

Energy Track & TRACE | 2025-04-11

Granular Certification Scheme Protocol

Proposed method for compliance with EnergyTag standards



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1. Introduction

Energy Track & Trace (ETT Europe) is a project developed by Energinet, Elia Group, and Elering. It aims to show that a detailed energy certification system can improve traceability, transparency, and trust. This system will offer more energy product choices and speed up the green transition.

ETT Europe believes that detailed certification will become the standard for documenting energy, helping to accelerate the energy transition. Currently, large companies are changing their energy buying strategies to better match their energy use with the actual time of production.

To benefit customers in the short and mid-term, ETT Europe is designed as a voluntary certification that works within the European GO scheme (art 19a REDIII).

Energy Track & Trace Denmark is a system used in Denmark to issue and manage Granular Certificates. It is based on an agreement between ETT Europe partners on how to implement such systems.

2. Identification

2.1 Identification of the GC Issuer

ENERGINET DATAHUB

Tonne Kjærsvvej 65
DK - 7000 Fredericia, Denmark

Contact: Michael Gimm Holdensen
(MIL@energinet.dk)

GC Issuer and GC Registry Operator in the
domain of Denmark (bidding zones DK1 and
DK2)

2.2 This document

This document aims to describe the Granular Certificate (GC) Scheme protocol of the Issuer:

- Energinet in Denmark

It enables assessment of compliance with the **EnergyTag Granular Certificate Scheme Standard V2**.

2.3 Transparency on open items & improvement areas

The Energy Track & Trace Granular Certification Scheme is under continuous development. We therefore find it important to be transparent about the items and topics which are currently not fully defined, or which require improvement in our view.

This document will list the open topics, grouped in each section.

2.4 Relevant reference documents

This document often refers to or quotes following reference documents:

- [1] Architectural concepts & insights:
<https://energytrackandtrace.com/wp-content/uploads/2023/11/2022-05-Paper-Architectural-concepts-and-insights.pdf>
- [2] EnergyTag Standard for GC Schemes:
<https://energytag.org/wp-content/uploads/2023/09/Granular-Certificate-Scheme-Standard-V2.pdf>
- [3] Energy Track & Trace: Locational Matching of Granular Certificates:
<https://energytrackandtrace.com/wp-content/uploads/2023/11/2022-09-Paper-Locational-Matching-of-Granular-Certificates.pdf> (energytrackandtrace.com)

2.5 Terms and conditions to use the Energy Track and Trace system

To use the Energy Track and Trace System users must agree to the current terms and conditions which can be found under the following link: <https://energytrackandtrace.dk/en/terms>

3. Definitions

3.1 The concept of granular certificates

Granular certificates are a new standard for tracking renewable energy with a high level of detail and transparency. These certificates are designed to track the characteristics of energy produced during a period of one hour or less. This approach helps in minimizing the risk of double counting and ensures that consumers can demonstrate compliance with regulations or meet their own voluntary goals.

The **Energy Track & Trace** system involves the use of advanced digital technology to transfer energy production as granular certificates from one wallet to another and match them against energy consumption records. This provides a more precise and transparent way to track renewable energy, ensuring that the energy consumed is truly green and helping to accelerate the transition to 24/7 clean power.

In essence, granular certificates offer a detailed energy certification system that provides clear tracking, openness, and trust, helping businesses show their efforts towards reducing emissions and supporting the development of a market for hourly energy certificates while giving incentive to be more flexible in markets with a high penetration of renewable energy.

3.2 Commonly used terms throughout the document

TERM	MEANING
Account	A record in an ETT Registration Database for a specific legal entity. It includes: • ETT Certificates issued to that entity by the Member managing the database. • ETT Certificates transferred to that entity by another entity (with notice to the Member managing the database).

TERM	MEANING
	These certificates have not been: • Transferred to another Account in this or another ETT Registration Database. • Cancelled. • Expired. • Withdrawn.
Account Holder	An entity that has an Account in an ETT Registration Database.
Domain	An area with Production Devices where a Member is authorized to issue ETT Products.
ETT Certificates	Either ETT Production Certificates or ETT consumption records ¹
Certificate Slices	When a certificate is issued, it comes with a single slice representing the full-face value. During its lifecycle, this quantity can be split into multiple parts that can change ownership through transactions. These parts are called slices.
ETT Registration Database	A database managed by a Member or a Registry Operator on behalf of a Member for ETT purposes. It includes: • Accounts and the ETT Certificates in those Accounts. • Details of Production Devices and related information provided during their registration with the Member or Registry Operator.
ETT Scheme Participant	A Registrant or Account Holder.
Member	A member of the Energy Track & Trace initiative in accordance with the ETT governing board.
Registrant	A legal entity that has a Production Device or Consumption Device registered in an ETT Registration Database for issuing ETT Products.
Production metering points	Metering points that are registered as production in the Danish electricity DataHub. Based on the data from these metering points only production certificates can be issued.
Consumption metering points	Metering points that are registered as consumption in the Danish electricity DataHub. Based on the data from these metering points only consumption records can be issued.
Production assets (windfarms, solar parks, etc.)	Production Assets • Include multiple production units and can also consume energy (e.g., for auxiliary services). • A consumption metering point is always installed to measure this consumption for settlement purposes.

¹ Consumption records are in regards of their cryptographical characteristics treated equally to Granular Certificates within the ETT system. Matching a Granular Certificate with a consumption record within ETT thus leads to a unique, verifiable and tamperproof claim of that a Granular Certificate has been cancelled towards the claimed consumption record.

TERM	MEANING
	If a registrant wishes to create consumption records to cover their auxiliary consumption, this will be possible via the consumption metering point.
Assets	- Energy production units within the geographical area of Energy Track and Trace Denmark (DK1/DK2). - All energy production units in this area can be issued granular certificates based on metering data from the Danish electricity Data-Hub operated by Energinet. - Initially, issuance will be limited to solar and wind production.
Registry	A system administered by the GC Issuer, recording the characteristics of the Production Devices and Consumption metering points for which that GC Issuer is responsible, and the Accounts and the Certificates held in such Accounts.
Wallet	- A personal "bank account" for holding all the granular certificates (GC slices) you own. - Allows you to collect and store ownership of GC slices in one place, even across different registries. - Each GC slice stays in its original registry, but the wallet lets you view and control your assets from a chosen location.
Transfer Agreement	- A contract between producer and consumer. - Digitally signed within the platform. - Ensures the transfer of granular certificates from producers to buyers (traders/consumers).
Contract	- To participate in Energinet's Granular Certificate scheme, users must sign a contract with Energinet. - This contract allows Energinet to obtain the necessary data and metering point information for the system. - Users must also accept the terms and conditions. When a metering point (production or consumption) is activated in ETT: - The ETT system creates a contract with DataHub. - This ensures metering point data is displayed in ETT, and granular certificates are issued.
Issuance	- Users with production and/or consumption facilities can activate the issuance of granular certificates based on their metering data. - Once activated, the system automatically issues granular certificates with the required data. - These certificates are then stored in the account holder's wallet.

3.3 Types of certificates being issued

- **Granular Certificates (GCs):** Introduced by Energy Track & Trace, these certificates shift energy certification from volume-based to time-based, matching the spot market settlement time-basis.
- **Production Certificates:** GCs are issued for each timespan, accounting for the Wh produced in that specific timespan.
- **Consumption Records:** Issued to ensure full traceability and enable matching between production and consumption across registries.
- **Digital Claims:** Consumption- and production certificates are matched within the same timespan by the Wh, creating a digital claim for accounting purposes.

The ETT software platform handles:

- Access to metering data.
- Issuance of granular certificates for production and consumption.

Project Origin software ensures tamper-evident transactions between producers and consumers.

3.4 Energy carriers for which certificates are being issued

Focus of this version on the ETT Scheme Protocol: Energy Track & Trace issuing bodies are focusing on granular certification for electricity (wind and solar in the starting phase).

Future Potential: The ETT system is designed to be energy carrier-agnostic, meaning it can easily be expanded to other energy carriers in the future, such as hydrogen and natural gas.

