ENERGY TRACK AND TRACE | 25. Mai 2022

Architectural concepts and insights.

GREENPAPER

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Executive summary

Project Energy Track and Trace (ETT) is an initiative, currently developed in collaboration between Energinet, Elia Group and Elering. ETT wants to demonstrate the feasibility of a granular energy certification system that provides enhanced traceability, transparency, and trust, to pave the way for a wider variety of choice of energy products for consumers and accelerate the green transition. This greenpaper is a working document which is open to changes. The intent is to give stakeholders insights into the technical concepts behind the work in the project and the alignment necessary to achieve a concrete and sturdy implementation of the proposed system. ETT is a prototype solution that is co-developed with a group of partners in order to design it towards their needs and infrastructure.

Traceability

The core aspect of ETT is giving consumers the ability to trace energy through its supply chain, including transportation and storage, with a high temporal resolution. ETT further aims at incorporating the total environmental footprint, including (but not limited to) emission of greenhouse gases, raw materials consumed, and other parameters from production technology.

Markets and trading

While it is not the responsibility of the ETT project to provide trading and commerce mechanisms (which we leave open to market parties), the system must be able to support use-cases essential to marketplaces, brokers, and third-party services to access the API.

Adaptability

The prototype development enables a soft introduction of the granular certification system into the market, allowing participants to test and adopt the infrastructure at their own pace. There are several solutions, legislative frameworks and standards being drafted at the time of writing that provide the frame for the productive and legally binding deployment of the system. EnergyTag (1) being one of them - defines a standard of system setup and integrations with existing solutions. It is important that the system supports seamless integration with the existing Guarantee of Origin scheme defined in the European Directive 2009/28/EC to avoid any forms of double counting.

Vendor and technology agnostic implementations

Our goal is to design an architecture that could be supported by any number of underlying technologies, thus not forcing implementations to be vendor- or technology-stack specific. Organizations participating in the network can create their own implementation or contribute to the shared implementations in the ETT working groups and organizations.

Governance and Transparency

The decentralized nature of the infrastructure and organization of the ETT network, sets a different set of requirements to governance in the network, transparency in the settlement of transactions and interactions between participants. The ETT working group is actively engaging in building working prototypes with bleeding edge technologies, to validate the promise they deliver and test whether the technology is fit for purpose in an ETT context. Currently it is planned that the project source code will be available as open-source software. Ensuring transparency, implementations will be available to the public as open-source, as a reference implementation and as a production-ready product.

General Requirements

The ETT undertaking is underpinned by a need to have verifiable, trustworthy insights and documentation of energy consumption. Currently, there is a residual mix declaration available that accounts for all energy present in the energy grid at a given time. To establish further proof of energy consumption, and offset the environmental impact, there is the possibility of buying Guarantees of Origin on a yearly consumption basis.

As the amount of RES energy in the grid has risen from 7.5% to 20% in 2020 and targeting 32% in 2030 for the EU on average (2), major changes are required in the energy infrastructure. The ETT approach is to have higher granularity on the time of production and consumption of energy and having an infrastructure that facilitates energy certification on a market resolution scale. Current electricity market resolution is hourly or less and, in the future, even lower time scales. The requirements for such a certification system are far from trivial but it needs to address some fundamental issues to be operational and functional:

- The system must be trustworthy and tamperproof by design and in its implementation
- It must avoid double counting with other certification schemes
- It must be able to scale according to adoption rate
- It must be energy efficient (low energy consumption of the tracking system itself) and be performant
- It should facilitate high degree of independence for the individual participants
- It must be able to generate high-resolution proofs of production, consumption, and settlement between participants (incl. transportation and storage).
- It should facilitate local and global governance to settle current and future agreements between parties
- It should facilitate a liquid and functioning market infrastructure with incentive to adoption from producers, consumer, infrastructure providers, market makers and service providers.
- The functionality provided by ETT can only be accessed by compliant counterparties that meets the prerequisites and dependencies of the infrastructure i.e., market resolution meter readings.

This list of requirements is comprehensive however not all encompassing, hence there are multiple edge cases that both challenge the choice of implementation and the feasibility of the undertaking. Keeping that in mind it is by no means an impossible task. Developments in technological infrastructure, software and sensor technologies provide the ETT initiative with the basic building blocks.

At ETT's core is a deceptively simple concept: along with the energy running through the grid there is an additional certificate that accompanies the energy from production to consumption.

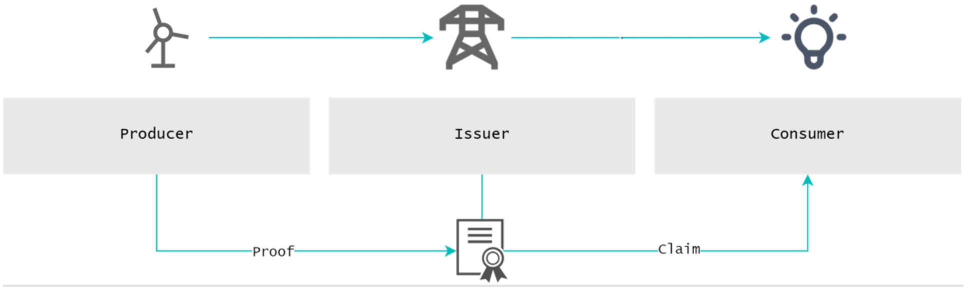

Figure 1 Energy Track and Trace delivers the digital infrastructure to create a digital proof of energy that can be tracked from production to consumption.

The certificate is dubbed a Granular Certificate (GC), because of the market resolution granularity it adheres to. The GC is issued by an issuer that receives metering data, the consumer can subsequently claim the GC or parts hereof and thereby validate their consumption using the GC as proof.

The underlying matching mechanism within the ETT system, is a temporal matching solution, that respects a set of globally acknowledged set of rules, local (ie. national) rule sets if required and customized application rules such as fuel and tech code for certificates to be claimed. As stated it is a deceptively simple concept, however, in practice it is a different story. This document provides the conceptual insights into what GCs are, their purpose and function and the infrastructure necessary to make ETT a working solution.

The vision is that by 2025, GCs should be playing an active part in reaching the goals of the green transition in Europe. In 2030, we expect GCs to be the leading method for documenting the origin of energy across Europe.

Demand for market resolution certification

There is an overall regulatory and commercial demand for accurate attribute tracking in energy consumption. With the increasing supply of fluctuating Renewable Energy Sources (RES) (1) in the European energy system the ETT initiative seeks to establish an infrastructure that facilitates tracking on an hourly basis, aligned with the power markets, high temporal resolution is one of the recommendations, outlined in the electricitymap article "*How leading organizations should measure their electricity emissions"* from 2021 (3), another recommendation being minimizing assumption by relying on measured real-world data.

The ETT network protocol and data-formats are being developed to facilitate rich descriptions of energy production and consumption to facilitate a broader and specific range of energy products. Elaborating on the existing Guarantees of Origins (GOs) scheme, the initiative introduces the concept of Granular Certificates (GCs) – that will change the energy certification from size- to time-stamped certificates that match the market settlement time-basis. GCs are issued for each timespan and account for the Wh produced in that timespan alone., which accounts in ETT context for a production certificate. To make full traceability possible certificates for consumption will be issued, making an actual match between production and consumption possible across registries, otherwise production would only be available for claims within a registry. The consumption and production certificates are claimed against one another by the Wh and produces a digital claim on the certificate is being created and acts as a record for accounting purposes.

