter roll-out

The penetration of smart meters in the Netherlands is at an advanced stage. Currently, around 2/3 of households and SMEs have a smart meter installed with an ongoing roll-out that have already reached 80% coverage. Industrial customers (> 100kW) are fully equipped with smart meters. In the Netherlands, metering points are divided in large meters (>3*80A) and small meters (<3*80A). Metering data is managed by DSOs for small meters and by metering companies for large meters.

- % Smart meters – 82.2% of penetration.
- Wide-scale plan – The wide-scale plan in Netherlands has been reached in 2019.

Data exchange infrastructure

- Data provider/s – The data exchange infrastructure is organised by EDSN, a company owned by the TSO and all DSOs.
- Type – The Netherlands has a partially centralised model, with centralised communications with multiple databases. Every metering company can have access (if provided with right authorization) to all the data collected by either other metering companies or DSOs for both production and consumption.
- Implemented, Planned or not Planned – Operational since 2013, and upgraded in 2018.

Data characteristics

- Settlement data – Metering data is validated for billing and imbalance settlement purposes.

- Customer types covered – All types of customers are covered by the Dutch data exchange infrastructure.
- Data Granularity – 15-minute granularity
- Data Availability – Available the day after physical flow
- Production and Consumption data availability – Production and consumption data are available.

Data access and rights

- Customer access – Customers can access their own data or grant access to their own data via the EDSN platform.
- Third-party access – Third-party access to customer metering data, is allowed when it has received explicit informed consent from that specific customer. Ealyze, a Dutch metering company, has in place an easy and digital authorization process for consent-based data access. Once all the paperwork is done, third-parties are able to retrieve metering data values.
- Third-party country registration – It is not mandatory to register a company in the Netherlands in order to access to metering data.

Technical information

- Data interfaces – Data can be accessed via FTP, email or API through the Ealyze service.
- Test user – A demo account is available in order to make connection tests.

Costs

- Access price – Access to metering data in the Netherlands is free for all market participants.

Austria

Smart meter roll-out

The plan to reach 2.2 million smart meters by the end of 2019 was not reached. Currently, out of the 6 million existing electricity metering points, roughly 1.25 million are smart meters, which constitutes a 21% penetration rate. Austrian DSOs are working out a roll-out plan for smart meters, in which each DSO follows a different schedule and smart meter penetration varies significantly between DSOs.

- % Smart meters – 21% of penetration.
- Wide-scale plan – Austrian DSOs are working out a roll-out plan for smart meters, in which each DSO follows a different schedule and smart meter penetration varies significantly between DSOs.

Data exchange infrastructure

- Data provider/s The Austrian Association of Grid Operators "Österreichs Energie" initiated the EDA Project (Energy Data Exchange Austria) to provide a common data exchange infrastructure.

- Type – The EDA data exchange infrastructure is partially centralised, with a physically de-centralised data management environment and logical centralisation, which means that data is kept as close at the source as possible (at the Metered Data Administrator/DSO, who also validates) and only exchanged within clearly defined business processes, but – they have one way to communicate and only a single integration for Austria as a whole is needed.
- Implemented, Planned or not Planned – The data exchange infrastructure is implemented since 2012.

Data characteristics

- Settlement data – Validated DSO data is available.
- Customer types covered – All customer with installed smart meters are covered by EDA.
- Data Granularity – 15-minute data granularity.
- Data Availability – Metering data is available after day of delivery.
- Production and Consumption data availability – Production and consumption data is available.

Data access and rights

- Customer access – Customer have access to their metering data through EDA user portal.
- Third-party access – Third-party have access to metering data by having previously the customer consent of accessing their data.
- Third-party country registration – It is mandatory to register the company within the country to access data.

Technical information

- Data interfaces – The service provider used by EDA for the data exchanges employs an open standard (ebXML) for the communication infrastructure, and offers technical support for market participants during ongoing data exchange operations.
- Test user – Does the data exchange infrastructure provide a test environment to test the interaction with metering data?

Costs

- Access price – Metering data access for customers is for free, and it will have a cost for third parties.

United Kingdom

Smart meter roll-out

Great Britain set a target to reach 100% smart meter penetration for households and small businesses by the end of 2020. As of March 2019, around 9 million electricity smart meters were installed in British households and small/medium businesses. All high voltage connected customers already have smart metering capabilities. This is still far off the target set for 2020, with well under 50% of the estimated target of 30 million sites to be equipped with smart meters.

It is unlikely that the government's ambitions can be met by 2020, and a more reasonable 75%-80% penetration rate should be expected.

- % Smart meters – As of 16 June 2021, there were 15.7 million smart and advanced meters in residential and non-residential in Great Britain. This means that 50% of all meters (30.8 million) are smart meters.
- Wide-scale plan – The country plan to finalise the wide-scale plan by 2021-2025.

Data exchange infrastructure

- Data provider/s – UK has one data provider, DCC (Data & Communications Company), and several private companies offer metering data access through DCC, as becoming DCC user is complex, time-consuming and costly. N3RGY is one example of these types of companies, it provides a simple, easy-to-use interface to authorise and access energy consumption, tariff and device information.
- Type – DCC data exchange infrastructure is fully centralised.
- Implemented, Planned or not Planned – DCC was created in 2013.

Data characteristics

- Settlement data – Available data is used for billing and imbalance settlement purposes.
- Customer types covered – All customers with installed smart meters.
- Data Granularity – Half-hourly metering data can be accessed.
- Data Availability – Data is available after two days of the physical flow.
- Production and Consumption data availability – Production and consumption data is available.

Data access and rights

- Customer access – Customers can access their own metering data through N3RGY customer portal. Customers can also download n3rgy app (IOS and Android) to track their data on their mobile phones.
- Third-party access – Third parties can sign up for the n3rgy data services and integrate with the API to third-party services. They encapsulate all customer consent procedures, and technical and regulatory aspects of the access to the metering data. The customer consent is encapsulated in n3rgy services and incorporated to the third-party agreement. The customer needs to sign an agreement with the third-party. This is fully compliant with GDPR regulations.
- Third-party country registration – It is not mandatory to register the company within the country to access data through N3RGY.

Technical information

- Data interfaces –The API provides a simply, fast and effective means of accessing the consumers energy data. SDK, Documentation and API key management is also available within the Customer Portal for effective self-management.
- Test user – N3RGY offers free access to their sandbox so users can test the data exchange infrastructure.

Costs

- Access price – Access is for free for end-customers. Third-party access has a cost. N3RGY pricing model scales with the number of metering points the third-party have access to. They offer a "Starter" package up to 50 metering points for 4K£/ year and "Base" package up to 100 properties for 6K£/year, above this they charge per metering point.

Latvia

A wide-scale smart meter rollout is planned to be implemented in 2021-2025, currently there is 73% smart meter penetration. A data exchange infrastructure has been implemented with a unique access point for all market participants.

Lithuania

A wide-scale smart meter rollout is planned to be implemented in 2021-2025, currently only 2.8% of smart meters are in place. There are plans to have a data exchange infrastructure by 2023 with a unique access point for all market participants.

Ireland

Smart meter roll-out

- % Smart meters – What is the status of the smart meter roll-out in terms of the percentage of metering points covered by smart meters?
- Wide-scale plan – Is the country have a wide-scale plan (> 80%) of smart meter roll-out?

Data exchange infrastructure

- Data provider/s – Who owns and who operates the data exchange infrastructure? There are more than one data provider offering access to metering data?
- Type – Is the data exchange infrastructure centralised, partly centralised or decentralised?
- Implemented, Planned or not Planned – Is the data exchange infrastructure already implemented, planned or not planned?

Data characteristics

- Settlement data – Is the metering data settlement data?
- Customer types covered – For which type of customers is data available? Residential customers, business customers or all customers?
- Data Granularity – What is the granularity of data available?
- Data Availability – What is the data availability of the metering data available?
- Production and Consumption data availability – Is production and consumption data available in the data exchange infrastructure?

Data access and rights

- Customer access – Does the customer have access to their meter values?
- Third-party access – Do third parties, such as suppliers, have access to metering values with customer consent? If so, how is the customer consent process?

- Third-party country registration – It is mandatory to register the company within the country to access data?

Technical information

- Data interfaces – Does the data exchange infrastructure have data interfaces for reading and exchanging metering values? (e.g., API, STFP)
- Test user – Does the data exchange infrastructure provide a test environment to test the interaction with metering data?

Costs

- Access price – Does the access to metering data values have a price? It is different depending on the stakeholder that wants to use the data?

Portugal

Smart meter roll-out

Smart meter deployment is still in its infant stage in Portugal, and the country have not reached the EU target of 80% smart meter deployment by 2020, limiting the options for customers, especially households and SMEs. Smart meter rollout in Portugal is currently around 50% for household and SME customers. All customers connected to the medium to high voltage network already have metering capabilities with a measurement capacity of 15-minute granularity. Two CBAs were performed for the smart meter roll-out by ERSE, the Portuguese regulator, both with a positive outcome.

- % Smart meters – 50% of smart meter penetration.
- Wide-scale plan A wide-scale smart meter rollout is planned for implementation in 2021-2025.

Data exchange infrastructure

- Data provider/s – E-REDES owns the data exchange infrastructure in Portugal. It is the main DSO, with almost 100% of the customers in the country.
- Type – The data exchange platform is fully centralised.
- Implemented, Planned or not Planned – E-REDES implemented the Portuguese data exchange infrastructure since 2019.

Data characteristics

- Settlement data – Validated metering data can be accessed through E-REDES web portal.
- Customer types covered – All types of customers with an installed smart meter can be accessed.
- Data Granularity – 15-minute granularity is available.
- Data Availability – Metering data is available after one day of physical flow.
- Production and Consumption data availability – Production and consumption data is available.

Data access and rights

- Customer access – The customer has access to their metering values through E-REDES web portal. They need to register first.
- Third-party access – Third parties have access to metering values, with a previous customer consent. Customer consent is done through E-REDES web portal.
- Third-party country registration – It is not mandatory to register the company within the country to access data. However, the web portal only permits to enter a Portuguese ID in the registration form. This problem needs to be solved by IT area of E-REDES.

