Technical support for RES policy development and implementation. Establishing technical requirements & facilitating the standardisation process for guarantees of origin on the basis of Dir (EU) 2018/2001

Task 3
Developing IT Systems Specification

Task 3.1
Develop a Vision for the Future IT Infrastructure

FaStGO
Facilitating Standards for Guarantees of Origin

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1. Framework

1.1. FaStGO

The FaStGO project has the objective of providing expert advice to the European Commission DG ENER, based on the terms of Reference N° ENER/C1/2019-517: "Technical support for RES policy development & implementation. Establishing technical requirements and facilitating the standardisation process for guarantees of origin on basis of Dir (EU) 2018/2001."

1.2. What and why

Taking into account the legislative frameworks, the operational experiences of the current system, and the additional requirements based on a revised EN 16325, FaStGO task 3 develops the design requirements for an IT systems infrastructure that enables reliable and efficient cross border exchange of GOs.

For enhancing efficient and reliable cross border-trade of guarantees of origin, IT systems have proven to play a central role. This FaStGO task 3.1 will elaborate on whether and how certification for different energy carriers set different requirements to such IT system. It incorporates the key findings and results from tasks 1 and 2 as well as develops a vision for the future IT infrastructure for all energy carriers.

The vision will be further developed into a data protocol and a high-level requirements specification in the other task 3 reports.

Glossary

GO	A guarantee of origin in the meaning of article 19 of REDII
REDII	The Renewable Energy Directive 2018/2001/EU
RES	Renewable energy sources

2. Executive summary

2.1. The objective of this document

This document seeks to advise member states on the architecture of an IT systems infrastructure which supports the features of a guarantee of origin (GO) system as proposed by the Renewable Energy Directive 2018/2001/EC (REDII). This architecture enables the national creation and use of guarantees of origin and enable international transfer and trade in GOs, in order to prove to consumers the source of their energy and to prevent double counting, while supporting data analysis.

2.2. Methodology

In doing so, it considers the alternatives and develops a vision for a suitable framework for the European infrastructure for administering GOs. It compares the alternatives, being:

- A peer-to-peer network, in which each registry has a separate linkage to each other registry;
- A distributed ledger approach, enabling direct transfer of GOs between account holders (also known as blockchain technology);
- A single central registry for all energy carriers and all member states;
- Multiple hubs for individual energy carriers & national registries for each member state, and for the same or different energy carriers in each member state;
- A single hub allowing GOs for all energy carriers to be transferred between the national registries for each member state;
- A mix of central & national registries; and
- A hybrid of the above, which might include the option for each member state to participate in a central facility which manages certain functions collectively for all participating member states, while keeping other functions at a national level.

It investigates the collection of the raw data upon which a GO is based, the collection of transaction information, how cancellation data might be made available to Competent Bodies, and the way in which the requirements of multinationals might be facilitated.

It builds upon the outputs and deliverables from task 1.3; the knowledge, expertise and opinions of relevant stakeholders (including the AIB, ERGaR, Grexel and CertifHy), which have experience as GO scheme owners, GO issuers and a long-standing GO registry provider; RECS International (having collected the experiences of the market participants over two decades); and seeks to align where possible with the intermediate findings of the REGATRACE project concerning the design requirements for cross-border trade of gas GOs.

This document acknowledges that developing a vision for an IT infrastructure first requires clarity on the allocation of roles and responsibilities and subsequently on the business processes for GO system management. The IT infrastructure supports these as a system enabler and is not a goal in itself.

2.3. Main findings

A peer-to-peer approach for cross-border transfer of GOs between individual national registries was rejected, given the technical and administrative complexity of connecting together upwards to 40 registries, and the need for central coordination to support a well-running, fraud-resistant and secure market.

Blockchain provides a technological solution which facilitates a market system that is organised without central authority. It may be appropriate in some circumstance, however the current regulation on GOs and allocation of roles and responsibilities in Europe does not seem to benefit from distributed ledgers. Therefore, blockchain cannot be recommended as a replacement for the current centralised IT structure and way in which trust is facilitated in the GO domain, because of a number of remaining open questions, and in particular due to the required fundamental organisational and regulatory changes.

Whilst partly (or fully) centralising the architecture would standardise interpretation of EU legislation, and in particular REDII, it would also introduce potential barriers to the ability of member states to implement REDII as they wish. **The decision whether or not to centralise is therefore one of whether the benefits of standardisation outweigh those of flexibility.**

Here it becomes particularly relevant to consider the processes that particularly benefit from standardisation across borders. There is no doubt that cross-border transfer of GOs has proven to be the main process that essentially needs a standardised approach and benefits from central coordination. A central facility (hub) which facilitates quality control on cross-border transfer processes has been proven to enhance efficiency and reliability.

Besides cross-border transfer, there are other activities in the operation of a GO system that may benefit from harmonisation and/or centralisation. A central approach can e.g. simplify the process of converting GOs for different energy carriers and so facilitate sector coupling, provided the differences between other aspects of national energy systems do not act against this. The benefits of there being a single registry for handling all guarantees of origin in Europe are that:

- collective purchasing, development and operation of registry systems can reduce an individual member state’s effort and therefore cost;
- multinational account holders will benefit from reduced administrative burdens associated with having to hold multiple accounts;
- there is likely to be positive impact on efficiency, speed, and accuracy of transfers;
- it would increase the opportunity for detecting VAT fraud; and
- linkages account holder and market facilitator systems would be simplified.

On the other hand, a single registry-participating member state that wishes to develop new IT facilities may find itself hampered in doing so by lack of support from other member states. The effort and complexity of administration of a central facility on behalf of perhaps 46 countries/regions[1], each with differing design and level of coupling of their interfaces to the system, should not be underestimated. Further, as mentioned above, any central system would need to interface with national systems for energy measurement, fuel disclosure, energy settlements, support, and in some cases even licensing and other data management purposes, and these may well be quite different from each other. Given the difficulty in estimating the work needed to provide such interfaces, any attempt at estimating costs of a central registry can only be indicative.

[1] *Includes the 28 European member states, 9 contracting parties to the Energy Community, 2 members of the European Economic Area, and allowing for the 4 regions of Belgium, 3 regions of Greece and three regions of Bosnia & Herzegovina = 46 domains*

Furthermore, a centralised registry to supporting all competent bodies for managing guarantees of origin is not applicable unless a future agency is created to provide such support. This would require support by all member states, and issuance of an appropriate regulation by the Commission – which is likely to take considerable time. Furthermore, member states have made significant investment in their own GO systems, and in particular the IT infrastructure to support it, and will be unwilling to move to a more centralised approach until there has been an acceptable return on this investment.

It is our understanding that member states wish to retain at least some aspects of GO systems at a local level. For example, the creation of the datasets for each GO, which will probably draw on data received from other national systems such as meter data, plant data, support information and so on. Therefore, a 'hub' that facilitates a one-to-many connection between the registries of the different countries is recommended as an optimal solution in the current legislative structure.

There little justification for developing competing hubs, or having separate hubs for each energy carrier, given the difficulties in tracking chain-of-custody, energy carrier conversion, cost-efficient data and transfer management at country level and overall at pan-European level, coordinating change, ensuring security, and detecting and preventing fraud.

A hub-centric system will allow member states to decide for themselves the features of the registry architecture that they feel should be centralised, and which should remain implemented at a national level. A one-to-many connection efficiently facilitates harmonised cross-border transfer while maintaining e.g. production device registration and meter collection at national control.

A collaborative approach should be adopted, whereby each competent body creates and operates a registry for GO issuing in its own domain and cooperate in the facilitation of inter-registry transfers and overall administration and supervision of the international aspects of GO systems. Such an approach is the most flexible, pragmatic and cost-effective – not just for the development and operation of IT systems, but also for the purposes of coordinating and gaining the agreement of competent bodies to the definition and implementation of changes to the system. Indeed, this approach was adopted and has been implemented by the AIB since 2001, and its value has been confirmed by the continuous joining of issuing bodies to the association up to 29 participating issuing bodies mid-2020. In this system, besides cross border transfer, over the years there has been gradual centralisation of additional activity, like registration of account holders, collection of statistical data, VAT fraud detection monitoring, quality control (technical audit).

Over time, with the collective support and participation of competent bodies for guarantees of origin and disclosure in each participating country, some features of the overall system could be centralised, where member states decide it is worth their time and effort. These might include such features as 'conversion' of GOs for one energy carrier into GOs for another energy carrier, to assist in VAT fraud detection, and enabling multinational consumers to cancel GOs for use in a number of countries without the need to manage accounts in each country. This principle of an evolutionary approach is broadly supported, as has been demonstrated by the consultation of stakeholders over summer, a recent AIB members opinion, and a recent REGATRACE project report[2].

This means that, unless at some future date a centralised approach is adopted by all member states, then each member state will remain free to manage its GO system(s) in

[2] *REGATRACE Report D2.4: "Investigative study of IT system options for harmonized European cross border title-transfer of biomethane/renewable gas certificates"- https://www.regatrace.eu/work-packages/wp2-european-biomethane-renewable-gases-goo-system/*

whatever way it wishes, subject to agreement of a set of rules for collaboration in the international aspects of GO systems.

Proceeding in this manner would offer the EU Commission and other institutions adequate time to consider whether the body supervising the hub should have formal status, in order to overcome the financial and legal objections inherent in providing such a service; and to make the necessary arrangements for doing so should the outcome of such a decision be positive. The level of success and the quality of the spontaneous harmonisation organised bottom-up between the member states themselves may be a driving element in such a decision.

Summary

The conclusions of FaStGO are that an evolutionary approach to system architecture is the most appropriate, whereby some facilities are provided centrally to all member states, other facilities are provided to those member states that require them, while those features that are specifically national in nature are kept at a local level. It is recommended that the central facilities themselves are reconsidered and revised on a regular basis as the market matures, and in line with changes to the design, regulation, and operation of the energy market.

Experience in this and other markets has shown that some degree of centralisation is appropriate, provided this is beneficial to all member states and to market parties alike and that it can be justified comprehensively. However, a national capability should be retained to address issues that are national by nature, such as the extraction and processing of data from other systems.

The following figure illustrates the elements for gradual consideration of centralisation under the evolutionary approach, for which it is recommended that consensus of the participating issuing bodies is the driving force in the decision whether or not to organise a specific responsibility at central level.

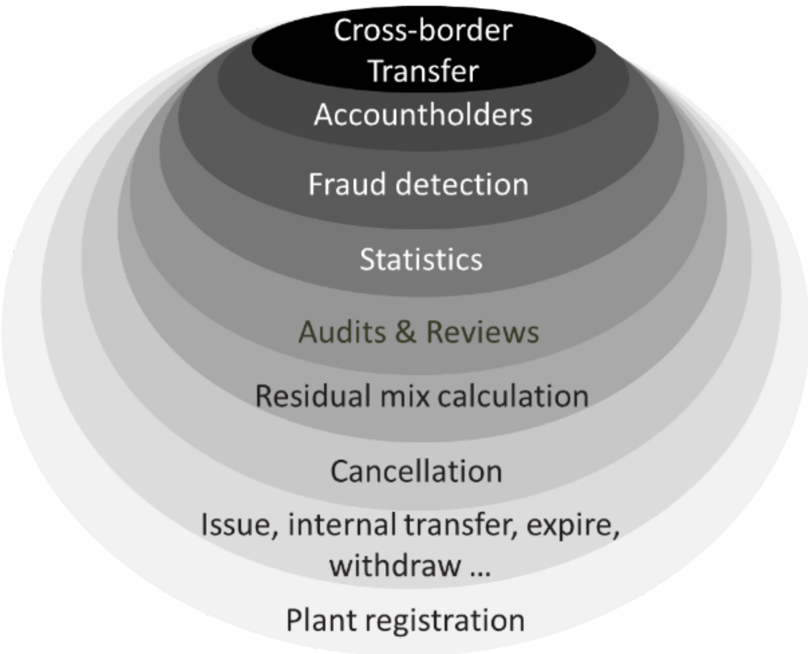


Figure 1: An evolutionary approach to the ongoing development of the IT infrastructure for guarantees of origin, with the consensual support of the issuing bodies [NB: Apart from the technical (IT-) audits, Domain GO scheme audits and reviews of Domain Protocols are not intrinsically part of an IT architecture, but they are mentioned here as they are an essential central facility]

3. Introduction

3.1. Managing title transfer of guarantees of origin

Guarantees of Origin (GOs) are electronic documents which are recorded in an electronic registry (database).

Each GO resides in a registry account associated with the account holder.

Within a registry, ownership of a GO can be transferred between account holders according to the protocol of that registry.

For cross-border transfers of GO ownership, it is relevant to consider the system infrastructure.

3.2. History: The development of the existing GO infrastructure

The Dutch *Groenlabelsystem* of 1998-2000 employed a systems architecture whereby each distribution systems operator (DSO) formed an "issuing body" to issue certificates for renewable electricity produced in their region, sending the data to a "central monitoring office" that monitored trade in such certificates, and their usage. These issuing bodies simply created the information which the central monitoring office converted into a transferrable – and thereby tradable – commodity, monitoring change of ownership and realisation of value upon usage – or "redemption".[3]

However, this system was national in scope and did not address some of the system fundamentals such as expiry of the certificate and disclosure of the source of energy. Nor did it attempt to address the complexities of international trade, and for this the Renewable Energy Certificate System - RECS - Test Phase was conceived in 1999 as a pilot of the concept.

The RECS Test Phase was the world's first international voluntary renewable energy certificate transfer mechanism, and the Association of Issuing Bodies – the AIB - and RECS International were founded in 2002 as a result. The AIB represents the administrators of certificate systems; while RECS International represents the market parties - being traders, brokers, exchanges, producers, and consumers.

The RECS transfer system went live soon after the first registries (the registry shared by the Nordic countries and the Dutch registry) emerged in 2001. The transfer mechanism defined the principles and rules of operation for transfer between registries of energy certificates. These registries were organised at national, international, or regional level, depending on the countries and organisations involved. Initially, the transfer of GOs was supported by a data protocol for moving XML files over secured emails from one registry to another. However, as the number of registries grew, managing peer-to-peer connections became too complex, due to the need for each registry to test its interconnection with other registries every time they amended their software; and, due to differences in technology, the need to connect to every other registry in a different manner.

As a result of a call for efficiency and reduction of manual handling of the growing number of cross-border transfers, the first interconnector hub was piloted in 2007 by the AIB. This meant that a single point of connection to the registry network was introduced, such that a 'plug-and-play' connection became possible: only one interconnection protocol was

[3] See https://publicaties.ecn.nl/PdfFetch.aspx?nr=ECN-C--02-049 for a description of the "RECS test phase". In particular, pages 95-108 contain an early version of EN16325 and the European Energy Certificate System – EECS – known as "the Basic Commitment". This was a development of the original "Basic Commitment", describing the fundamentals of the system, and conceived by Peter Niermeijer (then of EnergieNed) and Jos Benner (then of CEA).

required. This insulated each member of the AIB from differences in the technical details of each other's registry, and of national practice.

Since its introduction, the Hub has been rebuilt twice: first in 2011, to provide a more robust framework for further development; and again in 2016, to improve system security and provide additional features such as a registry of all national registry account holders, the provision of enhanced monitoring facilities, and facilities to collect and analyse market activity statistics.

The Hub remains a software application that enables certificates to be transferred between national registries in a standardised and secure way, from an account holder in one registry to an account holder in another registry. The sale and purchase of these certificates is totally separate from their transfer and is mostly carried out by over-the counter (OTC) trades between market parties, sometimes with the assistance of brokers and other market facilitators.

The reasons for the current architecture were partly the result of the organic development of the system's architecture, and partly due to member countries needing to:

1. Exercise direct control over the build, support, and operation of their own registries, and encourage competition in software development at a national level;
2. Keep investment in software development and operation within their own national boundaries;
3. Integrate their systems directly with:
    a. data collection services - e.g. for meter reading and settlements; and
    b. renewable energy support and energy taxation systems;
4. Set their own rules for operating an energy certificate system, in a way which offers national flexibility, coordinates with national support mechanisms, and reflects national policy initiatives.