Today, advances in software and digital technologies enable businesses, institutions, countries, and infrastructure companies to participate in large digital networks, where the assets and rules are defined by standards and conventions. ETT proposes an energy tracking system, based on a federated network architecture, which can support local governance, legislation, and business-specific rules while still facilitating transactions in a common marketplace and providing flexibility and scalability in the implemented infrastructure.

A core aspect of the system is to enable users as much insight into their data as possible and give them control over data by treating it as an asset on par with existing infrastructure such as banking and personal sensitive data. User data is to be made available through APIs, users must be able to do selective disclosure of their data, the ability to delegate access to any of their data and provide API access so that third parties (such as brokers or digital service providers) can act on their behalf with the users' explicit consent.

Emissions and environmental footprint

With a reliable traceability and tracking infrastructure in place there are a multitude of possibilities introduced into the energy markets, one of those is calculation of attributional emissions and the environmental footprint of a given consumer. ETT aims to provide insight into the total environmental emissions caused by energy consumption for the individual consumer. This includes (but is not limited to) emission of greenhouse gases, raw materials consumed during production, transportation or other processes involved in production of energy.

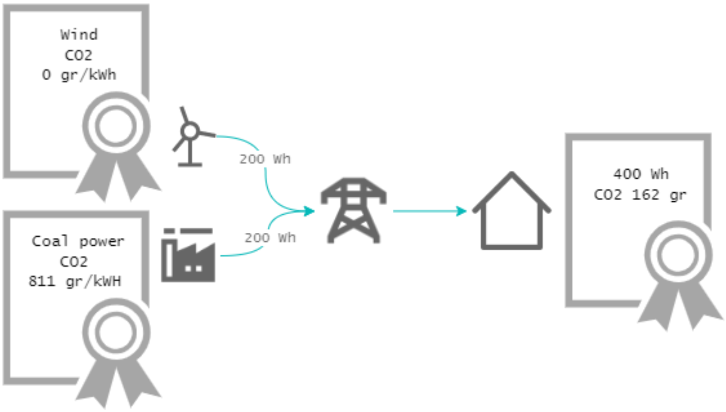

Figure 2 The environmental footprint is calculated by the Wh of claims on the consumption certificate. The emissions are calculated and appended to the consumption certificate – acting as a basis for the environmental footprint of the consumer.

A certificate’s environmental footprint is obtained by acquiring attribute data about the production unit and adding it to the certificate when it is issued. Emission of greenhouse gases could be added to consumption certificates in the form of units per claimed Wh as illustrated in Figure 2. If production certificates cannot be claimed for all consumed energy, one instead uses “grey” electricity from the grid. The emissions of these can be calculated based on residual mix emissions for the grid area.

Traceability of energy

To validate the feasibility to trace energy consumption to its origin, using state of the art available digital infrastructure, was the purpose of two proof of concept prototypes developed by the current ETT working group members:

- Green Tracking developed by Elia Group / Energy Web Foundation in 2021 (4) Facilitated 24/7 energy procurement toolkit.
- Project Origin developed by Energinet in 2020 (5) facilitated 50 users using Hyperledger sawtooth.

Both projects showcased the feasibility and ability to digitally trace and certify consumption of energy. The success of the projects became the foundation of the Energy Track and Trace initiative. The learnings and feedback from the first generation of prototypes showed that a dedicated approach for the GC system to be realized as a production ready system other and more appropriate solutions would have to be developed for the infrastructure to be operational

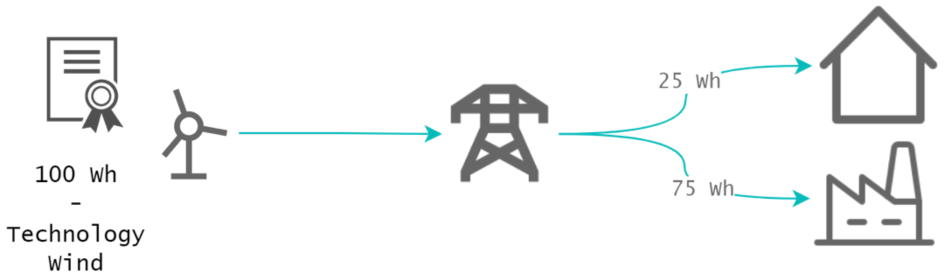

Figure 3 Traceability of energy from producer to consumer is the cornerstone in certification in energy consumption. Leveraging digital infrastructure and solution to create a trustworthy supply chain for the green transition.

To achieve transparency and traceability the Energy Track and Trace introduces a novel certification method, Granular Certification by leveraging meter readings on a resolution basis in Watt hours (Wh) in alignment with the current power market resolution.

Granular Certificates

GCs are a verifiable proof of an amount of energy produced or consumed within a single timeframe at market resolution intervals in a given energy carrier. As the GOs they contain information about the producer or consumer, amount of energy produced or consumed, technology and raw materials used in production, time of production or consumption, etc. GCs can be appended to any kind of energy carrier, such as electricity and natural gas, within their respective decoupled and separate grids.

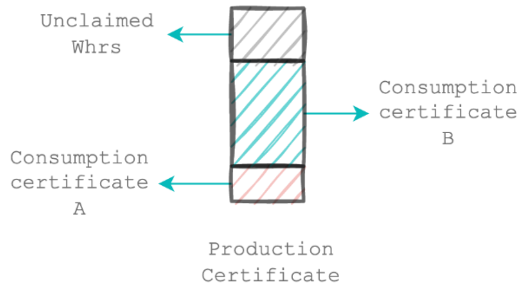

Figure 4 An example of a production certificate with multiple claims of the produced energy by consumption certificates A and B. The remaining unclaimed Wh on the certificate will be available for claims until expiration of the certificate.

There is no definite coupling between each certificate – as they represent a quantifiable amount of Wh produced within a time period. Each Wh can be claimed by consumption certificates until expiration of the certificate if both certificates are a temporal match at minimum, and preferably of the specificity that fits the consumption needs and wants in the marketplace.

From size bound to time bound

The current GO system locks the size of each GO at 1 MWh, so the owner of a facility can be issued a GO for every MWh the facility produces, while the start and end time of each GO varies from hours to months depending on the output of the facility.

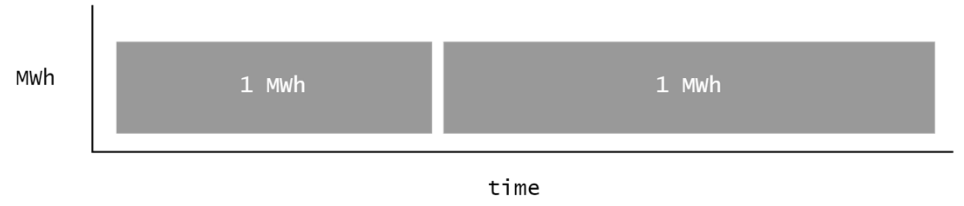

Figure 5 Size bound Guarantee of Origin are issued based on output in MWh with time as the variable.

The Granular Certificate (GC) are issued discretely in timespan matching market resolution and adds the total Wh produced within the specific timespan to the GC. Applying fixed time intervals instead of issuing by size, makes it possible to discretely issue certificates at market resolution.

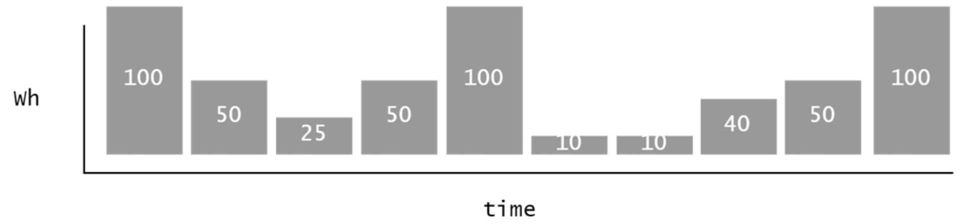

Figure 6 Time bound Granular Certificates are issued discretely at market resolution in Wh, currently hourly but can be shorter timeframes.