Technical information

- Data interfaces – E-REDES send metering data via an SFTP, in where third parties have to provide an IP, username, and password of their SFTP server, to allow E-Redes send the metering data.
- Test user – The platform does not count with a demo user.

Costs

- Access price – Accessing metering data in Portugal is for free for all market participants.

Poland

A wide-scale smart meter rollout is planned for implementation in 2026-2030, currently 8.3% of smart meters are in place. They are planning to have a data exchange infrastructure set up in 2024 with a unique access point for all market participants.

Belgium

Smart meter roll-out

Smart meter deployment was non-existent in Belgium until very recently. In July 2019, the Flemish region began to install smart-meters with a planned rollout period of 15 years. Priority is given to new and renovated buildings and solar prosumers. The Walloon region will start the deployment in 2023 and expects to substitute 80% of meters by 2029, even though some of the existing meter installations are already ready to supply 15-minute measurements. The Brussels-Capital region has opted for a framework enabling a smart meter deployment by segments (replacement, renovation, new buildings, injection of electricity into the grid -including flexibility, large consumers and on demand). This deployment has begun in 2019. A complete roll-out has not been decided and a CBA is ongoing.

- % Smart meters – Currently there is 3.3% smart meter penetration.
- Wide-scale plan – A selective rollout is being, planning to reach 80% in Belgium after 2030.

Data exchange infrastructure

- Data provider/s – Central Market System (CMS) will be operated by a company called Atrias, jointly founded and owned by the DSOs.
- Type – The CMS will be partially centralised, connecting the databases of the DSOs on one side, with the data systems of the energy suppliers on the other hand.

- Implemented, Planned or not Planned – Atrias is planning to implement a data exchange infrastructure in 2024

Data characteristics

- Settlement data – Available data will be validated data used for billing and imbalance settlement purposes.
- Customer types covered – Only retail data.
- Data Granularity – Data will have 15-minute granularity.
- Data Availability – Data will be available the day after the physical delivery.
- Production and Consumption data availability – Production and consumption data will be available.

Data access and rights

- Customer access – Not yet defined if users will have access to CMS. Customers can access their data directly from DSO / Data Manager
- Third-party access – Not yet defined.
- Third-party country registration – Not yet defined.

Technical information

- Data interfaces – Not yet defined.
- Test user – Not yet defined.

Costs

- Access price – Not yet defined.

Germany

Smart meter roll-out

Overall, smart meters are still an exception rather than the rule in Germany, leaving important room for improvement on infrastructure. Germany did not go through with a mandatory rollout of smart meters for households over the past years, following a negative outcome in the CBA performed by the regulator to set targets for 2020. Smart metering took a step back and is only offered voluntarily. The current target for Germany is a 23% penetration of smart meters by the end of 2020. The voluntary installation statistics are unknown, but in any case, less than 50.000 smart meters were installed by mid 2019. One of the reasons for this delay is the stringent certification process for smart meter gateways. Following the current law, customers with a yearly consumption of over 6.000 kWh and generators with a capacity above 7 kW have to be equipped with smart meters. This has not happened yet due to a delay in the roll-out caused by certification issues from the hardware.

- % Smart meters – Unknown.
- Wide-scale plan – Germany did not go through with a mandatory wide-scale plan for rollout of smart meters, following a negative outcome in the CBA performed by the regulator.

Data exchange infrastructure

- Data provider/s – Each DSO is the data provider for its own operative area.
- Type – DSO-centred decentralised data storage and access.
- Implemented, Planned or not Planned – There is no plan to implement a national data exchange infrastructure.

Data characteristics

- Settlement data – DSO available data is validated for billing and imbalance settlement purposes.
- Customer types covered – Depends on each DSO.
- Data Granularity – Various.
    - 1st generation of meters: 3 time bands for small customers (< 55kW rated capacity), 15 minutes for mid-size customers (> 55kW)
    - 2nd generation of smart meters: 15 minutes for all customers
- Data Availability – Depends on each DSO.
- Production and Consumption data availability – Is production and consumption data available in the data exchange infrastructure?

Data access and rights

- Customer access – Currently, the customer does not have access to their metering values.
- Third-party access – With the exception of the DSO, only those stakeholders that need data to fulfil their market functions get access to the necessary data. So, other third parties, do not have access to metering data.
- Third-party country registration – Third parties do not have access to metering data.

Technical information

- Data interfaces – Depends on each DSO.
- Test user – Depends on each DSO.

Costs

- Access price – There is no plan to implement a national data exchange infrastructure. So, this variable is not defined, and it will be not defined.

7.1.2. Results discussion

As a result of the conducted research, the 18 countries listed above were classified according to the following scores:

- Green. Countries with a wide-scale penetration of smart meters, with an existing centralised or partly centralised data exchange infrastructure and with processes of accessing data well defined without any barrier.
- Yellow. Countries with a wide-scale penetration of smart meters or planned before 2030, with an existing centralised or partly centralised data exchange infrastructure with processes of accessing data well defined, but with existing barriers.

- Orange. Countries with a wide-scale penetration of smart meters or planned before 2030, with a data exchange infrastructure planned before 2025 with processes not well defined.
- Red. Countries without a plan of smart meters roll-out or defined after 2030, or countries without a data exchange infrastructure planned.

The results of the analysis can be viewed as a summarised overview in Figure 17 and Table 6 below.

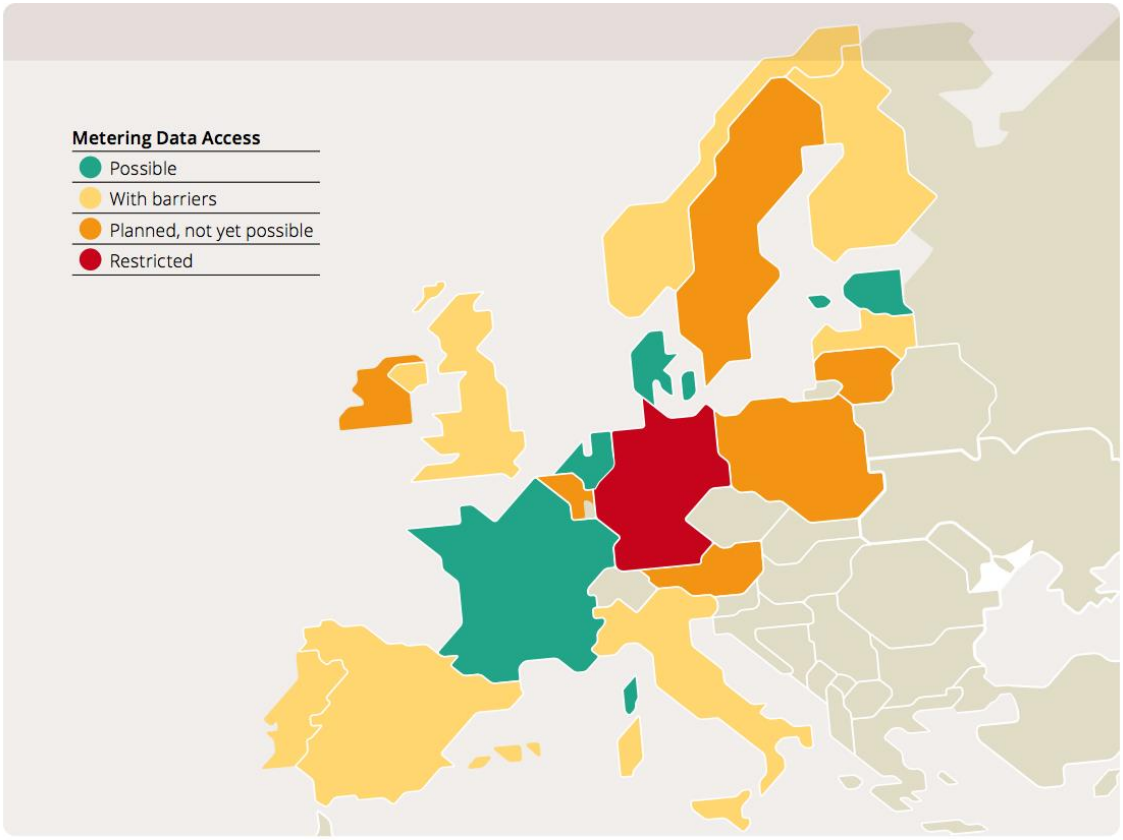

Figure 17. Status of metering data access in several countries in Europe. Own elaboration based on data collected from interviews and documentation

Table 6. Main variables of metering data access in several countries in Europe

Country	Smart meters roll-out	Data Exhcnage Infrastructure	Data characteristics	Data access processes			Existing Barriers		
				Customer access	3rd party access	Customer consent	Free price	Administrative	Technical
EE	Completed	Implemented	1-hour | D+1 Consumption/Production	Yes	Yes	Web portal	Yes	No	No
ES	Completed	Implemented	15 min | D+1 Consumption	Yes	Yes	Web portal	Yes	Yes	No
IT	Completed	Implemented	15-min | D+1 Consumption/Production	Yes	No	Web portal	Yes	No	Yes
FI	Completed	Planned 2022	1-hour | D+1 Consumption/Production	Yes	Yes	Paper based	No	No	No
SE	Completed	Planned 2024	1-hour | D+1 Consumption/Production	DSO	DSO	DSO	No	TBC	TBC
NW	Completed	Implemented	1-hour | D+1 Consumption/Production	Yes	Yes	Web portal	No	Yes	No
DK	Completed	Implemented	15-min | D+1 Consumption/Production	Yes	Yes	Web portal	Yes	Yes	No
FR	Completed	Implemented	1-hour | D+1 Consumption/Production	Yes	Yes	Web portal / Contract	Yes	No	No
NL	Completed	Implemented	15-min | D+1 Consumption/Production	Yes	Yes	Web portal / Digital	Yes	No	No
AT	Planned 2021-2025	Planned 2022	15-min | D+1 Consumption/Production	Yes	Yes	Web portal	Yes	TBC	TBC
UK	Planned 2021-2025	Implemented	30-min | D+1 Consumption/Production	Yes	Yes	Paper based	No	No	No
LV	Planned 2021-2025	Implemented	TBC	Yes	Yes	TBC	TBC	Yes	Yes
IE	Planned 2021-2025	Implemented	15-min | W+1 Consumption/Production	Yes	Yes	Email	Yes	No	Yes
PT	Planned 2021-2025	Implemented	15-min | D+1 Consumption/Production	Yes	Yes	Web portal	Yes	Yes	No
LT	Planned 2021-2025	Planned 2023	1-hour | TBC Consumption/Production	Yes	Yes	TBC	TBC	TBC	TBC
PL	Planned 2026-2030	Planned 2024	15-min | TBC Consumption/Production	Yes	Yes	TBC	TBC	TBC	TBC
BE	Planned after 2030	Planned 2024	1-hour | TBC Consumption/Production	Yes	Yes	TBC	TBC	Yes	Yes
DE	Planned after 2030	Not planned	TBC	DSO	DSO	DSO	DSO	Yes	Yes

The results show that although Europe is at the forefront of the process, only 3 countries out of the 18 analysed meet all the criteria required to allow consumers and their partners easy and cost-efficient access to relevant, granular metering data. 8 of these countries present some kind of obstacle, 7 do not have a system in place, although data is available in some way, and 1 has no smart rollout plan in place at all.

