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The state of renewable energy certificates in Europe

An analysis of gaps and areas for improvement in the current landscape

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Management summary

‘Green deal’, ‘Fit for55’, ‘Climate neutrality until 2045’ – the targets for climate neutrality are becoming increasingly ambitious. While these developments certainly are positive news for the climate it also means that massive growth is on the horizon. Is the market for energy attribute certificates (EACs) ready to handle such substantial growth? Can the existing infrastructure cope with increasing volumes?

This paper analyzes the current energy situation in Europe, identifies potential gaps, and highlights key challenges that the industry must address now in order to prepare for the massive growth that is predicted in renewable energy certificates.

Significant gaps have been identified, specifically in the area of Straight-through-Processing (STP). In order to make needed changes, market participants must take clear ownership and adopt a mindset for change. The future is bright, and the industry must take action now to be able to capitalize on growth opportunities.

Key findings

- Energy Attribute Certificates, specifically Guarantees of Origin (GOs) in Europe show a massive potential increase from approximately 900 million certificates in 2021 to between 2.5-8 billion certificates in 2030.
- Processing 900 million GOs currently brings market participants to their limits. Most registries use outdated platforms, and the Association of Issuing Bodies (AIB) Hub platform is operating at its limit. Producers, intermediaries, and consumers use semi-manual, in-house solutions which are the root causes of inefficiency and risk.
- Current inefficiencies create the risk of a dysfunctional market, and immediate action is needed to grow capacity. The sheer number of certificates requires improved processing. Otherwise, handling costs per certificate are predicted to significantly increase. Furthermore, daily operations and processing can be endangered due to a loss of oversight, and missed delivery and payment obligations. Failure to do so would cause operational as well as reputational damage to the industry.
- Intermediaries and service providers bridge significant gaps and play vital roles in improving the current certificate market. A shortage of skilled workers, time-consuming implementation, and budget restrictions call for more focus and the usage of specialists, support from whom makes short-term improvements possible.
- Action is needed to increase efficiency and decrease certificates’ total life cycle costs. A focus on straight-through processing (STP) in all market functions can help bridge the gaps.

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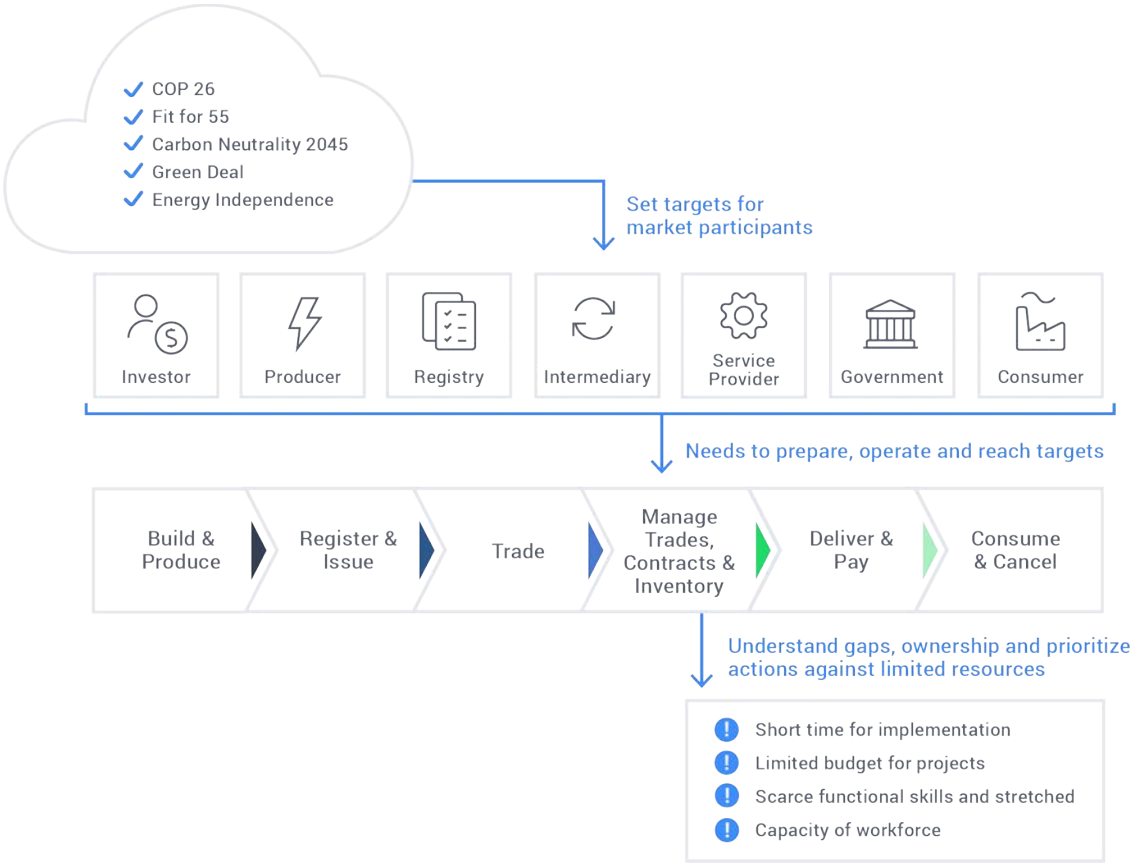
An urgent need to improve processing efficiency

The world is getting serious about combating climate change. In 2021, governments reaffirmed their ambitious plans for climate neutrality on global, regional, and national levels. At the UN Climate Change Conference (COP26) in Glasgow, most participating governments confirmed climate neutrality until 2050.

Also the European Union set an ambitious target of a 55% decrease in climate emissions for 2030 with the program 'Fit for 55'. Some EU members set even more ambitious targets for climate neutrality, such as Germany for 2045. And in the USA, the administration defined the 'Green Deal' with the ambition to reach net-zero greenhouse gas emissions by 2050.

These targets place added stresses on a certificate market that is already trying to cope with today's volumes. This means that in order to cope with ambitious climate goals, action is required by all impacted players – be it national governments, power producers, consuming industries, and systems for emission allowances and energy certification.

There is massive upside potential for the certificate market. This paper argues that this industry must address inefficiencies now in order to be able to capitalize on the exponential growth that is predicted.



Where to start?