Illustration from our architecture note [1]:

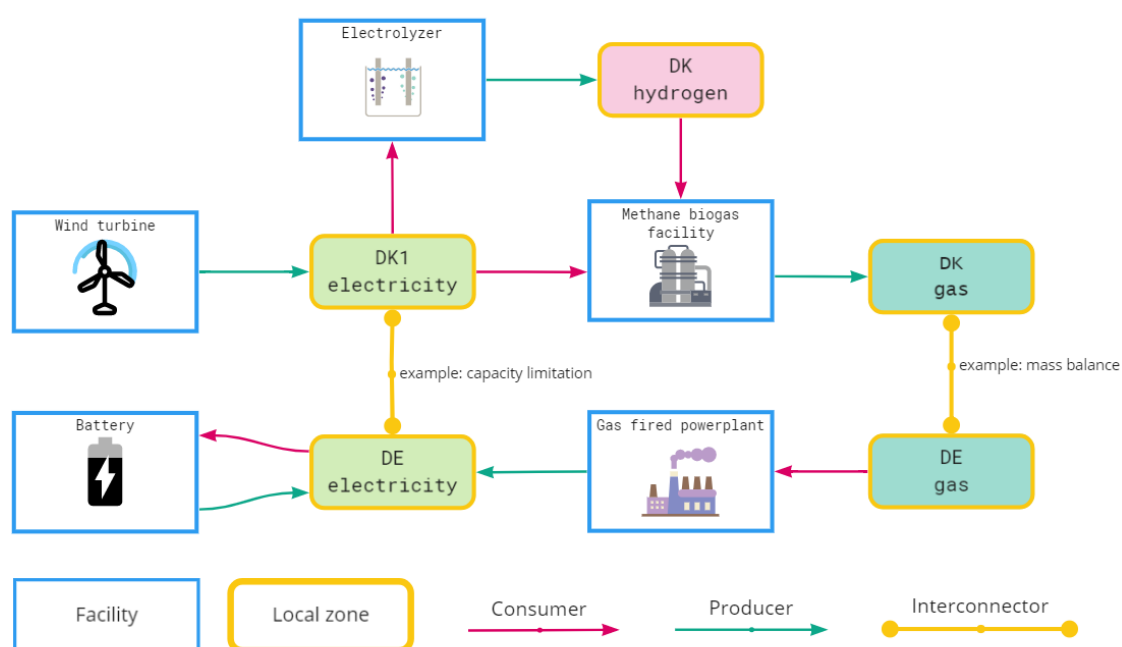


Figure 1 - Interconnected local zones (yellow square line), connects producer / prosumers across energy carriers (colored squares – green electricity, blue gas and red hydrogen). Each carrier has their own infrastructure and that is reflected in the ETT network.

3.5 Categorization of technologies of energy production

Energy Track & Trace is aligned with the EECS rules in terms of allowed technologies. We accept the same production device technologies and energy sources as EECS.

We refer to the **EECS Rules Fact Sheet 5: “Types of energy inputs and technologies”** as published on the AIB website.

4. Legal/regulatory framework

In fall 2023 the European Commission agreed on a revision for the renewable energy directive (RED III). Article 19 is in the new version amended as follows:

“A guarantee of origin shall be of the standard size of 1 MWh. Where appropriate, such standard size may be divided to a fraction size, provided that the fraction is a multiple of 1 Wh. No more than one guarantee of origin shall be issued in respect of each unit of energy produced.”²

At the time drafting this GC Scheme Protocol this amended version of the renewable energy directive is not implemented in Danish law. Thus, GO and Disclosure legislation in Denmark was not yet synchronized to the availability of GCs at the time of drafting this GC scheme protocol, yet such is expected.. This is especially to be aware of when using granular certificates for disclosure purposes or other accounting measures.

However, Article 5 of the renewable energy directive states:

“Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 21 May 2025.”²

As soon as this directive will be implemented, granular certificates issued from Energy Track & Trace will part of the Danish GO scheme and can thus be used for disclosure as well.

4.1 Interaction with legal framework for energy certificates

Preventing Double Counting: To prevent double counting, only one type of certificate will be issued. For example, no monthly GOs will be issued for metering point data used for GC issuance.

- This will be managed manually.
- In the future this process will be automated once it has been tested and deemed sufficient.

Data Source: ETT Denmark will use the same data received from the Danish DataHub and the national asset metadata registry for issuing granular certificates as the GO scheme.

² Directive - EU - 2023/2413 - EN - Renewable Energy Directive - EUR-Lex

4.2 Purpose of the certification system

The core aspect of system is to enable consumers to trace the origin of their energy through its entire supply chain, including transportation and storage, with high temporal resolution.

The aim of the ETT GC Scheme is to:

Enhanced Traceability, Transparency, and Trust: ETT defines a granular energy certification system to improve these aspects.

Consumer Choice: ETT aims to offer a wider variety of energy products for consumers.

Accelerating the Green Transition: ETT helps speed up the shift to greener energy sources.

4.3 Market set-up and level of market liberalization

ETT provides an open API solution that allows market participants to create their own tools using ETT software. ETT does not aim to be an active market player or directly develop the market. Instead, ETT aims to enable the market to use and trade Granular Certificates (GCs).

ETT will support the market by issuing, managing, matching, and canceling these certificates. Financial transactions and advanced services will be handled on other platforms. Market participants can gain third-party access through a power of attorney to offer these services.

ETT's trustworthiness is ensured in several ways:

- ETT is a collaboration of European Transmission System Operators (TSOs) and European Issuing Bodies.
- The technologies used in Project Origin ensure that the registry is tamper-evident, auditable, and that each entry is unique and verifiable using proof of inclusion.
- Production certificate issuance is based on the same production metering data from the national DataHub as the current GOs.
- For consumption records verified consumption metering data from the national DataHub is used.
- Energinet is issuance body on both types of certificates and coordinates issuance of only one type of certificate.

For more details, visit Project Origin Registry: <https://github.com/project-origin/registry>.

5. GC Scheme Configuration

ETT is a granular certification system created by a collaboration of European Guarantees of Origin (GO) Issuing Bodies (IBs) and Transmission System Operators (TSOs). It is a voluntary system aimed at corporate energy buyers and suppliers who want to increase transparency about their energy use and show their decarbonization efforts.

The system uses advanced digital technology to ensure trust and transparency.

Key points about ETT:

- **Positive Impact:** ETT and 24/7 Carbon Free Energy procurement positively impact the energy system.
- **Better Information:** Energy suppliers can provide better information to customers.
- **Decarbonization:** Corporate buyers can use ETT to decarbonize and improve their Environmental, Social, and Corporate Governance (ESG) reporting.

While ETT could operate independently from the established GO system, this could lead to double claims and reduced trust. Therefore, an effective interface between the GO system and ETT is necessary. To ensure trustworthy claims, ETT must comply with existing legal frameworks and coordinate effectively with current EACS issuing bodies, as required by the EnergyTag industry standard for GCs.

5.1 EnergyTag configurations for effective coordination

ETT uses Granular Certificates (GCs) that align with EnergyTag standards, featuring time intervals of one hour or less. These certificates can be used for both temporal and locational matching.

To prevent double counting, EnergyTag requires effective coordination between existing Energy Attribute Certificate (EAC) schemes (like the European GO scheme) and new GC schemes. There are two suggested configurations:

1. **Configuration #1:** The new GC Scheme evolves from the EAC Scheme.
2. **Configuration #2:** The new GC Scheme supplements the EAC Scheme.

In the European Union, Configuration #1 is supported by the revised version of the Renewable Energy Directive (REDIII), which must be implemented in Danish national law. This allows member states to issue more granular, time-based GOs instead of the conventional volume-based GOs (1 MWh). This approach helps avoid double counting and maintains market consistency. ETT Denmark will focus on Configuration #1.

5.2 Underlying EECS System

The ETT granular certification system in Denmark will be based on a **scheme that evolves from an existing underlying EAC³ Scheme** (Configuration #1 as described in the EnergyTag Standard Version 2).



The underlying EAC schemes are compliant with the Principles and Rules of Operation of the European Energy Certificate System (the **EECS® Rules**) and cover the Issuance of following EECS Product in their respective domains: ***Guarantees of Origin for Electricity from Renewable Resources (RES-E GOs)***.