7.1.3. Main challenges & barriers

The high rate of smart-meter rollout, along with already existing or planned data exchange infrastructures, places Europe at the forefront of the world in metering data collection and exchange. However, as is shown in the images above, the systems and processes being adopted to facilitate access and exchange of metering data present several barriers and remain highly diverse, fragmented and poorly documented. Corporates still face several barriers that make the consent and sharing process quite cumbersome. The most common and recurring barriers are:

Information

- Most companies are still unaware that they can access their metering data without needing to install any device or hardware. They are not well informed about the benefits of doing so. Sufficient information campaigns for customers are lacking, which leads to a majority of corporate consumers with smart meters installed not knowing that they can request to share the (sub-)hourly data with third parties. Therefore, the benefits cannot be realised.

Administrative

- Lack of unified access point and uniform and documented way to access data in a country.
- Lack of authorization process to grant third-party access. In most cases, processes are not well defined and/or poorly documented.
- Requirement to have the VAT number or national ID of the country in which the data access request is submitted.
- High price of accessing metering data.

Technical

- Lack of availability of metering data through a digital data interface (i.e., API, B2B messaging) and software interfaces.
- Lack of data standards for the energy sector to optimise interoperability, and differences in security and compliance requirements.

7.2. Guarantees of origin: Case studies

The purpose of this section is to compare several guarantees of origin systems, covering a wide range of different models in order to identify existing barriers and challenges to propose and discuss a standardised model to support the 24/7 Renewable Energy Certification.

7.2.1. Case studies

Spain

Issuing body

- Type: Regulator.
- Since 2007, the Spanish National Regulatory Authority (National Commission on Markets and Competition -CNMC-), is the official Issuing Body for guarantee of origin of electricity from renewable energy sources in Spain. Since April 2015, CNMC has become member of the "Association of Issuing Bodies" (AIB).
- Spain is the country with more GOs cancellations in the last 3 years (2017, 2018 & 2019), with 221 TWh of volume, representing the 13.1% of total European GO cancellations.

Privacy of the certificate

- Is the certificate public or private?
    - The guarantee of origin is a public registry in Spain. A list of cancelled guarantees of origin, with their details and account-holders can be accessed through the CNMC web portal, without the necessity of having an account.

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
    - In order to perform a cancellation, the account-holder needs to enter to CNMC platform and upload an Excel file template with all the following information:
        - Account-holder ID of the GO
        - Account-holder Name of the GO
        - Issuing number/Transfer number/Import number
        - Production plant ID from which the GO was issued
        - Number of GOs to cancel/claim
        - Metering consumption point ID (CUPS in Spain, Código Universal de Punto de Suministro)
        - Power contracted of the metering point
        - Year of the GOs to cancel
        - Consumption of metering consumption point (in MWh), stating month and year (Optional)
- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
    - The claim is made on behalf of the specific metering consumption point.

- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?
    - They can access via CNMC portal, by specifying their metering point ID, without the necessity of having an account.

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)
    - Yes, they can interact with the GOs via CNMC Web Portal.
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)
    - There is no interface to automatically interact with registries. Account-holders can only interact with the registries through the Web portal.

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)
    - As in Spain a GO is public, the customer can access to their cancelled GOs at every moment.
- If so, does the customer can authorize a third-party to access their data?
    - As in Spain a GO is public, a third-party, by having the information of the metering point can access to customers cancelled GOs at every moment.
- If third parties can access data, how is the process where the customer gives consent to access their data?
    - As in Spain a GO is public, there is no a consent process.
- If third parties can access data, does the third-party need to be registered in the country?
    - As there is no necessity to be registered in the CNMC web portal to access information about GOs, there is no need to register the third-party in the country.

Netherlands

Issuing body

- Type: TSO
- Since 2014, the Authorised Issuing Body for GOs in the Netherlands is CertiQ. Its role is to administer the EECS Registration Database and its interface with the AIB Communications Hub. CertiQ is part of TenneT TSO B.V., the national electricity grid operator in the Netherlands.
- The Netherlands is the second country with more GOs cancellations on the last 3 years (2017, 2018 & 2019) after Spain, with 189 TWh of volume, representing the 11.2% of total European GO cancellations.

Privacy of the certificate

- Is the certificate public or private?
    - GOs are a private registry in the Netherlands, and can only be accessed by being an account-holder of the GO and having an account in CertiQ Web Portal.

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
    - The cancellation is done by the account-holder of the GO through CertiQ Web Portal, they need to specify the following information:
        - Number of certificates to cancel
        - The beneficiary of the cancellation: Energy supplier or End customer
        - If the beneficiary is Energy supplier, specify the month and year that relates to the cancellation; If beneficiary is End customer, only the year needs to be specified.
        - If the beneficiary is an Energy supplier, specify the name of the Energy supplier; If the beneficiary is End customer, it is important that the EAN code of the end-consumer account is entered.
- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
    - The claim is made for the end customer as whole. Metering consumption point can be specified at the "Reference" field of the cancellation statement.
- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?
    - In order to be a beneficiary of a GO cancellation, the end customer needs to be registered at CertiQ Web Portal. By entering to MyCertiQ, all cancelled statements can be downloaded from CertiQ Web Portal.

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)
    - MyCertiQ is the platform to interact with GOs in the Netherlands.
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)
    - There is no interface alternative to obtain information automatically in the Netherlands.

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)
    - In order to be a beneficiary of a GO cancellation, the end customer needs to be registered at CertiQ Web Portal. By entering to MyCertiQ, all cancelled statements can be downloaded from CertiQ Web Portal.
- If so, does the customer can authorize a third-party to access their data?

    - As an intermediary a third-party can log in and register data on behalf of a producer and / or on behalf of an end-consumer.
- If third parties can access data, how is the process where the customer gives consent to access their data?
    - A third-party in order to act in behalf of an end customer needs to be registered in the eHerkenning system in the Netherlands. eHerkenning is a standardised login system which enables organisations to make their services accessible online and securely to companies, civil servants and consumers.
- If third parties can access data, does the third-party need to be registered in the country?
    - Third parties need to be registered in the Dutch Commercial Register in order to act in behalf of an end customer.

Norway

Issuing body

- Type: TSO
- The Authorized Issuing Body for GOs in the Norway is Statnett. Its role is to administer the EECS Registration Database and its interface with the AIB Communications Hub. Statnett is the Norwegian Transmission System Operator, responsible for issuing guarantees of origin to electricity producers. Statnett is also responsible for creating and updating the Domain Protocol for Norway and participates in the Association of Issuing Bodies (AIB) in Europe.
- Norway is the third country with more GOs cancellations on the last 3 years (2017, 2018 & 2019) after Spain and Netherlands, with 178 TWh of volume, representing the 10.5% of total European GO cancellations.

Privacy of the certificate

- Is the certificate public or private?
    - GOs are a private registry in Norway, and can only be accessed by being an account-holder of the GO and having an account in NECS Web Portal.

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
    - The cancellation is done by the account-holder of the GO through NECS Web Portal, they need to specify the following information:
        - Number of certificates to cancel
        - Country of consumption (Norway)
        - Name of the Beneficiary: Free text field
        - Location of the Beneficiary
        - Type of Beneficiary: Supplier or End-consumer

    - Usage category: Other (in case of End-consumer) or Disclosure (in case of Supplier)
    - Consumption period: Year of consumption
    - Cancellation purpose: Free text field.
- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
    - The claim is made for the end customer as a whole. The metering consumption point can be specified at the "Location" field of the cancellation statement.
- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?
    - They cannot access to their cancelled GOs. Only the account-holder that has performed the cancellation have access to the cancelled GOs. End-consumers that want to access to their cancelled GOs need to ask for the registry to the account-holder that has performed the cancellation.

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)
    - NECS Web Portal is the Norwegian platform to interact with the GOs in Norway.
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)
    - There is no interface alternative, registries can only be accessed through NECS Web Portal.

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)
    - They cannot access to their cancelled GOs. Only the account-holder that has performed the cancellation have access to the cancelled GOs. End-consumers that want to access to their cancelled GOs need to ask for the registry to the account-holder that has performed the cancellation.
- If so, does the customer can authorize a third-party to access their data?
    - As end customers do not have access to their cancelled GOs, they cannot authorize a third-party to act on their behalf.
- If third parties can access data, how is the process where the customer gives consent to access their data?
    - As end customers do not have access to their cancelled GOs, they cannot authorize a third-party to act on their behalf.
- If third parties can access data, does the third-party need to be registered in the country?
    - As end customers do not have access to their cancelled GOs, they cannot authorize a third-party to act on their behalf.

Sweden

Issuing body

- Type: Energy agency
- Since 2017, the Swedish Energy Agency (Energimyndigheten) is member of the Association of Issuing Bodies (AIB). EECS certificates for production devices in Sweden are now being issued by the certificate registry CESAR, which is operated by the Agency. Guarantees of origin can be issued either in a national version, which is only transferrable within Sweden, or in an EECS version for transfer anywhere in Europe.
- Sweden is one of the countries with more GOs cancellations on the last 3 years (2017, 2018 & 2019) after Spain, Netherlands and Norway, with 169 TWh of volume, representing the 10% of total European GO cancellations.