A number of factors are making it more difficult for the industry to tackle structural inefficiencies:

- a short implementation timeline,
- a limited workforce with required skills,
- budget restrictions, and
- siloed systems

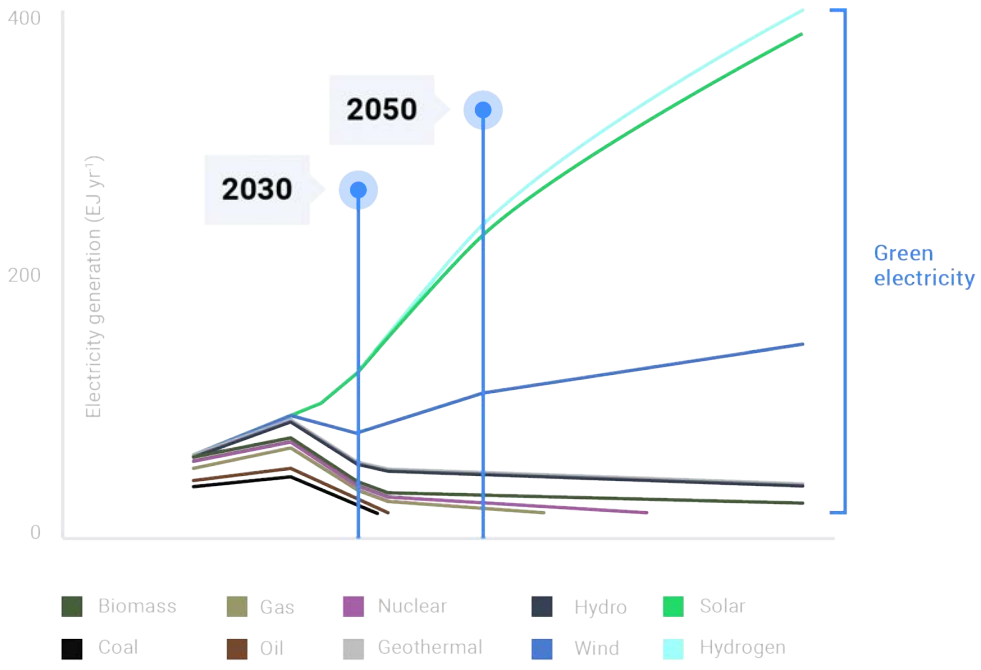
Taken together, these factors make it more challenging for players in the industry to achieve their targets. A successful journey towards climate neutrality must effectively allocate these limited resources to reach maximum efficiency in all relevant areas for implementation.

Using GOs as a model to map processes

This paper puts forth a way to use the GO lifecycle to help us see what is working well now in the industry, as well as pinpoint gaps and areas for improvement. We break down the GO lifecycle into steps, so that we can take a closer look at each stage of the life cycle, the different actors in each phase, who "owns" specific processes and thus, who is responsible for improvement.

Why GOs?

GOs were chosen as the use case for this paper because GOs play such a key role in the initiative for climate neutrality. Experts agree that the shift towards climate neutrality can only be reached by the decrease of emissions via the significant increase of green energy, especially green electricity.[1]



1 EJ yr = Exajoule per year / 1 EJ approx. 278 TWh Luderer et al. 2021; "CLIMATE PATHS 2.0 A Program for Climate and Germany's Future Development Expert Report For" 2021.

The approach

Our approach is to operationalize the European governmental climate targets mentioned above by introducing an analysis structure and applying it to the use case of European Guarantees of Origin (GOs). In our model we:

- Break down the GO life cycle into single phases.
- Identify specific areas for improvement within each phase of the life cycle by using the different roles (actors), their ownership of processes and their responsibility for improvement.
- Compare the maturity of the current market to an industry benchmark, which allows us to assess our industry's maturity in any given focus area against a de facto standard. We defined 'Maturity' as the connectivity and integration of platforms and processes, as well as core market functions and services offered.

Analysis approach: How to identify gaps and ownership

As a starting point, we perform a detailed analysis of today's processes, which allows us to objectively view the status quo. Later in this paper, we then compare the market against a benchmark.

We chose to compare the GO market with another, well-known European energy benchmark for this analysis: the European Energy Exchange's (EEX) Power Derivatives. We chose this benchmark to assess the maturity of the current market for green electricity certificates for two reasons:

1. Because Power Derivatives is a more mature market and
2. They share similar characteristics, which will be explained in this paper.

Once we have broken down the GO lifecycle into discrete phases or steps, we will compare and contrast them with Power Derivatives. Why?

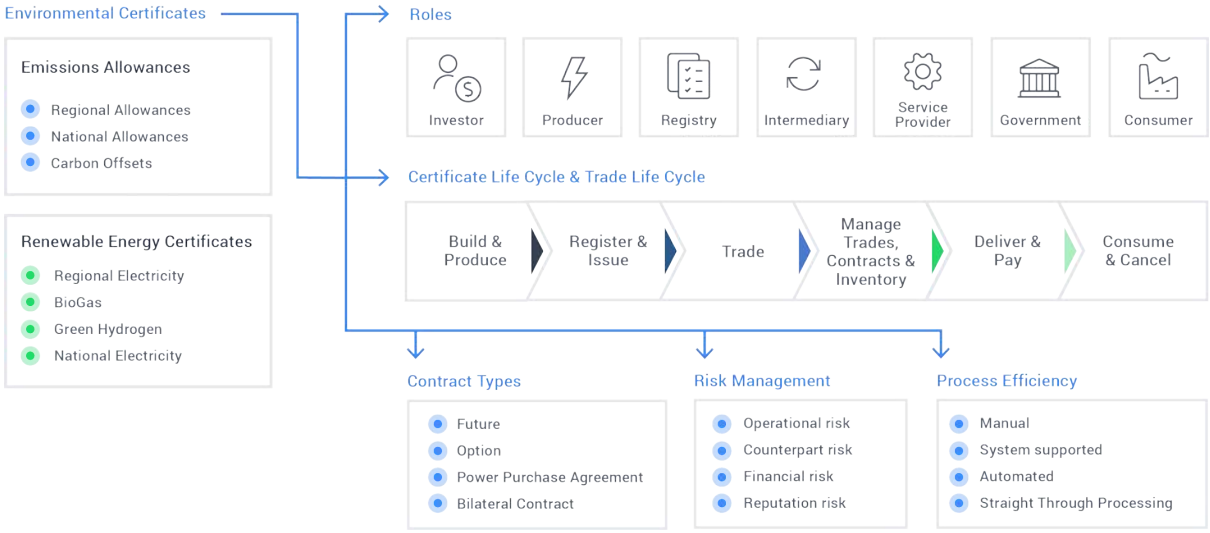
- To enable us to see potential gaps compared with a benchmark and prioritise those gaps. At the same time, when we look at how the market for Power Derivatives has evolved, we get ideas and inspiration for mitigating actions.
- To enable stakeholders (business leaders) to clearly see where they can optimise their own processes (e.g., risk management or settlement) vis a vis a benchmark - and track measures to solve those challenges.
- To enable the industry to see on a macro level where and how infrastructure must also evolve to become a benchmark.

