GO4Industry

Energy sources – Report E1

Prospects for the further development of Guarantees of Origin for electricity

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About the project

GO4Industry

Industrial companies will in the future have to achieve climate-neutral production. This requires an immense increase in the use of renewable energy at all stages of the production process. These efforts necessitate careful emissions accounting along the supply chain. This in turn requires a reliable verification system for renewable energy that functions across borders in all sectors: electricity, gases, heating/cooling. In the Renewable Energy Directive 2018/2001, the EU has instructed the member states to implement such a system at the national level. In the "GO4Industry" project funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (until the end of 2021) and the Federal Ministry for Economic Affairs and Climate Action (since 2022), Hamburg Institut and GreenGasAdvisors are developing the basis for a comprehensive national verification concept for renewable energy. This includes an analysis of how guarantees of origin and other verification concepts for renewable energy could enable cross-sectoral interaction in the future. The project results are available on the project website: https://go4industry.com.

Contents

List of abbreviations

AIB	Association of Issuing Bodies
BC	Blockchain
CEN	European Committee for Standardization
EC	European Commission
EEG	Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz*)
EnWG	Energy Industry Act (*Energiewirtschaftsgesetz*)
EP	European Parliament
EU	European Union
GO(s)	Guarantee(s) of origin
HKNR	German GO registry (*Herkunftsnachweisregister*)
HkRNDV	Implementing ordinance on guarantees of origin and regional guarantees for electricity from renewable energy (*Durchführungsverordnung über Herkunfts- und Regionalnachweise für Strom aus erneuerbaren Energien*)
MWh	Megawatt hour
PPA	Power Purchase Agreement
RE	Renewable energy
RECS	Renewable Energy Certificate System
RED II	Renewable Energy Directive II (Renewable Energy Directive (EU) 2018/2001)
RED III Draft	Renewable Energy Directive III Draft (Draft Renewable Energy Directive (EU) 2021/0218)
RFNBO	Renewable fuels of non-biological origin
SSI	Self-sovereign, digital identities
TWh	Terawatt hour

1. Introduction

In the electricity sector, **Guarantees of Origin (GOs) have so far been the only established and legally secure instrument to prove the renewable energy (RE) property and thus to prevent the double marketing of renewable electricity** – in Germany, in the European Union (EU) and beyond. Even though the purposes of GOs may differ by country, their scope of application is fundamentally limited at the European and at the national level. For example, according to Article 19 of the Renewable Energy Directive (EU) 2018/2001 (RED II), GOs serve the purpose of **consumer information** (especially in the context of electricity disclosure). They have **hardly any functions with regard to the fulfilment of legal specifications and requirements.**

However, the increasing market demand for green electricity, changes in the demand structure as well as new regulatory requirements (e.g. due to the existing European Renewable Energy Directive (REDII) and its amendment (REDIII)) influence the demands on verification systems for renewable electricity in the EU member states. This necessitates a further development of these systems and their applications. In this context, it is important to **clarify which role the existing GO systems will play in the future in the verification of renewable electricity and how these systems should be extended or supplemented with new systems**.

The **design of any further developments of electricity GOs or new systems** should be based on the intended use of verification, take into account interactions with the verification of other renewable energy sources (e.g. mass balancing systems for gases) and be worth the cost or effort. In addition, the most important function, namely the prevention of double marketing (Article 19 (2) and (6) RED II), must be guaranteed through reliable and secure verification of the origin of renewable electricity.

This report initially presents the current practice (section 2) and the new requirements and challenges (section 3) in the area of renewable electricity certificates. Subsequently, various **perspectives for the further development of the German electricity verification system** that take account of the upcoming requirements are explored (section 4). The existing electricity certificate system, within its given national and European legal framework, forms the basis of the analysis, but considerations beyond this are also presented. Finally, the results are summarised in section 5.

2. Guarantees of origin – current practice in renewable electricity verification in the EU and Germany

According to the EU legal framework (Article 19 RED II), GOs serve to assure consumers of the share or amount of renewable energy contained in the energy mix they receive (Article 19 para. 1 and 2 RED II).[1] In this context, GOs primarily fulfil **two functions: consumer information and consumer protection**. At the same time, GOs enable RE producers to **market the green characteristics of their energy,** even though electricity from renewable and non-renewable sources does not differ in purely physical terms.