Privacy of the certificate

- Is the certificate public or private? GOs are a private registry in Norway, and can only be accessed by being an account-holder of the GO and having an account in Cesar Web Portal.

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
    - The following details need to be specified when cancelling a guarantee of origin:
        - The number of certificates to cancel: Number of certificates to be Cancelled of the current selection.
        - Country of consumption: The country where this electricity has been consumed. Certificates may only be cancelled for domestic consumption.
        - Name of Beneficiary: The company/customer to which this electricity was sold or by whom it was sold. It is a free from field, not validated by a lookup.
        - Location of the Beneficiary: More detailed information of the Beneficiary like department, unit, division, or geographical branch. It is not mandatory. It could be used to specify the metering consumption point.
        - Usage Category: Disclosure or Other. Disclosure: Cancelled under a green labelling scheme or as proof of supply to consumers or for own use. EECS-GOs may be Cancelled for disclosure of electricity consumption in Sweden.
        - Consumption period: Time period of electricity consumption for which the certificates are cancelled.
        - Type of beneficiary: The type of the cancellation beneficiary. Supplier or End customer.
        - Cancellation purpose: Text to indicate the reason for Cancellation.

- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
    - The claim is made for the end customer as a whole. The metering consumption point can be specified at the "Location" field of the cancellation statement.
- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?
    - End customer which has not performed the claim of the GO with their Cesar account, cannot access through the Web Portal to their cancelled GO. They need to ask for that information to the entity that has made the claim. The only way they can access to their cancelled GOs using their Cesar account, is if they have performed the cancellation in their own.

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)
    - CESAR is the system for Guarantees of Origin in Sweden. It helps tracking the ownership of the certificates and facilitates issuing, trading, cancellation and expiration of guarantees of origin.
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)
    - There is no interface implemented yet, but they are planning to improve the system in 2023/2024.

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)
    - End customer which has not performed the claim of the GO with their Cesar account, cannot access through the Web Portal to their cancelled GO. They need to ask for that information to the entity that has made the claim. The only way they can access to their cancelled GOs using their Cesar account, is if they have performed the cancellation in their own.
- If so, does the customer can authorize a third-party to access their data?
    - Third parties can access to the system by having a role in the account-holder user. Third-party can have two roles, administrator or viewer. In order to login to Cesar they must have a BankID or Freja ID.
- If third parties can access data, how is the process where the customer gives consent to access their data?
    - Account-holders can give access to third parties at Cesar Web Portal.
- If third parties can access data, does the third-party need to be registered in the country?
    - In order to access to Cesar, a user must have a BankID or Freja ID, and this step requires to register the company in Sweden.

Italy

Issuing body

- Type: Energy agency
- Since 2013, in Italy, the role of Issuing Body is performed by the Electrical Services Manager (GSE). Its role is to administer the EECS Registration Database and its interface with the EECS Transfer System. From that date GSE is the sole competent body in Italy to issue, transfer and cancel EECS GOs from Renewable Energy Sources. GSE is the state-owned company which promotes and supports renewable energy sources in Italy. The sole shareholder of GSE is the Ministry of Economy and Finance, which exercises its rights in consultation with the Ministry of Economic Development.
- Italy is one of the countries with more GOs cancellations on the last 3 years (2017, 2018 & 2019), with 146 TWh of volume, representing the 8.4% of total European GO cancellations.

Privacy of the certificate

- Is the certificate public or private?
    - GOs are a private registry in Italy, and can only be accessed by being an account-holder of the GO and having an account in GSE Web Portal.

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
    - Only suppliers have the possibility to cancel the Guarantees of origin. To request the cancellation of certificates, the GO Portal offers the user three options: Single Cancellation, Multiple cancellation sending associated with a group of beneficiaries, Mass sending via a CSV file. For the three options of cancellation, the followed information needs to be specified:
        - Number of certificates to be cancelled
        - Beneficiary of those certificates (Free form field)
- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
    - It is not possible to associate a metering point in the cancellation process. The only required information is the name of the Beneficiary
- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?
    - End customer cannot access through the GSE Web Portal to their cancelled GO. They need to ask for that information to the entity that has made the claim.

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)

    - GSE Web Portal is the system for Guarantees of Origin in Italy. It helps tracking the ownership of these certificates and facilitates issuing, trading, cancellation and expiration of guarantees of origin.
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)
    - There is no interface in place. The interaction with the registries is through the GSE Web Portal.

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)
    - End customer cannot access through the GSE Web Portal to their cancelled GO. They need to ask for that information to the entity that has made the claim.
- If so, does the customer can authorize a third-party to access their data?
    - It is not possible for third parties to access to the Web Portal.
- If third parties can access data, how is the process where the customer gives consent to access their data?
    - It is not possible for third parties to access to the Web Portal.
- If third parties can access data, does the third-party need to be registered in the country?
    - It is not possible for third parties to access to the Web Portal.

Ireland

Issuing body

- Type: Electricity Market Operator
- SEMO is a member of the Association of Issuing Bodies (AIB) since May 2015 and is the body that is in charge of managing the GOs in Ireland. SEMO is the Single Electricity Market Operator for Ireland and Northern Ireland. SEMO's role is to administer the EECS Registration Database and its interface with the EECS Transfer System, which covers registration, requesting and issuing, transferring (including Exporting), importing, and withdrawal businesses processes. The registry that enables these processes is provided by Grexel systems.
- Ireland's GOs cancellations on the last 3 years (2017, 2018 & 2019) were 18 TWh of volume, representing the 1.1% of total European GO cancellations.

Privacy of the certificate

- Is the certificate public or private?
    - GOs are a private registry in Ireland, and can only be accessed by being an account-holder of the GO and having an account in Grexel Web Portal.

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
    - The following details need to be specified when cancelling a guarantee of origin:

        - Number of certificates to cancel: Number of certificates to be Cancelled of the current selection.
        - Country of consumption: The country where this electricity has been consumed. Certificates may only be cancelled for domestic consumption.
        - Name of Beneficiary: The company/customer to which this electricity was sold or by whom it was sold. It is an open text field, not validated by a lookup.
        - Location of the Beneficiary: More detailed information of the Beneficiary like department, unit, division, or geographical branch. It is not mandatory. It could be used to specify the metering consumption point. It is an open text field, not validated by a lookup.
        - Usage Category: Select the usage category. Disclosure: Cancelled under a green labelling scheme or as proof of supply to consumers or for own use. EECS-GOs may be Cancelled for disclosure of electricity consumption in Sweden.
        - Consumption period: Time period of electricity consumption for which the certificates are cancelled for.
        - Type of beneficiary: The type of the cancellation beneficiary. Could be an Energy supplier or an End-consumer.
        - Cancellation purpose: Text to indicate the reason for Cancellation.
- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
    - The claim is made for the end customer as whole. Metering consumption point can be specified at the "Location" field of the cancellation statement.
- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?
    - Account-holders (in the Irish case, 100% suppliers) who has performed the cancellation have access to the cancelled GOs. If an end-consumer want to access to their cancelled GOs, they need to ask to the account-holder who has performed the cancellation.

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)
    - SEMO operates the registry for Guarantees of Origin in Ireland with Grexel systems.
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)
    - At present there are no interface alternatives. However, they are continually reviewing the possibility of a more automated solution in the future.

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)
    - Account-holders (in the Irish case, 100% suppliers) who has performed the cancellation have access to the cancelled GOs. If an end-consumer want to access to their cancelled GOs, they need to ask to the account-holder who has performed the cancellation.
- If so, does the customer can authorize a third-party to access their data?
    - Third Parties are provided with the cancellation statements via their Energy Supplier, however, they are discussing the possibility of the functionality of a public link.
- If third parties can access data, how is the process where the customer gives consent to access their data?
    - Third Parties are provided with the cancellation statements via their Energy Supplier, however, they are discussing the possibility of the functionality of a public link.
- If third parties can access data, does the third-party need to be registered in the country?
    - Third Parties are provided with the cancellation statements via their Energy Supplier, however, they are discussing the possibility of the functionality of a public link.

Portugal

Issuing body

- Type: TSO
- The entity in charge of issuing and monitoring the GOs and of managing the GO system is REN, which is also the concessionaire of the Portuguese TSO. The name of the issuing body is "Entidade Emissora das Garantias de Origem – EEGO". REN's scheme membership was recently approved at the AIB General Meeting held on the 19th June 2020. The EEGO System was connected to the AIB Hub from the 1st of August 2020. Since that date, imports to and exports from Portugal are possible within Europe.
- Portugal's GOs cancellations on the last year (2019) were 0,2 TWh of volume, representing the 0.01% of total European GO cancellations.

Privacy of the certificate

- Is the certificate public or private?
    - GOs are a private registry in Portugal, and can only be accessed by being an account-holder of the GO and having an account in EEGO Web Portal.

GOs cancellation/claim process

- What are the requirements that end customers' needs to specify to perform a claim of their consumption?
    - The following details need to be specified when cancelling a guarantee of origin:

        - Number of certificates to cancel: Number of certificates to be Cancelled of the current selection.
        - Beneficiary: The company/customer to which this electricity was sold or by whom it was sold. The following type of beneficiaries could be selected:
            - The entity making the request - cancellation in account.
            - A different entity registered in the EEGO system (supplier or end-consumer). The destination account of the beneficiary shall be indicated.
            - An end-consumer not registered in the EEGO system - in which case the cancellation shall be made in an account together with the identification and address of the end-consumer.
        - CPE of the Beneficiary: Metering point of the beneficiary. If no CPE is inserted, then the GO is assigned to the beneficiary as a group.
        - Consumption period: Time period of electricity consumption for which the certificates are cancelled.
- On behalf of which entity is the claim made? The customer as a whole? The metering consumption points? Or is it possible to do both?
    - Metering point of the beneficiary can be specified in the cancellation statement. If no CPE is inserted, then the GO is assigned to the beneficiary as a group.
- How can customers access the registries that are cancelled in their name? Can they access via the Web Portal or they have to ask this information to the entity that has made the cancellation?
    - If the beneficiary of the GO has an account in the EEGO system, it can access their guarantees of origin; If the beneficiary has not an account in the EEGO system, it needs to ask the entity that have made the cancellation to collect the cancelled GOs.