Applying quantization to the timeseries gives a more accurate description of the energy consumption and production - it is possible only due to the adoption of meters that support reporting at these intervals. Increases in the accuracy of meter readings should be reflected in the certification process and is addressed in the following section.

The splittability of the issued certificates is possible due to the ability to claim, in full or partial parts of a GC, this is supported by a Verifiable Data Structure as described in (6) that can prove uniqueness of a claim in the data structure. This means that GC can be split by default as illustrated in Figure 6.

Reading resolution

Granular certificates are represented in the smallest measured unit supported by meter readings. For electricity this is in Wh and gas is in kWh - a composition of calorific value of the gas and the metric amount consumed. Each energy carrier will have their own instances (separate registry) in the ETT network, where conversion will be applied to account for the different minimum measurable unit.

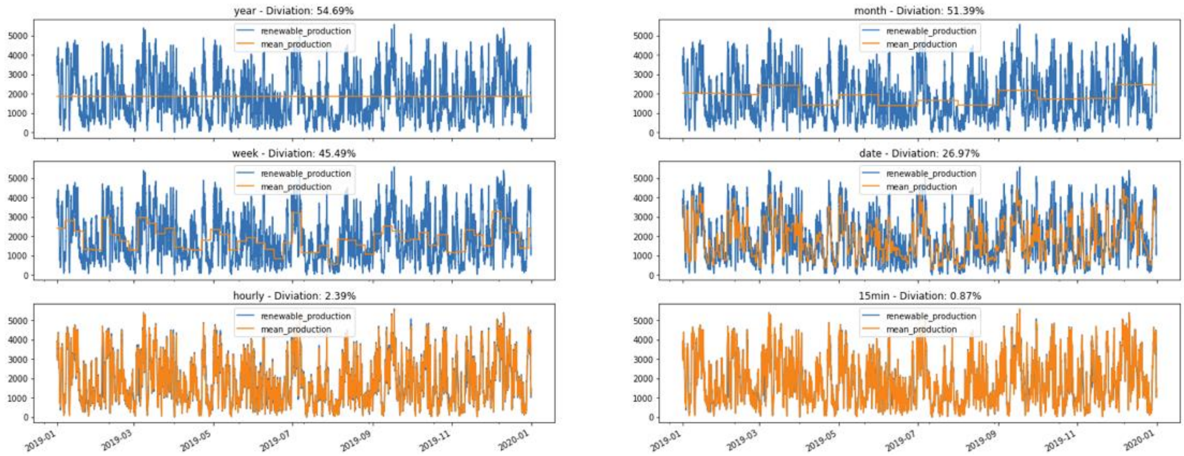

Figure 7 An example of the increase in accuracy from size bound yearly certification with deviations between time for production and time for demand above 50% to the mean of production, to hourly timebound certification with deviations less than 3% from the mean (7).

The reading resolution is of great importance to be closer to the actual physics and inner workings of the energy grids, the smaller the granularity of time-based measurements, the closer the insights into the actual production and consumption of energy. The improvement in documentation is intended to facilitate sector coupling and enhance the ability to account for the origin of energy (7). The electricity grid is an energy carrier not a storage facility, electricity must be used at the same time as it is created, it cannot be stored in the grid, like pressure in a pipe – and the certification can reflect that property by applying lower time intervals as illustrated in the example in Figure 7 where deviation from mean to actual readings reduces deviation between time of production and time for demand from the yearly mean of 50% to less than 3% deviation from the mean at hourly readings. This reduction of deviation increases the accuracy to a little less than 95% in the example from project origin and reduces the systematic error in the estimates, which leaves room for random errors to account for inevitable outliers. Which all in all will increase the trustworthiness of the GCs.

Integration with Guarantees of Origin

Integration with the existing schemes is important as a measure of both credibility and easing the adoption of the GC scheme – it is a prerequisite to avoid double counting between systems and thus a legal issue of great concern for the ETT working group. There can be local differences that will have to be addressed such as market resolution between zones etc –it is not in the scope of this document to address the issues of integration into existing certification schemes, but to tell the reader that these issues are being addressed.

Production and consumption certificates

GCs are issued based on either produced or consumed energy. GCs are based on validated meter readings and are issued to producers and consumers of energy in the grid. The two types of GCs exist to act as counterparties for the subsequent matching mechanism and is necessary for the claim process of consumption.

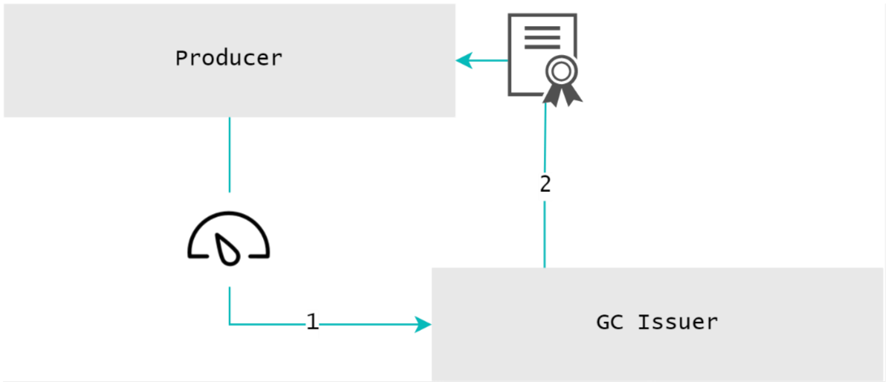

Figure 8 A producer is issued a certificate for energy contributed to the energy grid by an issuer in the network based upon meter readings.

The producer is issued a GC production certificate, which represents the amount of energy produced in a specific discrete timeframe. It contains additional validated information attributes about the producing facility such as its location, environmental footprint, and other arbitrary parameters describing the producer using the same descriptive methods as AIB have applied in the Guarantees of Origin specification (8).

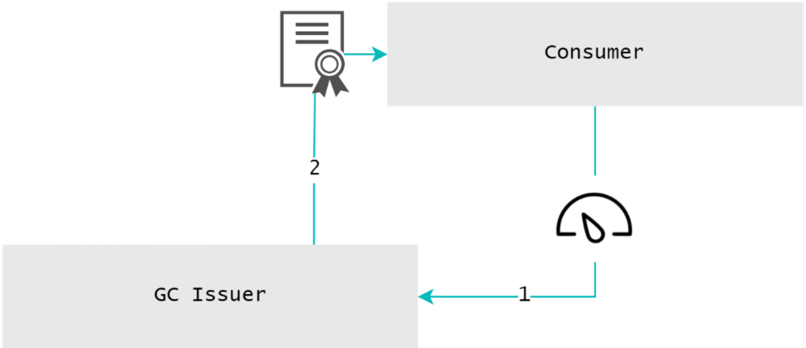

Figure 9 A consumer is issued a consumption certificate for consumption by an issuer of meter readings, in order to claim production certificates.

The consumer on the other hand is issued a GC consumption certificate, which represents the amount of energy consumed in a specific timeframe. This certificate is quantifiable, and when matched with a production certificate acts as proof of consumption of an energy from a specific origin. When consumption certificates are settled, the certificates themselves act a signed proof of origin and can hence be used in accounting processes.