GOs record key characteristics of a produced unit of energy, such as the energy source, technology, plant age and plant location (cf. Table 1). The cancelling of GOs makes it possible to assign these properties to the energy use of a specific consumer (see Maaß et al. 2019, p. 4 ff. for details). If, for example, electricity suppliers cancel GOs for the consumption of their green electricity customers, the latter are assured that an equivalent amount of electricity was generated from renewable energy sources and that the green property of each MWh fed into the grid was only marketed once.

According to the logic of the **"book and claim" principle,** GOs can be issued on request for the production of renewable electricity, and they are later cancelled for final consumption. **This principle makes the transfer of GOs independent of the physical transfer of energy.** GOs allow RE producers to trade the renewable characteristic of their energy, even if that electricity is fed into the grid as grey electricity, thus generating additional revenue for the quality characteristic of the renewable origin. By cancelling GOs for a specific amount of energy, the electricity quantities and properties are then merged again (cf. GO4I Fundamentals Report 1, Bowe and Girbig 2021; GO4I Fundamentals Report 2, Styles et al. 2021a).

[1] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast).

Table 1: Contents of GOs for renewable electricity in Germany

Type of information	Information displayed on the guarantees of origin
Formal information	• Unique identification number • Date of issuance and issuing country • Issuing body/registry • Plant identification number assigned by the registry • Designation of the plant
Mandatory information on the characteristics of the electricity generated	• Energy used for electricity generation by type and main components • Start and end of generation of the electricity for which the GO is issued • Location, type, installed capacity and date of commissioning of the plant • Information on whether, how and to what extent - investment aid has been granted for the plant - the power generation has enjoyed any other type of subsidy
Optional additional information	• Indication that the electricity has been generated in high-efficiency cogeneration plants (in which case there will be additional information on cogeneration pursuant to section 9(2) EEV). • Information on the way in which electricity is generated in the plant (quality characteristics, e.g. fish protection measures for hydropower). • Indication that the system operator has sold and delivered the quantity of electricity that underlies the GO to the utility to which he will also transfer the GO (optional coupling); in this case, further information is required in accordance with § 16 (3) HkRNDV (including information on the utility and balancing group to which the electricity is delivered).

Source: Hamburg Institut, based on § 9 (1) EEV and § 16 HkRNDV.

In Germany, **only electricity suppliers may cancel GOs in the context of electricity disclosure**, but not end consumers (see § 30 para. 1 HkRNDV). Some Member States follow a similar approach as Germany (e.g. Ireland, Italy, Austria). In some other EU member states (e.g. the Netherlands, Norway, Finland, Denmark), by contrast, **GO cancellation by end consumers** is possible in principle (CertiQ 2022; Fingrid 2022; AIB 2022a).

In Germany, the **national GO registry (Herkunftsnachweisregister, HKNR) operated by the German Environment Agency** has been responsible for issuing, transferring and cancelling GOs for electricity from renewable energy sources since 2013. GOs are not issued for electricity produced with subsidies pursuant to the Renewable Energy Sources Act (EEG). The option of **not issuing GOs for financially supported plants is open to member states** and is currently only applied in this way by Germany, Ireland, Lithuania and Serbia (cf. AIB 2022a; David and Feng 2019). Besides the HKNR, **the German Environment Agency is also responsible for the Regional Verification Registry (Regionalnachweisregister, RNR)**, which has allowed the issuance of regional certificates for EEG electricity since 2019, enabling electricity providers to offer regional electricity products based on EEG electricity.

When cancelling GOs, the **validity period of the certificates** must be taken into account (Artikel 19 para. 3 and 4 RED II; Umweltbundesamt 2021). GOs can be issued and transferred between accounts until up to 12 months after the end of the production period of the underlying energy. GOs must be cancelled no later than 18 months after the end of the production period. After expiry of this cancellation period, GOs are marked as expired (see, for example, Article 34 HkRNDV). Moreover, annual electricity disclosure requires the use of GOs whose underlying electricity was generated in the same year as the year the electricity was supplied to the customer (e.g., GOs with a production period in 2020 must be used for the electricity disclosure year 2020, see Article 30 para. 4 HkRNDV; BDEW 2021a, p. 44).