EAC: ³ Energy Attribute Certificate

The table below describes the underlying EEC System that is complemented by Energy Track & trace Denmark:

COUNTRY	DENMARK
EAC Issuing Body	Energinet
EAC Competent Authority (operator)	Energinet
EECS Domain Protocol (hyperlinks to public documents)	<u>Denmark</u> (covering the 2 current and additional future bidding zone areas within Denmark) ⁴
EECS Approved Measurement Bodies	Distribution System Operators (DSO) in Denmark
Last audit	2024

5.3 Effective coordination: GC Scheme interaction with EAC System

The EnergyTag standard outlines the high-level business processes needed for “effective coordination” but allows GC providers like ETT to develop their own methods. Here is our proposed method for effective coordination.

Challenges:

- **Different Operating Principles:**
 - **ETT Granular Certificates Scheme:** Time-based, matching production and consumption hourly within 12 months (unclaimed certificates expire after 12 months).
 - **Traditional Monthly GO Scheme:** Volume-based, with 1 MWh quantities that can be canceled within 12 months, regardless of the exact production time.

Due to these differences, the registry of the traditional monthly GO scheme cannot accurately represent transfers made with ETT. To coordinate the two schemes effectively, ETT Denmark has developed a simple method:

1. **Choice of Certificates:** The owner of a production device can choose to apply for issuance of either GCs or GOs (if prerequisites are met).
2. **Data Marking and Storage:** When certificates are issued, the data will be marked and stored in the underlying Database (DataHub in Denmark). This ensures data is used for only one of both types of certificates, preventing double issuance and claims.

This method requires changes to existing software and internal procedures, which will take time to implement. Until then, the process will be handled manually.

⁴ Energy Islands will be implemented as new bidding zones in Denmark.

The detailed process and requirements for “effective coordination” are described in the following sections. A visual overview is provided in the figure below.

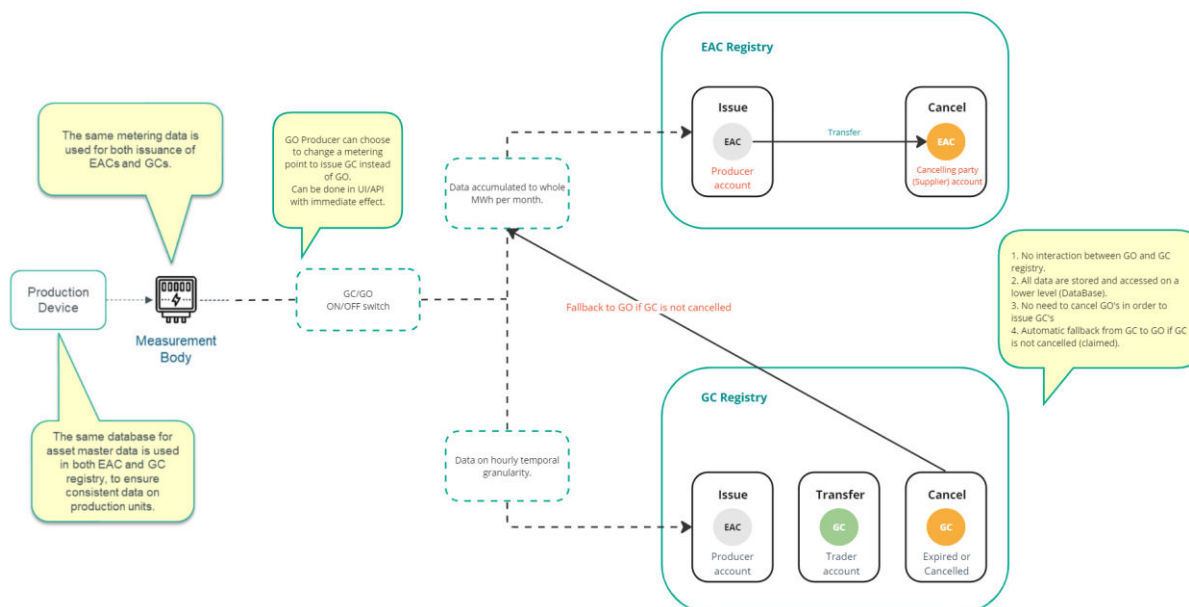


Figure 2 - Mechanism for integration & co-existence with EAC Registry (Guarantees of Origin)

5.3.1 Requirements for the Issuance of GCs

As Figure 2 depicts the following processes are initiated when the issuance of Gc's is requested by a producer:

Tagging Metering Data:

- Metering data in the underlying database (DataHub) will be tagged to ensure it is sent for issuance to either the GC or GO system, depending on the certificate system connected to the production unit. This ensures certificates are only issued in one system, achieving effective coordination.

Independent Issuance:

- GCs are issued via the ETT registry, and GOs are issued via the official GO registry. Both use the same source of metering data (time-series) from the Danish DataHub at Energinet, to ensure consistency.

Temporary Manual Coordination:

- No MWh GOs will be issued for the same production metering data for which GCs are issued. This will be a manual process during the Pilot(s). However, these mechanisms will be automated in the future to prevent double issuance/claims.

Hourly Synchronization:

- The ETT network synchronizes with one-hour intervals. Production units must have metering data with at least hourly granularity to participate in ETT. Units with less granular data (e.g., yearly data) cannot participate.

Single Source of Truth:

- Granular certificates are issued based on data from the Danish national DataHub at Energinet and the master data registry of the Danish Energy Agency. These official databases ensure a single source of truth for certificate issuance.

5.3.2 Requirements for Registrants

To participate in the ETT GC Scheme participants must have production metering points (wind or solar production) and/or consumption metering points within Denmark (DK1 or DK2). Furthermore, Service Providers are allowed as 3rd parties.

5.3.3 Requirements for transactions and cancellations of GCs

GC Issuance and Transfer: As described in Energinet's market rules D1⁵ there will be a certain delay (normally not more than 5 working days until valid measuring data are available in the Danish electricity DataHub. The ETT system is configured to issue when valid market data is available for Denmark. After the issuance certificates also can be transferred.

Claiming Certificates: There are no limitations for matching and claiming certificates if the consumption records match the production certificates within the same time span, leading to a claim in the ETT system.

For now matching and claiming is limited to the geographical area of Denmark. There are no limitations for claiming across the Danish bidding zones. However, this might be changed in a future version of the GC Scheme protocol.

Losses: Energy transport Losses are NOT covered systematically by the GC scheme. Instead, they will be managed by the TSO as part of its CSR reporting.

5.3.4 Coordination between ETT and EECS Registry

To ensure effective coordination between the GC Registry and the EECS Registry, Energinet is in a close internal dialogue to ensure consistency of both registries and prevent double counting. The following measures are already implemented (if not stated differently):

Sharing Asset Master Data:

- Ensure consistent information on production units between registries by sharing the same asset master data.
This is already in place as the DataHub is connected to the national registry for asset data.
- Multifuel combustion units with changing fuel types (e.g., waste incineration) are currently excluded from the GC scheme.
A method to handle changing fuel types will be developed in the future.

⁵ <https://energinet.dk/media/q1dbhp5q/forskrift-d1.pdf>

Using the Same Metering Data Source:

- Use the same metering data (time series) for issuing both GCs and GOs.
- This requires:
 - An agreement with the Data Owner (the Production Unit owner) to allow the Energy Track & Trace issuing body (and GC platform operator) to access:
 1. The metering data (time series) for the production unit.
 2. The identification number of the metering point used to meter the production unit.
 - Agreements will be handled digitally via Energy Track and Trace Denmark's OAuth2.0 system, which also manages the power of attorney for third parties. For LogIn the national LogIn system MitID is used, which also is accepted for digital signatures in Denmark.

Alignment with National and International Statistics:

- The GC registry will provide data for necessary national and international statistics to ensure renewable energy balances are correctly accounted for. The processes for this will need to be developed.

5.3.5 IT connection between GC and EECS Registries

An IT integration between the GC and EECS registries is planned to be implemented in the future. This integration will be established via the underlying database (DataHub) to ensure that no double issuance or claiming occurs (see section 5.3.1).

5.3.6 Retaining Issued, Transferred, Cancelled and Expired GCs on the registry

Due to Danish legislation and the market rules of the Danish DataHub all data will retain on the registry for 7 years, whereafter data will be deleted.

5.3.7 Unclaimed GCs are included in residual mix

GCs contain an attribute informing that they can be used for providing information on the attributes of consumed or supplied energy.

However, at the time writing this protocol GC's are neither part of the Danish legislation for guarantees of origin nor are unclaimed GC's included in the residual mix as internal procedures will have to be changed for this. Energinet is considering how and when GCs in the future may be included in the residual mix procedures under the scope of guarantees of origin.