Certificate lifecycle

The GCs have a predisposed lifecycle by design. The certificates themselves resemble the current working solution for Guarantees of Origin maintained by AIB (9) in accordance with EU wide legislation: Upon issuance from meter readings the certificates go through 3 major states:

1. Issued by an issuer in the ETT network, based on validated meter readings.
2. Transferred between accounts or by delegation to 3. Parties, thereby change of ownership or write permissions of the certificate itself.
3. End states of the certificates involves the following actions:
    a. Claimed by consumption, either wholly or partially.
    b. Expired upon expiration, wholly or partially
    c. Withdrawn by the issuer in case of faulty readings.

While the certificate is not claimed, expired, or withdrawn, it is in a state allowing any of these three actions. The remaining amount of Wh on the GC is thus available to be claimed by consumption. The claim process is open until the total amount of Wh are claimed or the certificate expires – there is no guarantee that certificates will be claimed in total prior to expiration.

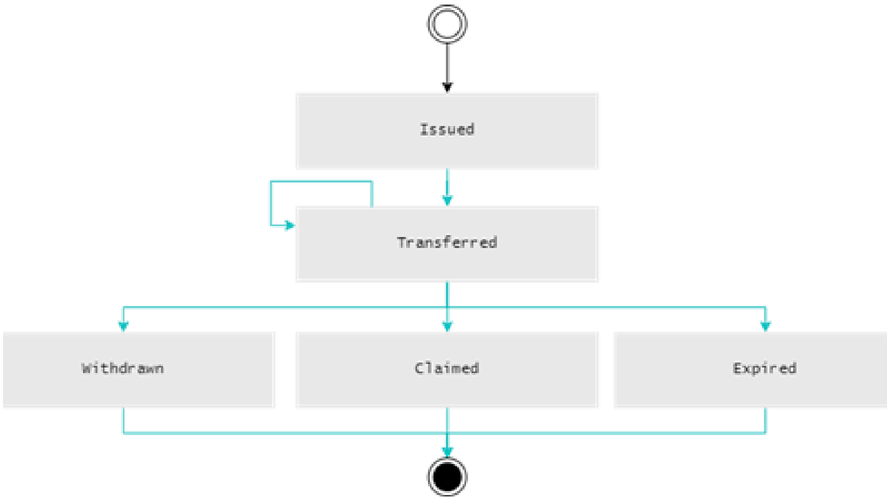

Figure 10 Certificate lifecycle of a Granular Certificate from being issued, to being transferred between accounts as a digital asset until it is withdrawn from circulation, claimed by a counterparty certificate, or expired.

Withdrawing certificates is a quality assurance mechanism available for the issuer upon faulty readings or data corruption of the underlying meter readings dataset. Such cases do occur, and to ensure credibility of the GCs issued, the certificates can be withdrawn from circulation during the lifecycle by the issuer. In the case of partial or total claims on a certificate that is being withdrawn the underlying claim is no longer valid and is cause to a failure to deliver the underlying. The lifecycle of the certificate is designed to give incentive to claim the production within expiration. The claim process itself is dependent on a matching mechanism to ensure several qualities such as temporal and geographical matching.

Matching mechanism

The mechanism by which production- and consumption certificates are matched prior to the claim process requires a set of rules - a topology - to be applied for a transaction to be valid. The general topology - ruleset are defined and governed by the ETT network and are the bare minimum for a valid match. The topology is designed to be adaptable to align with current and future changes in the legislative framework and is applied system wide.

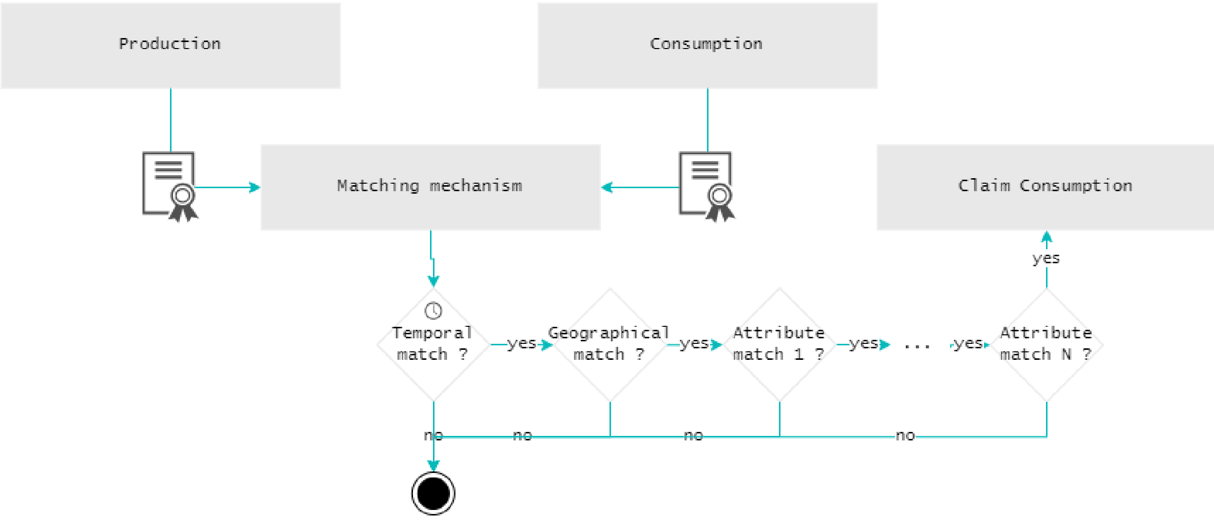

Figure 11 The matching mechanism requires a temporal match within the same timeframe and a geographical match to a grid zone. Additional attribute matching is to provide a richness and specificity to the consumers.

The ETT system supports third-party service providers to implement complex searches based on certificate's individual attributes. This makes the current source of energy, the grid mix, into a plethora of different products with a high degree of specificity that cater to the consumers demands, and thereby drive the green transition by demand by facilitating a broader and more specific range of energy products.

Temporal matching

To claim certificates, temporal matching of production and consumption certificates are required, only production and consumption made within the same timespan are valid matches and can be claimed. As described in the Reading resolution section, the timespan is assumed to be the same everywhere, additional rules for matching production and consumption needs to be defined in cases where they are not, this is in alignment with the recommendations by Energymap (3) to increase and to ensure credibility of the claims on the GCs.

Geographical matching

Claiming certificates within a zone by e.g., certain geographical region, interconnect of the physical grid or electricity market bidding zone can be thought of as a grid without any internal bottlenecks, analogous to a copper plate, there is no hindrance of flow and settlement of claims within such a zone. Claiming certificates across e.g. bidding zones could be subject to limitations at specific times to reflect the physical grid, such as its direction of flow, available capacity etc. – this includes the use-case of cross border settlements. (10) .

In collaboration with our group of partners we are currently assessing which transfer method is feasible and is creating the highest benefit for both, the energy system and our customers. The temporal and geographical matching will be governed by the global topology ruleset and is mandatory in the ETT network due to the increase in reliability of the claims using GCs.

Attribute selection

The system allows for attributes to be added to add specificity to production certificates, providing richness and a wider selection of energy products. The attribute selection is an additional and voluntary piece of information that producers can choose to disclose and gives consumers the ability to search for specific attribute parameters. Attributes appeals to consumers and producers by creating specificity to the underlying asset in the energy grid, third party service providers in the ETT network can hence facilitate marketplaces for certificates.