In addition to the book & claim principle, several other models capture the **coupling of the delivery of energy and its renewable property**. The following forms of coupling can be distinguished (see GO4I Fundamental Report 3, Werner 2022):

- In the case of **physical coupling**, GOs are supplied along with energy delivered by direct line between the power plant and the point of consumption.
- In the case of **balance-sheet coupling** (which corresponds to "optional coupling" in terms of the HKNR), a balance-sheet energy flow must take place or be simulated from the balancing group of the RE plant for which the GOs are issued to the balancing group of the energy supplier to which the GOs are transferred. This is to ensure that the GOs are "symbolically" tied to the amount of energy.
- In the case of **contractual coupling**, it is contractually agreed that the supplier delivers both the energy and the GOs from the plant specified in the contract. This does not necessarily require documentation of the delivery via the balancing groups from the generating plant to the energy supplier.
- By physical standards, a **temporal coupling of grid feed-in and feed-out** requires a direct line. In the public grid, meter or grid data can be used to verify the time and amount of energy of feed-in and of the associated withdrawal by a consumption point or balancing group (**virtual time simultaneity**).

In practice, the coupling of an amount of energy and its properties often occurs in the transfer of GOs pursuant to a **power purchase agreement (PPA) – a long-term contract between a RE producer and consumers**, of which there are many varieties (Hilpert 2018). In particular, a distinction is made between **physical PPAs** and **financial PPAs** (Hilpert 2018).

Physical PPAs are agreements regarding fixed amounts of electricity, which in the case of **on-site PPAs** are provided via direct lines and in the case of **off-site PPAs** via feed-in to the general supply grid and subsequent withdrawal by the consumer. In **financial PPAs** (also referred to as virtual PPAs), by contrast, the focus is on the contracting parties' hedging against electricity price risks (Hilpert 2018). A financial PPA is an agreement regarding an individual electricity price between producers and consumers and includes a contract for differences, which stipulates compensation for any difference between the market price of the electricity and the contractually defined reference price. **In the case of an on-site PPA, there can be a physical coupling of GO transfer and energy delivery; off-site PPAs can provide for balance-sheet coupling or contractual coupling.** The proof of virtual simultaneity of grid feed-in and withdrawal can in principle be combined with all forms of PPAs, including financial PPAs.

In current practice, GOs are mainly used in the context of annual electricity disclosure for the purposes of consumer information and consumer protection. The Internal Electricity Market Directive (EU) 2019/944 already provides a **harmonised set of European rules for electricity disclosure which, referring to RED II, also defines the role of GOs in the disclosure of renewable electricity.** According to the Directive, for the purpose of product mix disclosure, suppliers must indicate in their bills, among other things, the share of the individual energy sources in the electricity purchased by the customer (Annex I no. 5 in conjunction with Article 18 para. 6 of the Directive).[2] According to Article 19 (8) RED II, **electricity suppliers must use GOs to prove RE shares or quantities for electricity disclosure**.

There are two exceptions to this: **For non-tracked commercial offers** whose generation cannot be clearly allocated to an energy source, **suppliers can use the residual energy mix**. That mix corresponds to the total annual energy mix of the Member State, excluding the characteristics of any explicitly traced energy quantities (see AIB 2021a; Article 2 no. 13 RED II). The second exception results from the disclosure of RE shares according to Article 19 (8) RED II if the Member State does not issue a GO for RE producers who receive financial support. The latter is the case in Germany, where the requirements for electricity disclosure are implemented by § 42 of the Energy Industry Act (EnWG).[3] According to this, **renewable electricity that is financed from the EEG levy** must be reported separately.

GOs are also used to **highlight quality characteristics of green power products by quality seals or labels.** Due to the increased demand, the range of green power products on the electricity market is growing steadily. However, the multitude of offers differs significantly in terms of quality, and there are different perceptions of the characteristics that a green power product should possess. For example, some green electricity tariffs refer to electricity from hydroelectric power plants that have been in operation for a long time. While these tariffs sell electricity from renewable sources, they have no effect on the advancement of the energy transition, as there is no active investment in the RE expansion. In the period 2013-2017, just under half of the GOs cancelled in Germany came from Norway, and in particular

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[2] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 concerning common rules for the internal market in electricity and amending Directive 2012/27/EU.