The question now is whether to stay with this architecture or to move to one which is partly or fully centralised at European level.

Furthermore, the system needs to consider how to accommodate certificates for multiple energy carriers; and how to address the possibility that these certificates might serve multiple purposes.

3.3. Relevant existing and upcoming IT infrastructure

3.3.1. AIB

The AIB has 20 years' experience of operating integrated EU-wide certificate schemes for electricity, facilitating standardised cross-border transfer of energy origin tracking certificates, making use of a central one-to-many IT Hub connected with each of the national electronic registries where certificates are held on the accounts of their owners. Cross-border transfer over the Hub has mainly been used for disclosing to consumers the origin of electricity by means of guarantees of origin. This is in line with the relevant European renewable energy directives (2001/77/EU art. 5, 2009/28/EU art. 15 and 2018/2001/EU art. 19), and the voluntary tracking systems which acted as their predecessors. This configuration enabled automated multi-volume processing of cross-border transfers between 25 countries and regions, enhancing a lively market in guarantees of origin (>600 million GOs transferred internationally in 2019).

The operational rules for registries connecting to this IT hub are set out in a subsidiary document "EECS Registration Databases"[4], to the EECS Rules, also known as "HubCom".

3.3.2. ERGaR

The European Renewable Gas Registry (ERGaR) is a European association born from the cooperation between national renewable gas registries in Europe, which have been doing international transfers of biomethane certificates since 2015 through bilateral agreements. It benefits from the experience of its members to create an independent, transparent, and trustworthy documentation scheme for mass balancing of biomethane and other renewable gases distributed along the European gas network, while preventing double sale and counting. It proposes to use a central Hub for certificate transfers, based on a voluntary mass balancing scheme[5] and a book & claim scheme to which national registries will be able to connect in order to transfer certificates among them.

3.3.3. EU-ETS

The legal basis for providing a common registry for EU ETS is the Commission Delegated Regulation (EU) 2019/1122.

The European Union's Emission Trading System (EU-ETS) Registry was established pursuant to Directive 2003/87/EC, which has been amended several times since 2003.

The registry is an online database which ensures the meticulous accounting of emission allowances issued within the EU but can also contain carbon credits. The registry keeps track of the ownership of these allowances and credits, which can only be held in electronic accounts in the registry. Each EU member state manages its own separate section of the EU ETS Registry. The main purpose of the EU ETS Registry is to keep an account of stationary installations (transferred from the national registries used before 2012) and aircraft operators covered by the EU ETS Directive since January 2012.

The Registry records:

- National implementation measures (a list of installations covered by the ETS Directive in each EU country and any free allocation to each of those installations in the period 2013-2020);
- Accounts of companies or individuals holding such allowances;
- Transfers of allowances ("transactions") performed by account holders;
- Annual verified CO2 emissions from installations and aircraft operators; and
- Annual reconciliation of allowances and verified emissions, where each company must have surrendered enough allowances to cover all its verified emissions.

The European Union Transaction Log (EUTL) automatically checks, records, and authorises all transactions between accounts in the Union Registry. This ensures that all transfers comply with EU ETS rules. The EUTL is the successor of the Community Independent Transaction Log, which had a similar role before the Union Registry was introduced.

The EU ETS Registry is technically operated by the European Commission, which places the registry at the disposal of the member states. Further details about the EU ETS Registry are available on the European Commission's website.

Initially, EU ETS reflected the Kyoto system (whereby each state had its own registry and connected to a central registry) and was supported by national registries coordinated under an Independent Transaction Log (CITL). There followed a period of "learning by

[4] *The ruleset for EECS Registration Databases (HubCom) is available as EECS Subsidiary Document 03 on https://www.aib-net.org/eecs/subsidiary-documents*

[5] *The voluntary mass balancing scheme is described on the ERGaR website* at *http://www.ergar.org/mass-balance/*

doing", but after few years it was decided that this was not optimal: some countries had very secure and user-friendly registries, while others lagged behind.

Further, there were concerns relating to such matters as costs, optimisation of IT functions, functioning under the UNFCCC infrastructure and the role of Member States. In addition, there was serious criminal activity (e.g. hacking on the system, which allowed some allowances to be stolen, and VAT carouseling), which led the Commission to consider how best to amend the system to address this.

Notwithstanding the strong resistance of member states, following preparation of sound justification by the European Commission, in 2009 the principle of a Union Registry was established by legislators in the Council and the Parliament under Directive 2009/29/EC, and in 2012 EU ETS operations were centralised into a single EU registry operated by the European Commission. The Union Registry covers all countries participating in the EU ETS.

Some member states found the new system worse than their own systems. However, after the initial period the situation improved, and EU ETS works to the satisfaction of all member states.

The regulation describes the detail of how EU ETS should work as a single union registry. EU ETS is administered:

- by national administrators for each member state, who have direct contact to account applicants and account holders, and:
- by the Commission, which:
    - provides and supervises central features of the registry system and discharges its responsibilities under EU ETS legislation;
    - assists member states in executing their tasks and provides a help desk for national administrators;
    - undertakes quality assurance duties and promotes best practice;
    - manages change; and
    - chairs a quarterly round table where member states can discuss technical problems and register their preferences for (e.g.) system enhancements; and
- by a supplier of systems development and support (on a five-year contract extendable once for a further five years), at a technical level, for software maintenance.

In some cases, the national administrators have developed their own user management system to enhance the facilities provided by the EU ETS from a national perspective, providing support for 'Know your Customer' (KyC) checks and so on.

Unlike electricity and gas certificate registry systems, which link to national measurement and settlement systems (among others), the linkages between EU ETS and other national systems are limited and the only close linkage is between EU ETS and the Kyoto registry.

As a takeaway from the approach followed by DG CLIMA, any implementation of a centralised systems architecture should seek to provide all of the required functionality from the outset. This would need clear justification if it were to be accepted by member states – particularly given that most member states have already implemented at least part of their GO systems architecture. In addition, note that any move to a central architecture is likely to be irreversible: the effort involved in migrating the data back to national registry systems would not be tenable.

The drivers behind centralising the EU ETS registry, which were mostly related to fraud-resistance, may be covered by centralising specific activities in the GO system management. The extent to which quality and reliability can be ascertained in a hybrid model with partly centralised and partly nationally organised activity, is likely to be the crucial factor for maintaining the hub-centric evolutionary approach in the GO system.

3.3.4. EU Database for mass balancing biofuels

REDII sets a new target for renewable energy of 32% for the year 2030:

- a target of 14% of renewable energy consumption in the transport sector in 2030; and
- the inclusion of two new categories of fuels that can be counted towards the targets: renewable fuels of non-biological origin (e-fuels from RES electricity) and recycled carbon fuels (low carbon fuels from non-renewable sources).

Article 28 of the REDII includes provisions that require the European Commission and Member States to strengthen cooperation between national systems and between national systems and voluntary schemes and verifiers (including, where appropriate, the exchange of data), with the aim of minimising the risk of single consignments of fuels being claimed more than once in the Union. Furthermore, this article requires that the Commission sets up a Union database to enable the tracing of liquid and gaseous transport fuels that are:

- Eligible for being counted towards the target (specifically the numerator referred to in point (b) of Article 27(1) – the renewable transport target);
- Suitable for measuring compliance with renewable energy obligations; and
- Eligible for financial support for the consumption of biofuels, bioliquids and biomass fuels.

The Union database is intended to complement the existing traceability requirements for biofuels.

The so-called mass balance traceability requirements are currently verified at the economic operator level, usually in the context of independent auditing under the Commission-recognised voluntary and national schemes1.

In addition, the database is intended to facilitate cross-border trading of biomethane used in either the transport sector or in heating/cooling or electricity generation.

Member States will require economic operators to enter into the database information *inter alia* the sustainability characteristics of fuels placed on the market, including their life-cycle greenhouse gas emissions. A Member State may set up a national database that is linked to the Union database ensuring that information entered is instantly transferred between the databases. The application of the database aims to ensure that reporting of the production and use of renewable transport fuels and biomethane is consistent across the European Union (EU) and does not generate a risk of multiple counting of fuels in the EU or global markets. This is where it becomes relevant to ensure avoidance of multiple counting the attributes of those fuels by means of interplay with the GO system.

The EU Database for mass balancing biofuels, according to Article 28(2) of Directive 2018/2001/EC (RED II) is still under design and its design specifications are not yet public. However, a "Scoping Study setting technical requirements and options for union database for tracing liquid and gaseous transport fuels"[6] has been produced for the European Commission by Navigant Consulting.

The study notes that "*A number of different set-ups can be envisaged for the interaction between the Union database and Member State databases (where they exist) … the choice of which option to implement has a fundamental impact on the subsequent design of the database. The two main options we have identified are presented in Figure 3 below.*"

6 See https://op.europa.eu/en/publication-detail/-/publication/f9325197-f991-11ea-b44f-01aa75ed71a1/language-en/format-PDF/source-157051253

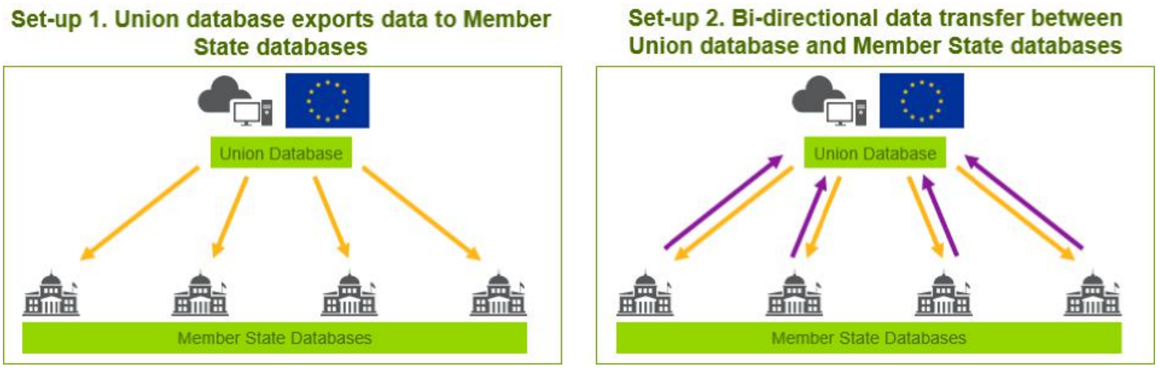


Figure 2: Interaction of Union Database with Member State databases

4. Issues for resolution

4.1. Facilitation of the market by the AIB IT infrastructure

The AIB Hub has evolved over a significant period – 13 years – and it is now opportune to consider whether the current strategy of national registries interconnected by a central hub remains optimal.

During this time, the renewable electricity GO market represented within the AIB has progressed from 16.5 million GOs issued and 5 million cancelled during the RECS test phase in 2001-2002, to 749 million issued and 659 million cancelled in 2019 – and these figures seem likely to be exceeded in 2020. At the same time, the price has progress from about 10 cents per RECS certificate in 2002 to the current price of perhaps 40c per RES GO, and a peak in 2018 of 2.10 EUR (which gave the renewable electricity GO market represented by AIB members a value during this period in excess of 1 bn EUR). The geographic scope of this market has increased from 14 countries/regions in 2002 to 29 countries/regions in 2020, with a further three having applied for membership of the AIB.

The market continues to grow, not only in terms of the geographic scope, the number of GOs issued, and the number of GOs cancelled.

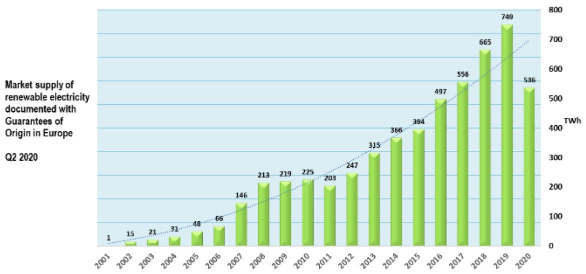


Figure 3: GOs issued - AIB, Aug 2020

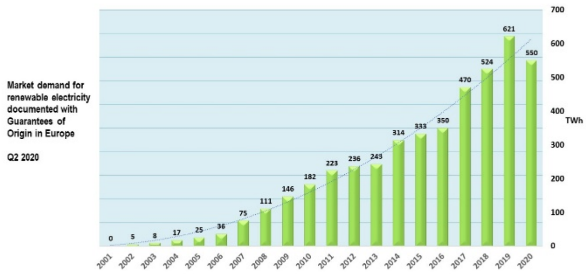


Figure 4: GOs cancelled - AIB, Aug 2020

4.2. Reasons for having a central hub connecting national registries

The reasons for the current architecture were partly the result of the organic development of the systems architecture, and partly due to member countries wishing to:

1) Exercise direct control over the build, support, and operation of their own registries, using available resources to develop software in-house at the competent body;
2) Supporting the diversity of national legislations and infrastructures, while:
   a. allowing reliable cross-border trading of GOs;
   b. integrating and/or reconciling with systems for:
      i. energy measurement;
      ii. fuel declarations;
      iii. financial settlement between market parties;
      iv. invoicing account holders for registration system usage;
      v. administration of taxation and public support;
      vi. statistical and other related reporting; and
      vii. facilitating national and international markets etc.;
   c. doing so according to national and international timelines;
   d. permitting member states to build in their own interpretations on international and national legislation and supplement functionality;
   e. protecting the confidentiality of national data; and

   f. doing so in a way which stimulates competition between software developers;

3) Integrate their systems directly with data collection services - e.g. for meter reading and settlements; and renewable energy support and energy taxation systems; and
4) Set their own rules for operating an energy certificate system, in a way which offers national flexibility, coordinates with national support mechanisms, and reflects national policy initiatives.

4.3. Strengths of the current IT architecture

The AIB registry systems architecture has developed organically over the last 20 years and have proved to be operationally efficient and effective. Its strengths should therefore be retained and, where appropriate, enhanced. These strengths include:

1) The Hub facilitates significant efficiency gains in the facilitation of multi-volume automated cross-border transfers compared to the bilateral transfer system which existed prior to the Hub concept (over 600 million GOs were transferred over the Hub in 2019.)
2) All AIB members have been involved in the design of the systems architecture over 20 years, allowing operational experience and best practice to be built into the overall concept, and fostering a strong concept of ‘ownership’ by requiring a qualified majority support of 75% for any change to the underlying EECS Rules, including the rules relating to registries and the AIB Hub (in practice, all such decisions have been unanimously supported);
3) The system is based upon a standardised certificate scheme developed to support international creation, exchange, and use of GOs, and which is again the collective intellectual property of the members, who jointly developed and maintain it;
4) The Hub concept:
   - Allows international transfers to be monitored for statistical and anti-fraud purposes and to assist in dispute resolution;
   - Provides a central point for the collection and dissemination of national information;
   - Ensures that data validation is enforced rigorously, including a sophisticated error control system; and
   - Offers an efficient way of reacting to the challenges imposed by change of membership, and of the amendment of individual registry software;
   - Avoids certificates being duplicated during transfer by means of a proven transfer protocol, handshaking procedure and transaction monitoring system.
5) Full responsibility for transfer operations lies at Member State level (along with legal responsibility);
6) There is a recognised, effective, and secure protocol for the transfer of certificates between member registries;
7) National registry systems are carefully integrated with other national systems for energy measurement, fuel declaration, energy settlements and so on;
8) The architecture supports effective local integration with national data management systems for purposes other than administration of GOs, such as meter data collection, support, and production device registration systems;

9) The management methodology ensures that any proposals for system change are considered carefully to identify and overcome potential effects on member registries and only implemented with the full support of members, and to agreed timescales.