Examples of such attributes include:

- Location of the producer.
- The technology and fuel used in production, noted by a technology- and fuel-code, as defined by EECS Rules Fact Sheet 5 (11).
- The manufacturer of the hardware used to produce the energy.
- Certifications of the production facility.
- Etc

The list of examples is not exhaustive, and attributes can be added to the production unit on a selective disclosure basis – where producers, inspectors and system operators can add descriptive data of the specific energy production unit. ETT believes this feature will facilitate a wide variety in products of energy and create the required information about energy that is necessary to create a varied selection of energy products.

When there is a required temporal and geographical match and of attribute selections between consumption and production certificates, the claims must be finalized by the matching mechanism by the claim process, that applies the general and local topology prior to approving the claim and a log entry on the ETT ledger will persist the claim.

Claim process

The claim process is an application of rulesets that govern the transactions in the ETT network, to ensure compliance with the current set of working rules within the network and the network instance. Claiming consumption certificates from production is a process that requires applying two sets of topologies or rulesets – the general topology that applies for all the ETT network, where mandatory rules are applied such as temporal and geographical matching –a local ruleset managed and operated by the instance owner, as well as the voluntary attribute selection for specificity purposes.

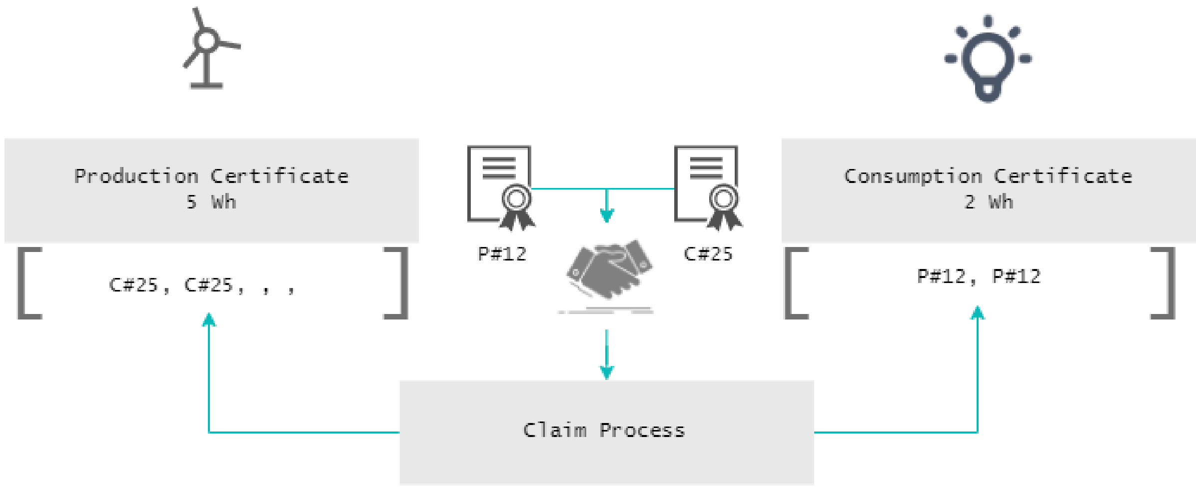

Figure 12 The claim process settles consumption against production writing the claims onto production and consumption certificates to finalize and validate the claim.

A temporal and geographical matching of production and consumption certificate is required to make a claim, these certificates are provided to the claim process that applies the topologies and if successful writes a claim onto the provided certificates. The claim process then persists the claim on both certificates and the claim is being provided to the owner of the consumption certificate for accounting purposes. The claim types being considered for implementation are Verifiable Data Structures (6) where a verifiable proof is provided as claim of parts or the complete underlying energy production.

Topologies

Topologies are the rulesets and legislative compliance engine that ensures that the settlement of claims is being conducted with compliance to the legal framework of operations and according to the agreements in the ETT network. Because of the varying legislation between pricing zones and sometimes within zones, the system comes with two sets of topologies to address the problem of compliance. The topology definition can be changed during the lifetime of the ETT network as an adaptation to changing demands from members and changes in regulations.

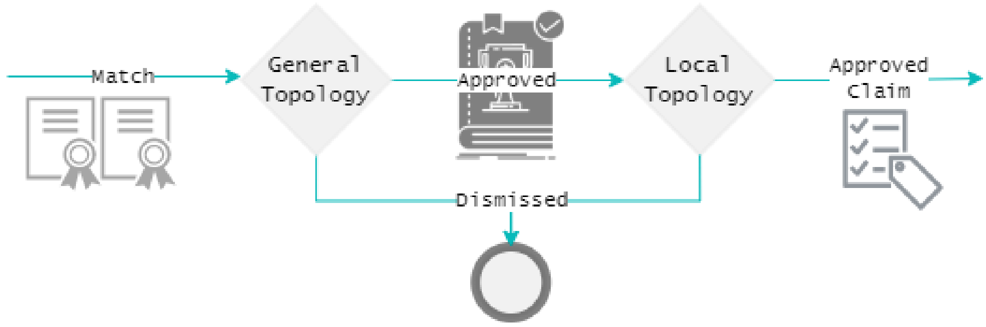

Figure 13 The inner mechanism of the claim process – a rule based engine. It requires a production and consumption certificate as input and as the general topology and local topology is applied and if approved will approve the claim.

General Topology

The general topology is aligned with the underlying energy carrier, since an instance is required for each energy carrier there is a viable opportunity to ensure that legislation such as RFNBO (10), REDII (12) are applied in an automated an non-ambiguous manner in the general topology. The general topology is where required matching rules are defined by energy carrier, as well as the rules regarding cross-border trades are addressed and specifics according to the settlements are defined.

Local topologies

The local topology is in place to address different legislations and ensure compliance with a local subset of rules. Depending on the energy carrier of the ETT instance there will be a local topology aligned with legislation for compliance of the transactions and claims on the underlying certificates on the instance. That could be local agreements, local experimental set of rules or even a ruleset agreed upon by all members of the instance.

When general and local topologies are applied and approved on the production and consumption can now undergo the claim process and have the claims settled and the qualitative data appended to them as illustrated in Figure 14. Figure 14 The final validation of consumption and production certificate claims, stamps the consumption certificate with the attributes of the production certificate.

Figure 14 The final validation of consumption and production certificate claims, stamps the consumption certificate with the attributes of the production certificate.

As the certificates are approved and validated by the matching mechanism – the consumption certificate is decorated with the attributes from the claimed production certificate. The claims on the consumption certificate now represents the claimed consumption and can be used as proof of consumption. The environmental footprint caused by producing the energy, can now be attributed to an individual consumer by applying the tech and fuel code attributes and derived emissions, to the Wh consumed on the certificate. This enables modelling of the environmental impact on an individual consumer basis.

Concepts

The concepts are a foundational understanding of the moving parts in the implementation, of the Energy Track and Trace network. They should be considered abstractions that will ease the implementation requirements of the ETT network. Establishing a sound foundation and understanding of the infrastructure – is a prerequisite, enabling discussion and consolidation of the ideas behind the implementation.

Figure 15 shows an example of a system of interconnected grid zones. It consists of four different zones, 2 electricity carriers and 2 gas carrier zones, each carrier are connected via interconnectors. The diagram shows a series of consumers and producers, in the case of facilities which are both (*prosumers*) – electrolysers, gas turbines and methane gas facilities – that consumes and converts energy into storage or to a different energy carrier.