5.3.8 Resigning from an account

If an account holder is resigning from their account unused certificates that are stored in this account will stay there until they expire.

5.4 Clarification of interaction with other certificate systems

Voluntary System: Energy Track & Trace is a voluntary system with no exclusivity in certificate issuance, cancellation, or allocation to consumption within the domain.

Current Status (2024): Currently, there are no other granular certificate systems in Belgium, Germany, and Denmark that complement RES-E GOs.

6. Governance and Roles

The following chapter will elaborate on the roles and governance within the Danish GC scheme. Energinet is the Danish TSO, issuing body for EACs (being traditional GOs) and develops the scheme for a Danish GC registry as the Danish GC issuer.

6.1 Roles

The Roles in the operation of the ETT Granular Certification scheme follow the definitions as set forward in the EnergyTag standard [3]:

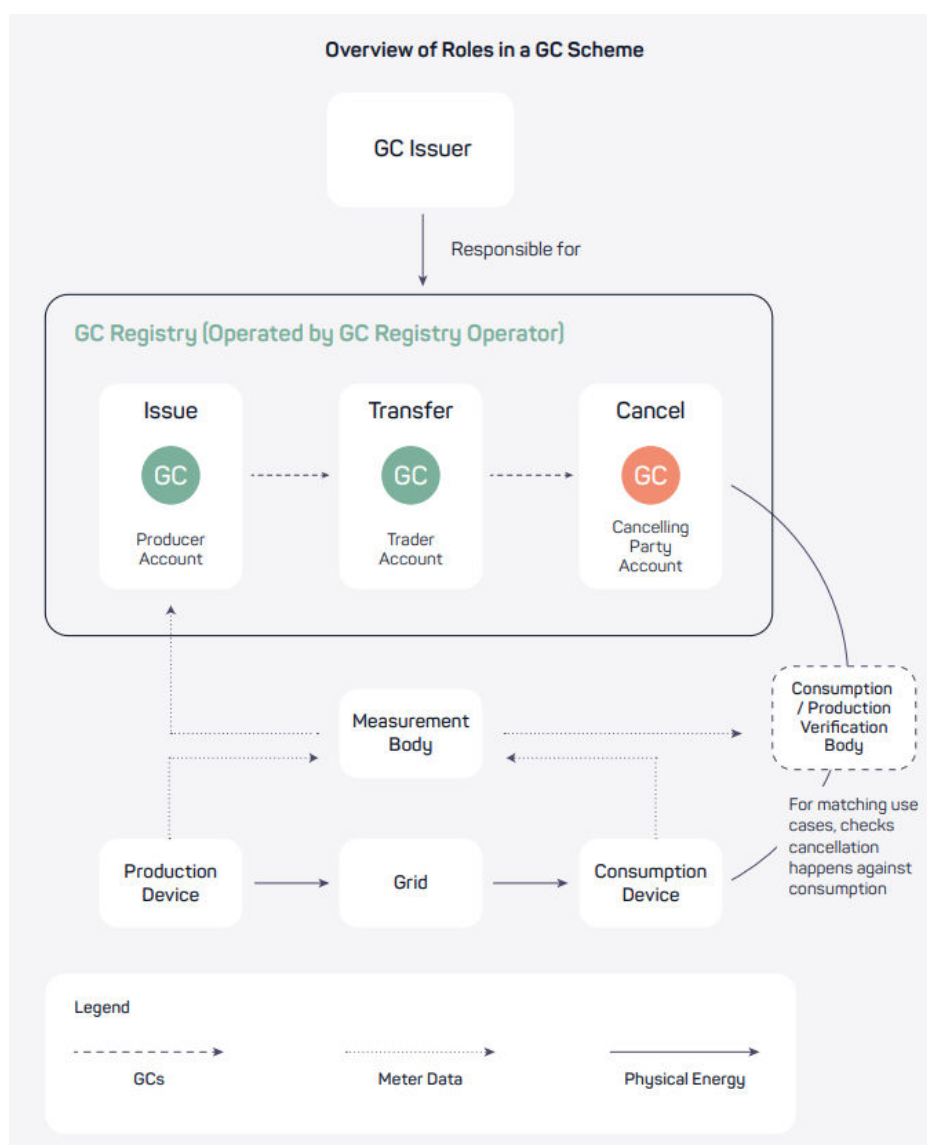


Figure 3 - Overview of roles in a GC Scheme (EnergyTag)

6.1.1 Account Holder

Any legal person who is not a member of Energy Track & Trace, or their affiliate or agent, can become an ETT Scheme Participant.

When logging into the ETT Registration Database for the first time, every Account Holder must register and agree to the standard terms and conditions. Additionally, you must own a national ID called "MitID," which allows you to sign on behalf of the company you represent.

Applicants can include:

- Owners of production devices
- Owners of consumption devices
- Service providers acting on behalf of the owners of production and/or consumption devices

The same application procedure applies to all types of applicants (see below).

6.1.1.1 Registration of an Account Holder

To open an account in the ETT Registration Database, a person or company must register. This registration links the official registry of companies and persons with the account request. The company and the person responsible for managing the account must provide their VAT number and use the Danish national login for companies (MitID) to open the account.

The registration/request for an account must be approved by the GC Issuer. Once approved, the GC Registry Operator will issue each authorized user a client ID and password for secure access to the registry. It is the responsibility of the ETT Scheme Participant to keep this identification confidential.

Access to the account is granted through the Danish national company login (MitID Erhverv), which also is used for legally binding digital signatures in Denmark and internationally.

Once a mandate is given to an individual responsible for the company's account, access can be granted to other individuals/employees of the company as extra users. Their rights and restrictions can be managed through the account. **This feature of extra users is not yet implemented.**

6.1.1.2 Maintenance of standing data

The Account Holder is responsible for notifying the GC Registry Operator, respectively the Production Registrar of any changes to information registered on the Account Holder (e.g. address, name, vat number, etc.) in the registry, and to any documents submitted to GC Registry Operator when applying for the Account.

6.1.1.3 Error handling

For correcting an erroneous certificate, we use a method called "withdraw", to withdraw the certificate. The technical implementation is described as follows:

1. If a certificate has been issued and is not valid due to i.e. wrong metering point or similar, we will withdraw the certificate including slices, entirely from the ecosystem. However, the certificate is still visible but now has the status "Withdrawn" and can no longer be transferred nor used.
2. If a certificate is issued with x amount, but a new measurement changes this to either x plus or x minus, we will withdraw the certificate and issue a new one with the correct amount.
3. If the correction means, that a certificate succeeding its lifetime must be re-issued, it will not be possible to claim.

As EnergyTrackandTrace Denmark is currently in the pilot phase these mechanisms are still to be implemented.

6.1.1.4 Resignation of an Account Holder

The Account Holder must notify the GC Registry Operator in writing at least one week before the intended account closure date.

If the account is free of certificates and upcoming certificate deposits, the GC Registry Operator will update the Registration Database to seal the account as of the effective date specified in the request.

6.1.2 GC Issuer

Independence: Energinet is independent of production, trade, and supply. As the Transmission System Operator in Denmark, Energinet must adhere to unbundling rules, ensuring this independence. Additionally, Energinet acts as an Authorized Issuing Body for EECS Products.

Ownership Restrictions: The GC Issuer shall not own or hold any beneficial entitlement to any ETT Certificate, except in the following cases:

- The certificate is purchased for:
 - Proving the nature of the output consumed.
 - Testing the system.

Notification of Transactions: If the GC Issuer or its affiliates sell or purchase an ETT Certificate for the specified purposes, they must notify the ETT Board by the end of the following month. The notification should include the vendor/purchaser, the number and type of certificates, and the reason for the transaction.

Reporting: In future the ETT Board will prepare and circulate a report to all Members detailing the sales and purchases of ETT Certificates as informed by the GC Issuer.

6.1.3 Production Registrar

Energinet is the production registrar and adds production devices to the production account holders' accounts based on data received from the Danish DataHub and the national asset metadata registry. Furthermore, assets that are registered in the GC registry also must be registered in the national EACs registry. Checks on this will be performed manually in the beginning and be automated in the future.

6.1.4 GC Registry Operator

This GC Scheme protocol covers in this initial phase Denmark only. The GC Issuer is also the GC Registry Operator. The GC Registry Operator is identified in chapter 2.1 of this document.