4.4. Challenges

4.4.1. Recognition of member state subsidiarity

One of the biggest challenges is that any systems architecture must recognise and support the different implementations of REDII by member states, which can and do implement REDII in different ways – some obvious, and some more subtle. For instance, some member states have instituted auctions of GOs, while others do not issue GOs for supported energy. Also, some competent bodies take direct responsibility for all aspects of certificate systems, while others delegate this to experts such as registry operators and production device registrars. This can result in differing national regulatory frameworks, which directly impacts GO registries.

Registry operators fulfil this task as a public service obligation, fulfilling national governmental legislation, including general administrative laws such as those relating to language requirements and confidentiality of information). Again, while these are governed by and comply with European legislation, they can be and often are applied quite different in each member state.

Hence, any system architecture must support variations in national practice and in implementation of REDII according to national legislation, meaning that a common approach may not be possible for some aspects of REDII.

While centralising the architecture would promote a standardised approach to interpretation of EU legislation, it would also introduce potential barriers to the ability of member states to implement REDII as they wish, as any member state wishing to address REDII in a way which differs from other member states would need to agree this with the central coordinator and with other member states. Such arguments will need to consider the impact any national derogation from the common approach on national supporting systems (e.g. energy measurement), as the impact of such derogation – or lack of it - may be far reaching. The decision whether or not to centralise is therefore one of whether the benefits of standardisation outweigh those of flexibility.

4.4.2. Further increasing the system efficiency

The question now is whether to stay with this hub-centric architecture or to move to one which is partly or fully centralised.

The main challenges are:

1) To retain acceptable flexibility and cost of change given the need to coordinate across many national implementations;
2) To harmonise between member states, permitting national subsidiarity while promoting full understanding
3) To promote transparent GO trade in the market and for system operators, by providing simple access to meaningful information about market activity;
4) To support clear and simple technical dispute resolution; and
5) To offer adequate market supervision, including fraud detection.

The relative simplicities introduced by a centralised approach must be weighed against the additional effort needed to integrate a central registry with national non-registry systems, and to administer the market supervision, dispute resolution, prioritisation and implementation of change, and harmonisation.

4.4.3. Enhancing further market development

A well-functioning market benefits from low system cost and an infrastructure that supports the market's needs:

1) To minimise the barriers of entry by ensuring clear and full specification of system requirements and tendering regulations;
2) To promote free movement of GOs amongst members of the EU, EEA and contracting parties to the Energy Community including addressing the need for multinationals to register on the registries of a number of countries in order to cancel GOs for use in those countries;
3) To ensure acceptably fast and accurate processing of transfers;
4) To provide an architecture that will permit flexible and cost-effective links to account holder systems, power exchanges etc.;
5) To ensure that the market has an acceptable level of technical support;
6) To minimise development and operating costs while assuring acceptable quality of service.

A central system can offer a number of benefits in this respect. Collective purchasing, development and operation of registry systems can reduce individual effort and therefore cost. Multinational account holders will benefit from reduced administrative burdens associated with having to hold multiple accounts. Transfers should be more efficient, faster, and more accurate. Linkages with account holder systems and those of market facilitators will be simplified.

On the other hand, a member state that wishes to develop new facilities may find itself hampered in doing so by lack of support from other member states. And the effort and complexity of administration of a central facility on behalf of 46 countries/regions, each with differing design and level of coupling of their interfaces to the system, should not be underestimated. Nor should the impact on issuing bodies in countries with large quantities of cancellations, whose income derived from cancelling GOs would be reduced accordingly: new arrangements would be required for funding and sharing the income derived from such central cancellations.

As a final consideration, in some countries' regulatory framework, cancellation may only be initiated by an account holder, and central cancellation would require legislative change.

4.4.4. Multi-energy carrier – multi-purpose – sector coupling

Directive 2018/2001/EU (referred to as REDII) extends the purpose of GOs to other energy carriers, and gaseous energy carriers in particular have attracted the interest of the market.

This will introduce the following additional challenges:

1) **Multi-energy carrier:**

   The EECS System and its Hub can easily accommodate guarantees of origin for non-electrical energy carriers within the existing Hub-centric infrastructure and the current type of transfer protocol. This will facilitate origin disclosure to consumers in an efficient manner. There are, however, a few additional aspects to take into account, as elaborated below.

2) **Multi-purpose electronic documents** (carrying one or more certificate purposes):

   REDII introduces additional purposes for tracking systems, especially in relation with the transport fuel target which requires a mass balancing system. This introduces certificates for different purposes: disclosure of the origin to energy consumers (guarantees of origin), and target accounting. **One or more such certificates can be conveyed by an electronic document.**

To keep both the GO system and the target accounting system reliable, **it must be ensured that the same MWh of renewable energy only gets accounted for once, for each purpose**, and that the user of a tracking certificate for one purpose (e.g. Target accounting) does not implicitly assume that it has also consumed the renewable attributes unless it, or an associated certificate, has also explicitly been issued as a guarantee of origin, or unless the green attributes have in another way legitimately been allocated to the target certificate, and issuance of a separate GO to the same MWh has been avoided.

3) **Sector coupling through energy carrier conversion**:

The origin of energy can be guaranteed throughout energy carrier conversion, and so the market demand for it will also be guaranteed. Gas from the gas grid can be proven to have a renewable origin, and if electricity is produced using it as input, then the electricity producer will claim renewable electricity production based on cancellation of a corresponding amount of gas GOs. Hence, energy carrier conversion becomes a core design criterion for a GO system for all energy carries. Elements of the background to be considered include the following:

i. FaStGO reports 1.3 (§7, §18, §25) and 2.1 (§2.11) introduce and elaborate this concept, called 'conversion issuance'. They do so a high level in the FaStGO text proposal for a revised EN16325 (FaStGO task 2 part 2, version 8/7/2020). This facilitates the essential level of harmonisation for reliable system operation.

The following diagram illustrates the importance of GO systems for different energy carriers being synchronised in their technical design and in their level of quality. They do so to facilitate efficiency in the issuance of certificates for the purposes of conversion between energy carriers. For example, guarantees of origin which have been issued for biomethane (energy source: agricultural gas) may be cancelled when the resulting gas is consumed by a gas engine that produces electricity; and the guarantees of origin for the resulting electricity may be issued, stating that the energy source is that consumed in the production of the biomethane (in this case, agricultural gas).

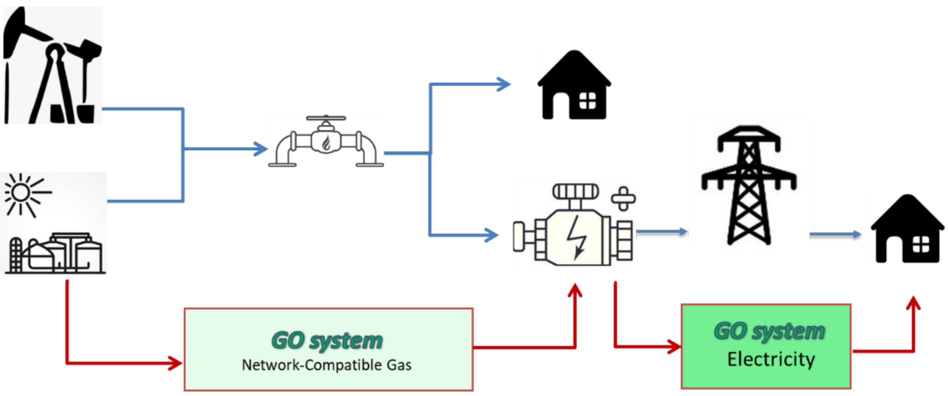


Figure 5: Connection between GO systems for different energy carriers

The principles introduced by the revised standard EN16325 raise an operational challenge relating to the checks to be done in relation to the issuance for conversion purposes for such electricity GOs. The extent to which the same registry can make automated checks on the correspondingly cancelled gas GOs is likely to determine the efficiency of operation once volumes of such converted GOs rise.

ii. For efficient processing of this 'conversion issuance', more detailed elaboration of protocols would be beneficial. Issuing bodies can voluntarily implement a deeper level of harmonisation at a practical level, which allows them to be flexible in their adaptation of the standard, in line with developing insights into system and market behaviour. This also implies that the certificates for the different energy carriers have the same data format and are operated in the same transfer protocol.

iii. At national level, role allocation has yet to be decided: whether to appoint a single issuing body for all energy carriers, or a separate issuing body per energy carrier.

1. When solely looking at the efficiency of the GO system management, it is clear that the operation of the GO system will avoid duplication of resource needs if it is allocated to a single issuing body per country/region. Carrier-specific technical expertise could be arranged by working with a single registry operated by different production registrars per energy carrier.

2. However, in some countries (either for historical reasons or for peculiarities in the legislative system or organisational architecture), a different issuing body might be appointed for different energy carriers.

3. This document supports the allocation of the role of issuing body for a specific geographical area, either to a single issuing body for all energy carriers; or to multiple issuing bodies, each responsible for a separate energy carrier. Indeed, it works from the assumption that all issuing bodies, for all energy carriers, adopt the same protocol for international transfers. In this way, the transfer of a GO to the registry of an issuing body for another energy carrier in the same domain can be considered as a similar process as cross-border transfer between registries handling GOs for the same energy carrier.

In summary, the challenge is for multi-energy carrier, multi-purpose certificates to provide a way of identifying the 'chain of custody' of GOs in such a way as to facilitate:

a. adequate market supervision (including anti-fraud measures);
b. energy carrier conversion;
c. monitoring and control of the interplay between GOs (REDII art. 19); sustainability certificates (REDII art. 25-31); and GOs and EU-ETS; and
d. improved market intelligence.

This will require the resolution of questions regarding whether separate or interlinked architectures are appropriate; and how this can be put in place while at the same time providing adequate regulatory and supervisory controls.

In summary, then, the central approach has a major benefit in that it can provide an effective interface between the GO systems for different energy carriers, which will simplify the conversion process and so facilitate sector coupling. That being said, it is possible that the differences between other aspects of national energy systems may lead to member states overcoming this by implementing GO conversion in a different way to the common approach, meaning that a central approach is on occasion inappropriate.

5. Feedback from consultation

Under FaStGO task 1.3, which maps GO system management challenges, a consultation was run in February 2020. The answers to the consultation are available in the annex to the task 1.3 report and a main summary is in the task 1.3 report.

Further, in May-June 2020, the FaStGO project conducted a further consultation in a survey format, this time on its text proposal for a revised EN16325 under this project's task 2. Further relevant feedback was received and considered from that survey and also in additional conversations and meetings with issuing bodies and market parties.

5.1. Questions for "System management challenges" consultation

The questions raised in the task 1.3 consultation were as follows:

1. Making abstraction of the timeline of implementation, what would be your preferred level of registry centralisation? Please provide the reasoning behind your preference:
    a. Single European GO registry (such as the EU ETS);
    b. Single European GO registry with a possibility to connect national registry;
    c. National/Regional registries and an interconnection hub with centralised transaction log and reporting;
    d. National/Regional registries interconnected through a hub; and
    e. National/Regional registries and standard peer-to-peer connections.
2. What is the last time the GO registry of your country was re-built?
3. If a change to the infrastructure were to be set-up, and assuming all concerns were overcome, what would be the earliest year in which your country would be able to participate?
4. What would be the essential concerns to be overcome for your country to participate in a centralised GO registry (registering ownership and transfer of GOs)?
5. What would be the essential concerns to be overcome for your country to participate in a centralised production device registry?
6. Should different energy carriers (power, gas, heating/cooling, and hydrogen) have separate registries/hubs? (Yes/no/no opinion/other namely…)
7. What are the drivers for your preference? What are your concerns on this subject?
8. Do you have specific suggestions in order to overcome any challenges mentioned here?

5.2. Takeaways from the "System management challenges" consultation

5.2.1. Preferred registry configuration

The majority of parties responding to the consultation were from the electricity and gas sectors, with half as many from hydrogen, and heating and cooling. These were predominantly producers, traders, suppliers, grid operators and GO issuing bodies.

The majority of respondents preferred a national registry, all but one of them supporting interconnection via a Hub, and three favouring a central transaction log and reporting; although two of them were prepared to reconsider if a central transaction log and reporting was not cost-justified.

Only two respondents (both active in the gas sector) favoured a centralised registry, but even these acknowledged that such a registry would need to take into account national policies. They felt that in order to protect fluidity in trade and transfers and to avoid transfer cost, registries should at least be properly linked and feature a centralised transaction log or hub, and while national registries connected to a European hub may be a good option, a European registry connected to national registries is likely to be the best trade-off. The general sentiment was that moving towards a single European registry would be politically difficult, as it was felt that REDII placed responsibility for operating a registry on individual member states. The development and support costs of a central registry may well be lower than a network of national registries, but this must be balanced against possible difficulty in allocation to stakeholders and might introduce risks in the form of complex governance in order to meet the needs of the different states and markets. Further, this architecture raised concerns about a higher risk of cyber-attacks and frauds due to focusing all GO market activity on a single point, which on the other hand might be strengthened by increased resources from jointly borne cost. Any decision needs to balance the required duplication of functionality at central and national levels against the cost of providing flexibility in central systems to meet the needs of individual member states.

Conversely, there was fairly broad support for holding GOs in national registries, which are closer to national stakeholders. Respondents felt that they ensure a greater degree of comfort concerning transparency, integrity, compliance and integration with national systems and legislation. Once they have sufficient size, these registries should foresee in automated processes for issuing GOs based on verified measurement data, and for supporting their transfer and cancellation etc. They should be linked to other European registries in order to reassure that the veracity of guarantees of origin is at all times controlled under the supervision of a competent issuing body. However, it was acknowledged that there was room for improvement in the current functioning of national registries.

Each Member State has its own legislative basis setting out the requirements for national registries, which need to support a register of energy production plants, GO accounts and subaccounts, disclosure supervision, administration, cost allocation, national languages and interface to systems administering matters such as energy measurement and settlements, fuel declarations, national financial support policies and so on.

In order to facilitate efficiency in the handling of international transfer of GOs and the related checks on data security, quality and reliability, efforts can be centralised. In order to facilitate multilateral connections efficiently for so many connected registries, the linkage to other registries should be connected by a Hub, which would be used to collect information about all transfer activity in order to detect and prevent fraud and to improve security.

5.2.2. Opinion of Issuing Bodies in the AIB

The members of the Association of Issuing Bodies, historically based in the electricity sector but now moving into the gas sector, voted in late September 2020 by a majority that:

"The AIB supports the principle of a systems architecture which:

1. *Provides services and is supported by a single Hub for guarantees of origin for all energy carriers and*
2. *Continues the current AIB practice of requiring consensus between participating member states for the development and provision of shared facilities relating to guarantees of origin and*
3. *Takes into account the requirements of all national guarantee of origin schemes*".

The only member voting against felt that a single system addressing all energy carriers and handling all minor differences was too complex a task. They suggested focusing on each sector in turn and accepting sector-specific differences, converting between energy carriers locally, in order to provide flexibility in supporting new products. Abstaining members expressed a wish to have more clarity over the way forward and to consider the matter further before coming to a decision.

5.2.3. Participation cost for multinational market participants

Companies who consume (or whose clients consume) energy in various European countries currently need to hold an account in the national registry of every country in which they operate, since GOs must be cancelled in the country of consumption. Such market participants shoulder an administrative burden by needing to go through the formalities and fee payments for account opening and administration in every relevant country. These companies request administrative simplification and would strongly prefer to cancel GOs in a single registry for consumption across the whole of Europe (this has been considered in section 4.4.3).

Disclosure experts, on the other hand, respond that if cancellation is to be organised at a central level, then it must be ensured that each national/regional supervising competent body for origin disclosure has easy access to this data. This is necessary for them to be able to know the total quantity of GOs claimed for consumption in one country, so that they can match it with the actual consumption of energy, in total and per supplier, and to ensure the quality of the calculation of the residual mix.