Our requirements for the analysis approach we used were that it must be robust to ensure transparency and to enable the market to reuse/test it. The following analysis approach combines hands-on experience in establishing markets with academic research on market engineering for the initial rollout and ongoing development of electronic markets.

Drill down into life cycles, processes, and roles

For environmental certificates[2] , the market's maturity is developing along the same dimensions as energy derivative markets. Both markets use products as the underlying instruments for synthetic contracts. Both provide mechanisms for issuing contracts, matching supply and demand, and mitigating settling trades and risks.

The following dimensions can be used as an analysis grid to assess the impact and potential solutions for identified gaps and inefficiencies:



The scope of this analysis is limited to renewable energy certificates (EACs) such as the Guarantee of Origin (GO) in the EU and European Economic Area. Emissions Allowances are only shown for completeness of environmental certificates.

[2] Defined as all certificates issued and used for targeted climate neutrality. This ranges from emission allowances (e.g., European Allowances) to certification for green energy (e.g., Guarantees of Origin).

The categories we chose to analyze

The graph on the previous page shows a breakdown of various factors and/or processes we chose to analyze for this research. Below is a description of these factors. Later, we will go into more detail in terms of the breakdown of each of them.

Contract types develop over time, starting with simple bilateral trades for immediate payment and delivery. Further complexity is added, with, for example, long term contracts or different jurisdictions. In mature markets, standard derivative contracts are offered with options and futures.

The Certificate Life Cycle includes the steps performed by registries concerning the issue, transfer, and cancellation of a certificate. Certificate issuance depends on the successful registration of a power plant and account opening at registration.

Trade life cycle is critical to fully understanding the certificate flow from trade agreements to settlement with delivery of products versus payment. Certificate life cycle and trades are combined, as all steps of both life cycles overlap.

Roles allow the precise allocation of the ownership of process steps. Market participants can take on multiple roles – an energy company, for example, can act as both producer with its plants and intermediary as market buyer and seller. Nevertheless, in each instance the company acts as though it has only a single role.

Risk management is an integrated function in all business activities. In a market with trading and settlement, defaulting market members or in-house errors are significant risks and can lead to high costs.

Process efficiency is used as a base measurement of efficiency. It ranges from level “manual” to STP, providing frictionless connection and data flow between all process steps, functions, and life cycle phases.

Note: The dimensions introduced above do not cover all aspects of a market, but are sufficient to start and identify specific gaps – and the natural “owners” who need to act.

Assessing maturity against a benchmark

Energy derivatives markets have a long history of striving for efficiency and risk mitigation.[3] The EEX with its “Power Derivatives Market” is one example. It has a high level of trade automation, robust delivery mechanisms, and built-in risk mitigation throughout a contract’s life cycle. That’s why it makes sense to use EEX Power Derivatives to provide a good blueprint for other evolving markets, specifically as a comparison for GOs.

The EEX Power Derivatives market is characterized by Straight-through-Processing (STP), which is a hallmark of efficient markets. In the case of the EEX Power Derivatives, there is full automation in all phases of the trade cycle, as well as frictionless data flow within and between market participants. The trade contracts are fully standardized, future contracts are kept and processed 'on exchange' until settlement date and trading is against a central counterpart significantly reducing the delivery and payment risks.

It is useful to compare the level of maturity that the GO market has reached compared to this blueprint. This understanding enables all market participants to focus and prioritize areas for improvement in terms of efficiency of processing.

We created a qualitative score, based on definitions which are presented in the table below. Maturity levels (definitions shown in lines) are used to set the score per analysis dimension introduced in the previous chapter.

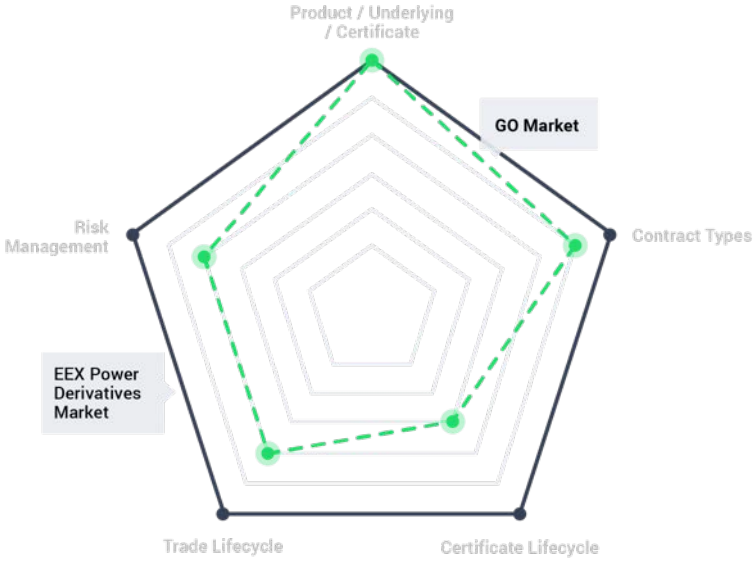
Markets can be assessed a score of 0 to 3. In the table, high-level definitions are provided in column 2 which describe what different maturity levels look like in practice. For each dimension, a specific definition per score is deducted from the general definition. The matrix can thus be used to set a maturity score for each analyzed certificate market.

[3] A Central Counterpart in a market taking the risk of delivery and payment against buyer and seller, for example.

The graphic below shows the results of scoring with the benchmark market. EEX Power Derivatives, which has a score of 3 in all dimensions.

In contrast, the GO market (choosen as use case) is expected to show several scores with lower maturity than the benchmark.

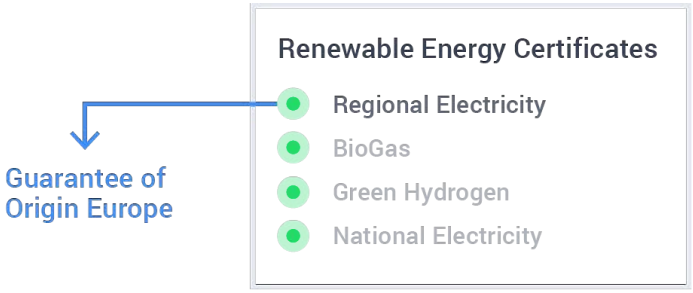
This scoring enables market participants to gain a perspective on where the market stands vs. where it could be, and what kind of positive difference improving a score in a specific area could make - ultimately to businesses' bottom lines.