6.1.5 Measurement Body

6.1.5.1 Production Devices

EAC scheme. The Measurement Bodies are listed in the EECS Domain Protocol (referenced in *section 5.2 “Underlying EECS System”*).

6.1.5.2 Production Devices

- Production units can only register with ETT if they are also registered with the GO scheme in the same Domain for now. If in the future other units (residential PV or other small units) are showing interest in participating in this scheme a specific registration procedure for these units will have to be defined within this scheme.
- Both GCs and GOs for the same production unit must use the same metering data source.
- Measurement Bodies for Production Devices in the ETT GC Scheme are the same as those in the underlying EAC scheme. Registration data are used from the same national asset metadata registry, which ensures consistency between registered assets in the GO system and the GC system. Data from the national asset metadata registry are constantly copied to the national DataHub, which also provides metering data for the system. Thus, full consistency between both systems for all devices is guaranteed.

- These Measurement Bodies are listed in the EECS Domain Protocol (see section 5.2).

6.1.5.3 Consumption Devices

- The ETT GC Scheme requires Consumption Records for every Registrant that wishes to match their consumption with Production Certificates (see section 3.2). Matching can be initiated both in the web UI and via API calls.
- Measurement Bodies for Production Devices are also allowed for Consumption Devices.

6.1.5.4 Consumption Verification Body

A Consumption Verification Body is defined as follows by EnergyTag: *An organisation checking that Granular Certificates (GCs) are Cancelled against the energy consumption measured at one or a group of multiple Consumption Points in compliance with the guidelines in the GC Use Case Guidelines. This organisation can be a GC Issuer or a different organisation, such as an auditor.*

In the ETT GC Scheme, Production and Consumption records are issued. These Certificates have identical time granularities within one Domain, and are all based on trusted measurements, guaranteed by the Measurement Bodies of that Domain.

This means that matching is covered by the ETT software and thus the GC issuer is the Consumption Verification Body in the ETT GC Scheme in Denmark.

7. Granular certificate issuing

Granular Certificates (GCs) are issued for specific time periods and only cover the energy (Wh) produced during that time. In the ETT system, this is known as a production certificate.

Certificates are issued based on metering data from the Danish electricity DataHub. EnergyTrackandTrace.dk is directly connected to the DataHub, which means that data is instantly available for the issuance as soon as the DataHub received data from the national DSO's responsibility to measure consumption and generation of electricity. The DataHub's market rules (D1⁶) state that the maximum interval for sending data is 5 working days after receiving it from the meter.

To ensure full traceability, also consumption records will be issued. This allows for matching production and consumption within a single registry but also across different registries, which is essential for cross-border trades.

Production and consumption records are matched by the Wh, creating a digital record for accounting purposes.

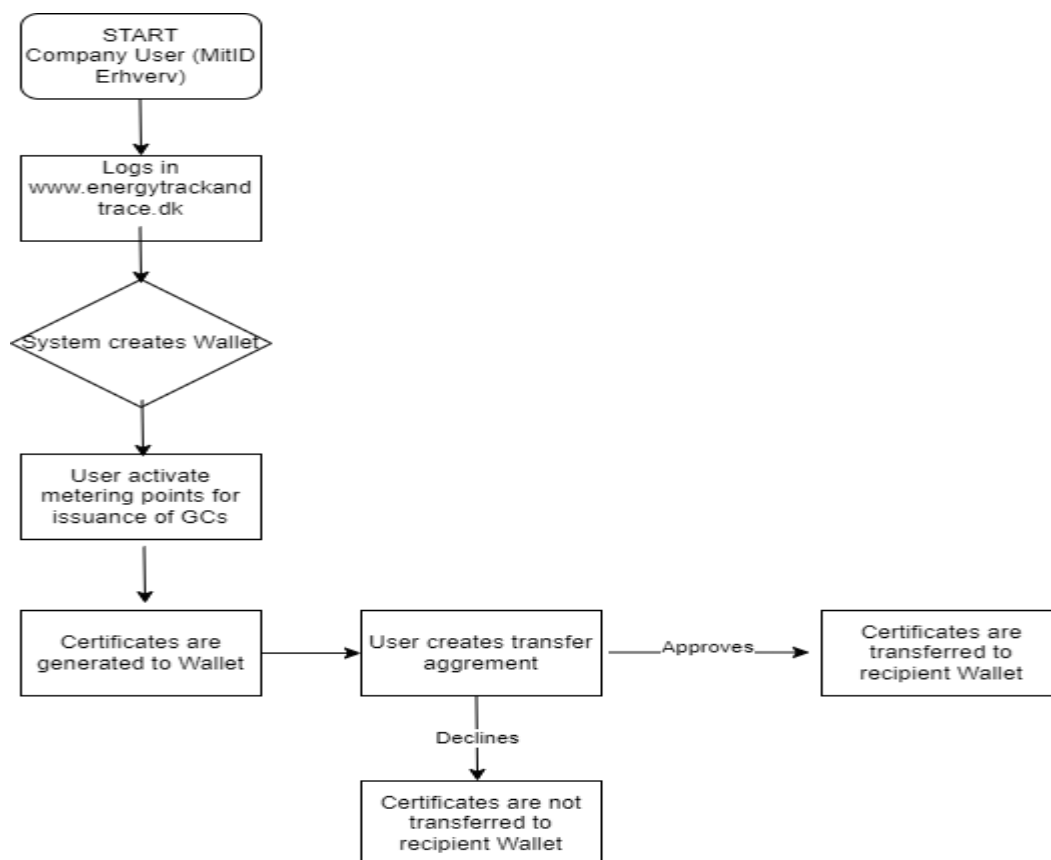
This system requires both production- and consumption metering points to be registered in ETT.

⁶ <https://energinet.dk/media/q1dbhp5q/forskrift-d1.pdf>

7.1 Production/Consumption registration

7.1.1 Production/Consumption Device registration

The figure below shows the process for onboarding new users and assets. An asset is any production device or consumption metering point for which an application is submitted in the ETT GC scheme.



On First Login by the User:

Accepting Terms:

- After the first login, the user must accept the terms.
- Agree to apply for either GCs or GOs for the same energy production. Consent to use asset information and metering data within the ETT GC Service framework.

System Actions After Accepting Terms:

- ETT Creates a certificate account (Wallet) to hold the Granular Certificates for the asset.
- ETT Creates a contract with DataHub to get validated metering data for the user's registered assets.

On any login:

Activating Metering Points:

- Granular certificates will be issued for active metering points until they are deactivated (for both production and consumption).

- All issued certificates are stored in the user's Wallet
- All issued certificates are registered in the Registry.
- If the user has both production and consumption metering points, the system will automatically match production certificates with consumption records.

Transferring Production Certificates:

- To transfer production certificates to another user, the user must create a Transfer Agreement with the receiving company. Only production certificates can be transferred, not consumption records.
- A Transfer Agreement must have a start date and may have an end date.
- Once accepted by the receiving party, a Transfer Agreement can be edited or terminated by both parties.
- Any transfer of certificates from one Wallet to another within ETT, is registered in the Registry. A cross-border transfer is registered and synchronized in all ETT registries.
- A Transfer can either be established via the systems user interface or the API's.

7.1.2 Metering data

As mentioned in section 7.1.1, an asset can only be added to the ETT if the asset owner has given consent to use their asset information and metering data within the ETT GC service. This consent must be proven by the asset registrar.

With this consent, the ETT GC Issuer gets validated metering data from the Measurement Body.

Additionally, the same metering data source must be used for both GCs and GOs for the same production unit. This ensures accurate measurement and reporting of volumes.

7.1.3 Net energy production & consumption

ETT Production Certificates are issued for energy that flows into the grid ("Export"). These certificates are based on the grid metering point excluding any energy used by production auxiliaries, lost by storage auxiliaries, or consumed on-site.