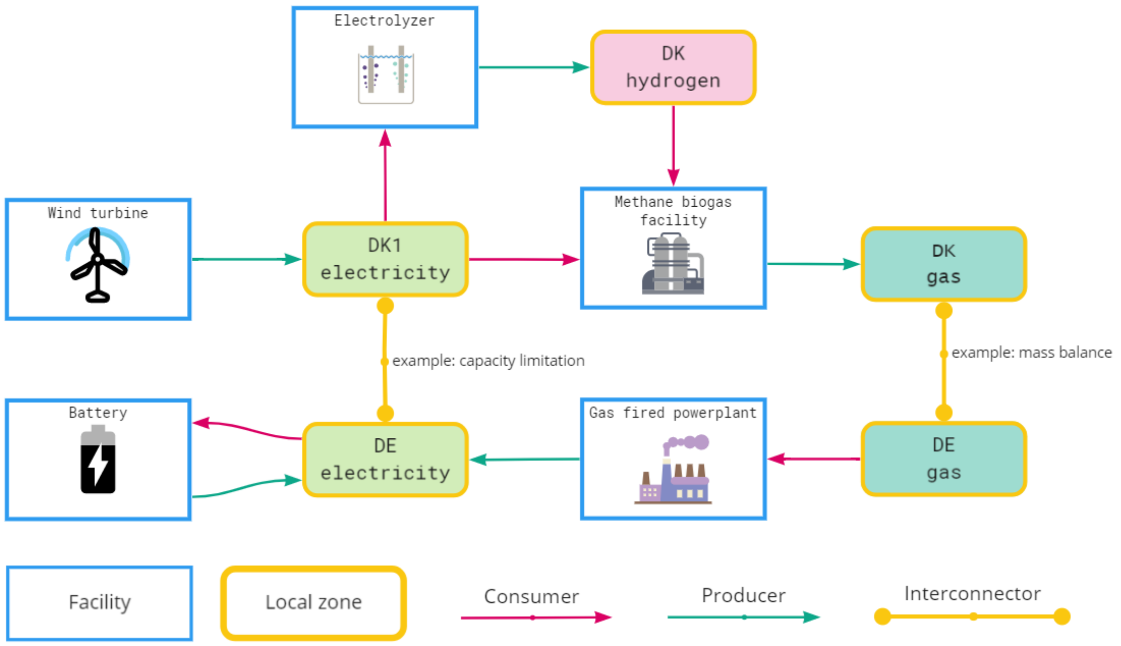

Figure 15 Interconnected local zones (yellow square line), connects producer / prosumers across energy carriers (colored squares – green electricity, blue gas and red hydrogen). Each carrier has their own infrastructure and that is reflected in the ETT network.

Generalizing the system into primitives and simplifying each concept into a core component, makes the ETT network a robust foundation for manageable infrastructure. Each concept is defined and regulated by a series of properties, thus making them susceptible to individual behaviour. The goal is to encompass current and future use cases by being able to describe a wide range of components using the same basic building blocks - named primitives in an ETT context. Concepts and primitives can be added to the definitions and topology of the ETT network and we project, minimum 1 or 2 additional concepts to enable modelling and representation of the possibilities in the energy grid. Roaming entities such as tanker ships, electric cars, trucks any entity that can hold and transport energy from one energy carrier to another or has the capacity to store it for later use within the grid at a later time.

Local Zone

A local zone is a geographical or technical area for which we adopt the definition from the electricity market bidding zone definition, meaning it has no internal bottlenecks or limitations hence it is analogous to a copper plate.

Figure 16 A local zone is a bidding zone as known from the energy markets – each local zone is considered a copper plate where consumption and production certificates can be claimed with no restrictions than temporal and geographical matching.

Current bidding zones will be used as local zones, the ETT network is not limited to this convention, it improves understanding and is an appropriation to the current bidding zone scheme of the electricity markets as opposed the GO system based on country borders. A bidding zone can consist of a sub-set of local zones. Local zones are exclusively defined for a single type of energy carrier and can be connected to other local zones of the same energy carrier type using interconnectors.

A local zone can for instance be a local energy community (13)or co-location zone/landing zone (14) or other behind the meter set-up wanting to sell their excess of RES to other consumers.

Interconnector

An interconnector ties two bidding zones together and enables claiming of granular certificates across local zones and across prizing zones as cross border trades. They represent an actual connection that enables transfer of energy, whether it is between bidding zones or multiple local zones. Interconnectors can be subject to limitations at specific times to reflect the physical grid, such as its direction of flow, available capacity, as defined in RFNBO (10). Different models have been discussed to reflect cross pricing zone bottlenecks as described in the Geographical matching section.

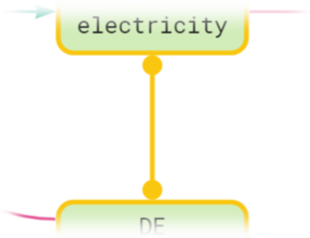

Figure 17 The interconnector is an abstraction of the underlying physical infrastructure. Each has a global identifier along with a topology that governs transactions on certificates across the interconnector..

Interconnectors connect exactly two zones of the same energy-carrier. Each interconnector has a globally unique identifier along with a topology, set of rules governing the transferring of certificates at any given time. The interconnectors in the ETT network are known to all participants in the federated network which allows clients to make well-informed, intelligent decisions and provides for applying a rule-based topology when claiming certificates across zones.

Metering point

The concept of a metering point (MP) is at the core of the platform – it is the information source that the platform rely upon. A MP can be one of two types, a production (ingress) or consumption (egress) point. For electricity, this means it either supplies energy into an energy carrier grid or consumes energy. A single physical meter which both uses and produces energy, could be modelled as two MP in the ETT network. The logic is that a single facility can both deliver and consume energy within the same settlement period, and depending on the local legislation, either the sum or both MP readings are required. Two MP are needed for prosumers, summing the production and consumption MP in a discrete time interval, prior to sending passing the information to the issuer in the ETT network. Each MP is connected to a single local zone and is tied to a single facility to avoid double counting.

Facility

Facilities are consumers or producers of energy, or both, prosumers. They consist of one or more metering points that each measure either production or consumption from a local zone. A prosumer (a facility that both produces and consumes energy) consists of at least two metering points: one for measuring production output, and one for consumption input. A facility consists of one or more MP and can be connected to different local zones and energy carriers.

Figure 18 A facility can have multiple metering points and act as producer, consumer and even prosumer in a single time interval. A facility can be connected to different local zones

The facility becomes an abstract of the total MP available and can consume and transform energy between local zones and energy carriers. Simple facilities like a solar farm can consist of a single metering point which produces electricity to a local-zone. Energy storage can be modelled as two metering points: one for production and one for consumption. Power-to-X facilities will be more complex and consist of multiple MP from different local-zones with different energy carriers.

Roles and actors

Each role is associated with a set of responsibilities and limitations within the network for the purpose of distribution of responsibility and ensuring trust and transparency between its participants. Implementing the ETT system there is certain requirements, concepts and a set of roles / actors / agents that must be defined by responsibility, authority, and limitations.