	Manual	System Supported	Automated	Straight-through-Processing
Description of maturity levels	All processes and tasks and functions are executed manually	Some processes and tasks are executed with support of IT systems	Some processes and tasks are executed by IT systems within one organization or role	All processes and tasks are executed automatically across all involved organizations or roles
Score Value	0	1	2	3
Product / Underlying	The product is not standardized and is individually defined for each trade	The product is standardized and issued with some IT support	Standardized products are issued automatically	Standardized products are fed into an STP life cycle
Contract types	A contracts is not standardized and is individually defined for each trade	A contract is standardized and setup with some IT support	Standardized contracts are available for automated processing	Standardized contracts are fed into a STP life cycle
Certificate Lifecycle	Manual handling of issuing, transfer and cancellation	Some system support in specific lifecycle phases	Automated processing in each phase	All steps are fully integrated allowing STP processing within and between alll phases
Trade Lifecycle	Manual trade definition, monitoring and settlement	Some system support in specific lifecycle phases	Automated processing in each phase	All steps are fully integrated allowing STP processing within and between alll phases
Risk Management	Manual risk capturing and monitoring	Some system support for risk capturing and monitoring	Automated capturing and monitoring within phases or organtisational units	Automated risk capturing and montitoring with STP processing within and between alll phases

Use case: Guarantees of Origin in the European Union

Certificates for green electricity as part of green energy are the most interesting use case due to current and future production capacity, number of certificates, and its representation of the primary green energy source for a climate-neutral future. The European Union introduced GOs as a regional EAC scheme, which was used by more than 27 countries issuing more than 800 million certificates in 2020 (RECS International secretariat 2021a).



Where are the gaps and challenges, and who must act?

We now use the methodology that we presented in the previous section to analyze the EU GO market to discover gaps and challenges.

- The combined life cycle of certificates and corresponding trades, as well as the roles of market participants, make up the below table.
- The findings summarized in the table above are argued in detail in the following chapters, with the corresponding numbers added in each field.
- Critical gaps and challenges are allocated to the combination of phase and role. Their impacts are assessed based on a simple RAG (Red, Amber, Green) scoring. The score for each field is then aggregated for each life cycle phase. The scores are defined as follows:

Red	Major improvements required
Amber	Some gaps require improvement
Green	No major gap – or gaps are outside of market infrastructure

The below topics have either general validity for all markets or show specifics for GO markets. Two subsequent sections will delve deeper into the findings presented in the table.

	Build & Produce	Register & Issue	Trade	Manage trades, contracts & inventory	Deliver & Pay	Consume & Cancel
Investor	• Finance capacity ■ 2 4	-	• Maximize revenue by all producers in portfolio ■ 4	• Define & monitor ESG targets for Consumers in portfolio ■ 4	- ■	• Risk of financial & reputational damage in case ESG targets not reached in portfolio ■ 4 6
Producer	• Build capacity ■ 2 4	• Request plant registrations & certificates ■ 1 2	• Number of GO trades to maximize revenue ■ 1 3 4	• Manage trades, contracts and certificate blocks ■ 1 2 3	• Transfer certificates • Settlement risk for payment ■ 1 2 3 6	-
Registry	-	• Number of plant registration • Certificate issue • Energy sources ■ 1 2	• Conduct of monthly auction (if offered) ■ 5	• Certificate blocks per account ■ 1 2	• Transfers, imports & exports ■ 1 2 5	• Cancellations ■ 1
Intermediary	-	• Differing domain protocols to handle ■ 4 5	• High variety of contracts ■ 3 4 6	• Trades, contracts and certificate blocks • Manual registry interfaces ■ 1 2 3	• No system integration Settlement risk for delivery and payment ■ 3 5	• Manual registry interfaces ■ 5
Service Provider	-	• Different levels of registry maturity • All but one without API (as of Jan '22) 4 5	No trade & contract management for daily trading ■ 4 6	Manual registry reports only ■ 5	• No payment service No API for transfer events ■ 4	• Different rule sets, no automation ■ 5
Consumer	-	-	• Number of GO trades to cover consumption ■ 1 3 4	• Trades, contracts and certificate blocks to manage ■ 1 2 3	• Payments • Settlement risk for delivery ■ 3 6	• Funding risk & reputational risk in case of error in environmental accounting and missed ESG target ■ 4 6

Quantitative & Qualitative factors that impact GO efficiency

These factors impact the current and future performance of processes and functions within each phase of the life cycle:

3 major quantitative factors

- The increasing number of certificates.
- The growing number of plants and certificate blocks issued.
- An indicative development of costs per certificate – with and without improving the overall efficiency of a certificate's life cycle and corresponding trades.

3 major qualitative factors

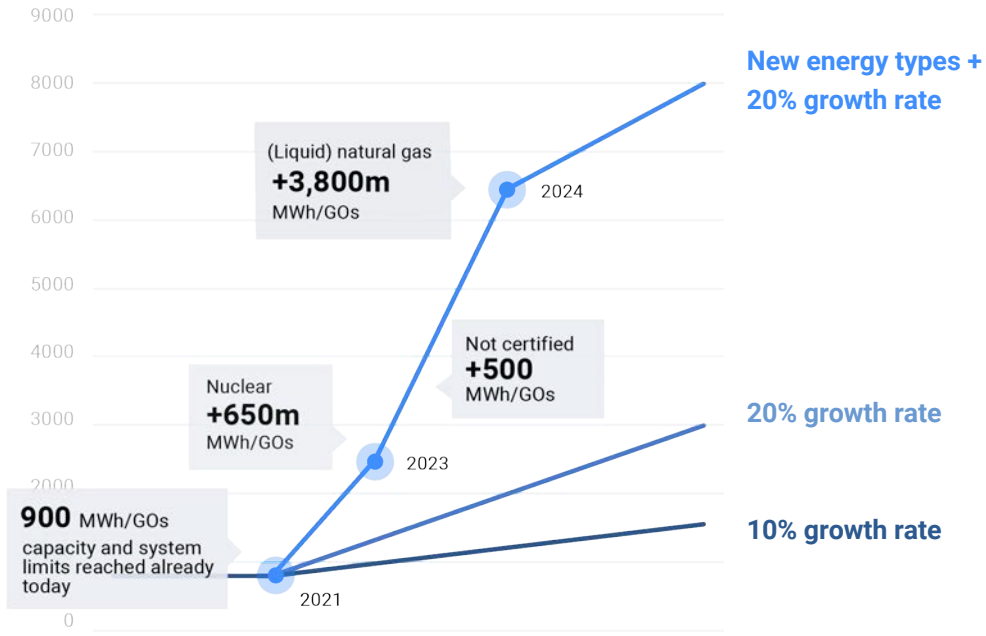
- Findings and statements from market participants.
- Expected timeline for improvements in the registry network.
- The most relevant risks in the GO market.