If this matter cannot be resolved, then multinationals are likely to resolve the situation for themselves. They could always ask a market facilitator to act on their behalf, but this will have an associated cost, with no benefit to anyone except the market facilitator. Alternatively, they could cancel GOs for use in the country of cancellation, when the energy is actually consumed in other countries, and account for the cancellation in other countries within their own accounts – this would be difficult to detect without careful audit of supply claims, and would impact the residual mix of source and destination countries. Or they might simply not cancel such GOs but allow them to expire, again with consequent damage to the residual mix for the country in which the GOs are held. There will be other solutions, and these may have unknown consequences and be difficult to detect, so it is in the interests of all stakeholders that such market imperfections are resolved.

As noted earlier in section 4.4.3, most issuing bodies currently recover from the holders of accounts on their registry the cost of operating their registry, including the cost of connection to the hub. The impact of centralising cancellation for multinationals may impact this fee income and therefore the ability of the issuing body to operate cost effectively; and will need careful attention.

5.2.4. Consolidated or separate registries or hubs for each energy carrier

Four respondents (representing market parties and a gas certificate issuing body) felt that it was preferable to hold GOs for each energy carrier in a different registry, and that GOs for each energy carrier should travel to other registries by way of a hub dedicated to that energy carrier. They arrive at this conclusion for reasons associated with the following aspects:

- The different production processes and separate physical energy transportation and transmission routes to market, for electricity, grid-supplied gases, and transportation fuels;
- Avoidance of cross-subsidy between support schemes for different energy carriers, due to greater or lesser use of registry systems by individual energy carriers;

- Possible difficulties in gaining sign-on from national governments to separate GO infrastructures for individual energy carriers, due to conflicting political goals and ambitions, departmental budgets, and responsibilities;
- The reluctance of stakeholders for each energy carrier to work collaboratively with stakeholders of other energy carriers (i.e. distributors for electricity and gas, network operator for district heating, …); and
- Impact of developing and amending systems to address more than one energy carrier on other energy carriers.

They stressed that processes should be developed to support conversion of GOs for one energy carrier to another by the different registry networks, and that costs need to be evaluated as voluntary registrants in various member states would in effect fund the system as a whole.

However, one respondent (a multinational energy producer and distributor) felt that common registries for the different energy carriers could be implemented with separated facilities for each energy carrier, to minimise costs and boost efficiency; and two other respondents supported this view, feeling that the different energy carriers should not be managed in separate registries or hubs per energy carrier.

While all respondents express a preference for cost-efficient operation, at the time of the consultation, the understanding of how to establish such, differed. A key reason for this may have been that handling of energy carrier conversion processes were not in the focus of the respondents at the time of the consultation. Given that energy carrier conversion with GO cancellation is not yet taking place, experiences yet have to develop on this field.

While there are issuing bodies in Europe who operate a registry for GOs for multiple energy carriers, these were not taking part in the consultation, and their views are not represented.

It becomes clear that member states will individually decide whether or not to handle GOs for different energy carriers in the same registry. In general, centralisation requires higher level evaluation and successful harmonisation between all Member States.

5.2.5. Analysis of some suggestions raised by respondents

There were comments from proponents of blockchain technology. While certain aspects of this technology are attractive by themselves (the use of smart contracts, chain-of-custody tracking, low-cost/low-hassle involvement of small producers, automated expiry, …), their use to the GO system has not been clarified since, to date, the challenges which GO system administrators have faced relate more to issuance and usage of GOs than to their transfer. The strengths of the blockchain system do not seem to bring any substantial gain nor relieve any existing shortcomings of the GO system. Such fundamental change as is implied by moving to a distributed ledger (blockchain) approach is unlikely to be supported in this round of change, as the current Directive simply does not provide the platform for it. See further analysis on distributed ledger -based systems in section 0 below. Also, several of the proposals supported by a blockchain approach, while attractive, may not be sustainable under EU financial services and other legislation; and would need fundamental change to the management of information in the energy sector of individual Member States.

6. Systems architecture options

6.1. Overview

This section sets out several options for IT infrastructure for maintaining records of guarantees of origin and their ownership and cross-border GO transfers, including an evaluation of each of the options.

The ways in which the architecture might be configured are as follows:

1) **Peer-to-peer**: each registry communicates directly with every other registry (not to be confused with distributed ledger, where communication is in effect between account holders).
2) **Hub-centric**: Each registry communicates with each other registry via a central hub – *this is the status quo*. There are several variants:
    a. **Simple hub-centric**: all registries, regardless of energy carrier or purpose of certificates, are connected to a single hub;
    b. **Communicating hubs,** each supporting a different certificate type, where the type can be:
        i. **a purpose** (support, target compliance, disclosure to consumers); or
        ii. **an energy carrier** (electricity, hydrocarbon gas, hydrogen, and heating and cooling)
    c. **Non-communicating hubs**, where each registry communicates via a hub which is specific to a certificate type (purpose or energy carrier).
3) **A centralised single registry**, replacing national registries. This might require:
    a. National creation of GO datasets, which can then be transferred to a central certificate system for transfer and cancellation; and/or
    b. Multiple central registries, each administering a different type (purpose or energy carrier) of certificate and communicating with each other for purposes of sector integration.
4) **Direct transfer between account holders** (also known as distributed ledger technology, e.g. blockchain-based), whereby certificates are created by a national authority and transferred to the relevant account holder's system. These can then be transferred to the systems of other account holders, one of which is the cancelling authority (and from which the certificates can no longer be transferred).

The abovementioned architectures are further discussed in in the rest of this section.

The ideal solution may well be to implement a hybrid solution, benefiting from the strong points of the systems architecture which is currently in place, but enabling individual member states to derogate at their discretion. These might include:

5) **National data collection and central registry:**
    a. National registration of production devices, collection of metering data and calculation of the quantity of certificates to be issued; and
    b. A central registry of account holders for certificate entitlement, registration, and transfer;
    c. A central database which would facilitate GOs issued for one energy carrier to be cancelled, and GOs for another energy carrier to be created. Such conversion at a central level could help with VAT fraud detection and be useful to multinational consumers wishing to cancel GOs for use in a number

of countries without the need to manage accounts in each country. However, this would require the collective support and participation of competent bodies for guarantees of origin and disclosure in each participating country.

6) **Central registry / hub**

   a. A combination of option 2 and option 5, allowing national issuing bodies to select the option which they consider preferable: their own national registry, or use of the central registry; and

   b. A hub facility to provide a linkage between the (semi-) central registry and the remaining national registries.

The hybrid models are evaluated in section 10 below.

The advantages and disadvantages of each of the first three 'basic' architectures are elaborated here below, to provide a basis for consideration later in this document of the benefits of adopting an evolutionary hybrid solution.

The fourth option - direct transfer between account holders - will be evaluated as a technological option in section 7 on how technology is trust facilitating, as a separate criterion compared to the overall architecture of roles and responsibilities.

6.2. Option 1: Peer-to-peer

A peer-to-peer network requires each member of the network to connect to each other member of the network. Usually, there is a common standard for message format, data transfer, testing, etc. to make it easier to establish new connections. However, a peer-to-peer model has a number of drawbacks: not only does each member have to maintain a link to each other member, but they have to re-test this every time they, or the other member, makes a change to their registry. Not only is this time consuming, but it is fraught with error. This is due to the large number of systems interconnections and technologies employed at each, along with differences of interpretation of agreed rules and protocols, as well as the amount of change experienced by members of the network.

An analogy for a peer-to peer systems network can be seen in the world of voice telephony, where the initial systems in place at the turn of the 19th/20th century required a separate line for each connection, such that while two parties could communicate by a single line, three parties would need three lines and so on, according to the theorem n(n+1)/2, where n is the number of nodes.

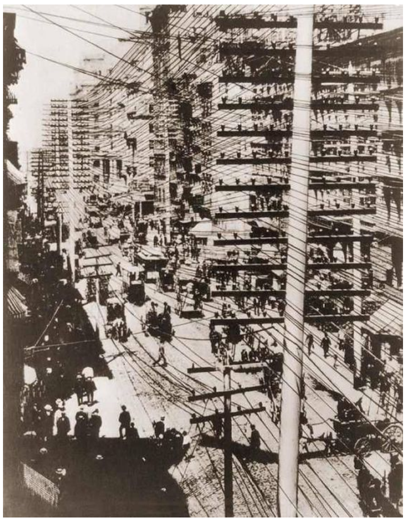


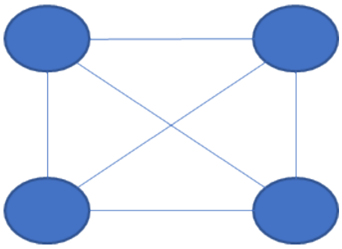
Figure 6 The Telephone Wires of Manhattan, 1887

Thus, it can be seen that to interconnect the 39 countries involved (28 members of the European Union, two members of the European Economic Area and 9 contracting parties of the Energy Community) would require 780 connections between them. And that does not take into account the countries which have appointed regional competent bodies. If we add Belgium (four regions), Greece (three regions) and Bosnia & Herzegovina (three regions; nor does it take into account that there may be more than one registry in some countries. Assuming 46 domains (countries / regions) and two registries in each, the number of interconnections might rise into the thousands.

Each connection will inevitably have its own peculiarities in terms of supported languages and protocols, and some measure of conversion will therefore be needed. Even in the presence of an agreed language protocol, the number of physical connections would be onerous.

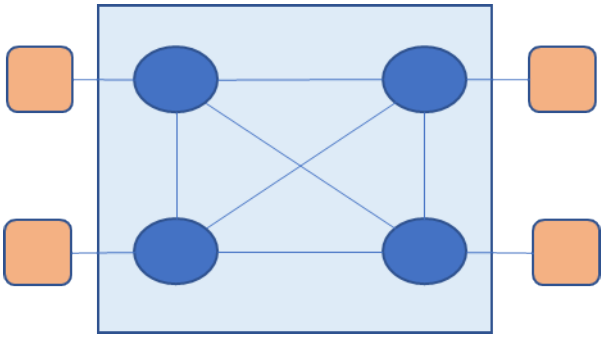
6.2.1. Variants

6.2.1.1. Simple peer-to-peer



A simple peer-to-peer network provides a direct connection between members of a network. For a small number of registries (less than five), this might be effective; but it would be a challenge, and administratively difficult, for 39 countries with at least one – and perhaps three to four - registries.

6.2.1.2. Distributed Peer-to-Peer



A distributed peer-to-peer network provides members with a centrally-maintained node on their premises, each such node being preconfigured to interconnect to that of any other member.

This architecture was employed by EFET as part of the EFETNet, which has now been replaced by a hub-centric network (Equias[7]). While it removes the issues raised by different technology platforms at each member, requiring them only to connect to the central node, there is still the issue of ensuring that each member employs protocols for communication which are compatible with the central node. Further, such a network has high maintenance overheads.

6.2.2. Evaluation of the peer-to-peer model

This is the most basic variant of what is required of member states under REDII.

For a peer-to-peer network to provide an effective transfer mechanism, it would require detailed standardisation of inter-registry protocols at a greater level than a centralised or hub-centric model, given that a number of different technologies and communication protocols may need to coexist. There is also the question of whether central monitoring can be undertaken: this is necessary for the resolution of disputes, identification, and policing of opportunities for fraud, and so on.

A peer-to-peer network is only a suitable transfer mechanism if the number of participating nodes is small (preferably less than five), and if there is no need for network-wide service level guarantees or monitoring. That is not the case in the GO system as provided by the European legislative framework, where as many as 3-4 registries might exist in each of 39 countries.

[7] See www.equias.org

6.3. Option 2: Hub-centric – the status quo

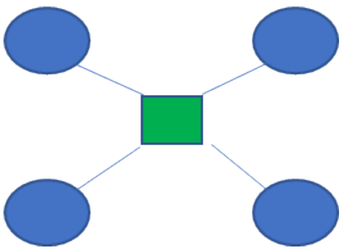
In a hub-centric network, all inter-member communications are handled via a central system which reduces communications to a single 'plug-and-play' approach. It also allows inter-member communications to be monitored and regulated, although it does admittedly introduce some measure of duplication given that any transfer needs to be administered both on the sending and receiving registries, and on the hub.

Extending the analogy of voice telephony, the equivalent is an exchange. Here, each party simply need to connect to the exchange to be able to connect to all other parties connected to the exchange, so the number of physical connections is much lower. Add to this an agreed common language and set of communication protocols (perhaps the need to say 'over' after speaking, then 'over and out' at the end of the conversation; or simple courtesies during discussions), and communication is inevitably more simple.

Figure 7: Sunderland GPO telephone exchange, 1949

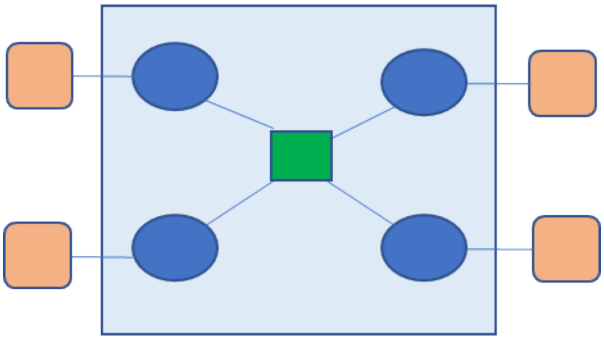
6.3.1. Variants

6.3.1.1. **Simple hub-centric**: national GO registries and a central Hub



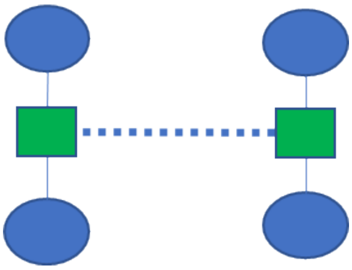
This is similar to a peer-to-peer network, but the inter-registry linkages are replaced by linkages between each member and the hub. In this model, all energy carriers are supported by one registry and one central hub. It has been proven to work effectively, though the lessons learned (as mentioned above in section 4), should be taken into account.

6.3.1.2. Distributed Hub



Similar to a distributed peer-to-peer network, a distributed hub network would provide each registry with a node, these nodes being interconnected to a central Hub. While this might reduce the opportunities for error in hub connection, it does so in a rather inefficient way and suffers from the disadvantages of a distributed peer-to-peer approach (see section 6.2.1.2 above). However, this infrastructure would also be not very resilient to constantly changing system specifications.

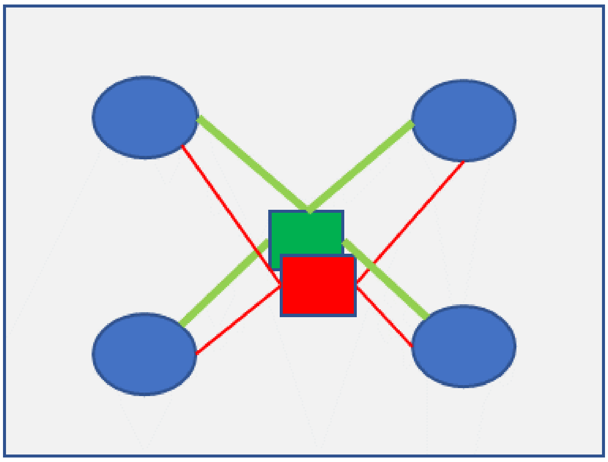
6.3.1.3. **Communicating hubs**: *national GO registries connected to multiple central Hubs, each for a different type of certificate*



Here, registries for each type of certificate connect to their own hub, and where certificates travel between account holders on the registry for type of certificate and account holders on the registry for another type of certificate, then this is achieved by a telecommunications "bridge" linking the hubs. This has the advantage of allowing each hub to be developed specifically to support a single type of certificate, but with the constraint that it must also be able to administer transfers in a way which is compatible with the other hub(s) – at risk of incompatibilities and possible difficulty in resolving errors where the protocols employed by the two hubs are in conflict, such that development of one hub might hinder the other and vice versa.

A further disadvantage is that certificates do not "reside" on a hub (it is not a registry) which simply passes packages from registry to registry in order to transfer certificates. As the hub only passes on information, adding such an extra link in the chain simply introduces inefficiency and further risk of error. It poses the question: why not link the registries to both hubs directly, as the following paragraph sets out.