Guarantees of origin Portal

- Does the country have a platform to interact with the EACs? (Digital, Email, Excel Spreadsheet, Paper, etc.)
    - EEGO Portal is the system for Guarantees of Origin in Portugal. It helps tracking the ownership of these certificates and facilitates issuing, trading, cancellation and expiration of guarantees of origin.
- Interface alternatives - (API, Web service, Web portal, Excel, etc.)
    - The interaction with the certificates is all done through the EEGO Web Portal. There is no API available for the moment. EEGO team is working on a new platform, which is planned to be launch in 2022. The actual one is based on one created in 2013.

Customer & Third-Parties access

- Does the customer have access to their own data? (For instance, to the certificates that are cancelled in their name)

- If the beneficiary of the GO has an account in the EEGO system, it can access their guarantees of origin; If the beneficiary has not an account in the EEGO system, it needs to ask the entity that have made the cancellation to collect the cancelled GOs.

- If so, does the customer can authorize a third-party to access their data?
  - A user can authorise a third-party by adding the to the registered contacts.
- If third parties can access data, how is the process where the customer gives consent to access their data?
  - The consent is done by the responsible of the account by sending completed and signed a form to EEGO email.
- If third parties can access data, does the third-party need to be registered in the country?
  - The third-party does not need to be registered in Portugal.

7.2.2. Results discussion

After gathering all information about GOs schemes and its cancellation processes in selected countries, in Table 7 the main results can be observed.

Table 7. GOs Systemes analysis results. Own elaboration based on documentation and interviews with several stakeholders of the GO scheme.

Country	Market development		Integration	Scheme	Issuing Body	Type of issuing body	Is as well metering data provider?	Privacy of certificate	Claim entity	Beneficiary consumption point	Interface	End customer access	Third party access
	Cancelled GOs 2017/18/19	% of Total											
ES		13,1%	Yellow	EECS-GO	CNMC	Regulator	No	Public	Supplier	Yes	Web Portal	Yes	Yes
IT		8,7%	Orange	EECS-GO	GSE	Energy agency	No	Private	Supplier	Free form field	Web Portal	No	No
SE		10,0%	Orange	EECS-GO	Energimy ndighete	Energy agency	No	Private	Supplier	Free form field	Web Portal	No	No
NW		10,6%	Orange	EECS-GO	Statnett	TSO	No	Private	Supplier	Free form field	Web Portal	No	No
NL		11,2%	Yellow	EECS-GO	CertiQ	TSO	No	Private	Supplier	Free form field	Web Portal	Yes	Yes
IE		1,1%	Orange	EECS-GO	SEMO	Electricity Market	No	Private	Supplier	Free form field	Web Portal	No	No
PT		0,0%	Orange	EECS-GO	REN	TSO	No	Private	Supplier	Optional	Web Portal	Yes	Yes

7.2.2.1. Integration score

The integration score explains the interoperability of the system, and the ability to interact with end customers (in this case, corporates) and third parties.

Green – Platform/webapp/system in place, working with zero (or close to) bureaucratic or financial barriers for non-supplier accounts.

Yellow – Platform/webapp/system in place, working with some degree of bureaucratic or financial barriers for non-supplier accounts.

Orange – Platform/webapp/system in place, working with bureaucratic or financial barriers for non-supplier accounts

Red – No system in place and/or complete inability to integrate

7.2.2.2. Main barriers and challenges

Not customer centred – Most of the analysed GOs systems are centred in suppliers for disclosure purposes, and there are not centred in corporate consumers. As can be observed in Table 7, end customers only can access to their cancelled GOs in Spain, the Netherlands and Portugal.

Beneficiary consumption point – In most of the countries, it is not possible to state the metering point id that refer to the consumption of the cancelled GO. As a result, it is not possible to do the match between consumption and production, due to the fact that each for metering point (smart meter) corresponds a different value of electricity consumption.

Technical – All analysed countries do not have in place an interface, such an API, to interact with the registries in an easy, efficient and automatic way.

Administrative – Lack of documentation of cancellation process. Most of the process are constructed for disclosure purposes, and need to also be redefined for renewable energy claiming of corporate consumers.

Administrative – Lack of authorization process to grant third-party access. In most cases, processes are not well defined and/or poorly documented. Third parties are a key stakeholder in sustainability reporting.

Time-consuming – As it is not possible to directly gather information about their cancelled GOs, corporate customers waste time asking their retailers for this information.

7.3. Proposed system for metering data exchange and EAC infrastructures to support granular energy attribute certificate scheme

A system proposal for hourly metering data exchange infrastructures and changes in the GO scheme to support granular certificates will be proposed in this section.

The aim of this section is to prove that:

- Metering data exchange infrastructures, harmonized and standardised can serve with validated hourly production and consumption data to all systems and stakeholders involved in the 24/7 approach.
- Hourly issuance and matching can be achieved within the GO scheme.
- Hourly GOs can work within the existing IT systems used by issuing bodies and the AIB hub.

7.3.1. Proposed granular certificates and GO link process

The aim of this section is to outline a possible methodology to link the existing EECS-GO schemes with the granular certification scheme.

Requirements:

- The granular certificate issuer should be an approved account-holder on the official GO registry managed by the Issuing Body. This shall take place within the constraints of national regulations – e.g., intermediary account, broker account, trader account.
- Producers, traders and end-consumers (both industrial and residential) should be account-holders on the granular certificate registry.
- Consumers should be allowed to use the official GO scheme for their Scope 2 market-based reporting based on yearly accounting.
- The volume of issued and claimed granular certificates must be at any time the same as recorded on the GO registry. All GOs will be claimed on the granular certificate issuer account in the respective GO registry.
- Granular certificates can be transferred among granular certificates issuers. The same volume must be transferred also in the respective GO registry.
- Granular certificates and GOs are to be linked between each other through the total production volume over a fix time period. The time period shall be adapted to the issuance process of the GO Issuing Body. Example:
    - Production period: 14/05/2021 – 13/06/2021 (30 days)
    - Volume: 100 MWh
    - Production asset details
    - GO ID range: XXX-XXX (100 IDs)
    - GC ID list: (number will be = 30 days *24 hours), in which the energy contained in each GC will be given by the energy produced in that hour, verified by the metering data exchange infrastructure.

Proposed process:

1. The Granular Certificate Issuer submits production data on behalf of the asset owner. Hourly production data will be obtained from the data exchange infrastructure of the country.
2. A GO Issuing Body issues GOs on the asset owner account, specifying, in addition to the actual information contained in a GO, the production profile.
3. The Granular Certificate Issuer granular certificates on the asset owner account on the Granular Certificate Registry for the same volume as the GO.
4. Granular certificates are ready to be transferred and cancelled.
5. Once received the Granular Certificates, consumers can execute the cancellation. The Granular Certificate Issuer will cancel the same volume of GOs on its account on the GO registry.
6. For the cancellation to be valid, the time synchronicity between the Issuance and Claim (same start/end time of production and consumption) needs to be verified by a third-party. This can happen by a one-time audit of the code and rules that manage the allocation of Granular Certificates among Granular Certificate Issuer.
7. Matching Consumption & Production Verification Body: Will receive the consumption data. Will check that cancellation happened against consumption.

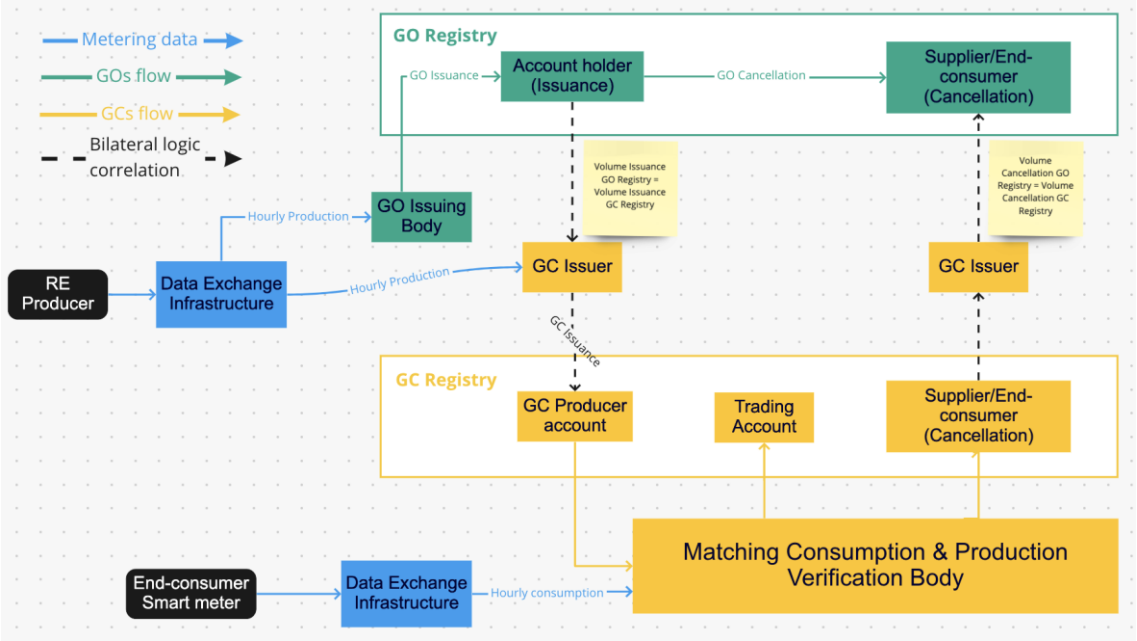

Figure 18. GO/GC Link proposed model

EnergyTag, in its white paper [6], covers high-level principles. The following principles are defined in the EnergyTag white paper:

- Time period of max 1 hour.
- Use of UTC for time.
- Usage of settlement metering data, provided by Data Exchange Infrastructures.
- Transferability to an Account in the same and in other Registries

- Possibility of participation of assets not covered by the existing GO scheme (e.g., small RES generation or non RES assets), with the approval of relevant authorities.
- Emissions: GCs may be used for scope 2 market based, and potentially other uses.
- Period of validity: limited validity
- Storage: hourly certificates could bring additional value to storage, it's important to include it in the scheme.
- Verifiability of claims: each Registry shall enable mandated third parties to verify the GCs cancelled as proof of the Attributes of energy consumed. The Matching Consumption & Production Verification Body will be the organization responsible of checking that Granular Certificates (GCs) are cancelled against the energy consumption measured at one or a group of multiple Consumption Points. This organization can be a GC Issuer, or a different organisation.
- Standardization: EnergyTag will work on guidelines to standardize exchange of information (e.g., data format, APIs)
- Reference to another GC: Where appropriate, GC systems should support the identification of previous GCs of the same or different energy carrier, for full traceability and transparency of the history of energy tracking. This could be used for instance for energy storage or conversion from one Energy Carrier to another.