Substantial growth in numbers & increasing costs

1 More certificates to manage

The growth in issued certificates per year is dependent on:

- The speed of building additional power plants
- The increasing degree of coverage of existing green electricity production
- The inclusion of new energy types in the GO certificate scheme, such as nuclear or natural gas



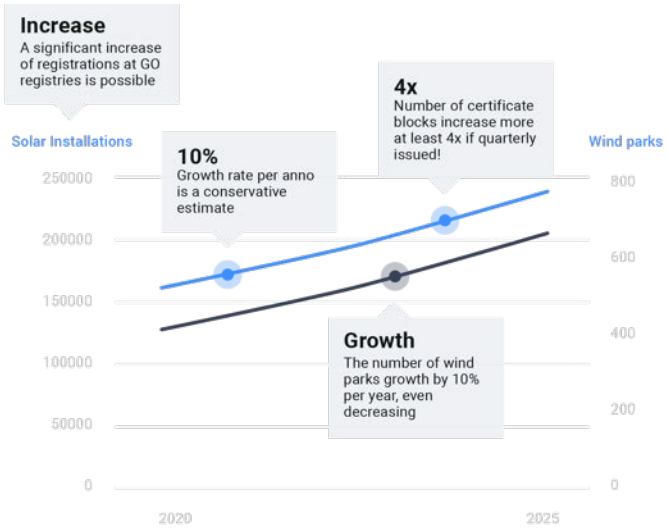
The overall growth from 2019-2030 can be estimated between 800 to 1.6 billion, 2.3 billion, or 8 billion certificates issued per year. The graphic starts in 2019 with 800 million MWh certified GOs, and show thee possible development paths:

- Two simple scenarios are based on either a 10% or 20% growth rate per year against 2019, resulting in 1.6 billion or 2.3 billion certificates.
- The third scenario considers a 20% growth rate and adds three possible events:
    - GOs are issued for 500 million MWh of currently uncertified green electricity (RECS International secretariat 2021b).
    - 650 million MWh of nuclear energy are certified.
    - 3,800 million MWh of natural gas are certified (British Petroleum report 2021).

These growth rates and events would result in 8 billion GOs per year. The simple scenarios alone show a significant increase, with up to three times more certificates per year in 2030 than 2019. Within the third scenario, every event alone would test process and system limits for all market participants due to its substantial numerical jump.

❷ More plants and certificate blocks to consider

More green electricity requires more generation capacity, especially using solar and wind energy sources. According to developments in previous years, the annual growth rate for the number of solar and wind parks is approximately 10%.



For **wind plants**, the expectation is that the growth rate of the absolute number of installations is flattening over time due to[4]:

- Repowering of existing wind farms via the replacement of old wind turbines with those that are newer and more efficient (ENBW 2021). Cases show a 500% increase of production capacity, meaning the number of wind turbines per country may keep a constant growth rate, but energy production capacity will rise (Sesto and Lipman 2020).
- Increasing capacity of offshore wind parks.

There is potential for a much steeper increase in numbers regarding **solar plants**: The German government targets installing an additional solar capacity of 16 GW per year, starting from the current 54 GW. This is a capacity growth rate of +30% per year and requires additional solar plants (source). The government also plans to install solar panels on every new building constructed. Each new installation could potentially be registered at the German GO registry "HKNR,"[5] as an example resulting in the issue of 6-12 GO certificates per year for a single-family household.

Overall, these targets lead to an increase in registered plants and producer accounts at registries, as well as considerable growth in the number of certificate blocks booked to producer accounts at a registry. An increased number of accounts and certificate blocks affect inventory management, risk monitoring, and financial planning, directly increasing processing costs per certificate.

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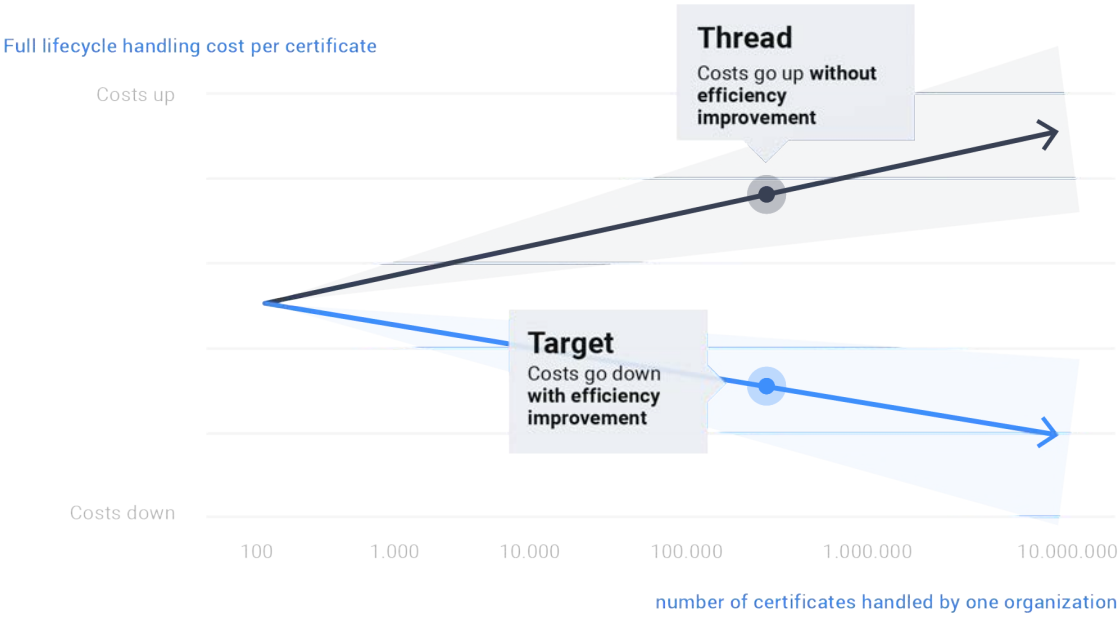
[4] Report of Statnett (Statnett 2021) estimating new wind power production from 2021 to 2026. The overall growth rate for new wind power production is around +10% per year with a maximum for Finland of +23%

[5] HKNR = Herkunfstnachweisregister is the GO registry of the German Environment Agency

❸ Higher handling costs per certificate

Producers, consumers, and intermediaries bear similar costs for managing their inventories, trades, and risks. Registries have costs according to the volume of events for plant registration, certificate issuance and cancellation, and process controls.