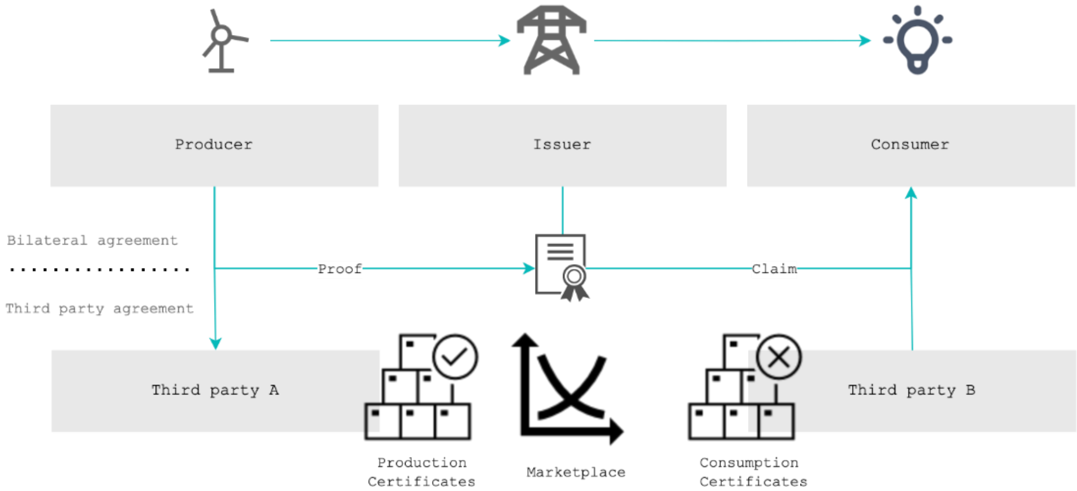

Figure 19 Due to the amount of certificates being issued, there is a need for third party API access for business to provide services in the ETT network i.e. A marketplace for bulk trading of certificates. Each role is associated with a set of responsibilities and limitations within the network for the purpose of distribution of responsibility and ensuring trust and transparency between participants.

Issuer

The issuer is an organization responsible for issuing granular certificates based on verified meter readings. An issuer can be any organization who have been delegated the responsibility by, for instance, local authorities, governing bodies, or approved by the Metering Point Operator (MPO), Distribution System Operator (DSO), Transmission System Operator (TSO) in an agreement. The Issuer of GCs have authority to issue and withdraw Granular Certificates.

Measurement Body

The measurement body is responsible for collecting readings from meters of its customers. It is also responsible for verifying the collected readings – just as the current modus operandi where readings are the foundation of billing the data can be used as a basis of issuance of GCs. The measurement body distributes its readings to the appropriate issuer that subsequently issues certificates. Any inconsistencies with meter readings post-handover to the issuer, the measurement body can request a recall and have the issuer withdraw the certificates in circulation for readings that are deemed faulty. This quality control mechanism is in place to both ensure data trustworthiness and tackle inevitable errors in the network.

Meter owner

The meter owner has ownership of one or more metering points and will typically be a customer at the measurement body. Identity and authenticity are verified by the measurement body as per billing onboarding procedure, and the KYC required is already established and in place. Readings from meters associated with the meter owner, acts as a basis for issuance of new certificates on their behalf, by the issuer. Upon issuance the meter owner receives the issued certificates on their associated account and becomes the exclusive owner of newly issued certificates.

Auditor

The auditor's role is to ensure compliance, legitimacy, and validity of the claims made by consumers in the ETT network. The auditor can inspect and validate GCs and actors in the network to ensure validity of issued certificates and that issuers are free of material misstatements, whether due to fraud or error. Auditors may also be engaged to perform other agreed-upon procedures. The auditor role also acts as a health inspector and quality control manager for the individual instances – reporting their health status to the network for availability and assurance of consistency in the deployed data structure. The auditor does not need to be an individual, an automated service mechanism, an auditory bot as well as an audit team can be validating any of the instances in the network – by signing of their audits and reports, a multitude of solutions can be applied in practice.

Third-party service providers

The responsibility of the Energy Track and Trace project is to provide a documentation, governance and certification infrastructure for energy carriers to deploy instances in the ETT network as a service to their customers, be it suppliers or end-costumers, not to provide trading and commerce mechanisms but delivery of the underlying asset - energy of a specific source using GCs. The system must be able to support use-cases essential to marketplaces, brokers, and the like, as these would provide the essential services and liquidity necessary for an operational and optimally functioning infrastructure.

The importance of third-party services cannot be understated for the smooth functioning of an underlying marketplace to the ETT network documentation layer. The cooperation and collaboration with third parties provides smooth customer journeys, brokers and marketplaces, liquidity, and facilitate payment layers on delivery of claims and transfer of certificates. Third-party services gain access to the ETT network through an API, either using their own identity or on behalf of other actors in the network, typically its users (meter owners).

Scale, Trust and Governance

It is of utmost necessity to deliver an infrastructure with the ability to scale to meet the current and future demands of participants, coupling disparate grid and operator models into a governable, operational it-infrastructure. Describing how trust and governance is enforced locally and, on a system, wide level in the ETT network is discussed in the following section.

Federated network

The choice of infrastructure, design, and architecture as a distributed, federated network - in contrast to a single centralized system have a technological, infrastructure, and legislative basis. It allows the flexibility to define a set of streamlined rules, a topology, based on agreed-upon standards and policies, while also allowing participants in the network to enforce local rules and regulations. This common topology is applied via predefined protocols, interfaces, and data formats, with local rules and regulations can be applied via customized implementation by each issuer and instance owner in the ETT network.

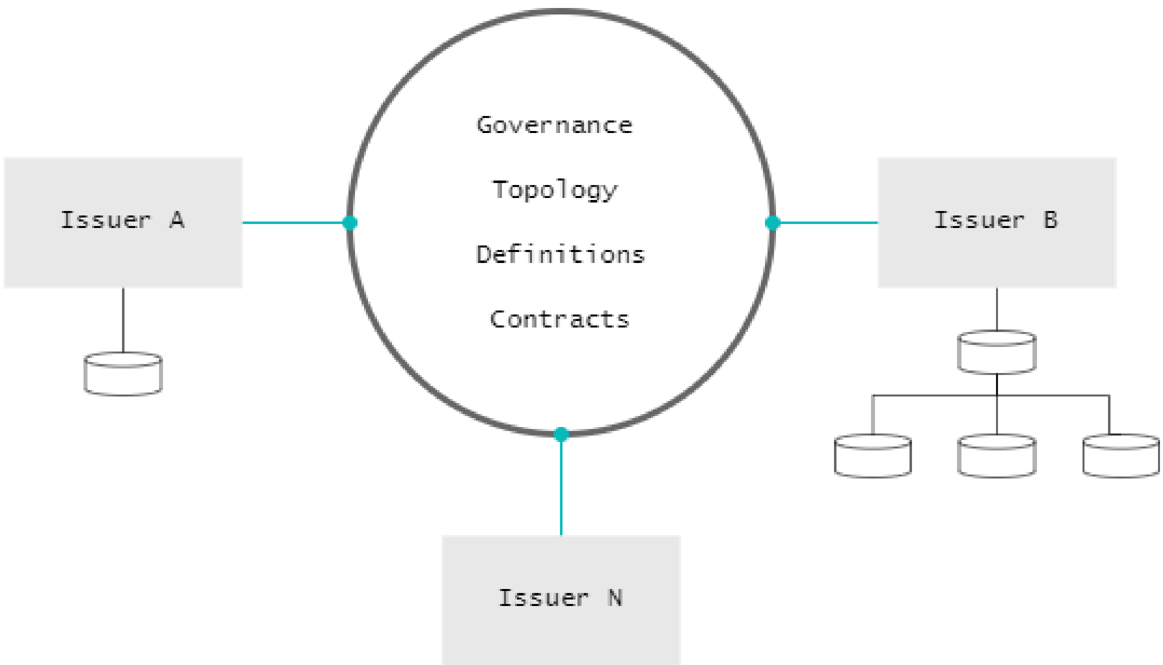

Figure 20 The federated network is governed by participating issuers, where the network topology, definitions and contracts are subject for changes and updates by voting.

This model enables interoperability and transparency between organizations in the network and provides a consistent user experience for clients engaged across multiple organizations, while still supporting autonomy for organizations in the network. It also allows organizations to join and leave the network at any time, resulting in a faster time-to-market overall for the Energy Track and Trace participants, and allows for wider and easier adoption as the system is designed with loose coupling in mind to facilitate widely different working infrastructures and states of digitization.