[3] Energiewirtschaftsgesetz - EnWG of 7 July 2005 (BGBl. I p. 1970, 3621), last amended by Article 84 of the Act of 10 August 2021 (BGBl. I p. 3436). For the design of electricity disclosure, see BDEW (2021).

from Norwegian hydropower (Güldenberg et al. 2019). Although this is in line with the principle of the EU internal market, it makes it more difficult for green electricity customers to promote the widespread and, above all, local expansion of renewable energy systems through their purchasing decisions. Quality seals or labels have been established to identify high-quality green electricity products. These can refer to the characteristics of the cancelled GOs (e.g. generation from certain energy sources or technologies, plant age, plant location or other evaluation criteria, e.g. investment by the utilities). In particular, such labels rely on GOs to demonstrate green energy characteristics that provide "additionality" to accelerate the energy transition (see GO4I Fundamentals Report 3, Werner 2022).

In addition to the use of GOs for electricity disclosure by energy suppliers, they are also increasingly being used for **verification in the context of climate accounting and sustainability reporting by companies** that for this purpose depend on reliable verification systems. For example, according to the internationally recognised guidelines of the Greenhouse Gas Protocol, GOs can be used to ensure a reliable and unambiguous allocation of emission factors to specific consumers when applying the market-based climate accounting approach for "Scope 2" emissions from procured energy (WRI and WBCSD 2015, p. 62 ff.; Mundt et al. 2019).

For climate accounting, international companies in particular depend on international, or at least Europe-wide, standardised guarantee of origin systems. In this context, the **European Energy Certificate System (EECS) serves** the European carbon market as **a standardised system for guarantees of origin** that is used by the member countries and regions of the Association of Issuing Bodies (AIB). Also important is the **European standard CEN – EN 16325**, which in its current version builds on the experience of the EECS system for electricity.

Electricity GOs are currently only used in Germany for the annual electricity disclosure and as a verification tool for sustainability reporting by companies; they do not serve any other regulatory compliance purpose. By contrast, **electricity GOs are also used for other purposes in other European countries**. In the Netherlands, for example, data collected for the issuance of GOs is also used for verification in the national RE support scheme (RES Legal 2019). In most member states, revenue from the sale of GOs also constitutes a market-based remuneration component for subsidised RE plants (David and Feng 2019).

The use of GOs for other regulatory compliance purposes is severely limited. The legal framework currently does not envisage a function with regard to the European RE expansion target or the achievement of the RE share in transport, nor do GOs play any role in calculating the share of RE in the individual Member States (Article 19 (2) RED II).

For detailed explanations on the existing practice in dealing with (electricity) GOs and further possible application purposes, see the GO4I Fundamental Report 2 (Styles et al. 2021a)***.***

3. New requirements for verification systems for renewable electricity

An important aspect of the debate on renewable electricity certificates is the **question as to which purposes these certificates are to be used for**. Depending on the intended use there are different requirements for their design. As mentioned before, in accordance with Article 19 of RED II, GOs so far mainly serve the purpose of **consumer information** (e.g. in the context of electricity disclosure by energy suppliers) and find little application beyond that, especially in Germany. However, current developments indicate an increasing number of applications for which proof of using renewable electricity must be provided and, at the same time, increasing demands on (e.g. the quality of) green electricity certification. Both of these developments will drive up the demand for such certificates and necessitate the further development of the existing guarantee of origin systems and/or the implementation of new forms of guarantees, the expansion of their scope of application, as well as a reformed legal framework. In the following, existing and new challenges arising in the context of verifying green electricity characteristics are presented.

3.1 Strengthening the credibility of guarantees of origin

A lack of understanding of the Book & Claim system has created mistrust of GOs among some consumers. The separability of the renewable energy property (as certified by GOs) and the physical electricity supply repeatedly leads to greenwashing debates in the green electricity market (see e.g. Energy Future 2021). The fact that utilities, industrial companies and other actors can label domestically generated grey electricity as green electricity using GOs (mostly from Scandinavian hydropower plants) creates mistrust among consumers and other stakeholders about the credibility of the green electricity credentials, which is understandable given the quite low GO prices in the past, the overall low transparency in the GO market and the resulting lack of knowledge. In order to strengthen credibility vis-à-vis different stakeholders (green electricity customers, corporate customers, etc.), the different characteristics of green electricity should be transparently comprehensible and selectable (see chapter 4.1).

3.2 Legal innovations at the German and the EU level

Legal changes that will impact the verification of renewable electricity have already been made or are about to be made at both the national and the EU level. The most important new regulations for the electricity GO system are presented below.