Higher numbers of certificates and blocks[6] result in higher handling costs per certificate, so long as the current processes and IT platforms of market participants remain unchanged.



The effort for regular tasks might grow linearly, but an additional workforce with specific knowledge and a stepwise capacity increase of systems and platforms are required. A qualified workforce is difficult to source, and current platforms are at their architectural limits. This will result in higher wages and increasing costs due to needed enhancements to and operation of current IT systems. The risk of errors and repair costs will also increase due to diminishing oversight. This means there is a threat of increased handling costs per certificate as the number of certificates also increases. This is illustrated in the above graphic.

The goal, then, must be to decrease handling costs per certificate. This can be achieved by improving efficiency in processes, IT systems, and registry platforms, which lowers costs within an organization, and for processes interacting with registries.

[6] Certificate block = A series of certificates is issued by a GO registry for one registered plant and period. Example: 10 GOs are issued one month for one plant as a block. The block is shown as one line in the inventory account of the producer with a consecutive numbering.

What needs immediate action?

The need for immediate action is not only driven by numbers, volumes, and costs, as discussed above. Market participants in all roles have highlighted the need for change and indicated increasing pressure to improve, as deficiencies in daily business become more painful.

Improvement speed differs between market participant groups. It also differs within individual groups, as highlighted in paragraph 5, which shows the expected timeline for registry network improvements.

Again, this qualitative discussion focuses on essential aspects in the GO market, but does not provide a complete view from all market participants or analysis dimensions.

❹ Market participants' insights and targets

Investment companies currently set **voluntary decarbonisation targets** for **consuming companies** in their investment portfolios. Leading investment company Blackstone, for example, set an explicit goal to reach a lower-carbon future:

"In January 2021, we announced our Emissions Reduction Program and started implementing a new goal … of reducing energy usage by 15% in aggregate over the first three years of ownership." ("Blackstone – An Integrated Approach to ESG" n.d.).

The fulfillment of this 15% target must be proven by each consuming company in Blackstone's portfolio.

A further investor target is securing maximum return on investment (ROI) by **producing companies** in their portfolios. This requires that all produced electricity and GO certificates are sold. Investor-level controls can include aggregated inventories of portfolio-held GOs and setting alarms on unsold certificates with upcoming expiration dates.

Overall, audit-proven environmental accounting is becoming increasingly important. However, it is dependent on the efficient integration of certificate management within a company, especially for monitoring certificate inventory and cancellation.

Interviews with producers and intermediaries highlighted detailed shortcomings in GO life cycles and trade management (x-markets research 2021):

1. Differing domain protocols – details matters (e.g., regarding cancellation)
2. High variety of products and trade agreements due to OTC (over-the-counter) trading
3. Systems used in the GO network appear to reached their capacity limits and partially technological end of life (see AIB HUB announcement)
4. Registry interfaces show substantial differences regarding performance, connectivity, and responsiveness

Most registries are not yet at a technological level that allows for STP via APIs. Operators must instead manually process certificate transfers, imports, exports, and cancellations through the web interface provided by their respective registries.

Fragmented GO flows

The overall fragmented nature of markets makes transaction settlements a time-consuming, expensive, and error-prone process.

The process flow of a GO life cycle requires the exchange of information among stakeholders at several levels, particularly trading and transferring (settlement) activities that operate through different communication channels. There is currently no comprehensive IT solution available.

The GO lifecycle usually extends over more than one national domain. This increases process interfaces and complexity due to differing applicable rules. Most stakeholders use IT systems from different providers and with differing stages of automation, internal integration, and external connectivity. This fragmented system landscape leads to workarounds and undesired manual effort.

RECS Energy Certificate Association emphasises future initiatives that can increase the volume and complexity of the GO market:

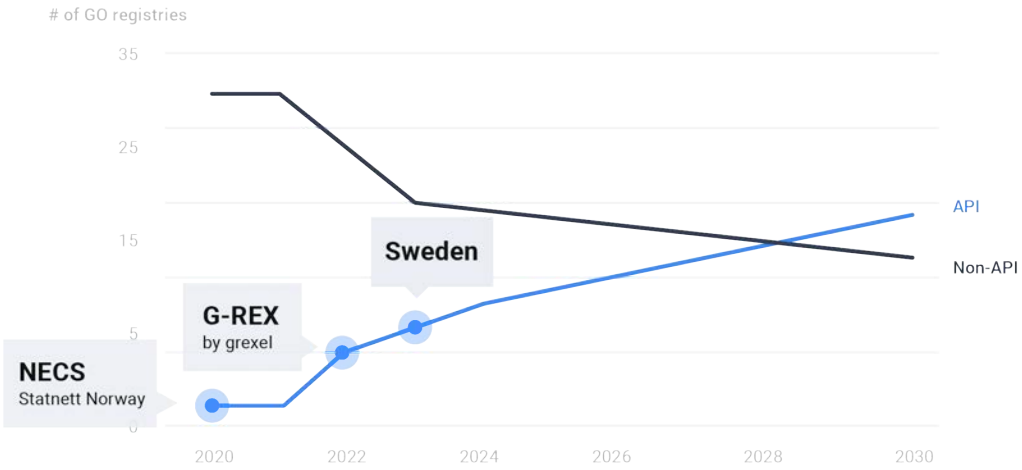
1. **Full consumption disclosure:** All green energy, coal, and gasoline consumption are tracked via GO certificates. Energy type is reflected in the corresponding field of the GO standard scheme. This would add a significant number of certificates, plants, and accounts to the GO market ('What full disclosure means, and why it is so important', RECS May 2020)
2. **Evolving needs of consumers:** Consumers develop increasingly specific requirements over time regarding attributes of GOs with which they want to cover their energy consumption. This can be the energy type (such as wind, water, or solar) or a specific region.
3. **24/7 GO granularity:** Some intermediaries and consumers discuss the need for 24/7 granularity of GOs by providing a time stamp based on hours – or even minutes. One driver is Power Purchase Agreements and the need to match green power delivery to GO certificates. This enhancement would impact registries' issuing processes, as well as inventory management at producers, intermediaries, and consumers.