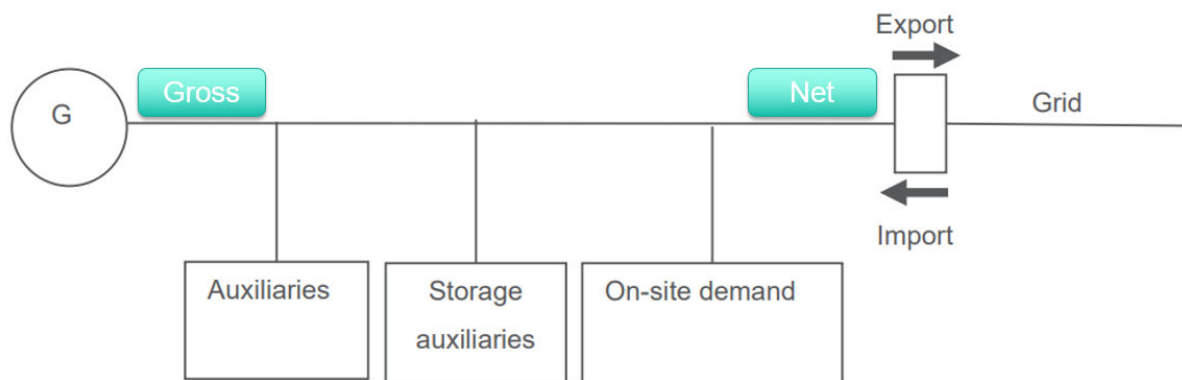


Figure 4 - Net energy production & consumption

7.1.4 Verification of energy source

The ETT GC Issuer checks the suitability of each asset (production or consumption device) for which an application submitted to the ETT GC Scheme and receive Granular Certificates.

Assets can be admitted based on this verification because they have already passed a thorough suitability check or audit as part of the underlying EAC GO scheme.

8. Double counting is avoided within GC Scheme

8.1 Transfer of ownership is facilitated

Production Certificates are unchangeable, meaning their renewable attributes cannot be separated. When issued, they have a face value in Wh (whole number).

However, in real-life scenarios, the face value of a Production Certificate often needs to be split and owned by different parties. To allow this, we introduce slices (sub quantities of a certificate) (inspired by the M-RETS Renewable Energy Certificate scheme). This ensures that batches can be split (see Merkle Proof).

ETT Granular Production Certificates are represented by two objects:

- **Production Certificate:** Contains all unchangeable attributes like the unique certificate id, producing/consuming asset, fuel code, technology code, etc.
- **Slice:** Linked to the Production Certificate and represents a specific part of the face value in Wh, which can be owned by different parties.

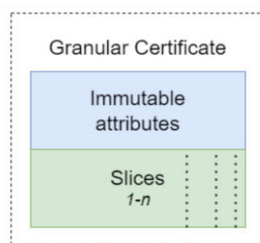


Figure 5: Schematic example of a GC in ETT

When a Production Certificate is issued, it comes with a single slice representing the full-face value. During its lifecycle, this quantity can be split into multiple parts that can change ownership through transactions.

Example: If a production certificate is transferred to another account, the original slice is reduced, and a new slice is created. The original certificate remains unchanged and stays in the root of the transaction tree. One slice represents the transferred part, and the other represents the part that stayed in the original Wallet. This process is shown in the figure below.

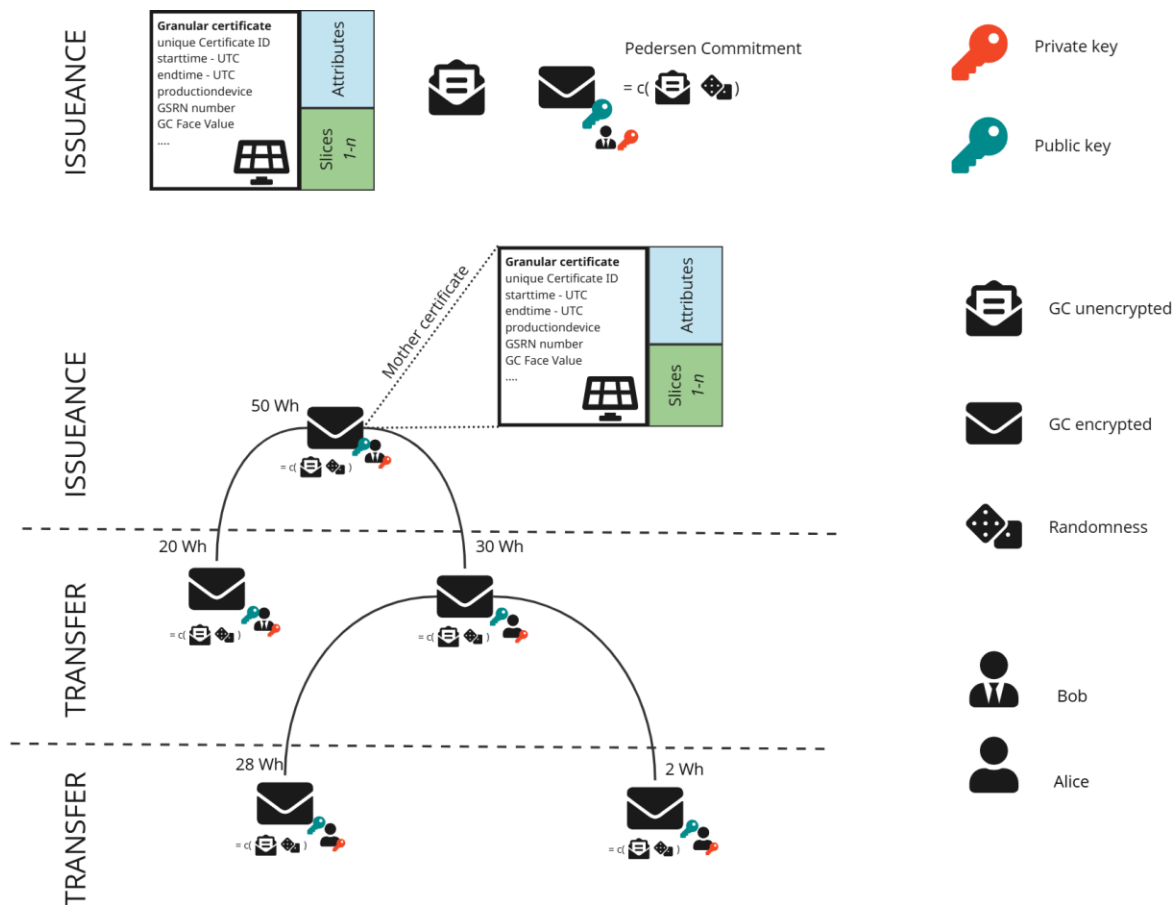


Figure 6 - Partial transfer of a Production Certificate by means of associated Certificate Quantity objects

Splitting slice objects is a transactional process, meaning it either fully succeeds or is completely reversed. The following criteria must always be met:

- The amount of a slice must be less than or equal to the amount of the associated Production Certificate.
- The total amount of all slice objects linked to the same Production Certificate must equal the amount of that Production Certificate.

Furthermore, multiple technologies are used to secure the users privacy and verification of the slicing (pedersen commitments), logging of events (certificate transactions), ensuring tamper-evidence, within the whole system (merkle trees) and tracking the ownership and support privacy (HDkeys and wallets). All these technologies com-

bined create the registry software, that finally publishes transactions on a event log or a public blockchain for verification. The following paragraphs give a quick overview of the single components of the system. For further information on these topics please consult the project origin documentation.^{7,8,9,10,11}

8.1.1 Pedersen Commitments



Figure 7: Pedersen Commitments ensure privacy while at the same time enabling verifications

- Pedersen commitments are a cryptographic method that allows data to be securely hidden while still enabling verification. It has homomorphic properties that allows for arithmetic computation of the commitments – meaning that reliable values can be calculated without revealing the underlying data.
- In the context of energy certificates, this technique ensures that the specific amount of energy associated with a certificate remains private while allowing others to verify that the data is consistent and unique. This prevents double-counting energy and double-issuance or tampering with recorded values, and ensures that each Wh can be accounted for in Energy Track and Trace registries as the values (Wh) are transacted and eventually claimed against consumption records.
- The Pedersen commitment (C) obfuscates the energy values as message (m) combined with a random value (r). All values in production and consumption certificates have commitments for transformation and hence they keep the homomorphic properties enabling the verification of slicing events by simple mathematical operations such as $C(m_1, r_1) * C(m_2, r_2) = C(m_1 + m_2, r_1 + r_2)$

⁷ <https://github.com/orgs/project-origin/discussions/19>

⁸ <https://project-origin.github.io/docs/concept/pedersen-commitment.html>

⁹ <https://project-origin.github.io/docs/concept/wallet.html>

¹⁰ <https://project-origin.github.io/docs/concept/hd-keys.html>

¹¹ <https://energyinformatics.springeropen.com/articles/10.1186/s42162-023-00283-2>

8.1.2 Hierarchical Distributed Keys



Figure 8: In combination with the wallets HD keys ensure tamperproof identification of ownership and limit the slicing to the overall certificate amount

- Hierarchical Distributed Keys is a cryptographic framework that combines layered key management with decentralized control to ensure security and scalability in large systems. The method organizes cryptographic keys into a hierarchy, where each level serves a specific purpose.
- For each certificate a new root key is generated. If a certificate is sliced and transferred, new keypairs are generated for each slice and stored in the owners' wallet after the transfer was completed.
- These keypairs act as a tamperproof identifier for both ownership and origin of slices as the keys are chained together in a tree, showing each slices related mother and child slices. Furthermore, the HD key structure limits the slicing to the overall mother slice size meaning that the maximum amount of keypairs is limited to the volume of the mother certificate in Wh.
- The setup with HD keys ensures while owners of single slices are obfuscated in the overall system.