6.3.1.4. **Non-communicating hubs**: *national GO registries connected to multiple stand-alone central Hubs, each for a different type of certificate*



As the fourth variant of a hub-centric architecture, each certificate type could have its own hub, connecting to each registry for this certificate type, but the hubs would not be interconnected. For example, some countries might have different registries for different energy carriers, each connecting to the relevant hub. Registries handling several energy carriers would then need to connect to several hubs, each of which potentially requires a different connection method. Also, registries handling a single energy carrier might need to connect to a hub of another energy carrier when automating imports following Energy Carrier Conversion for issuance of the resulting certificates.

This raises the question of whether any benefits may be derived from non-communicating hubs. On the positive side, hubs specific to a type of certificate might be better able to serve specialised issuing bodies and be more agile to carrier-specific needs than a hub addressing the needs of all types of certificate. However, the cost for all national registries to connect to a different hub per energy carrier will greatly increase the overall system management cost. In addition, every change to a carrier-specific hub will demand the corresponding adaptation to every registry, similar to the situation with a peer-to-peer architecture. When changes to one of the hubs contradicts the system design of another hub, a registry connected to both hubs would be placed in a compromising position.

This brings us back to the question, why not immediately integrate both hubs into a single overall transfer solution - and we are back at the 'Simple Hub Centric' option set out in section 6.3.1.1.

6.3.2. Evaluation of the Hub-Centric model

6.3.2.1. Advantages and disadvantages of a Hub-Centric Model

In the hub-centric model, national competent bodies control technical implementation, business rules, integration, supervision and so on. They also provide a single point of connection for national registries and can facilitate varying levels of centralised functions such as market monitoring, reporting and account holder databases. Compared to the peer-to-peer model, the hub-centric model is likely to provide more efficiency and quality for a maturing market.

On the other hand, each country joining a hub-centric architecture must have its own fully-featured registry system. To be able to connect to the hub, the registry must be compatible with certain technical standards from day one - and remain so. Implementing such a registry by all member states (and possibly separate registries for different energy carriers) is a major cost item. It also requires considerable effort to make sure that an adequate level of quality is reached by the national registries, and that trust in the system can be maintained. Further, once all registries are adequately equipped for hub connection, then any proposal to upgrade the hub must consider the corresponding impact on national registries.

However, when opting for a hub-centric model, the **simple hub-centric** model remains the preferred option over the more complicated hub-centric models for reasons of efficiency and cost control.

6.3.2.2. Pros and cons of competing hubs

So far, we have considered the provision of a hub (or hubs) as an effective monopoly, but could such hubs operate in competition? While competition is generally good for both suppliers and consumers in that it motivates suppliers to work harder and focus more effectively on product differentiation and innovatory ways of meeting customer needs, the increased pressure to compete on price can damage quality and lead to larger players dominating the market. Furthermore, the presence or absence of competing hubs may impact the energy market as a whole, so this consideration must be approached with care.

Competition for supply of hub software and services is well within the scope of EU competition rules, which ensure fair competition, encourage enterprise and efficiency, stimulate choice, reduce prices, and improve quality. However, competition between hubs is only part-addressed by EU competition rules; and we should also consider the impact on the energy sector of a number of such hubs competing for what is in reality an EU-wide network, and might be seen as a natural monopoly.

Technically, given an agreed protocol for systems interconnection, there is no reason why this should not be possible, although it does raise some issues:

- Where certificates pass through several registries and hubs, it may be difficult to track the chain of custody and resolve inter-party disputes in the event that the tracking facilities provided by each hub differ, or exist on one hub and not on another.
- Systems upgrades which involve more than one hub will need to be carefully managed, if they are to be implemented in a coordinated and controlled manner: it is, for example, no good for one hub to upgrade its software if this negatively impacts registries using another hub as well as this hub.
- Any conflict or gap between security provisions offered by competing hubs would need to be overcome: a weakness in the security software of one hub might enable fraudsters to penetrate the registries using another hub.
- Fraudulent behaviour by account holders will need to be detected and prevented, and all interconnected registries and hubs need to share a common approach to overcoming this.

There are commercial challenges as well, including:

- The overall network of competing hubs and registries must be carefully managed across several energy sectors and certificate purposes, which will involve different government departments and energy sectors. Gaining their timely cooperation and approval of change will inevitably be both essential and time-consuming.
- Conflicting requirements of competing hubs will need to be carefully managed, especially as they evolve, if the changes in one environment are not to conflict with another environment.

- Changes affecting several hubs will need to be carefully planned, executed, and tested so that change is implemented in a coordinated manner, and certificates transferred across the network are not lost, damaged, duplicated, or misrouted.
- Where one market experiences rapid growth, this may have an impact on another market due to market coupling and lead to challenges in terms of data storage and/or processing capacity. It may also lead to additional system upgrade requirements that would be relevant to only one of the involved markets.
- The cost of change involving multiple hubs and registries will need to be carefully allocated between them, so that one industry sector does not in effect subsidise another. This is a matter of sensitivity in a number of countries.
- A single hub must be prevented from becoming too dominant, if its ability to control the entire energy sector is to be constrained. Such risk can be mitigated by joint (delegated) management by all the issuing bodies operating through this single hub, or other measures ensuring the same purpose.

Hence, while competing hubs could technically co-exist, this should be approached with care. Any decision to do so should only be undertaken with cross-sectorial (and international) support and appropriate management.

6.4. Option 3: Centralised single registry

A centralised registry, operated by a single information systems services provider, collects from national systems the base data which it uses to create certificates, and uses this for purposes such as energy source disclosure. Depending on the type of central registry, some functionality may still be retained in national registries, which then connect to the central registry to exchange certificates etc.

The following are usually managed at a national level, and it would be difficult to justify their inclusion as part of a multi-national IT system:

- **collection of measurement (meter) data and declaration of fuel consumption** relating to energy production and consumption;
- **registration and auditing of production device information**, which may be inter-dependent upon other processes (e.g. financial support mechanisms, environmental licensing …); and
- **determination of the quantity of GOs to be issued, based on energy settlements information**. While the general principles are the same everywhere, there are differences in the detail of national practices, in line with national policies. For instance, meter accuracy and calibration requirements, and national definition of auxiliaries).

6.4.1. Variants

6.4.1.1. Central – uniform GO system management for all countries

In a fully central system, the functionality provided to each member state would be identical and national certificate systems would be identical. However, given that national law and practice differ (e.g. relating to small differences in calculation practices regarding the quantity of GOs to be issued, along with the way in which data is integrated in national data management and policy instruments, …), this is unlikely to be an acceptable solution.

6.4.1.2. Central certificate system - with locally customised functionality

A variant on the simple central registry (section 6.4.1.1 above) would be to segment a central registry into a core section, providing all common processing, and either: allowing national systems to create certificates locally and transfer these to a central registry; or adding to the central registry separate sections allowing each country to create its own certificates centrally as illustrated below:

a. Creating certificates nationally, while retaining and administering these in a central registry

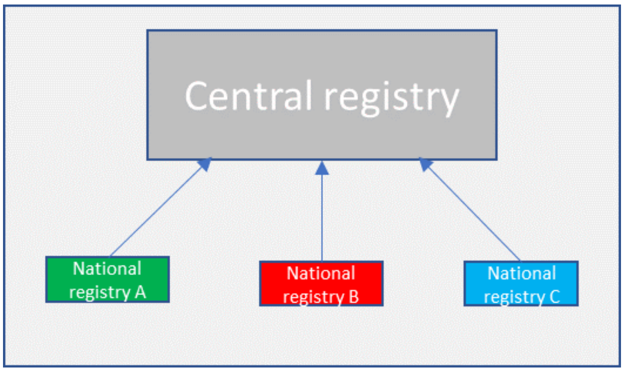


Figure 8 National systems create certificates locally in their own separate registry and feed these into a central registry for ownership registration, transfer, and cancellation

b. Creating, retaining, and administering certificates centrally based on data provided by each member state

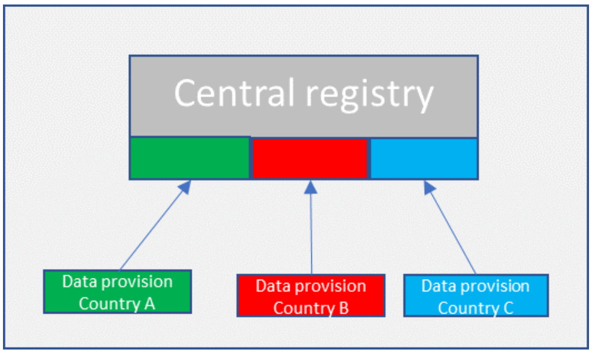


Figure 9 Central registry has separate sections for each country, allowing them to create their own certificates centrally. Data provision is arranged at national level.

In practice, there is little to choose between these, although option a. does offer member states the higher opportunity to embed certificate issuance within their own systems, which may use these certificates and/or their data for other purposes.

6.4.2. Evaluation of Centralised Registry Model

From a purely IT theoretical viewpoint, a centralised registry model would potentially provide the best cost / quality efficiency, as the most challenging parts of the infrastructure, along with transactions and issuance, would be implemented only once. Transfers would be immediate and predictable, calculations and business rules controlling issuance would be uniform.

Arguments in favour:

1) **IT operational efficiency**: Ideally, there would be no inter-registry transactions, so further reducing the (albeit minor) possibility of data integrity being lost in transactions and synchronisation efforts when interlinking registries.
2) **Flexibility to IT upgrades**: Changes to the data model and business rules could be implemented more swiftly, as there would not be a need to coordinate the implementation across all of the participating registries.
3) Enable **facilitation of energy carrier conversion at a central level**

   a. In order for single energy carrier registries to facilitate energy carrier conversion in an automated way, those registries would need to be able to import GOs issued for another energy carrier, cancel them, and transfer the relevant data fields to newly-issued GOs.

   b. As an alternative to the need for importing GOs from another energy carrier, a centralised "conversion-cancellation" solution could assist issuing bodies with this.

4) Facilitate more **centralised control on VAT fraud** by enabling full chain of custody tracking to tax authorities.

On the other hand, there would be other concerns arising from:

1) **National policy and legislation** – how to ensure that these are respected, and national variations are built into any central registry and can be simply and effectively revised in line with changes to law and practice;
2) **Conflicting system design requirements by different issuing bodies –**these may be due to national policy and legislation, as noted in (1) above, but they may also be due to the characteristics of national energy industries and national preferences. This could lead to long discussions, as they limit the freedom for an individual member state to go its own way.
3) **National claims for data ownership** – the ownership of individual data items will need to be established, along with how data protection legislation should be applied;
4) **National requirements for functionality** – each country will have its own laws and practices. These will need to be supported;
5) **Division of costs, responsibilities and liabilities** – attention must be given to the agreement between parties which allows the central registry to be used, and the appropriate responsibilities and liabilities should be clearly allocated between all stakeholders – account holders, national authorities and the central registry operator.

   Furthermore, allocation of the costs of building and operating centralised facilities fairly to all registry operators for several energy carriers would be difficult due to the number of:

   - **Accounts**. While some member states will have limited numbers of account holders, others (perhaps with high penetration of solar PV) may have hundreds of thousands.
   - **International transactions**. Also, the number of national and international transactions will vary considerably between member states, and the related transfer costs must be allocated fairly across all account holders such that those which solely operate nationally but not pay for the additional costs associated with international transfers.
   - **Types of certificate**. Any central facility would need to support the types of GO operated by each member state, and costs should be attributed accordingly – for instance, not all member states issue high-efficiency guaranties of origin (HEC GOs).

6) **Integration with local systems**, given that these will change independent of the central registry – this includes meter data acquisition, energy settlements, systems for administering public support schemes, target achievement monitoring and so on.

7. Technology options for facilitating trust – what about blockchain?

The technology used to provide an acceptable measure of trust in the overall system must be considered separately to the infrastructure and the allocation of responsibilities to national or international agents. Where the above options discussed merely the latter, this section dedicates itself to technological concepts.

Two main options present themselves, traditional central database, and distributed ledger -based.

7.1. Traditional central database

Today, registry operators use a database containing details of certificates hosted in a central location or in "the cloud". Such systems allow database operators to control the infrastructure of the entire process. In Europe, the GO system is controlled by national authorities commonly referred as Competent Bodies or Issuing Bodie. They have delegated specific responsibilities, such as Production Device audits and technical registry operation to their trusted agents. In other words, market participants trust the certificate and transaction data they see in the central database-based systems, because they trust the authorities and their agents running the systems. So far, this arrangement has worked well.

7.2. Distributed ledger-based

Distributed ledger enables direct transfer between account holders via a peer-to-peer network (also known as blockchain technology). Certificates are created by a national authority on its own system or automatically based on smart contracts regulating the creation of certificates out of metering and production device data. Certificates are transferred to or born in the relevant account holder's system. The details of the certificates and their ownership history is available to holder of the certificates. Certificates are transferred directly between "wallets" held by account holder. Cancellation could be implemented for example by transferring then finally to a central cancelling authority, from which the certificates can no longer be transferred.

Several technology-led companies have proposed the use of distributed ledger technology to provide a platform for the interchange of GOs. Blockchain is an example of distributed ledger, where it is counted as a cryptocurrency (medium for exchange with strong cryptography).

7.2.1. Distributed ledger technology options

Again, there are different variants and levels of distributed ledger usage. These include:

- In a **pure distributed ledger-based certificate system**, all certificate content is stored in the blocks, and in principle the registry infrastructure is completely distributed. This would require fundamental revision of not only the current architecture, but also the enabling legislation and regulations, which currently place responsibility for the operation of the GO system upon the member states individually rather than collectively.
- A **Transaction-distributed ledger** has the majority of certificate data stored centrally in traditional databases, but all transactions take place by means of a blockchain. The blocks refer to certificate data in a central database using unique certificate IDs. This model could facilitate transition from the current model to a future new model, as part of a hybrid solution (see section 10.2).

- An **Isolated ledger** means a distributed ledger-based national registry that communicates with other registries and hubs using traditional means. This, too, might form part of a hybrid solution (see section 10.2).

However, to date, none of the proposals has provided a business model which explains precisely how this might be implemented; and what exactly would be the benefits of doing so.

We understand that the benefits of distributed ledger include:

- Implicit verification of correctness, abolishing the need for third-party verification;
- Immutability of data;
- Chain of custody tracking, including time-stamping;
- Reliability of data maintenance and resistance to loss of or damage to data;
- Distribution across all participants, to enhancing confidence;
- Transparency of transactions to supervising authority;
- Transfers are secure, private, and efficient; and
- Automatic event triggering is possible, depending upon conditions.

These assurances are also provided to a large extent by the current Hub architecture, apart from chain of custody, which might be provided by an audit trail of transactions passing through the hub. They are the result of implementing system specifications, which will be needed in all infrastructure scenarios.

On the downside, a blockchain-based solution would have to be implemented for each account holder. Also, the degree of resistance to loss of or damage to data may be prejudiced unless precautions are taken to overcome this. The amount of electricity needed to power this is currently unknown, but care should be taken to ensure that in seeking to achieve energy transition, it is not done in a way which disproportionately increases energy consumption. Further, we have concerns about the speed of transactions and the potential for use of certificates for illegal operations, such as money laundering. That being said, there may be benefits of using a blockchain-based solution in some circumstances: for instance, in the aggregation and management of GOs issued to small or domestic production devices; where prosumers would be provided with a simple way of accessing the market. A simplified example of such a structure would be a certified roof-top solar inverter issuing certificates automatically if installed by a certified electrician.

Where blockchain is often used for eliminating a central controlling organisation, the European legislative framework for GOs is essentially organised around such central control, for which block-chain loses its main driving argument.