Attributes that a GC will have, defined by EnergyTag whitepaper [38]:

- Energy carrier
- Unique serial number
- Date Production Device became operational
- First and last dates/times of production of associated energy
- Originating energy source
- Type, identity, location and capacity of Production Device
- Country and date of issue
- Face value of GC
- Identity of issuer
- Purpose of GC (normally disclosure to consumers)
- Responsible competent authority for related GO, where appropriate
- Whether support has been received, and whether this is for production and/or investment support
- Any labelling schemes under which this GC is eligible
- CO_2 emitted and/or saved in the production of energy associated with this GC

7.3.2. Metering data exchange infrastructures proposal

The metering data exchange infrastructures will be key stakeholders of the 24/7 approach, they will need to provide several stakeholders involved in the process with verified production and consumption data, in order to match production and consumption in every hour of the year. According to the variable analysed in the previous section, a proposal has been developed below:

Smart meters roll out – EU countries will need to have smart meters in place, both for production devices and electricity end-consumers.

Data characteristics – Available production and consumption data will need to be verified by a competent body (TSO/DSO) and with a minimum of 1 hour of granularity.

Interoperability –Will need to have the ability to integrate technically with existing GO issuing bodies and coming GC Issuers and Consumption & Production verification bodies. Mentioned stakeholders will need to integrate its systems with the Data Exchange Infrastructures systems, and as mentioned in the metering data section part, an API development is one of the most efficient and optimal way to integrate two systems, automatically without any manual work.

Authorization process for third parties – Processes needs to be clear, well defined and well documented. One example that should be taken into account is the case of Estonia, which its authorization process is clear, easy, and only requires few steps in order to authorize/revoke metering data consent access.

Unified access point– In order to make the system works efficiently and to avoid several integrations, all country metering data must be accessed through one single access point. Exchange of information should be made by an API. FlexiDAO, with their experience of working with different types of data exchange infrastructures, considers that the unique access point (either with a centralized or decentralized model) is one of the most important characteristics that a data exchange infrastructure should have to fulfil the needs of energy buyers and services providers in their journey of 24/7 renewable electricity approach.

EU access – For EU stakeholders, registration within the country should not be required, an EU digital identity could be use, such as the European Digital ID [39].

Standardization and harmonization – Data Exchange Infrastructures should be harmonised, and ultimately standardised, across Europe to allow market participants to share their metering data with any secure and trusted service provider they wish (e.g., GC Issuer for 24/7 certification).

Metering data exchange infrastructure role in 24/7 certification – Will be responsible for bridging the Data Exchange Infrastructures with the rest of the stakeholders involved in the 24/7 approach (producers, consumers, verification bodies, GO Issuing Bodies, GC Issuers). The metering data exchange infrastructure will expose metering points and measurements from the consumers and producers via an API. GC Issuers will import measurements from the metering data exchange infrastructures and publishes them to the blockchain while at the same time issues GCs to the blockchain for production meters. To enable importing of data, users (producers and consumers) must be required to submit an authorization which will allows all different stakeholders of the system to import data for and make it available to the rest of the platform.

Data Quality – A verification protocol shall be put in place that guarantees the correctness of the quantity of GCs issued, their energy source, production technology and any other data recorded on them as Attributes. A Data Exchange Infrastructure is responsible for measuring the energy produced and consumed. Data used for the issuance of GCs shall be derived from the registered

details of the production facility and the meters that are used for the purposes of energy settlements when determining the quantity of the corresponding physically traded energy. GCs cannot be issued for production periods for which there is no measurement data available.

7.3.3. Changes needed in the actual GO schemes to support granular certificates integrations

Existing GO systems need to be amended in such a way as to support hourly matching. Where this is for some reason not feasible in the short term, then a complementary system may be considered, provided it excludes double-counting of attributes in relation with existing accounting methods for energy attribute declaration in that country or region, and is integrated with the existing GO system.

As observed in the previous section, existing GOs systems vary depending on the region. GO systems, as Data Exchange Infrastructures need to be standardized and harmonized. Proposals for changes needed to support granular certificates are specified below:

- Each GO of 1MWh will need to have the production profile specified in the registry.
- Cancellation statements needs to be accessed by the account-holder and the beneficiary.
- Third-parties, and all involved 24/7 stakeholders needs to have access to GOs, in accordance with a user consent process.
- Cancellation beneficiary should be only registered users of the GO Registry. Cancellation for users outside the system should not be allowed.
- Metering consumption point of the beneficiary should be an optional field in the Cancellation process, and it needs to be linked with the metering points existing in the Data Exchange Infrastructures. A GO must be cancelled against energy consumption at one or multiple Consumption Points that took place during the same timeframe (start and end time) as the production period for which that GO was issued and for the same Energy Carrier to which that GO relates (e.g., electricity).
- GO systems shall support the linkage of GOs issued for stored energy with the cancelled GOs from which the energy originates.

7.4. Assessment: Business case analysis. FlexiDAO as a GC Issuer for Granular Certificates

7.4.1. Market size

As the business is related to the actual guarantees of origin scheme, the market will be measured according to this field. In the years 2019 and 2020, 3,454 million and 3,754 million of GO transactions were produced in the GO market (see Table 8), including issuing, transfers, imports, exports, expires and cancellations.

Table 8. GO Transactions [35]

GO Transactions	2019		2020	
	Volume	IB Revenue	Volume	IB Revenue
Issue	675.588.327	8.726.187 €	786.599.106	10.160.049 €
Transfer	878.375.790	11.345.476 €	929.845.859	12.010.285 €
Import	605.334.915	7.818.764 €	617.818.279	7.980.004 €
Export	605.635.400	7.822.645 €	617.925.570	7.981.390 €
Expire	40.244.871	519.820 €	61.295.998	791.725 €
Cancel (Own Domain)	598.271.964	7.727.536 €	674.979.936	8.718.328 €
Cancel (Ex Domain)	50.431.119	651.390 €	65.051.330	840.231 €
Total Transactions	**3.453.882.386**	**44.611.817 €**	**3.753.516.078**	**48.482.013 €**

Taking into account average tariffs of current Issuing Bodies per transaction, which is €0.0129 per transaction [40], the current monetization for the market represents 44 M€ for 2019 and 48 M€ for 2020.

Table 9. Market size. TAM, SAM, SOM. 2021-2025. Own elaboration

Variable	Definition	2019	2020	2021	2022	2023	2024	2025	2026
TAM (EU)	Revenues (M €)	44,61	48,48	52,36	56,55	61,07	64,13	67,33	70,70
	Volume (M GOs)	3.454	3.754	4.054	4.378	4.728	4.965	5.213	5.474
	Market growth (%)	11,3%	8,7%	8,0%	8,0%	8,0%	5,0%	5,0%	5,0%
SAM (ES, DK, NL)	Revenues (M €)	5,16	6,94	7,49	8,09	8,74	9,18	9,64	10,12
	Volume (M GOs)	399	537	580	627	677	711	746	783
	Market growth (%)	11,3%	8,7%	8,0%	8,0%	8,0%	5,0%	5,0%	5,0%
SOM (ES)	Revenues (M €)	1,67	1,81	1,96	2,11	2,28	2,40	2,52	2,64
	Volume (M GOs)	130	140	152	164	177	186	195	205
	Market growth (%)	11,3%	8,7%	8,0%	8,0%	8,0%	5,0%	5,0%	5,0%

By 2026, the GO market is valued at 70,7 M € with annual growth of 5%. Target markets for 2026 is composed by Spain, Denmark and Netherlands and represent 14% of the total GO European market. Finally, FlexiDAO will first try the Spanish market with a value of a 2.64 million € for 2026, for which we pretend to get a 20% of the GO market share for granular certificates, that is 0.5 € of revenues that year.

7.4.2. Key activities

FlexiDAO's job will be to first verify the sources of energy production, and then certify the source and volume of energy produced, and integrate its granular certificate registries with the existing

GO scheme. FlexiDAO will be a Granular Certificate Issuer, which is an organisation responsible for:

- Administration and operation of the Granular Certificates register, which shows how, when and where renewable electricity was generated
- Production devices & account-holders registration
- Issuance, transfer, import, export and cancellation of the granular certificates within a Domain, ensuring avoidance of double-counting of the Attributes represented by the Granular Certificates it administers throughout their lifetime.

Leading buyers are requesting hourly certification today, and regulated bodies are not ready to offer it. FlexiDAO's objective is to become the granular certificate certifying platform that leading market players use for their 24/7 progress tracking and certification.

Key features of the GC Registry will include:

- Issuing of GCs based on actual energy production, extracted from the Data Exchange Infrastructures
- Setting up transfer agreements to [continuously] transfer issued GCs to trading partners
- Cancelling of GCs to prove the origin of consumed electricity
- Generating environmental declaration based on retired GCs, including detailed emission data and source technologies
- Onboarding users to access their actual measurement data (production & consumption)
- Using a blockchain as ledger for public verifying data

At the core of the GC Issuer platform is the blockchain. It is intended to be the single source of truth where end-consumers, third-parties, etc. can verify GCs.

The GC Issuer do not seek to replace or act as an alternative to existing GO systems; rather, they offer an extension of such systems to support hourly matching of supply and demand.