8.1.3 Wallets



Figure 9: Wallets keep track of the certificate ownership

- The wallet is a fundamental component which stores and manages the ownership of digital assets, specifically Granular Certificates (GCs) and their corresponding slices.
- The wallets are based on the concept of Hierarchical Deterministic Keys (HD Keys) to ensure the uniqueness and security of keys used for each slice, and to provide a secure and convenient way to manage ownership of GCs within the system.

8.1.4 Merkle Proof

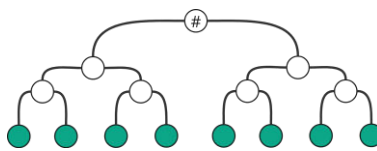


Figure 10: Merkle proofs enable us to publish millions of transactions effectively

- Merkle-proofs acts as a mechanism for auditing of millions of transactions, which makes tamper evidence a built in feature of each energy track and trace registry. It has an additional feature proof-of-inclusion that enables the end-user auditing every transaction in their wallets.
- Merkle proofs are sensitive to the slightest changes of initial conditions, meaning any change in underlying data will change the composition of the proof. At the same time the proof is one-way computational which means no underlying data can be reconstructed from the proof.
- Each transaction on the certificate can have a proof of inclusion in each published merkle proof. Each wallet owner can make a proof of inclusion of their transactions in the registry, using the published merkle proof, making their energy certificate records auditable for authorities, auditors and other stakeholders - using proofs and tamper evidence of records.
- Each registry owner, issuing body or members of the Energy Track and Trace network can request a recompute of the proof based on the transaction logs in the registry. If result differs from earlier results the registry transaction log has been changed making the registry tamper-evident. For example, if one registry owner request another issuer to recompute the merkle-proof that has previously been published – the initial registry can prove by computation that no records have been tampered.

8.1.5 The registry



Figure 11: The registry combines all technologies

- The registry finally combines all of these different technologies and writes single transactions on a public blockchain (or another sort of public event log). For public verification for both issuers and end-users alike – making it possible to provide proofs of the transactions.
- This enables the end-user to verify transactions on the blockchain and enables issuing bodies to verify consistency, tamper-evidence, between registries by making auditing registry transactions possible by cryptographic comparing proofs between the published log and the underlying registry transaction data . The concept of Pedersen commitments and merkle trees enables users at the same time to check if their certificates and transactions are included while still securing the end-users privacy

8.2 Location-matching for cross-border energy flows

Cross-registry transfer of Granular Certificates is not possible at this moment. This functionality will be added later if requested by users and technically/legally possible. The paragraphs below describe our current view on locational matching.

The following three options for cross boarder transfer have so far been discussed in Energy Track and Trace network. However, these will have to be tested, when the market for granular certificates is more advanced:

- Option 1: Locational matching rules based on physical interconnector capacities.
- Option 2: Locational matching rules based on actual power flows.
- Option 3: Locational matching rules based on prices correlations.

Read more about these mechanisms at: <https://energytrackandtrace.com/wp-content/uploads/2023/11/2022-09-Paper-Locational-Matching-of-Granular-Certificates.pdf>

8.2.1 Locational matching

Locational matching shows how electricity can be “transported.” While it’s only an approximation, it helps align the certification scheme with the actual grid. This is crucial for maintaining the trustworthiness of the tracking system.

It also sends the right investment signals and avoids unrealistic situations. For example, transferring certificates between zones that are not well-connected could harm the system’s credibility.

8.2.1.1 Technical implementation of locational matching

ETT System Design

The ETT system is a decentralized, federated network. Unlike a single centralized system, a federated network allows flexible rule-setting (a topology) based on agreed standards and policies. Each node in the network can enforce local specifics and regulations.

In the ETT network, each local granular certificate registry is a node and a trusted party.

This model enables interoperability and transparency between organizations. It provides a consistent user experience for clients across multiple organizations while supporting autonomy for each organization.

Organizations can join and leave the network at any time, speeding up the time-to-market for ETT participants and allowing for wider adoption across Europe.

Topology and Matching

The topology is crucial for the ETT network. It defines how production and consumption records can be matched (or “cancelled”).

One discussed mechanism is temporal matching (as in the EnergyTag initiative).

The ETT system ensures that generated electricity can only be matched with consumption volumes if both occurred in the same timeframe (i.e., certificates have the same timestamp). If not, the registries automatically reject the transaction request.

A similar process applies to locational matching. Locational matching involves rules for transactions of GCs between two registries. Registries accept transaction requests only when certain locational conditions (like the availability of physical capacity in the grid) are met.

Ongoing evaluation of options for locational matching rules across bidding zones and country borders In 2022, we explored the best locational matching mechanism for the ETT system. Our goal was to meet customer expectations, create a positive impact on the energy system, and make it easy for consumers to understand. The results are in the ETT paper “Locational Matching of Granular Certificates” [4].

Within bidding zones, GCs can be exchanged without limits, following electricity market logic. We analyzed three options to approximate the physical exchange of power between these zones:

- **Option 1:** Based on physical interconnector capacities.
- **Option 2:** Based on actual power flows.
- **Option 3:** Based on price correlations.

Our Conclusion:

Locational matching is crucial for the ETT tracking system. It gives consumers realistic information about their energy use and ensures Granular Certificates benefit the energy system. We will provide clear rules once ETT is fully operational. This will ensure the quality and credibility of customer claims.

The 2022 paper provides an initial assessment of the options, but more data is needed to choose the best solution. The upcoming testing phase, with many customers connected to ETT, will provide this data. This will help us refine the topology and identify the best locational matching mechanism with our customers.

During the testing phase, we won't set explicit rules for locational matching. Instead, customers can choose their preferred method. We will offer different locational matching mechanisms as optional features and gather customer feedback.

The first option we will offer is Option 1 (based on physical interconnector capacities). This is preferred by most customers and is seen as credible and feasible. Depending on new regulations and customer needs, we will also develop Options 2 and 3.

Data from the testing phase will be analyzed to choose the best option for the ETT system.

As long as this evaluation is ongoing granular certificates in ETT Denmark can only be claimed within Denmark. Furthermore, no specific rules for transfers between bidding zones will apply in the beginning. However this might be changed in the future if necessary.

9. GC Attributes

The attributes related to an ETT Granular Certificate are described in *the EnergyTag standard V2*¹².

- By adhering to the EnergyTag standard, it is demonstrated that **ETT GC certificates replicate the attributes of the underlying EAC system** (the European EECS GO system for electricity).
- All **timestamps are expressed in UTC** – on the webinterface in a human readable way, on API level in Unix time, which easily can be converted to “YYYY-MM-DDThh:mm:ssZ”.
- The name of the production device will be added, containing the GSRN number for the specific production unit that identifies it uniquely
- The unique Certificate ID – see also section 8.1 for further explanation.