7.3. Conclusions and recommendations on Distributed Ledger Technology

Distributed ledgers are permitting the exchange of cryptocurrencies, but an energy certificate certifies the origin of the energy and is meant to disclose this information to final consumers. Several pilots using blockchain for energy certificates exist in different countries. However, when considering its use for GOs, several questions remain open:

- Should an energy certificate be able to be traded as a (crypto-)currency directly between the wallets held by market participants?
- How would the supervision and control of the market by authorities, as required by the current regulation be possible in the world of distributed peer-to-peer transactions?
- If distributed ledger guarantees trust in transactions in the network itself, how would the trust be facilitated at the edges of the networks, where certificates are issued and cancelled?

- How would inevitable errors be corrected if transactions are finite and secured in a distributed manner by the network itself?
- How would transparency, for example public statistics, be implemented if all transaction data is distributed in the network?
- Would the energy consumption related to blockchain overall system management be justified by its benefits?
- What would be the effects on energy markets?
- Distributed ledgers are meant for peer-to-peer transactions, what would become the role of traders and other market facilitators?
- The current trend is to work in the cloud. Is a distributed ledger compatible with this?
- Where a certificate has been wrongly issued, how to control the process of retraction and data correction.?
- How to organise updates of the smart contracts which steer the distributed ledger? Flexibility for system upgrades may be challenging, especially in a continuously changing regulatory environment.

Some of the above questions can be solved by using hybrid structures when distributed ledger and traditional central databases controlled by national authorities are both used. The energy consumption of the blockchain itself would be reduced by restricting the validators to (for example) Issuing Bodies instead having a full peer-to-peer distributed ledger. In that model, corrections would also be easier to manage, though still not as flexible as in the traditional central database models.

However, the current regulation on GOs and allocation of roles and responsibilities in Europe may not be compatible with the very nature of distributed ledgers. Distributed ledger may be useful for green energy trade special applications as discussed above. Thus, it cannot be recommended as a replacement for the current centralised IT structure and how trust is currently facilitated in the GO domain because of the remaining open questions, and especially because of the required fundamental organisational and regulatory changes.

8. Considerations on overall infrastructure

8.1. Ability to implement a centralised solution under REDII

If a decision were to be made at European policy making level to centralise GO management, then the current mandating cascade – member states discharging competent bodies to administer GO systems, perhaps via agents - would need to be revised.

This would require the European Commission to be mandated to directly supervise the issuance of GOs, and to do so a new regulation[8] would be required. In addition, a new and properly mandated agency would need to be established to run the registry. Having all of this in place as a solution for RED II Art. 19 implementation is unlikely to be possible (certainly within the required time-frame), and would require a high level of political will, even in the long term. This is only likely to emerge in case of substantial problems with a distributed infrastructure based on cascaded responsibilities, which can be avoided by successful cooperation between issuing bodies. Any central system offering the ability to transfer GOs between account holders, supported by other than a formal institution of the EU, would need to surmount formidable legal obstructions and financial barriers.

8.2. Cost of an IT infrastructure for managing GO entitlement, transfers, and cancellations

8.2.1. AIB estimates of likely costs

The total cost of ownership of an information system can be divided into costs relating to:

- Design and acquisition
- Building and
- Operation and maintenance (each of which is of roughly equal size, assuming a five-year lifecycle).

While it is virtually impossible to predict overall costs, due to the number of variables (cost of systems development and support, number of registries and hubs, GO activity volumes, GO prices …), the following have been prepared to give an order of magnitude. They are for guidance only and should – must – not be seen to be anything more than indicative.

Hub-based option

A very rough estimate for the average total cost of ownership (over the five-year lifecycle) of a national energy tracking certificate registry, meeting EN16325 requirements[9], is €750k[10] - but there is a lot of variation. If we assume that separate registries are being maintained in all EU and EEA countries, as well as some energy community countries and autonomous regions, we can estimate that there will eventually be 40-60 GO registries implemented across Europe. This would translate into an average annual cost of €7,5m for the whole European IT infrastructure. For an estimate of the post RED II GO market volume we can use 1 000 TWh issued and cancelled annually. These numbers would result in an IT cost alone per each 1MWh certificate over its whole lifecycle to be €0,0075.

Some of these costs could be saved because the EECS system has already documented its business-level requirements (for international transfers at least), as well as the technical

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[8] *Similar to that issued for ETS registry "COMMISSION DELEGATED REGULATION (EU) 2019/1122"*

[9] *Since the work in CEN on revising EN16325 is not finalised before publication of this report, this document relates to EN16325 as to the FaStGO text proposal for a revised EN16325, published on 8/7/2020*

[10] *An average initial investment, as estimated by Marko Lehtovaara, a long time CEO of Europe's leading certificate registry provider, is €250k consisting of management, specification and tendering (€50k) + software development (€200k). Annual cost of ownership consists of management (assuming 0,2 FTE: €20k), Support, maintenance and inevitable further development (€30k), and hosting (€50k)*

requirements for international transfers. However, the readily-available material only covers part of the design phase. Some costs can also be saved because system providers compete and can recycle work already done.

Peer-to-peer

While the initial cost of a registry in a peer-to-peer network is relatively low, once the cost of interconnecting to the other registries in the network has been factored in, then costs rise substantially. This might be mitigated to some extent by the presence of standards and protocols for interconnection between registries, but any measure of collective control of such a network would be hard to introduce, so comparison with hub-centric and centralised options would be misleading.

Centralised option

To be able to compare the centralised solution with the more distributed ones, use an expert estimate for the total cost of ownership of a centralised solution to be €1 500k annually[11].

A similarly very rough estimate of the total cost of ownership for a centralised solution would be €7,5m over a 5 years' lifecycle, meaning €1,5m per year, €0,0015 per certificate and 0,3% of the total market value of certificates.

Although the overall IT operational cost from this rough estimation may be about 5 times lower in a central registry than in an hub-based approach , this does not take into account the likely high cost of integrating such a centralised system with national systems for energy measurement, fuel declarations, settlements of energy purchases, support systems and so on; and so, again, comparison with hub-centric and peer-to-peer options would be misleading.

8.3. Change – flexibility and cost

In a centralised structure, change will have to be commonly agreed before being implemented, which will take time in any implementation. National practices will have to be amended and their implementation harmonised. Furthermore, making sources of data fit with a centralised structure will require restructuring of existing data, and again if this is amended that change will need to be agreed with all parties.

Similarly, making changes to a decentralised structure where each Issuing Body manages its own registry according to its national regulation, budgets and IT standards can be a slow and expensive process. For example, if there is a need to add one field to common certificate data, this will need to be first agreed between all issuing bodies and such a change will then be binding upon all registries. After that, the change will need to be implemented by each registry and, in the hub-centric model, the hub. The deployment to production will have to be carefully planned and coordinated across all registry operators. If the change is more complex, then it will probably require all registries to re-test either their connection to the hub, or (in the peer-to-peer model) with each other.

The amount of coordination required, the cost, and the high degree of integration between registries, makes decentralised system architectures resistant to change. That being said, the same or similar could be said of a centralised architecture, where all members must also be convinced to support change.

When it comes to operational, registry level changes which do not affect other registries, it is the other way around. The cost of changing a registry in a P2P network is relatively

[11] *This estimate is based on simply assuming that a cost of a centralised registry solution is five times the cost of an average single registry total cost of ownership. Marko Lehtovaara, a long time CEO of Grexel Systems, Europe's leading registry system provider, considers the estimate credible. Grexel Systems has been developing and maintaining a central registry that is capable of hosting multiple national registries in a single physical system*

low - unless the cost of changes to linkages with other registries and operating costs associated with re-testing such changes is taken into account, in which case it could be substantial. Also, in the hub-centric models the changes to the registries can be done rather easily as long as inter-registry transactions are not affected.

8.4. Harmonisation and trust

In decentralised models, harmonisation is sought via technical standards. Regardless of the level of detail, they always give room for misunderstanding and varying approaches to implementation. To achieve the desired level of compatibility and trust, frequent technical audits are needed. In technical audits, the national implementation is checked to make sure it is done according to the agreed standard. When a deviation is detected, it is recorded as an audit finding, and a timetable for corrective actions is given. All this requires considerable effort both from the coordinating entity and from the Competent Body, as well as from its IT vendor.

Registries could be further harmonised by using the same module for the interface elements (webservice to hub). At the moment, only the XDS schema is implemented in the AIB registries and hub. A further evolution of this system might be to create an Open Source Project to make the code for the webservice available to members of the AIB, or even all interested parties. An intermediate step could be to provide AIB members with a pre-compiled webservice module, which could facilitate the connection of new registries, or the renewal of software in pre-existing registries. This could be further promoted by offering a ready-made database, graphical user interface and webservice tool.

Distributed IT infrastructure gives room for national variations. Some countries have, for example, introduced technical means to block the import of given GOs, instead of preventing the use of them. This decreases market transparency, and it is difficult for the market parties to identify or foresee this.

The centralised model automatically harmonises and makes transparent many aspects of the system and the business processes.

8.5. Transparency - market and system operators

In the eyes of the market, the value of a certificate is completely dependent on its trustworthiness. A central element of how certification schemes seek to increase trust lies in the transparency of the scheme. Not only must proper issuing and disclosure schemes be established (as addressed in FaStGO Task 2), but the availability and level of detail of public statistics greatly increases transparency.

A feature of decentralised IT-infrastructure models is the difficulty of accessing reliable and detailed public statistics about the market.

First, registries may interpret differently how certain statistical figures should be calculated. For example, one registry might report that the quantity of certificates issued during a given time period relates to energy production that took place (or was measured) during that period; while other registries may report the quantity of certificates that were issued during the period. Some registries might deduct corrective withdrawals from the figure, while others might deduct all withdrawals or not deduct withdrawals at all.

Even the date of an international transfer might be reported differently, according to whether it is the date of export or the date of import. One registry might book it according to initialisation time, and other according to finalisation. That time period from initialisation to finalisation might overlap change of month and year in some cases. For example, if there is a technical malfunction that has to be solved manually, or if the receiving registry requires the receiving account holder to manually approve the incoming transaction, then a significant amount of time can elapse between initiation and finalisation, and in all cases it is non-negligible. Proof of the existence of such errors can be found by inspecting the currently published EECS statistics, as the volume of imports and exports rarely match.

Second, as transaction information is distributed to all participating registries, it must be manually collected, checked, and published. This process is laborious and prone to errors because it depends on tens of different data sources and requires manual work to aggregate the data. It also consumes calendar time, as the data can only be published after all registries have corrected obvious errors etc. and produced the statistics.

In more centralised models, reliable and timely market statistics are easier to implement. A single registry can publish harmonised statistics real-time. A hub with centralised statistics and high level of standardisation could also do so.

8.6. Technical dispute resolution

Every now and then there are problems which involve several registries, and possibly a hub.

A typical example would be GOs being exported from one registry to another just before their expiry date. Usually, the expiry date is 12 months from the production end date, but national differences exist. If there is a problem in the transaction that requires manual intervention (for example a technical glitch in the connection between the Hub and the receiving registry), then the receiving registry may consider that some of the certificates have already expired or that there is too little time before the expiry, and this may cause the registry to reject the import. This would lead to the certificates being returned to the sender's account, where they would immediately expire and lead to loss of value for the original owner of the corresponding certificates. Some general rules do dictate how such a situation should be handled at a business level, but whatever the final solution is, it might require manipulation of transaction data and/or certificates in two registries and possibly a hub, all typically managed by different organisations. This is costly, time-consuming, and can introduce complex liability issues.

The normal process is for the affected parties to seek a solution between themselves, following a Code of Conduct such as that proposed by the AIB dispute resolution protocol, before escalating it to the AIB. Here, after validation and investigation by the AIB Secretariat, the matter is raised to the AIB Board, which will direct it to an assessment panel drawn from members and supported as required by experts (see EECS Subsidiary Document SD01, “Assessment Panels”).

A central registry model would typically maintain data integrity automatically, and any required corrections would only be needed in one place. Also, the issue illustrated in the above example would be nearly impossible, as both the transferrer and the transferee are account holders in the same system. Moreover, dispute resolution related to technical transfer errors would be easier because all data regarding transactions and user actions would be stored in the same database.

8.7. Market supervision

Technical fraud prevention typically requires purpose-specific transaction reporting and logic to detect suspicious activity.

An example of such suspicious activity is the same certificates repeatedly entering and leaving the same account, which can indicate the existence of Missing Trader Intra-Community (MTIC) fraud. In theory, such fraudulent transactions will be international, and hence in a hub-centric model it should be possible to detect them in the hub alone, without involving participating registries. However, most registries accept account holders from foreign countries, enabling cross-border transactions between account holders registered with different national VAT authorities in the same registry (possibly in a different country to either account holder), leaving monitoring of market activity and fraud detection and prevention by the hub ineffective.

Furthermore, brokers and service providers may use their own accounts to hold their clients’ GOs. This allows an account holder to operate several sub-accounts, each on behalf of different clients. These transactions do not go through the hub and are not even reported to the hub as transfers. This is because the registry will not see these as certificate transfers between account holders, but instead it will view them as being administrative transactions by the account holder. Hence such international transactions can take place without the knowledge of the registry operator or the operator of the hub, preventing effective monitoring and control.

Centralised registry models enable more efficient fraud detection and automatic market supervision (e.g. detection of potential carousels, identification of unexpectedly high transaction volumes relating to an accountholder …), perhaps making use of artificial intelligence and machine learning to detect suspicious activities in real time. This is one of the reasons why DG CLIMA adopted a centralised model for the EU-ETS registry. On the other hand, the fraud carousels can 'spin' faster in a totally centralised registry model, so it is always a race between the fraudsters and the supervisors.

In conclusion, a hub-based approach provides a good compromise solution, as it permits central monitoring of international transactions, while leaving national registries responsible for fraud detection in their own domains.

This matter was addressed in FaStGO Task 2, and the FaStGO text proposal for a revised of EN16325 included provisions with regard to ownership of a GO that seek to prevent the sale of GOs without this being accompanied by an actual transaction in a registry. It is considered further in FaStGO Task 5: "Financial Fraud Prevention".

8.8. System access

The cost and complexity of setting up a certificate registry of one's own creates a barrier to entry for new countries looking to join the common market. The costs have discussed earlier in this document: such an investment by a public body naturally requires separate budgeting and EU level public tendering, possibly involving separate tenders for specification, development, and ongoing operations. After the system is built, it needs to be connected to the other registries using the hub if it is to be part of the common infrastructure, and such connection is requires appropriate testing and technical audit and takes time and money.

This means that the time needed for a country to become part of the common market - starting from when a competent authority is mandated to undertake the task and ending to the first international transfers - can be 2 years or more. This can be due to technical reasons[12], but often it is due to the time it takes to bring the relevant member state's fuel mix disclosure legislation into line with the quality requirements of other member states – for instance, a common issue is for it to be possible to sell electricity as renewable in the country of production, while exporting the related GO to a market party in another country.

A centralised model would probably make the technical connection of one country to the hub, and therefore to the rest of the market, much faster and more affordable. On the other hand, countries may find that a centralised model is not suitable to their national practices and surrounding regulation, which may cause delay and cost for other reasons.

This suggests that the more flexible solution of offering some central facilities while permitting national derogation is preferable to a fully centralised approach.

Note that in any case, the design, development, and operation of a centralised model would need to be tendered centrally, meaning that the costs would in effect be shared and any delay would impact all member states collectively. It also has the potential downside

[12] *In some cases, the process can be considerably faster. For example, Powernext of France managed to go live within seven months of being appointed, partly by using in-house development; while other countries use readily available registry services or have framework contracts in place to provide such services*

that such complex software can hinder the ability to change the supplier of the software and/or services.

8.9. Free movement of GOs

As provided in Directive 2001/77/EC, 2009/28/EC and most recently 2018/2001/EC, member states are required to recognise GOs issued by other member states. This implies that GOs can be transferred or at least used cross-border. However, the current decentralised registry structure requires each registry to be controlled by a national or regional authority, which means that:

1. Each registry must have its own account holder onboarding processes, including Know-Your-Customer, fees, user interface, etc.; and
2. To be able to maintain control over importing and usage of GOs in the registry's territory, GOs have to be imported into that registry and then cancelled there for use for disclosure.