Besides abolishing the EEG levy as of 1 July 2022, as part of the so-called "Easter Package" (BMWK 2022a,b), **the German Federal Government has also planned changes to electricity disclosure**. According to section 42 para. 1 no. 2 of the EnWG, subsidised renewable energy sources are to be labelled as "subsidised pursuant to the EEG", and RE with GOs are to be labelled as "not subsidised pursuant to the EEG".

Since the reform of the electricity disclosure rules of 1 November 2021, suppliers have already had to disclose their actual electricity purchases in the disclosure of the overall energy mix (Section 42 EnWG).[4] The share of EEG-subsidised electricity that is allocated to electricity suppliers in parallel with EEG levy payments is no longer shown in the supplier's overall energy mix. Instead, the RE shares will be calculated exclusively via the actually purchased RE quantities (based on GOs). In the product mix (or in the company mix, if the supplier offers only one electricity product), on the other hand, the EEG share will continue to be shown, as will the share of RE with GOs that was not financed from the EEG levy. In addition, in the overall energy mix as well as in the product mix, electricity that cannot be clearly allocated to an energy carrier on the generation side (e.g. in the case of procurement from an electricity exchange) is reported in accordance with the ENTSO-E energy carrier mix for Germany, adjusted for the shares of renewable power for which GOs have been issued or which was supported by the EEG, and for other potentially double-counted electricity quantities. This new regulation on reporting the actual RE procurement applies for the first time to the 2021 electricity reporting, which has to be published by November 2022. It is expected to lead to a significant reduction in the reported share of green electricity in the overall energy mix of many electricity suppliers (Maaß 2021).

The abolition of the EEG levy, as decided on in mid-2022, will have an impact in particular on the reporting of the product mix (and the company mix, for electricity suppliers that offer only one product). After the abolition of the EEG levy and the transition from EEG financing to budget financing, the share of "renewable energy that is promoted under the EEG" in German electricity generation is to be shown to every end consumer in the product mix of electricity disclosure pursuant to section 42 (3) sentence 1 EnWG (or in the company sales mix pursuant to section 42 (3) sentence 2 if the supplier only offers one product). This replaces the previous share of "renewable energy financed from the EEG levy" that was allocated to consumers in parallel with the financial allocation of the EEG levy, allowing electricity suppliers with a high share of non-privileged consumers to show particularly high RE shares in their product mixes. In the future, the green attributes of power from subsidised plants will therefore be reported to every consumer in the same amount (i.e. the amount of the share of EEG-subsidised generation in the German electricity mix). This is justified in the draft law by the fact that the budget-financed EEG is financed by the consumers as taxpayers.[5] At least for private customers (i.e. for electricity suppliers whose customers were previously predominantly non-privileged), this will reduce the RE shares in some product mixes, which could motivate climate-conscious customers to switch to tariffs with higher RE (i.e., GO) shares. Conversely, product mixes of electricity suppliers with many previously privileged consumers (especially industrial customers) will now contain higher RE shares,

[4] Energiewirtschaftsgesetz of 7 July 2005 (BGBl. I p. 1970, 3621), last amended by Article 5 of the Act of 20 July 2022 (BGBl. I p. 1325).

[5] At the time of writing, the amendments presented here have not yet been made law.

which in turn will make the product mixes of these (industrial) customers look greener and thus reduce their incentive to procure additional green electricity.

Another planned change in this context that is significant for GOs is that Section 42 (1) no. 3 EnWG will stipulate that the electricity disclosure for **renewable energy with GOs must in the future state the country in which the electricity was generated and what share each country of origin has in the supplied renewable electricity**. The regulation is intended to create more transparency for consumers and more security for authorities with regard to the marketing of electricity products with a geographical indication of origin. Since the EEG's ban on double marketing precludes the issuance of GOs to subsidised EEG plants, comparatively few GOs are currently issued in Germany (see 4.2). Additional demand for domestic GOs from unsubsidised plants could in the future result from stricter requirements being placed on green electricity flowing into the production of RFNBO (renewable fuels of non-biological origin, see the next section). Such stricter requirements could include the geographical proximity of electricity consumption and production. Large quantities of regional and national GO electricity may then no longer be available for delivery to other customers. Thus, much of this GO electricity would have to come from countries with high RE shares in their national mix, especially Scandinavia, which in turn may not help with building credibility and raising consumer demand. On the other hand, the increasing competition between different modes of electricity consumption (RFNBO versus other final consumption by business and private consumers) potentially provides an incentive to expand local green electricity production.