Governance

Governance of the ETT network is an ongoing process of decision making, where proposals to changes of the operational model, the topology and ruleset, the definitions and the contracts available to participants. It is governed by the issuing bodies in collaboration that can vote on proposals for changes in the network and append or change the rules governing the network. Each issuer signs a participatory contract when onboarded onto the network, acknowledging the current ruleset in the network – and is subsequently delegated voting rights and access to the network in return. Giving all issuers the ability to vote on contracts in the ETT network, makes for application of a dynamic set of rules dependent on consensus of the participating issuers. By using digital contracts for decision making, it opens for a wide range of management tools from changing definitions, voting on membership, voting on updates and development decisions. The network thus supports and enforces its own set of rules – and facilitates issuers can have their own topology / ruleset in each of their own instances of the network. Governance becomes flexible for the individual issuer and general for the ETT network at large is a technical feat and makes for a highly flexible infrastructure that can adapt to issuer's wildly different infrastructure and decencies by maintaining loose coupling between governance and certification infrastructure.

Adaptability and mitigating double counting between declaration practices

To ensure that the system can be integrated into existing infrastructure and facilitate adoption to the ETT network, there are considerations and mitigations that needs to be addressed and handled in the design of the system. Compliance with the current legislation and solutions such as the existing Guarantee of Origin scheme defined in the European Directive 2009/28/EC (12), is facilitated by adopting the certificate design and logic from AIB (9) and applying the working solution on a lower time resolution as described in the Granular Certificates section. A choice of a federated network system and not a centralized solution a set of challenges must be addressed in regard to business logic, the technological stack and the infrastructure required for the ETT network to operational and functional.

Integration between Granular Certificates (GCs) and Guarantees of Origin (GOs) is an obvious example of adoption into the existing infrastructure in place to certify energy consumption and avoid double counting. There will however be multiple ways of declaring emissions and energy origins, which will be difficult to integrate. One solution could be to enable integration between authoritative datasets e.g., providing energy mix data per bidding area or country with GC and GO mix subtracted. This issue however is not part of the ETT initiative as is.

It is the intention to build an open infrastructure that can adapt to the future technologies being brought to market by loosely couple the ETT network between governance – and the infrastructure deployed in each bidding zone. Appropriating solutions that have fewer dependencies – gives a higher degree of freedom to the developers of network infrastructure, leaving room for innovation and improvement.

Appropriation

The choice of loose coupling between the Issuers in the network and the underlying implementation makes for adaptability in choice of technology stack and gives a wider range of choice to the individual participants in the ETT network. There are current and future changes in the available technologies and through loose coupling it will be easier for issuers to change their underlying stack as they deem fit and appropriate. Catering for flexibility will make appropriation and integration easier for participants and will give approved participants a say in the governing of the network. This perspective is of importance to the ETT working group because without participation of additional organizations, infrastructure providers and third parties the project will not be able to achieve the goal as a working solution for Europe, that has very different energy infrastructures in place at the time of writing.

Trust

Trust is the foundation of all meaningful interactions in a documentation framework as ETT, without it there is no incentive to engage with other participants. Trust can be achieved in variety of ways – through legislation and contracts or through technology stacks such as Distributed Ledger Technologies (DLT) that shares state across participants. ETT proposes using DLT technologies and is actively searching, prototyping and testing possible infrastructures for this end. There is a requirement for high throughput of messages between parties due to the market resolution requirements for hourly certification. This cannot be achieved currently through existing DLT solutions, microservice architectures can accommodate the throughput necessary for hourly certification. Combining technologies under a standard topology, definition and contract can be defined by shared ledger for the ETT network. The shared ledger – acts as a record of governance decisions such as: approval of new members, voting on changes to the topology, changing of definitions and governance through proposals, discussions and voting by legible members. A messaging layer between members using hi-throughput message microservices for the certification layer of the ETT network.

Settlement

In addition to a trusted record of decisions and shared ledger of the current state of the topology, definitions governing decisions. There is a need for a mechanism to validate all issuers internal data structure on a market resolution level and sharing it with the ETT network on a shared ledger or immutable record. An illustrated example of such a mechanism is an hourly health check in / hashing of all changes in the underlying dataset for each issuer. To validate and assure the consistency of their datasets and provide proof to other participants in the network, that their respective datasets are sound and coherent. Such proof could be a prerequisite for accepting cross-border trades and publication of current production of RES in each respective grid. Designing and implementing such a solution gives participants incentivizes appropriate handling of internal data operations by default by applying rigorous, coherent, and compliant on a market resolution level not just on occasional audits. Being able to proof to other participants the internal soundness of data, is a matter of trust in other participants and acts as health check. Settlement of trust thus becomes a prerequisite to settlement of GCs across instances in the ETT network. Hence the ledger itself is providing a publishable trust anchor for all participants and acts as a green light for subsequent settlements across instances. Another requirement of publishing the hourly amount of production certificates available within each pricing zone and validating it using shared hash, a dataset of a tally of total production for each issuer in the network would provide live insights into the RES accounted for in the ETT network.

Conclusion

The ETT working group is a novel endeavor – it is breaking new ground by application of technological infrastructure, having an open-source approach to ensure transparency, using Distributed Ledger Technology for trust in the energy sector and by working across TSO/DSO boundaries in a combined effort to facilitate the infrastructure necessary to accelerate the green transition in Europe.

This paper has established terminology and a conceptual foundation for the current and future work in the ETT working group. Considerations about Granular Certificates, actors, validation mechanisms, trust, proofs, and infrastructure have been elaborated in this paper. There is a multitude of initiatives underway in the energy sector and Energy Track and Trace is one of them – the focus for this working group is to facilitate market resolution certification of energy as infrastructure. ETT is a documentation layer that is appended to the existing infrastructure converting the current residual mix into a plethora of different energy sources. The certification is on a market resolution level and will require third-parties to engage and handle the complexity of settling energy consumption on an hourly basis. Bringing awareness about our individual emissions and environmental impact by having a certification system that reflects the underlying physical reality of the energy grid – is a necessary tool to bring awareness to the energy we consume daily – directly or through the products we consume. Creating the insight and incentive to choose energy sources, store excess energy in times of abundance and supplying it in times of scarcity will be a way to balance the increasing amount RES in the grid and that requires a documentation system that is close to the physical reality of the energy grid.

The Energy Track and Trace endeavor is underway – it is a work in progress, and we encourage the reader to get involved if they feel inclined to do so. There will be future conferences, publications, and open-source contributions, in the coming year see the Contact information section for further information. But first and foremost, we will thank you the reader for your time and hope that this paper has given food for thought and insight into the Energy Track and Trace initiative.

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Contact information

Additional information about Energy Track and Trace can be found at **energytrackandtrace.com** .
We are open for collaboration and engaging and developing the implementation with additional TSO/DSO and service providers and with possible users of the proposed certification scheme.

We are as a working group committed to an open process and engaging with stakeholders from industry to develop the infrastructure necessary to facilitate the green transition through engagement and delivery of working solutions.

Feel free to reach out and engage with the us at Energy Track and Trace or follow the open-source repository at **github.com/Energy-Track-and-Trace**.

Contact

Estonia
Elering
Kadri-Liis Rehtla | **P** +372 5348 2948 | **Kadri-Liis.Rehtla@elering.ee**

Belgium and Germany
Elia Group
Michaël Piron | **P** +32 2 546 76 68 | **Michael.Piron@elia.be**

Denmark
Energinet
Morten Houborg Andersen | **P** +45 20 36 53 34 | **MHU@energinet.dk**