Governments and environmental initiatives intend to create an efficient market to keep entry barriers and costs as low as possible. For European Allowances (EUA), the market structure follows the energy derivative market with trading and clearing services. The "Taskforce on Scaling Voluntary Carbon Markets" in the United States proposes a similar approach to create a priced product which can then be traded (T. Adams et. al). Both aim to keep energy-consuming companies in business by using pricing mechanisms that result in market trades. The approach focuses on or creates market efficiency via role integration in all phases and efficient data and event exchanges.

❺ Slow development of network efficiency

Registry

At the majority of registries, the appetite for significant change is low. In late 2020, Statnett-operated NECS, the Norwegian registry for Guarantees of Origin, rolled out a new registry platform, allowing account holders to connect via an application programming interface (API) for automation and integration with its in-house IT systems. It is currently the only registry with an active API.



Possible route of migration to API enabled registry platforms

Platform vendor grexel also plans to roll out its new registry platform, 'G-Rex' in 2022. Additionally, the Swedish registry plans to migrate to an API platform in 2023. Both CertiQ Netherlands and Pronovo Switzerland have also indicated their plans to switch to new platforms. This shows long-term development to registry platforms with APIs in the coming decade. Neither disruptive events nor service centralisation are expected.

❻ Lack of risk services

As of January 2022, the GO market does not offer central risk management services, be it via registry networks or service providers.

	Build & Produce	Register & Issue	Trade	Manage trades, contracts & inventory	Deliver & Pay	Consume & Cancel
Investor	• Financial full revenue					• Financial • Reputation
Producer	• Financial • Reputation	• Operational	• Market Mistrade • Price movement • Volatility	• Operational	• Settlement • Payment	
Intermediary			• Market Mistrade Price movement Volatility	• Operational	• Settlement • Payment & Delivery	
Consumer			• Market Mistrade • Price movement • Volatility	• Operational	• Settlement • Payment	• Financial • Reputation

Comprehensive risk management[7] is not only essential for a companies themselves, but is expected by investors – and required by law for publicly listed companies or those operating in specific markets and roles. Established derivative markets even require the subscription to build-in risk service to assure market stability in volatile trading phases, or should market participants default on delivery or payment. Market risks are the same in certificates markets. Standard financial risks, including those stemming from operational errors and ESG-specific reputation risks, complete the major risks within the GO market.

The only active mechanisms are integrated into each registry platform and the AIB Hub, ensuring consistency and integrity for certificate issuance, transfer, and cancellation. Monthly auctions offered by some registries require certificate pre-delivery and pre-payment to escrow accounts, meaning there is no settlement risk, but results in spot-trade availability approximately only once per month. Future contracts and continuous trading are not covered.

Market, financial, and reputation risks are handled by market participants individually, either manually or with in-house solutions – if at all.

[7] Risk management is the identification, evaluation, and prioritisation of risks (defined in ISO 31000 as the effect of uncertainty on objectives), followed by coordinated and economical application of resources to minimize, monitor, and control the probability or impact of unfortunate events, or to maximize the realisation of opportunities.

The need for risk mitigation services for all types of trades came even more into focus at the end of 2021, with increasing bankruptcy of small electricity suppliers in the role of consumers, potentially leaving trades unpaid.

Types of risk in GO markets

Market risk is the risk of loss in positions arising from movements in market variables such as prices and volatility, including settlement risks.

Financial risk is the possibility of losing money on an investment or business venture. More standard and distinct financial risks include credit, liquidity, and operational risks (HAYES 2021). Operational risk is a sub-risk category (Federal Deposit Insurance Corporation 2006), with the risk of loss resulting from inadequate or failed internal processes, people, systems, or external events.

Reputation risk is the risk of losing financial capital, social capital, or market share resulting from damage to a firm's reputation. This is often measured in lost revenue, increased operation, capital, or regulatory costs, or destruction of shareholder value.

Examples along the GO trade life cycle:
Financial risk especially increases for producers, intermediaries, and consumers due to the number of certificates and their resulting trading volumes. If certificates are not delivered, a consumer's environmental targets might be missed, resulting in additional fees for late buys, fines for non-coverage, or a negative impact on a company's ESG rating.

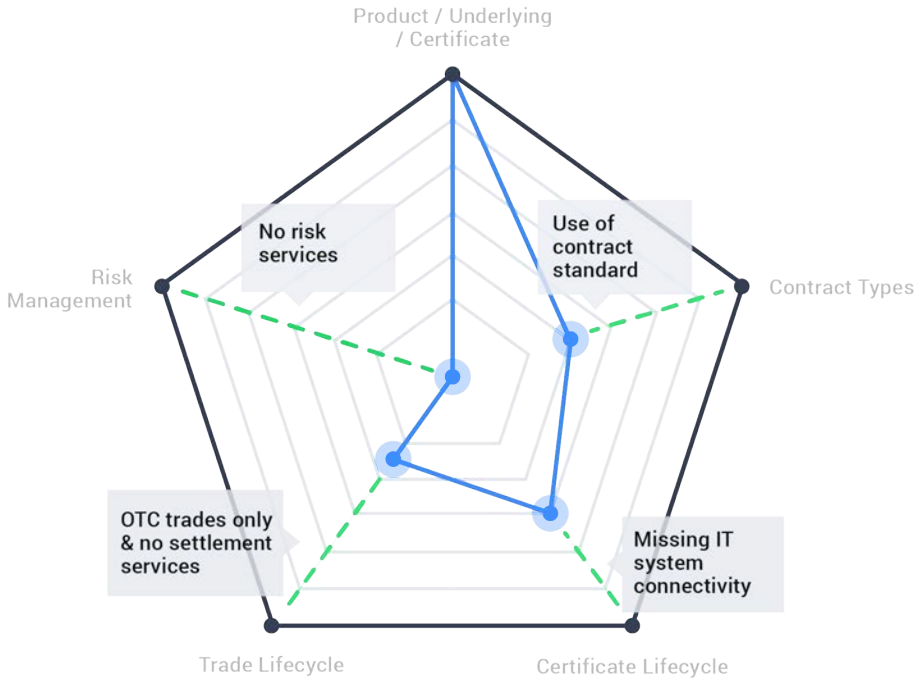
The operational risk of losing oversight of GO inventory can result in incorrect deliveries or payments, which require effort and financial capital to resolve. Intermediaries face an especially high-risk position due to their dependency on the producer and the consumer side (European Central Bank 2020).