Furthermore, the planned **changes to the optional coupling of GOs** described in report G3 were included in the Easter package (BMWK 2022a). These changes mainly concern the verification and confirmation of the coupling of GOs as well as the number of balancing groups involved, both of which are to be regulated in section 30 of the HkRNDV. In the future, the coupling of GOs to the underlying electricity should only be checked and confirmed when the GO is cancelled, rather than when it is issued, so that the electricity supplier decides for itself before cancellation for which GOs coupling is requested. In addition, coupling shall be permitted for the supply of electricity via not just one balancing group but two, provided that only renewable energy plants feed into the intermediate, first balancing group, which furthermore does not receive any scheduled deliveries from other balancing groups. Delivery via two balancing groups accordingly enables coupled electricity delivery across control areas and national borders. However, it remains uncertain to what extent these simplifications will lead to an increase in demand for coupled GOs or generate a benefit for the energy transition. This is because, due to prohibitive monitoring costs, the planned innovations cannot prevent offsetting or swap transactions, which undermine the coupling mechanism (Maaß et al., 2017). In addition, it is conceivable that instead of optional coupling, other means such as PPAs will be used.

Finally, the amendment to the EEG provides for another change that has a significant impact on the discussion about additionality. According to §§ 28, 28a and 28b of the EEG 2023, **new unsubsidised RE capacity is to be deducted from the EEG quantity to be tendered for**

wind and photovoltaics (Müller et al. 2022). This type of quantity control would be problematic in that a demand for renewable power from new, unsubsidised plants in Germany would no longer serve to accelerate the RE growth, as these plants would be deducted from the state-financed growth.

Various legal regulations with a potentially major impact on the electricity GO market are also in preparation at the **EU level**, with the reforms in the current RED II and its forthcoming amendment (RED III) deserving special mention. An important part of this is the draft **Delegated Act on Article 27(3)**, announced in RED II and published in May 2022, **which sets requirements for the regulatory recognition of green electricity to be used in the production of RFNBO in the transport sector** (European Commission 2022). According to the Easter package, the exemptions from national levies (e.g. the German levy for combined heat-and-power (CHP) plants) are also based on the logic of the delegated act. The contents of this first official draft can be summarised as follows:[6]

Table 2: Requirements for renewable electricity for the production of RFNBO to be used in transport

Based on the delegated act, Article 27 (3) RED II, draft of May 20, 2022	
Verification for electricity that is not passed through a grid	• **Direct connection** between electrolyser and RE plant; or electricity generation and RFNBO production in the same plant. • Commissioning of the power generation plant **not earlier than 36 months before the electrolyser**; subsequent capacity expansions of the electrolyser are possible; repowering (investment > 30% of the investment for a comparable new plant) counts as commissioning for power plants. • **No grid connection** of the power generation plant, or **proof via smart meter** that no electricity is taken from the grid for RFNBO production.
Verification for grid-bound electricity	1) Electricity may be assumed to be fully renewable if the electrolyser is located in a **price bidding zone whose average RE share in the previous year exceeded 90%** and the RFNBO production does not exceed a maximum number of hours that equals the product of the total number of hours in a year and the RE share in the bidding zone. 2) Electricity may be assumed to be fully renewable if the RFNBO producers have concluded **PPAs** for equivalent RE quantities and the following criteria are met: a) Commissioning of the power generation facility **no earlier than 36 months before the electrolyser**; subsequent capacity expansions at the electrolyser are possible and repowering counts as commissioning for power generation facilities

[6] The contents of an earlier "leak" of the delegated act are discussed in the GO4Industry Fundamentals Reports G4 and G1.