7.4.3. Key partners

GO Issuing Body – The GO issuing body manage and operate the guarantees of origin scheme. FlexiDAO will integrate with the GO Issuing Body in order to relate issued Guarantees of origin with Granular certificates, ensuring no Double Counting between GC/GO and ensuring same energy quantity covered by GCs and GOs issued per production unit.

The Association of Issuing Bodies (AIB) – AIB is an international partnership of energy certification system administrators, of which GO issuing bodies are member. AIB members issue GOs (that can be traded internationally). AIB seeks to standardise certification systems to facilitate international trade. To that end, it has developed a common standard: the EECS® Rules.

Measurement Body – Measurement Body is responsible for installing and maintaining meters, collecting electricity production and consumption data electricity from the meters and submitting this information FlexiDAO with express authorization of producers and consumers.

Producers – Producers generate electricity or heat and supply it to a grid or consume it on-site. FlexiDAO certifies the energy generated in order to make the origin of the energy transparent and traceable. FlexiDAO issues GCs for sustainable electricity.

Consumers – You can't tell just by looking at it whether the electricity coming from a wall socket is from a renewable source or not. FlexiDAO's GCs provide consumers with reliable and transparent information on where their energy is from and how it was generated, hour by hour, thereby enabling them to make an informed decision on the energy they buy.

Suppliers – Energy suppliers are companies that purchase energy (including grey and green electricity) and sell it to commercial and private users. As such, it is the energy supplier who has the supply contract with the customer. Every energy supplier in Europe that wishes to supply green electricity will need to have a certificate account with FlexiDAO.

Traders – Traders enter into agreements with producers for the purchase of GCs. A producer informs FlexiDAO of the trader it does business with. CertiQ credits the corresponding certificates to the account of this trader. A trader can trade the certificates or use them as proof of supply to end-consumers.

REC International - RECS International represents market players, from generators, traders, wholesalers, suppliers and consumers, in a constant dialogue with national legislative bodies and European policymakers to further develop a standardised pan-European electricity tracking system. RECS International has worked since 2001 to improve and simplify the system of tracked electricity, the certificates used in that system and the claims consumers can make after their certificate purchases.

7.4.4. Value Creation Ecosystem

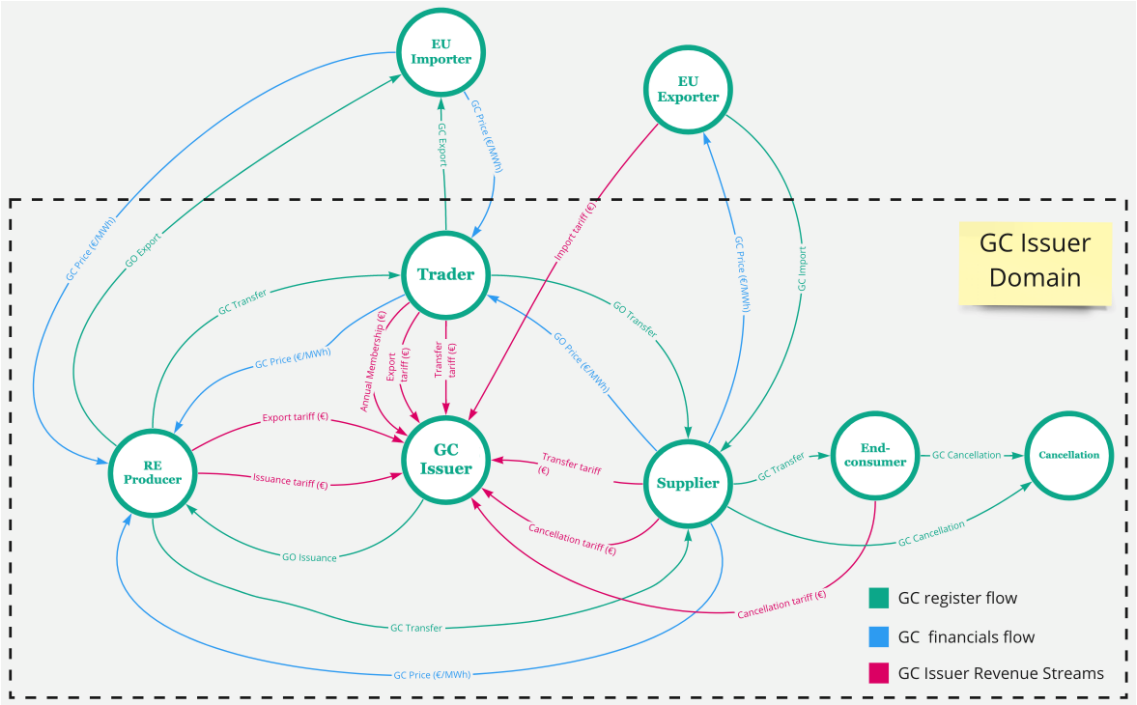

Figure 19. Granular Certificates Value Creation Ecosystem. Own elaboration

The objective of the Value Creation Ecosystem is to understand all the stakeholders (including the value chain that directly impact the business) that influence the creation of value to the end customer (and other possible beneficiaries of the system), which final aim is to match consumption and generation with an hourly granularity.

All stakeholders involved in the GC Issuer Business are represented in Figure 19, being represented for each one of them their value contribution, revenues, as well as their costs. For instance, in the case of FlexiDAO, as being the GC Issuer, will issue, transfer, import, export and cancel granular certificates, and in exchange, all stakeholders involved will pay a tariff per transaction, as they will be explained in a section below.

7.4.5. Main Competitors

In Table 10 main competitors are analysed, showing their value proposition, location of their business, the most important customers they have, the technology they are using to trace electricity and the main investors and funding.

Table 10. Main Competitors Analysis. Own elaboration

Variable	Clear Trace	Elblox	TEO
Value proposition	Cleartrace is Climate Accounting as a Service that connects smart metering devices to trace 24/7 the energy.	Complete value proposition for enterprises: Communities, sustainability reporting, PPA, on-site production	Blockchain application to trace origin of renewables in real-time. Focused on Energy Retailers
Geography	US	EU	EU
Flagship Customers	Accenture, JP Morgan & Salesforce	General Electric Switzerland	Engie / Air Products
Technology	Blockchain	Blockchain	Blockchain
Investors / Funding	Clean Energy Ventures, Brookflied Renewable partners / 4M$. Series A	Axpo / 6M€. Series B	Engie, funding unknown

Indirect competition:

- Regulated entities such as Issuing Bodies and their software providers (e.g., Grexel) can be seen as indirect competitors since they might decide to start offering 24/7 certification and disclose services, especially as the regulatory environment evolves. At the same time, they could all be potential exit strategies.
- Established sustainability advisors (Schneider, Accenture, Deloitte, etc.) are starting to include 24/7 in their radar and might start offering consulting services.

7.4.6. Revenue streams

The monetization model will be based on two main revenue streams:

- Memberships of Traders and Account-holders – A fixed yearly membership fee will be charged to all traders and account-holders of the system. The membership will amount for 5,000 €/year, according to the membership fees AIB Issuing Bodies are charging today [41]. Account-holders and Traders are users of the Scheme that have in their accounts Production Devices and/or granular certificates.
- Transaction fee – The GC Issuer will charge a transaction fee to all stakeholders involved. The transaction fee will be defined per MWh of related granular certificate electricity, as it is in the Guarantees of origin scheme. A monthly invoice will be charged per stakeholder according to the different transactions done in the system. All transactions types - issue, transfer, import, export and cancellation - will have the same price, defined as 0.01 €/MWh, following transaction fees that AIB Issuing Bodies are charging today [41].

7.4.7. Cost structure

Following costs are identified as GC Issuer's main costs:

- Costs for process automation systems: This item concerns payments for the use of automation and communication systems for the purpose of registrations and settlements. These systems are provided by the metering administrator.
- Hired personnel: The hired personnel will be internal and will be integrated by:
    - Management team: CEO, CTO and COO.
    - Employees: 1 Product Manager, 1 Sales Director, 5 Software developers
    - The main accountancy and legal services will be subcontracted.
- General administrative expenses: The general administrative expenses include all costs of accommodation, consultancy and office requisites and travel and subsistence expenses.

In order to understand the cost per MWh of operating an Issuing Body, an analysis of CertiQ annual reports was done, from 2006 to 2020 [42]. CertiQ annual reports provide a good picture of developments in recent years, including all technologies involved in the business. They also include balance sheet and profit and loss reports, which with the total transactions per year were used to determine the cost per MWh of each operating cost.

Table 11. Operating costs per MWh transactioned [42]

Costs for process automation systems	*€/MWh*	0.003
Hired personnel	*€/MWh*	0.005
General administrative expenses	*€/MWh*	0.003

7.4.8. Annual Cashflow 2022-2026

An annual cashflow was developed (see Table 12), taking into account the three markets that FlexiDAO will target in the first 5 years of the GC Issuer operation, that are Spain, Netherlands and Denmark, as they are countries with the GO scheme well established, with the systems operating efficiently and representing 14% of the GO market in 2020, according to AIB statistics [40].

The annual cash flow contains main revenues streams and operating costs, defined above. The system will operate for Spain the first two years (2022-2023), the following two years (2024-2025) will operate in Spain and Netherlands, and the last year will operate in Spain, Netherlands and Denmark. In Spain, the GC Issuer will be integrated with CNCM, the Spanish Issuing Body, in Netherlands will be integrated with CertiQ, the Dutch Issuing Body and in Denmark will be integrated with Energinet, the Danish Issuing Body.