A **reputational risk**, especially for investors and consumers, involves erroneous environmental accounting[8] and reporting. If a consumer cannot prove that GO certificates cover its ESG targets, reputational damage can follow. A decrease in reputation can result in financial impact, should investors withdraw investments.

[8] Definition: Ecological accounting, also known as "green accounting," is defined as the modification of the System of National Accounts to incorporate the use or depletion of natural resources. Environmental accounting is vital for managing natural resources' operational and ecological costs. Natural resource valuation is an essential input into social cost-benefit analysis, as well as certain approaches to environmental accounting (I.V.Muralikrishna 2017).

Assessment against benchmark

The insights discussed previously in this paper support the following maturity assessment of the GO market against an established market for power derivatives:



The graph above needs explanation. Starting clockwise, from top to right:

1. The GO **certificate** follows the CEN 16325 standard. The same technical standard is used by all AIB-connected European registries that allow STP of inventory within and between registries (score 3).

2. **Standards**: There is a contract standard from RECS Energy Certificate Association which is often used and amended by market participants for OTC trades. Still, the terms have to be agreed for each trade between buyer and seller, including settlement conditions (score 1)'

3. **Connectivity**: Missing IT system connectivity prevents STP in the **certificate life cycle** for certificate issuance, inventory management, transfer, and cancellation. The only STP-enabled market function is the transfer of certificates between registries via the AIB hub, once manually triggered in the User Interface of the source registry (score 1,5).

4. **Settlement**: Over the counter' trading and manual settlement. The majority of trades are agreed 'Over The Counter' (OTC) and settlement is done manually for payment and certificate delivery. For the trade life cycle, only local monthly auctions support spot trading. The majority of trades are completed OTC via manual settlement processes (score 0,75).

5. As discussed in the previous chapter, there are no risk services supporting **risk management** for market participants. Settlement risk for local monthly spot options is managed by delivery and payment to escrow accounts, allowing 'no-risk' settlements, but requiring preparation and the blocking of certificates and cash (score 0).

Conclusion & next steps

This paper has made the case that the GO market is at an important crossroads. The market is healthy and set for massive growth due to both governmental targets and changing societal preferences for green energy.

In order to thrive, the market must critically analyze its strengths and weaknesses in order to strengthen the infrastructure needed to manage the upcoming growth in volumes demanded.

Significant gaps have been identified in this paper, specifically in the area of STP. In order to make needed changes, market participants must take clear ownership and adopt a mindset for change. A first step is for market participants to assess whether current processing is sufficient for their business success:

- Does the existing infrastructure fit process automation and do the participants' have the adequate skills and capacity within their organisations?
- What about timing and money?
- Are current infrastructures and participants' interactions capable of handling this development?
- What are measures for sustainable improvement – can they happen in the short term?

Addressing these questions on a micro level in businesses and on a macro level in market associations and organizations is recommended, e.g. in committees. The EEX Power derivatives market is a useful and practical map against which organizations can compare their current status and future potential.

The future is bright for the GO marketplace. If the industry takes the steps it needs to create efficiencies throughout the trade process, it will be well-positioned to capitalize on the massive volumes coming its way.

List of Abbreviations & Glossary

Abbreviations	Title
Agent (economic)	In economics, an agent is an actor (more specifically, a decision-maker) in a model of some aspect of the economy. Typically, every agent makes decisions by solving a well- or ill-defined optimizationoptimisation or choice problem.
AIB	Association of Issuing Bodies www.aib-net.org
API	Application Programming Interface
Buyer & Seller	Buyers (consumers) and sellers (producers) are two common agents in partial equilibrium models of a single market.
EAC	Energy Attribute Certificate
EEX	European Energy Exchange www.eex.com
ESG	Environmental Social Governance
EUA	EU Allowance / European Allowance
EU ETS	European Emissions Trading System
GO	Guarantee of Origin – an digital document that has the sole function of providing evidence to a final customer that a given share of energy quantity was produced from renewable sources.
GW	gigawatt-hour (electricity or energy production capacity)
HKNR	Herkunftsnachweisregister Germany www.hknr.de
Market	A composition of systems, institutions, procedures, social relations, or infrastructures whereby parties engage in exchange.
Market participants	For this paper: All agents acting in the context of climate neutrality, including emission control and green energy
MWh	megawatt-hour (electricity or energy production)
nETS	European Emissions Trading System
OTC	over-the-counter
RAG	Red Amber Green scoring
RECS	RECS Energy Certificate Association (renamed from RECS International)
Straight-through Processing (STP)	An as-yet-unimplemented process that would allow transactions and payments to occur without manually re-entering information. STP would permit all information on a transaction to electronically transfer to the appropriate broker, dealer, or other parties.

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Appendix

Assessment against benchmark – matrix

Market	Role	Product / Underlying / Certificate			Contract Types			Certificate Lifecycle			Trade Lifecycle			Risk Management		
		Score	Sub-Score	Description	Score	Sub-Score	Description	Score	Sub-Score	Description	Score	Sub-Score	Description	Score	Sub-Score	Description
EEX Power Derivatives Market	All	3		Standardized underlying for each contract type	3		Standard derivates for tradingfrom day to year contracts	3		Automated issue and expiry	3		On exchange trading mechanisms, automated settlement	3		Central counterpart
EUA European Allowance	Investor	3	3	Standardized European Allowance covering 1 ton of CO2 emission	3		Primary & secondary market on one platform	1,5			3		Automated trading	3		Central counterpart for primary market, not for secondary market
	Company in scope of EUA					3			1	manual access to registry platform		3			3	
	Registry					3			3	Automated issuing, transfer and cancellation by companies		3			3	
	Intermediary					3			1	Manual access to regstry		3			3	
	Service Provider					3	Access to Data & Events		1	Manual access to regstry		3			3	
	Government															
	Associations & Foundations															
GO Guarantee of Origin	Investor	3	3	Standardized with EECS Guarantee of Origin scheme, issued for 1 MWh green electricity	1	1	OTC contracts only with RECS contract template	1,5			0,7	0	OTC only to generate maximum revenue	0	0	Only manual risk management
	Producer								1	manage certificates manually, only inventory per registry		1	Majority OTC incl. manual handling for settlement. Monthly auction in some countries			
	Registry								2	Issue and make certificates available for transfer & cancel		1				
	Consumer								1	receive and cancel certificates based on manual monitoring		1				
	Intermediary								1	receive and cancel certificates based on manual monitoring		1				
	Service Provider								1	receive and cancel certificates based on manual data access		0	Only manual processing			
	Registry Hub AIB								3	transfer certificates						
	Government															
	Associations & Foundations															

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