	• Special rules apply to RE plants with PPAs with RFNBO manufacturers that are terminated • Applicable only from 01.01.2027; not applicable to RFNBO plants that are commissioned before then (yet applicable to subsequent capacity expansions). b) **The power plant has not received investment or operating cost support.** Exceptions: support prior to repowering or support that is not net support (e.g. refunds). • Applicable only from 01.01.2027; not applicable to RFNBO plants that are commissioned before then (yet applicable to subsequent capacity expansions). • Does not apply to RFNBO plants for **research, test and demonstration purposes** c) **Production of RFNBO** either: • during the same **one-hour period** as the RE production covered by the PPA (transitional rule until 31.12.2026: during the same calendar month); or • with electricity from a **storage facility** that is located behind the same grid connection point as the electrolyser and that was charged during the same **one-hour period** as the RE production covered by the PPA (transitional rule until 31.12.2026: during the same calendar month); or • during a one-hour period in which the **day-ahead electricity price** in the price bidding zone falls below certain limits (≤ 20 €/MWh or < 0.36 times the carbon price). d) The **location of the electrolyser** meets at least one of the following criteria: • The PPA power plant and the electrolyser are located in the **same bidding zone** (at least at commissioning). • The PPA power plant and the electrolyser are located in **adjacent bidding zones** and **day-ahead power prices** in the adjacent bidding zone are equal to or higher than in the RFNBO bidding zone. • The PPA power plant is located in an **adjacent offshore bidding zone.** • The Member States may state **additional criteria**. 3) Electricity may also be assumed to be fully renewable if the RFNBO producer demonstrates that **RE generation plants were subject to curtailment during the electricity consumption period** and the electricity consumption for RFNBO production reduces the need for curtailment.
Documentation requirements	**Hourly documentation** is required of the amount and type of electricity used, the electricity generation of the RE system and RFNBO output.

Source: Hamburg Institut, based on the draft delegated act.

The requirements for grid-bound electricity show that the construction and fundamental repowering of RE plants as well as the temporal and spatial proximity of electricity and

RFNBO production are to be incentivised. However, some criticise the susceptibility of this regulation to double marketing, which is not entirely ruled out as the rules fail to incorporate GOs (AIB 2022b, RECS 2022). RED III could potentially stipulate that it must be possible to transfer GOs to the contractual partners within the framework of long-term PPAs. Accordingly, it must be implicitly envisaged that GOs can also be transferred in PPAs under the delegated act (see the next section). Nevertheless, according to Article 19 of RED II in its current form, certain criteria, in particular temporal correlation, cannot be fulfilled with electricity GOs. If the delegated act is adopted in this form, the existing electricity GO system will have to be modified or new adapted certificates will have to be developed, and double marketing must be prevented with the existing systems.

Additional reforms that are relevant to the electricity GO system were established in **Article 19 RED II.** They concern, among other things, the requirement that verification systems must comply with the European standard CEN - EN 16325, which harmonises requirements for the registration of registry users, the issuance and content of GOs, their transfer and cancellation, error correction and validity period, measurement procedures and audits, as well as other requirements relating to specific energy carriers (the standard is still under revision as of autumn 2022). Additional requirements relate to taking into account the market value of GOs in the context of financial RE support schemes (paragraph 2, subparagraphs 3 and 4) and recognising third-country GOs (paragraph 11). Article 19 (8) subparagraph 2 RED II also provides clarification on the relationship between GOs for renewable electricity and GOs for electricity from high-efficiency cogeneration (CHP) that can be issued pursuant to Art. 14 of the Energy Efficiency Directive 2012/27/EU.[7] If electricity from RE sources is produced in high-efficiency cogeneration (CHP), only one GO may be issued to indicate both characteristics. In Germany, the German Environment Agency has been responsible for issuing combined CHP GOs since 1 July 2021; previously, CHP certificates under the EED were issued by the Federal Office for Economic affairs and Export Control (BAFA) (under Section 31 of the CHP Act).[8] GOs for renewable electricity from high-efficiency CHP also contain information on heat generation in CHP plants (including thermal output and use of heat, see Section 9 (2) EEV). However, the value of GOs relates to the electricity generated in CHP and thus serves electricity disclosure purposes.[9]

The implementation of the new requirements from RED II has not yet been completed. However, there is already a **draft amendment to RED II from July 2022, the so-called RED III** (European Commission, 2021). The reforms proposed therein are still being discussed, but

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[7] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

[8] https://www.umweltbundesamt.de/sites/default/files/medien/376/dokumente/hknr_newsletter_3_2020.pdf; Kraft-Wärme-Kopplungsgesetz of 21 December 2015 (BGBl. I p. 2498), last amended by Article 88 of the Act of 10 August 2021 (BGBl. I p. 3436).

[9] Erneuerbare-Energien-Verordnung of 17 February 2015 (BGBl. I p. 146), last amended by Article 87 of the Act of 10 August 2021 (BGBl. I p. 3436).

if they were to become effective in the currently presented form, this would mean substantial changes for the verification of renewable electricity.