Compliance with EnergyTag standard GC attributes are included in the ETT GC definition:

- **“Production Device - Commercial Operating Date” attribute:** Is added to the definition, but marked with N/A, since we do not have access to the information – will be accessible later on.
- **The GC can be used for disclosure as defined by the EnergyTag standard Version 2:** yes/no
- **“Energy Carrier” attribute:**
This attribute is added to the definition, but hardcoded ‘Electricity’, as ETT currently only supports the electricity carrier.
As described in section 3.4, the concepts behind the ETT system are designed in an energy carrier-agnostic way and can therefore easily be expanded towards other carriers in the future (hydrogen, natural gas, etc).
- **“GC Issue Device Type” attribute (either “Production” OR “Storage”):**
This attribute is added to the definition, but since ETT currently doesn’t support storage the default setting for now is ‘Production’.
- **GC Production Device Commercial Operation date attribute:**
This attribute is added to the definition, but currently the default setting is ‘N/A’ because ETT do not get this information from the DataHub at this point.
- **Following attributes are also included in the GC Definition:**
Connected Grid Identification (bidding zone, either DK1 or DK2)
Country
GC Face Value
GC Issuance Datestamp
GC Issue Market Zone
GC Issuer
Produced Energy Source
Produced Energy Technology
Production Device Capacity
Production Device Location

¹² <https://energytag.org/wp-content/uploads/2023/09/Granular-Certificate-Scheme-Standard-V2.pdf>

Production Device Unique Identification
Production Ending Interval Timestamp
Production Starting Interval Timestamp

To be compliant with GDPR regulations as well as the EnergyTag Standard, we have hashed some of the above-mentioned attributes in the Register. This means that it is possible to verify the data and that it is tamper-evident and secures the system against double claiming. The data considered to be personal relatable (if the company exists of 1 person only) is secured behind Pedersen commitments and hashing. These technologies make sure that the data is inaccessible to the public but ensure that the data is verifiable in a secure manner. Both Pedersen commitment and hashing are one-way algorithms which make it next to impossible to recover the original data from the output. We cannot delete information from the Registry block-chain – but we have secured the data according to GDPR-regulations.

An example of a certificate issued by ETT Denmark is shown in the follow figure.

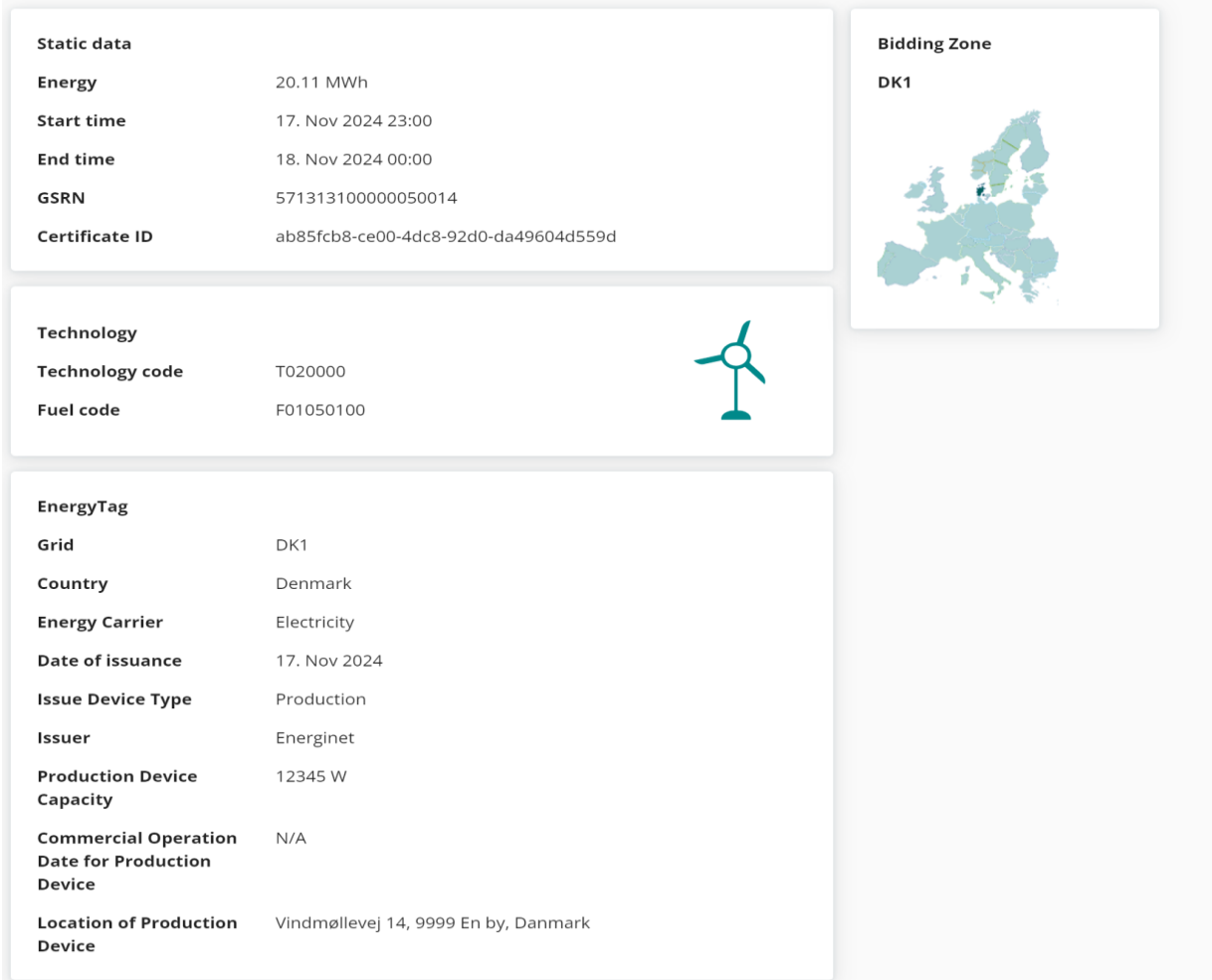


Figure 12:Example of a production certificate in ETT Denmark

9.1 Immutability

All issued production and Consumption records in an ETT Registry are **immutable** from Issuance to Cancellation - that is, once a GC has been Issued the data recorded on it is never removed or modified. This data remains intact until the point of Cancellation.

10. Fraud prevention and detection measures

Energy Track and Trace Denmark uses the national login system MITID and the national asset metadata registry for all production device characteristics.

- **MitID** is the national Danish login system which both is used for digital signatures and general login for both national and private apps and homepages. When logging in, some general information about the user (such as the companies name, the companies vat number and the signees email address.)
- The **national asset registry** holds asset data on the energy infrastructure in Denmark and is owned and operated by the national energy agency. This registry is constantly synchronized with the DataHub and information such as fuel type, technology type, geocoding of the asset, etc. can be directly deducted from this registry. These data are directly added to a customer's account when the customer's assets are added to the platform.

Energy Track and Trace Denmark, as the registry operator, can monitor both accounts and the certificates they hold.

If Energy Track and Trace Denmark detects any signs of fraud or any other irregularities these will be reported to the authorities in charge.

Additionally, Energy Track and Trace uses Merkle trees and Pedersen commitments to store public keys on a blockchain, making them publicly verifiable and traceable.

To ensure fraud control, various measures and procedures will be implemented. The team is also developing tools to create relevant statistics on issued and claimed certificates from blockchain transactions, enhancing fraud control. <https://project-origin.github.io/docs/chronicler/index.html>

11. Storage

At this moment, Storage Devices are not allowed to participate in the ETT GC Scheme.

A concept and ruleset for handling Storage devices is planned in 2025. This ETT GC Scheme Protocol will be updated when the rules for Storage Devices are further defined by ETT and EnergyTag. As from that moment, Storage Devices will be allowed to participate in the ETT GC Scheme.

12. IT security

IT security is crucial for our business because we handle sensitive and confidential data from our clients and partners. We are continuously improving our security measures and are committed to enhancing our standards and practices.

We are working towards ISO27001 certification, an internationally recognized framework for information security management. By following ISO270001 guidelines and requirements, we aim to protect our information and IT systems from unauthorized access, use, disclosure, modification, or destruction.

13. Account holder behaviour control and transparency

Currently, any legal entity can become a Certificate Account Holder. Account Holders¹³ can make decisions about all ETT Certificates in their account. They can initiate transfer and cancellation actions, either directly or through an authorized intermediary¹⁴, using API calls to the ETT GC Registry.

The current public API version is available here: <https://energytrackandtrace.dk/developer/> (Energinet instance). The API's will evolve together with the product. We don't follow the EnergyTag API standards.



For further information, please contact:

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¹³ Users must accept Terms & Conditions on log in – link to Danish version (not available in English yet)

¹⁴ Service Providers must accept Terms & Conditions – link to English version