From the account holder's perspective, this requires an account holder with consumption or clients in several countries to open accounts in all relevant countries, go through onboarding procedures, pay any associated fees, and learn how to use the registry. This added complexity and cost inhibits the free movement of GOs and is fundamentally caused by the implementation of a distributed registry model. A more centralised model could make use of a centralised onboarding of account holders. It would also easily support cancellation of GOs cross-border by dividing such a cancellation into an export to the country, and a cancellation in the country.

On the other hand, this would need a central registry to exist, and national competent authorities might feel that central cancellation would damage their technical ability to supervise and restrict the use of GOs, and they could well be unwilling to have to rely on a party that is not under their competence to supervise (even if this is legally possible, which is not always the case).

8.10. Speed, integrity, and duplication

The decentralised structure lengthens transaction processing time, in some cases to days or weeks because of technical issues and incompatibilities. It also prevents real-time validation of a transaction. This is because part of the validation is done by the receiving registry and possibly by a hub, leaving account holders unsure whether a transaction is actually irrevocably processed. In the hub-centric models, a transfer from one registry to another gets recorded 3 times, each of which takes time and introduces a possibility of something going wrong. Not only is data being triplicated, but as observed earlier, systems must be carefully designed to ensure that data integrity is protected by preventing transactions being recorded in a slightly different way in different places.

In the centralised models, transactions could be committed immediately and irrevocably, and would not need the same measures to protect data integrity.

8.11. Support for maturing of markets

An efficient and secure transaction infrastructure enables a more mature market with sophisticated services such as multilateral marketplaces, clearing and settlement services, and risk hedging instruments. A distributed transaction processing model does not optimally support sophisticated market services. For example, a full-fledged marketplace with clearing requires a clearing account. For a clearing house to be able to guarantee timely and reliable delivery of GOs, it must require market participants to have their counter accounts residing in the same registry as the clearing account. Clearing services typically require a registry to have modern and reliable Application Programming Interfaces (APIs) to automate and secure their processes. Currently, many registries have

APIs, but they are not standardised and vary in functionality. The lack of common APIs also prevents the automation of account holders' business processes.

A centralised registry model would enable other market infrastructure to commit and confirm transfers immediately. On the other hand, it could be seen to be too efficient, if fraudsters find ways of benefiting from any weaknesses elsewhere in the system.

8.12. Chain of custody

Under EU law, the purpose of GOs is to prove to consumers the origin of energy (usually renewable energy) in a supplier's energy mix. For that purpose alone, a simple book-and-claim system suffices, as has been seen in practice. However, various stakeholders are calling for the chain of custody for GOs to be identifiable for a number of reasons, each being set out in separate sections of this report:

- The risk of VAT fraud carouseling calls for clear focus on the areas in the GO transfer system where a risk of fraud exists.
- The interplay between GOs (REDII art. 19) and sustainability certificates (REDII art. 25-31) must be carefully provided for, to ensure that each cannot be used for the purpose intended for the other, and a chain of custody will provide proof that this has not taken place.
- There is market demand to use GOs in order to waive obligations under EU-ETS. Again, GOs and emission trading credits should not be used interchangeably, and a chain of custody will provide proof that this has not taken place.
- Market dynamics displayed in statistical aggregated data could enhance market transparency and market functioning. On the other hand, the potential market barriers such innovations might introduce should be investigated, and this will be facilitated by information on the chain of custody.
- Chain of custody enables supervision of market actors for multiple purposes, such as dispute resolution and investigation of market (mis-)behaviour.
- Chain of custody will assist energy carrier conversion – data tracking on the GOs of the preceding energy carrier(s) – and hence sector coupling.
- In principle, the chain of custody can be recorded and retained in all registry models, as all transactions could be collected from several registries to build the total picture of transactions. However, in practice, it would take far too much time and would run into too many issues of such things as confidentiality and data protection to be a useful way of investigating issues. In a centralised model, chain of custody would be easily available.

9. Potential future developments

The following considerations do not directly impact the specific form of architecture, but as they impact the abovementioned criteria, they are relevant. They should be taken into account in the design of any systems to support the selected option, although it is recognised that it may be difficult to agree a collective approach given that the scope and challenges encountered in each member state may differ.

9.1. Multiple purposes for energy tracking certificates

9.1.1. Tracking for Different Purposes

The purpose of guarantees of origin is to demonstrate the origin of energy to final consumers, but there are also other tracking purposes which should ideally be linked with, or at least not to interfere with the purpose of, GOs. The most important such tracking purposes are support systems and accounting for the achievement of targets.

Tracking for target accounting is needed when a target to buy/sell/consume energy with certain production attributes is applied to an entity other than the energy producer, for example a member state, a distributor, or a final consumer. Article 25 of RED II effectively sets a target of 14% of the renewable share to distributors of transport fuels.

Tracking for support means the process of allocating public support according to compliance with specific energy attributes, such as energy source, age of installation, and generation technology. For example, in the Swedish-Norwegian Elcertificate scheme, new installations using certain energy sources and technologies receive an Elcertificate for each MWh produced. A quota obligation is placed upon energy suppliers and large consumers, which are required to buy and cancel Elcertificates representing a certain share of their sales/consumption. Similar quota obligation certificate systems are in place in Belgium (all three regions) and in Italy.

9.1.2. Implicit Cross-Purpose Double Counting

One might hypothesise that GOs, or a specially designed single-certificate system, could be used for all tracking purposes. Most of the time, this is not a feasible solution due to the difference in markets, attributes, calculation rules and (for example) audit requirements. As a result, a multi-certificate system often emerges, where certificates for different purposes are issued for the same MWh of produced energy. A well-known drawback of such multi-certificate systems is cross-purpose double counting. This means that an energy consumer in Sweden can only be certain that it has received a certain share of renewable power (based on the Elcertificate quota of its energy supplier), if GOs issued for the same energy have not been sold elsewhere.

9.1.3. Concept of Multipurpose certificates

A data field on the electronic document that displays its purpose has, for a long time, provided support for certificates with multiple purposes. The FaStGO text proposal for a revised EN16325 standard comprises such a data field on the GO, allowing the use of the same electronic document for multiple purposes.

While it would be theoretically possible to design an all-purpose single-certificate system, without doubt it would be intellectually challenging when additional requirements pop-up relating to a specific purpose.

Another option would be to coordinate and harmonise the different certification systems such that they maximise the synergies, such as common audits and information systems, and minimise the likelihood of implicit double counting and costly compromises.

9.1.4. Disclosure and support

In countries where the financial support system utilises a certificate system, this provides motivation for applying the same data structure for GOs as for support certificates.

Given that support systems are national, multipurpose certificates which include support as a purpose usually remain at national level. In Flanders, between 2006 and 2013, the same certificates bore the purposes of Disclosure (GO) and Support (Quota Obligation for Green Certificates). In 2013, both purposes were unbundled as separate certificates which, however, still have the same data structure.

Also, the Walloon and Brussels support certificates are based on the same data structure as the GO, with an explicit communication that support certificates cannot be used for claims on the origin of the corresponding energy consumption. Indeed, a pure support certificate simply entails the notion that an amount of energy has received support. The same applies to Swedish and Norwegian Elcertificates, with the exception of a few data fields and business rules.

9.1.5. Disclosure and targets

9.1.5.1. General

Since targets as provided by REDII art. 3 are national production targets, and since production is usually well known, the GO data system has not been applied for target accounting.

9.1.5.2. Mass Balancing

Mass balancing must be carried out on a consignment-by-consignment basis for two principal reasons:

- the full chain of custody can be covered in this way; and
- each individual consignment has different sustainability characteristics.

Mass balancing ensures traceability of a specific gas consignment from the consumption, passing through the trading stages, to the production and finally up to the cultivation of the biomass. For a mass balancing system to be operational and trustable, it must guarantee the link between the biogenic properties and the physical flow of a specific consignment of renewable gas, which will lead to the legal transfer of ownership of that specific gas consignment. The biogenic properties are documented according to Article 30 of RED II. These properties are inseparably attached to the origin of the gas consignment. Thus, it is irrelevant whether the renewable gas injected into the grid mixes along with the other non-renewable gases in it because the above documentation for that consignment guarantees its biogenic properties. A mass balance proof allows to evidence to be given of compliance with the sustainability criteria from RED II. That is, the raw materials used were obtained according to the Directive's land-related sustainability criteria, being that:

- the greenhouse gas emission value is compliant with the Directive's sustainability criteria; and
- the raw materials used, and their origin are described.

Thus, the sustainability documentation required by Article 30 of RED II can serve for the achievement of support mechanisms or the fulfilment of certain quotas (e.g. transport).

9.1.5.3. Linking mass balancing with GOs

With a view to avoid the cross-purpose double counting, as mentioned in section 9.1.2, there is a good reason for connecting the documentation that enables verification of the sustainability criteria and mass balancing, with the GO. This is further elaborated in the report of [FaStGO task 1.3] section 10. This can be done through a connection between the

GO and the documentation according to article 30 of REDII. Making this connection inseparable and clarifying multiple purposes for the same electronic document, provides a solution to the risk of double consumption claims for the same amount of renewable energy.

9.1.6. Different Tracking Purposes as Extensions of the GO System

A way of linking different tracking systems would be to use a standard GO system as a basis, and link to it tracking for other purposes by conveying different certificates (e.g. GOs and support certificates) on the same electronic document. A GO system provides a good basis for the creation of an electronic document, because it is based on an official standard and covers all relevant energy media. In addition to the facilities offered by a GO system, systems for tracking other purposes could require:

- Additional audit features such as voluntary scheme sustainability and proof of supply;
- Mass balancing and chain of custody tracking;
- Additional attributes, such as CO2 emissions and savings; and
- Restrictions of trade and other trade rules.

In ideal world, the simplest solution would be to have a multi-purpose certificate system, where all purposes are carried by a single certificate per unit of production. Because of the different requirements imposed by tracking for different purposes, the ideal system might not be achievable given the current regulatory environment. A practical solution could be that certificates for other purposes are considered to be an extension of GOs. In such a solution, we would require issuance, cancellation, and possibly transfer of certificates for other purposes to be linked to the respective GO transactions. GOs would be handled and governed by the national competent bodies, while certificates for other purposes could either be handled by the same bodies and use the same registry, or they could be administered by different government or private organisations in a separate registry.

Linking GOs to other tracking instruments or vice versa could be done to prevent (even implicit) double counting, without undue interference with other markets.

For example, gas GOs could be issued and governed by a national competent body implementing CEN-EN 16325; while another organisation could manage support certificates and sustainability certificates, linking these to the related GOs via unique GO IDs. This would mean that a producer requesting the issuance of supply and sustainability certificates should first request the issuance of standard GOs and present the proof of issuance, together with other required evidence such as audit statement to the body governing supply and sustainability certificates. Thereafter, these certificates could have separate lives up to the point of cancellation.

When seeking the cancellation of supply and sustainability certificates, the account holder should first have the GOs cancelled and present these, together with any other required evidence, to the supply and sustainability certificate scheme administrator. The scheme administrator would then check (for example) whether the GOs are cancelled for the same user/geography/organisation, along with any mass balancing documentation, as appropriate. If the scheme requires the full chain of custody to be same for GOs and supply/sustainability certificate, then a similar procedure could also be required for transfers.

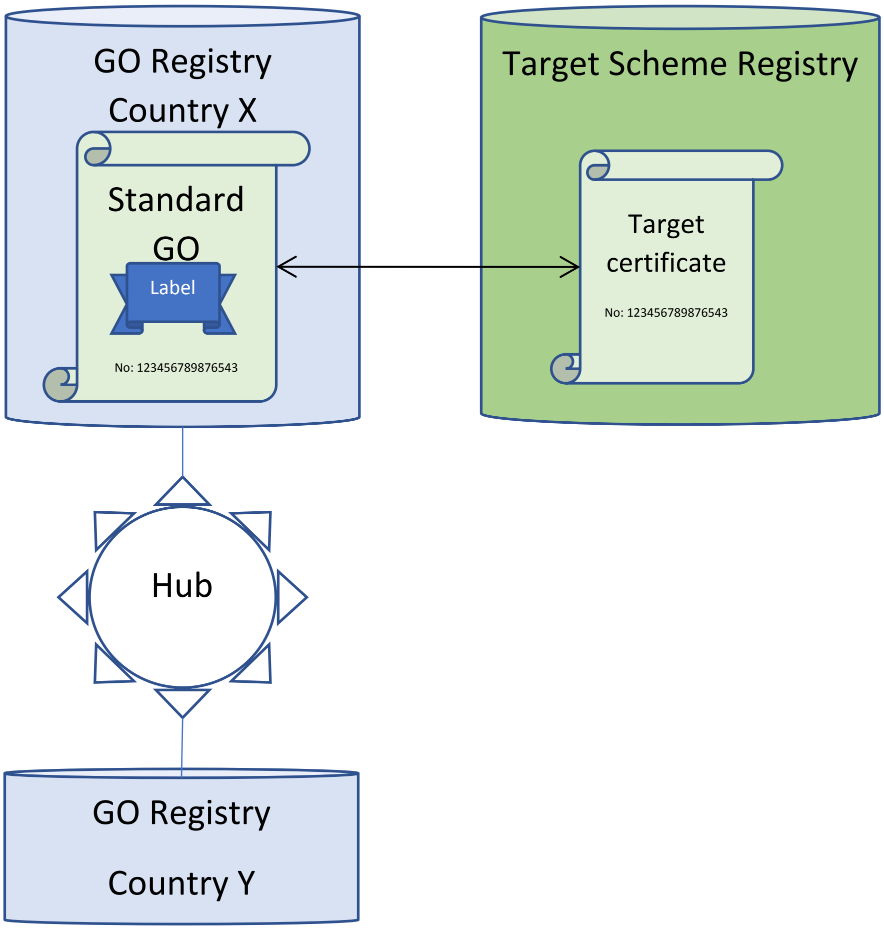

Figure 10. Linking other purpose certificates to GOs

As a result, the standard GOs would be handled by competent bodies without extra processing, or additional requirements on data fields. Certificates for other purposes could be handled in another registry and by another organisation, applying the relevant certification rules and making sure that the linkage to GOs remains by using GO IDs.

Besides managing the quality of the different certification systems, the corresponding certificates will need to be matched so that the issuing body can state that the right types of certificates have been cancelled, and the requested documents can be issued.

This raises the question whether such matching should be manual or automated, which will be heavily influenced by the amount of matching required. If this is substantial, then an automated linkage between the various involved registries will be essential. This could be as simple as GO registries providing an API, which the Target Scheme Registries could query for relevant issuing and cancellation details of GOs to automate cancellation and issuing

9.2. Energy carrier conversion

Energy carrier conversion provides the main reason for synchronising the data infrastructure in GO systems for the various energy carriers. This will be required from the moment REDII enters into force, although deciding the detailed implementation could be deferred.

Following art. 19 of REDII, a GO needs to be issued on request - e.g. when a producer requests GOs for electricity production from gas from the gas grid, of which the origin was proven with a renewable gas GOs, the issuing body needs to be able to issue a renewable electricity GO.

When confronted with requests from producers to issue GOs **following energy carrier conversion, an Issuing Body will need a procedure in place to handle such requests. At energy carrier conversion, a quantity of GOs of the input energy carrier must be cancelled corresponding the amount of physical energy input into the conversion production device. The issuing body will have to match the measured input with a quantity of cancelled GOs for the input energy carrier**. When importing a GO from another carrier, an issuing body will experience a dilemma in implementation. This can be illustrated as follows, for the case of conversion of gas into electricity:

1. Allow import of the gas GO only electronically in the electricity registry (this option enables automated processing, but may require IT updates in registry); or
2. Allow import of the gas GO by means of an Ex-Domain Cancellation (this option is cheaper in the short term in relation to IT cost, but involves significantly more manual work for the issuing body); or
3. Facilitate energy carrier conversion centrally as a service to issuing bodies. This could be facilitated by cancellation of the GOs for the input to the energy carrier conversion in a central facility, the output of which clarifies which data elements are to be reproduced in the new-to-be issued GOs following the energy carrier conversion. This option omits the need for single-energy-carrier issuing bodies to organise the importing of all the data fields of GOs for other energy carriers. It would require investment at central level to set this up.