Table 12. Annual cashflow (2022-2026)

Country				2022	2023	2024	2025	2026
Spain		Memberships	M€	1.40	1.51	1.59	1.67	1.75
		GC Transactions	M€	1.52	1.64	1.77	1.86	1.95
	Total revenues		**M€**	**2.92**	**3.15**	**3.35**	**3.52**	**3.70**
		Process automation systems	M€	-0.43	-0.46	-0.50	-0.52	-0.55
		Hired personnel	M€	-0.70	-0.75	-0.81	-0.85	-0.90
		Administrative expenses	M€	-0.48	-0.52	-0.56	-0.59	-0.61
	Total operating costs		**M€**	**-1.60**	**-1.73**	**-1.87**	**-1.96**	**-2.06**
	Operating result		**M€**	**1.31**	**1.42**	**1.49**	**1.56**	**1.64**
Netherlands		Memberships	M€			1.46	1.53	1.61
		GC Transactions	M€			4.36	4.58	4.80
	Total revenues		**M€**			**5.82**	**6.11**	**6.42**
		Process automation systems	M€			-1.22	-1.29	-1.35
		Hired personnel	M€			-2.00	-2.10	-2.21
		Administrative expenses	M€			-1.37	-1.44	-1.52
	Total operating costs		**M€**			**-4.60**	**-4.83**	**-5.07**
	Operating result		**M€**			**1.22**	**1.28**	**1.34**
Denmark		Memberships	M€					0.32
		GC Transactions	M€					0.98
	Total revenues		**M€**					**1.30**
		Process automation systems	M€					-0.28
		Hired personnel	M€					-0.45
		Administrative expenses	M€					-0.31
	Total operating costs		**M€**					**-1.04**
	Operating result		**M€**					**0.26**
Total	**Total revenues**		**M€**	**2.92**	**3.15**	**9.17**	**9.63**	**11.41**

Total operating costs	M€	-1.60	-1.73	-6.47	-6.79	-8.17
Operating result	M€	1.31	1.42	2.71	2.84	3.24

7.4.9. Potential use of the GC Issuer Platform

The GC Registry of the GC Issuer could serve for end-consumers to generate an environment declaration with detailed emission data and source technologies based on the account's actual consumption and GCs.

GC Registry could serve for:

- Keeps track of user's stored, retired, and transferred GCs
- Transfer GCs to other users
- Cancel GCs to any of the user's metering points
- Access information and statistics about user's account
- Submit transfers and retires to the blockchain ledger, and keep its database synchronized blockchain ledger

GC Registry interface will allow users to set up GCs transfer agreements with other users, set up retiring of GCs to their metering points, while also providing a visual overview of the user's current account balance of GCs. Furthermore, the user will can easily generate and download an environment declaration in PDF format based on up-to-date/live data.

Transfer agreements will be proposed by one user, then later accepted or declined by the counterpart user. They last for a specific period of time, and during this period up to an agreed-upon number of GCs are transferred between the users. The receiving user is able to retire the inbound GCs to their metering points, or transfer them further to other users, thus acting as a middle-man.

7.4.10. Main challenges, risks and opportunities

Regulatory risks – Any solutions for 24/7 certification should ideally be harmonised across European and other electricity markets, and be in line with laws and regulations. Not well-defined regulations imply a risk in the 24/7 approach.

Technical risks – The number of transactions with GCs will increase as the unit will be the electricity produced in one hour, and the GOs have a fixed unit of 1 MWh. Due to the fact that the number of transactions will increase, there is a technical risk of managing large number of certificates compared with the current GO system. The adoption of 24/7 matching poses a challenge to volumetric units by counting temporal units of less than an hour. A unit of energy generated by a given production site in an hour or less will contain a different kWh or MWh quantity of energy depending on the size and productivity of the production device at that specific moment. This difference could add to the challenge of 24/7 matching as those seeking to match their renewable energy consumption in every hour will have to find the specific GOs that cover their consumption for each hour of each day.

Market risks – Since the GC scheme will be voluntary, there is a risk that end-consumers and businesses will abstain from buying and trading GCs if they do not trust the price formation. 24/7 Market is at its infancy, and it is not yet proved.

Double-counting of GOs and GCs – Processes of integration between both systems needs to be implemented in order to prevent the double-counting of both types of certificates. GOs that were cancelled in form of GOs, cannot be cancelled again in form of GCs, and vice versa. Double-counting happens when the same electricity attributes are allocated to two different end-consumers.

Regulatory opportunity – EU will define strict requirements for carbon-free electrification. This will inevitably require temporal and geographical correlation of RE production and consumption.

Corporate opportunities –100% RE is not the end goal, RE consumption must be proven every time of the day due to volatility.

8. Conclusions

This thesis presented the 24/7 approach that is arising the market, and it could serve for corporations, electricity market actors, and policy makers to plan the needs that this approach need, fundamentally access to metering data and standardisation of current GO systems across Europe.

First, in order to identify the current limitations of the emission reporting, preliminary research was conducted on the ways that corporates buy renewable energy and report its usage. After that preliminary research, the 24/7 approach was presented, describing its main benefits and needs. The thesis focused on the two main needs that the 24/7 approach have, the metering production and consumption data access and the changes needed in the current GO scheme.

This Master's Thesis is innovative in that it relates metering data access with certifications systems, with an in deep research of several EU countries. In addition, a link between the existing GO system and the coming granular certification system is presented. Such study facilitates the understanding of the status of metering data exchange infrastructures, and its barriers that needs to be tackle in order to reach a 24/7 approach.

More generally, the thesis has also contributed to gathering a lot of valuable and up-to-date information about the metering data exchange infrastructures and GO systems in an accessible way for a large public.

A fundamental need is for regulated and non-discriminatory access to metering data through transparent, secure and digital consent mechanisms. These systems should be harmonised, and ultimately standardised, across Europe to allow market participants to share their metering data

with any secure and trusted service provider they wish. All metering data would need to have at least hourly granularity to support hourly matching of electricity production and consumption, be available as soon as possible after physical energy flow (a maximum of one day after physical energy flow) and without geographical limitations within Europe. Hourly matching will be a journey from the current annual matching periods used in most European countries, but hourly metering data must be available and accessible now to support this transition.

Currently, only 3 countries out of the 18 analysed meet all the criteria required to allow consumers and their partners easy and cost-efficient access to relevant, granular metering data. 8 of these countries present some kind of barrier, 7 do not have a system in place, although data is available in some way, and 1 has no smart rollout plan in place at all.

The integration of the actual GO schemes with other systems presents several barriers in the analysed countries. All analysed countries do not have a technical interface to exchange data, such as an API. Also, except for Spain, corporate consumers can not access to cancelled guarantees of origin without the necessity of asking that information to their suppliers. There is no integration between metering data exchange infrastructures and GO schemes.

An integration of GO schemes and metering data exchange infrastructures can provide the data required to time-stamp GOs and respective GCs, in a cost-efficient way. Getting metering production and consumption data directly from the certifying authorities of the countries in charge of the data exchange infrastructures is the perfect case for the 24/7 approach.

The business case shows a big opportunity for new innovative service providers, that will contribute to the evolution of the 24/7 renewable energy market, helping corporates with an easy-to-use tool to match at every hour at every day their consumption and production, and understand their environmental impact. A granular certificate issuen can expect 1.3 M of revenues with only 1 country in their scope, and it can expect 3.4 M with 3 countries in their scope, such as the demonstrated case.

With the actions of main corporations towards 24/7 renewable energy, it is expected that hourly matching between power generation and consumption would become the norm. Future collaboration between technology, government, and the market will undoubtedly be necessary to detail the relevant rules and offer feasible paths for implementation in order for 24/7 matching to be widely adopted. EnergyTag, a non-profit company, is developing frameworks and markets for GCs (i.e., hourly GOs), which enable consumers to purchase and match their consumption with renewable sources with a more time-granular basis.

9. Future research and next steps

The conclusions of this report are only high-level, and there is still significant work to do. The definition of a new granular certification scheme will make more reflective the physical availability of clean energy. Public perceptions of clean energy claims may improve and it could support new carbon accounting methodologies.

Future research using the coming granular hourly certificates in new carbon accounting methodologies is needed. A comparison between the real impact, both economical and environmental, of existing and new proposed carbon accounting methodologies is needed in order to serve as scientific demonstrations to help change in carbon accounting regulations.

As shown in this study, current carbon accounting methodologies do not show the real impact in GHG emissions. The real impact of new carbon accounting methodologies using the proposed granular certification scheme need to be reasearched with real use cases, in countries in where the renewable penetration is significant.

In countries with relatively high renewable penetration, the difference between yearly and hourly accounting is non-negiligible and will become increasingly significant as more renewable generation is added into the system and the carbon intentisty varitations during the year and the hour of the day become more important.

Among the many topics that need to be addressed as next steps, the following ones are identified as a priority.

- The market effect – The market effect of 24/7 certification at scale is not yet known, and will depend on the varied individual preferences and load shapes of the number of companies that will pursued this strategy. It is needed future research in how this 24/7 certification scheme will affect prices and whether those pricing changes will be enough to affect new renewable energy projects and new development of storage systems to support the need of renewable energy in periods where renewable is not available

In conclusion, in addition to the new carbon accounting methologies impact reasearch, an indepth market modelization of the granular certification scheme is needed. This reseach could answer the following questions which are not yet answered:

- What is the amount of demand for renewable energy in low carbon-free energy hours that would be needed locally in a region to create a high local market price for renewable energy in that hour? And then who can react to that price to create new generation in that hour?
- When and at what level will hourly procurement send sufficient demand or price signals for different technologies in a region?

The market and decarbonization effect of 24/7 certification is not yet known, we need more analysis of the market effective of 24/7 certification in different regions and its real impact on decarbonization. The 24/7 certification impact in demand response is not yet known it need to be analysed as next step for this coming granular certification scheme.

Another importan topic to be analysed and reasearched is the unit of energy of the coming granular certificates. There is a clear benefit to having a standard volumetric unit of energy, set in Europe and all major EAC schemes at 1 MWh. The volumetric unit of GOs allows them to be easily traded in bundles hundred GOs or more, reducing transaction and handling costs. The adoption of 24/7 matching poses a challenge to volumetric units by counting temporal units of less than one hour. A unit of energy generated by a given production site in an hour or less will contain a different generation quantity of energy depending on the size and productivity of the production device at that specific moment. This difference could add to the challenge of 24/7 matching as those seeking to match their renewable energy consumption in every hour will have to find the specific GCs that cover their consumption for each hour of each day. This contrasts starkly with annual or even monthly matching where a consumer simply has to calculate their MWh of consumption over the relevant period and buy the same number of GOs - one for one. This is a fundamental issue which needs a lot more analysis and discussion.

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