Once markets for the non-electrical carriers achieve big volumes, the first option will be the more desirable. It will require GOs for the various energy carriers to be handled in the same data format and transfer protocol. The third option provides a worthy alternative.

9.3. Voluntary data and GO immutability

Immutability is a core principle for a reliable GO system: a guarantee of origin may not be modified after it has been issued (except to correct errors, and only by its original issuing body). If, after its transfer to another registry, data on a GO is modified (e.g. changing the energy source of the corresponding energy), the credibility of the whole GO system could be at stake. Therefore, it is essential that all registry operators involved commit to the principle of immutability.

One challenge to this principle arises regarding the treatment of additional optional data fields by issuing bodies for various energy carriers. Optional data fields exist to meet the demand of some stakeholders, while keeping costs low for others. Also, while voluntary information should not be modified, it is questionable whether this can be dropped when the associated certificate as imported. A reason for not doing so might be that the importing registry has not foreseen a need for these data fields in its registry architecture.

A decision has to be made about this when deciding about the details of the transfer protocol. It is also relevant to the building of an overall IT infrastructure: in a central registry that would manage GOs for all energy carriers, there are no cost arguments for leaving out optional data, as the data structure facilitates all voluntary fields.

9.4. Real-time GOs

Another upcoming trend is the concept of "real-time GOs". The purpose of these is to associate produced and supplied energy for a specific hour, rather than a specific day as at present. The benefit of this is that the carbon emission and price of production at a specific time can be more accurately calculated, and where production of renewable energy in a specific hour does not meet demand, then the supplied energy is not sold as "renewable". Note that such real-time GOs could not be issued the instant that the energy is produced but would instead be issued when any measurement issues have been resolved and matched ex-post.

Real-time GOs might be issued for smaller energy units, e.g. kWh, and the production periods would be hours or less instead of weeks and months. They could then be automatically issued, transferred, and cancelled for a beneficiary according to smart contracts. Real-time GOs could be provided as an extension of the current systems, or they might be supported by a separate system – provided a way can be found of preventing double-counting.

Real-time GOs would be a way of allocating production to consumption, in line with daily and hourly consumption and production profiles, and trials of this are already being conducted by some competent bodies.

Real-time GOs would enable more realistic accounting of "actually consumed energy" and a new kind of demand-side management of renewable power, as well as enabling the attribution of the actual production costs and emissions of consumed energy to consumers. Consumption of renewable energy would not be possible when there is insufficient production to cover it real-time; but enabling reliable accounting for a 'green peak' may assist in its (market-based) funding.

Well-designed smart contracts for blockchain may relieve an issuing body from certain aspects of its work, especially when interfacing with other agents like measurement bodies and production device inspectors.

There has already been work done on the use of distributed ledger, but real-time GOs could be supported by modifying the current system with other technologies. Also, the blockchain design can be such that it still relies on limited trusted parties, for example issuing bodies.

10. Conclusions

10.1. The technical (but impractical) ideal and its constraints: why a single centralised registry is inappropriate

If a peer-to-peer architecture is rejected as both unwieldy and costly to operate, a blockchain-based architecture is rejected as 'a solution without a problem', and a hub-based architecture is viewed as duplicating effort, transactions and data, then a central system might be seen to hold certain advantages. These include:

- Low total costs for central services compared to multiple registries and hub(s);
- Easier to adapt to scheme changes, as changes are only implemented in one system;
- Efficient and immediate transfers;
- Storing the full chain of custody in one place would enable efficient and automatic reaction to suspicious market behaviour;
- A lower barrier to entry to the market in new countries, which would not need to implement their own national registry; and
- Data integrity as (for example) transactions are only stored in one place.

While the fully centralised model might find favour in an ideal world, when "taken out of the laboratory" it would clash with real-world constraints. These include:

1. **Political and legal issues.** As noted above (section 8.1) an exclusive single GO registry would probably require the European Commission to be mandated to directly supervise the issuance of GOs, and to do so a new regulation[13] would be required. In addition, a new and properly mandated agency would need to be established to run the registry. Having all of this in place as a solution for RED II Art. 19 implementation is unlikely to be possible (certainly within the required time-frame), and would require a high level of political will, even in the long term. Any central system offering the ability to transfer GOs between account holders, supported by other than a formal institution of the EU, would need to surmount formidable legal obstructions and financial barriers.
2. **Linkage with other national systems.** Most, if not all, member states have closely-coupled their registry systems to other systems, such as energy measurement, fuel disclosure, energy settlements and support systems, and will be reluctant to lose control of them. More important, moving this coupling from a national to a central registry would need substantial reworking of national systems and the provision of member state-specific functionality of the central registry. Not only would this in itself be costly, but it would also require considerable management oversight to ensure changes are made in a timely manner to reflect changes to the national systems. As much as anything, this argues strongly against a central registry.
3. **Cost.** Most competent bodies have spent large sums of money on the development of the computer and associated manual processes – some quite recently. In addition, their staff will be familiar with the operation of this. They are likely to be more than reluctant to abandon this investment.
4. **National requirements.** As noted in section 0 above, provision of features which support national preferences and reflect the demands of other energy-related systems will, in addition to the interfaces mentioned in item 2 above, add complexity to a central system and reduce the flexibility of provision of support.

[13] *Similar to that issued for ETS registry "COMMISSION DELEGATED REGULATION (EU) 2019/1122"*

Further, much of the flexibility with regard to the IT development that is gained by centralising would probably be lost to discussions relating to IT design.

5. **Migration**. The migration from the current architecture to the new structure would be a time-consuming and difficult task and, should experience suggest that it was the wrong solution, then reversing it out would be extremely challenging.
6. **Flexibility.** Even though a central system would probably be flexible to changes in regulation, from member states' and market parties' point of view it might be seen to be an inflexible compromise solution which is unlikely to be reactive to user requirements.

To sum up, while in theory the fully centralised model might be the best alternative, in practice the preferred solution should be something which benefits from the best of each of the centralised and distributed worlds.

10.2. Why an evolutionary, hybrid model is preferable

An evolutionary, hybrid model allows member states to retain their own national registries if they wish to do so, offering a hub to interconnect them; while providing a centralised registry for those who prefer a common approach, including those which are not using a hub-based approach at present or who do not have a registry currently – such as those required to support the hydrogen and gas industries.

10.2.1. Starting from a hub-centric approach for cross-border transfer only

The existing framework provides a one-to-many connection for facilitating international transfer in a trustworthy manner with facilitation of quality control. This has been proven to work well where GO system management is delegated from the European legislator to the national level. It saves duplication of effort with regards to facilitation and quality checks for cross-border transfer of GOs.

10.2.2. Advantages of an evolutionary, hybrid model

It would also have to provide facilities for all member states to carry out such functions that would benefit from a central oversight, which might for example include:

- Public reporting;
- Private (non-public) transaction reporting for purposes of detecting and assuring fraud resistance;
- Residual mix cancellation;
- Quality assurance reviews and audits of member implementations of REDII; and
- Cancellation.

Even though this model may not be an ideal solution from the perspective of information technology, it offers a more optimal solution in the real world. The benefits of the model include:

- Many of the benefits of a fully centralised registry model for those wishing to take advantage of them, including lowering the barrier to entry for new participating countries;
- Availability of central supervision for purposes of:
  - fraud detection;
  - reporting;
  - dispute resolution; and
  - facilitation of cross-border transfers;

- The possibility of continuing to use the existing national registry, so as to protect sunk investments;
- Better localisation and implementation of national deviation by use of the national registry;
- The ability to move gradually to a more centralised infrastructure, should member states individually or collectively decide to do so; and
- Enabling a phased implementation which meets political and legal developments.

10.2.3. Challenges of an evolutionary, hybrid model

An evolutionary, hybrid model provides many of the benefits of the central model, while retaining other benefits of a hub-centric model. It avoids many critical pitfalls of both models but, being a compromise, it would have some drawbacks of its own:

- As a system, it combines the complexity of a multi-domain registry and an interconnection hub. However, given the differences between individual national administrative legislation and energy markets, against this must be balanced the additional costs and complexities of customising any central registry to provide national systems interconnection and nationally required features.
- The selection of the operating entity and required mandates need to be decided.
- There may potentially be an inequality between members states and account holders using the centralised registry, and those using a national one.

10.2.4. Evaluation of the evolutionary hybrid model

All in all, an evolutionary hybrid model has the potential to overcome most problems associated with each of the simple models described in section 0.

It offers a robust and resilient solution that would respect the investments of member states in terms of system development and integration with other national systems, while providing a basis for enabling long-term development towards a more mature and secure market infrastructure.

10.3. Conclusion: a pragmatic way ahead

10.3.1. General description

The FaStGO text proposal for a revised EN16325 was published on 8th July 2020 (FaStGO task 2, part 2, version 2). The IT architecture considered in this paper supports this proposal and bears in mind that member states are individually responsible for appointing competent body and its agents.

It may be that, over time, certain features of a centralised approach could be adopted, leaving member states to decide whether it is worth their time and effort to move to a more fully centralised solution.

However, a collective approach to supporting competent bodies is not applicable unless a future agency is created to provide such support. This would require support by all member states, and issuance of an appropriate regulation by the Commission – which is likely to take considerable time. Furthermore, member states have made significant investment in their own GO systems, and in particular the IT infrastructure to support it, and will be unwilling to move to a more centralised approach until there has been an acceptable return on this investment.

Instead, a more collaborative approach should be adopted. Such an approach would require each competent body to create and operate a registry for GO activity in its own domain, and to cooperate in the facilitation of inter-registry transfers and overall administration and supervision of the international aspects of GO systems. Such an approach is the most flexible, pragmatic and cost-effective – not just for the development and operation of IT systems, but also for the purposes of coordinating and gaining the agreement of competent bodies to the definition and implementation of changes to the system. Indeed, this approach has been adopted by the AIB since the outset, in 2001.

Over time, with the collective support and participation of competent bodies for guarantees of origin and disclosure in each participating country, some features of the overall system could be centralised. These might include 'conversion' of GOs for one energy carrier into GOs for another energy carrier, to assist in VAT fraud detection, and enabling multinational consumers to cancel GOs for use in a number of countries without the need to manage accounts in each country, while ensuring that the functioning of the issuing body is not compromised.

However, it seems likely that member states will wish to retain at least some aspects of GO systems at a local level. For example, the creation of the datasets for each GO, which will probably draw on data received from other national systems such as meter data, plant data, support information and so on; and the cancellation of GOs (for all account holders, or just for non-multinationals).

Proceeding in this manner would offer the EU Commission and other institutions adequate time to consider whether the body supervising the hub should have formal status, in order to overcome the financial and legal objections inherent in providing such a service; and to make the necessary arrangements for doing so, should the outcome of such a decision be positive.

Hence, unless at some future date a centralised approach is adopted by all member states, then each member state should be free to provide support for GO systems in whatever way it wishes, subject to agreement of a set of rules for collaboration in the international aspects of GO systems.

10.3.2. Implementation of this approach by the AIB since 2006

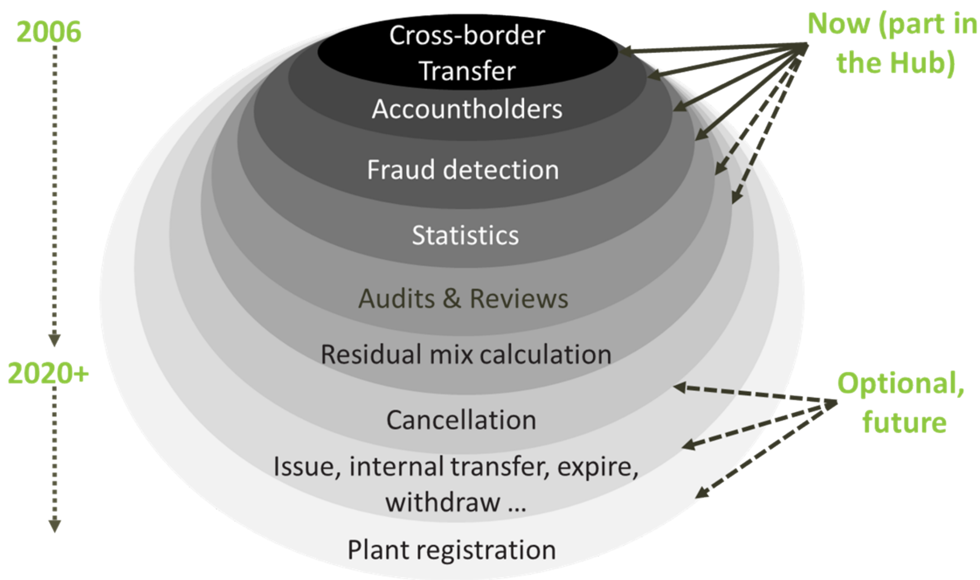

Figure 11: Evolutionary development of registry architecture [NB: Apart from IT-Technical audits, Domain Scheme audits and Doman Protocol reviews are not intrinsically part of an IT architecture, but they are mentioned here as they are an essential central facility]

The above figure shows the development of the registry architecture since 2006, when the AIB Hub was first put in place as a mechanism for facilitating simple and efficient international transfer of GOs.

This was followed in 2018 by the addition of a database of account holders, to make transfers more secure by ensuring that the correct account was nominated in transfers by counterpart registries, and facilities to detect potential fraud and market misbehaviour.

In 2020, the collection of statistics relating to GO activity (issuing, transfer, and cancellation) was automated, and further work is planned on the manipulation and presentation of statistical data as a service to members and market participants.

Supporting initiatives

While the following initiatives are not provided by the central hub, they support the smooth and efficient operation of the overall framework provided by EECS.

Since 2001, a system has been in place to review new member domain protocols (each setting out the detailed implementation of the GO scheme in a member country) and conduct triennial audits of compliance in each member country. This review/audit regime continues to be refined.

Also, since 2015, the AIB has provided a service to calculate the residual mix in each European country, having taken over this responsibility from the now completed RE-DISS II project.

The further possible enhancements of the system are shown to give context and would naturally be subject to exhaustive discussion and agreement amongst the issuing bodies before any decision is made to implement them.

10.4. Recommendations for EN16325

The current peer-to-peer and hub-centric architectures to be found in electricity and gas GO registries are adequately served by EN16325, which requires no revision to address the needs of these architectures other than to recognise the inclusion of gas in the standard. The allocation of roles and responsibilities as provided in the FaStGO proposal for the revised EN16325 refines the standard to reflect the requirements of REDII (and, in particular, the need to support electricity, hydrocarbon gas, hydrogen and heating & cooling), and to allow for a level of centralisation that is jointly agreed between the mandated issuing bodies.

However, if the decision is made to move from the current Hub-centric architecture towards a functionally-centralised IT architecture, in order to reduce the level of duplication of effort and associated cost by (1) retaining the issuance of guarantees of origin (GOs) at a national level; and (2) moving transfer, expiry and cancellation to a central platform, then the following aspects of EN16325 may need to be revised:

- The definitions of: Competent Body, Issuing Body, Domain and Registry;
- Allocation of responsibilities; and
- Limitations for: Export, Import and Cancellation.

A national regulatory framework can delegate responsibilities to an issuing body and/or its agent(s), which may be national or a pan-European supplier of registry services.

Currently, the mandate to a registry operator comes from the relevant national competent body, which can decide whether its registry is distributed or centralised, so guaranteeing that the IT infrastructure complies the national data management strategy as this mandate is under its own national control.

If, in future, a decision should be made at European policy making level to centralise GO management, then this mandating cascade would need to be revised.

As REDII does not currently support such a change to the systems architecture, no specific amendment of the draft standard EN16325 as proposed by FaStGO on 8th July 2020 is necessary to facilitate the solution as brought forward in this document.