The arguably most far-reaching change for the German GO system is envisaged by the Commission draft in Article 19(2) subparagraph 1, which stipulates that Member States must now issue GOs for subsidised electricity. This would mean the **end of the German ban on double marketing**. Even if this would result in significantly more GOs from German plants coming onto the market, the effects on the GO market in Germany and beyond are difficult to assess, as they result from an interplay of supply and demand. Chapter 4.2 discusses the possible consequences of such a new regulation in more detail.

Related to this new regulation is the provision under Article 15 (8) of the draft, which stipulates that **GOs must be transferable within the framework of long-term PPAs**. Since PPAs can also be concluded with subsidised plants, it must be possible to transfer GOs to consumers from both unsubsidised and subsidised PPA plants. In conjunction with the delegated act, it would in principle be possible to require that PPA plants that produce electricity for the generation of RFNBOs for transport within the scope of the delegated act from Article 27(3) RED II also transfer GOs to the electricity consumers (e.g. electrolyser operators).

Further amendments to Article 19 provide for the deletion of subparagraph 5 ("In order to take into account the market value of the guarantee of origin, Member States may decide, inter alia, to issue a guarantee of origin to the producer and cancel it."). Also, the reference to the procedure in case of non-issuance of GOs for subsidised plants is deleted from paragraph 8 (1). According to the draft, no other changes are currently planned for Article 19, although it has been criticised that no legal regulation is proposed at this point that prescribes the introduction of additional systems which could enable higher temporal and quantitative granularity as well as checks for the spatial alignment of supply and demand (European Parliament 2022a,b).

Similarly important for RE verification in the electricity sector is the plan to **extend the scope of the rules for the production of RFNBO, which currently only apply to transport sector uses, to all areas in which these fuels are used**. This will mean that the requirements for renewable electricity for RFNBO production will apply much more widely. Neither the current draft version of the delegated act nor the RED III draft contains any indications of these strict criteria being applied to directly used renewable electricity, e.g. in e-mobility. Nevertheless, it should be noted that these requirements currently only have to be met if corresponding RFNBO quantities are to be used to earn regulatory credit (in various sectors). Thus, a market for (partially) renewable hydrogen with less stringent criteria may still emerge, and this market may then in turn be used for other purposes, such as heat and gas disclosure, climate accounting or sustainability reporting.

3.3 Green electricity attribute certificates in industry

Given their sustainability and climate neutrality strategies (including climate accounting) as well as far-reaching disclosure obligations (e.g. within the framework of the Corporate Sustainability Reporting Directive), companies are increasingly becoming the drivers of a rising demand for renewable electricity. However, expected changes to regulatory requirements can also affect the demand for green electricity and the corresponding GOs. Due to the abolition of the EEG levy and its impact on electricity dislcosure, some industrial power consumers now benefit from a higher share of green electricity in their product mix, which in turn could reduce their demand for additional green electricity. Other regulatory innovations include the EU's plan for a renewable energy target for the industrial sector, a requirement to label the exact renewable energy content in products, and an RFNBO quota for energy and non-energy consumption (European Commission 2021). These developments could increase the demand for green electricity and related verification. In the future, there will be an increased need for coordinated rules on electricity verification and climate accounting, not just across Europe but globally. This results from the increasing interest of legislators and market parties in making green properties in products measurable and verifiable in order to determine CO_2 levels in cross-border trade and to be able to account for those emissions in international settlement mechanisms.[10] As mentioned above, some of these aims require a further development of the capabilities of the verification systems (e.g. for proving the simultaneity of RFNBO and electricity production).

Particularly in the area of climate accounting, a certain problem arises with regard to the double marketing of the renewable attributes of electricity. Companies can choose between two fundamental approaches to account for green electricity, the **location-based** or the **market-based** approach (see also GO4Industry Industry Report 1, Sakhel et al. 2022), and they are free to pick the approach that leads to a more favourable outcome (although accounting for both outcomes is recommended, see WRI and WBCSD 2015).[11] The location-based approach uses the average emission intensity of electricity in the public grid to which a consumer is connected (national or regional mix). However, a supply of renewable electricity is only possible up to the average RE share in the grid. To reduce emissions from electricity procurement, companies can then only reduce their electricity consumption (Styles 2022). The market-based approach, on the other hand, allows for the purchase of green power attributes as part of a supply contract, with verification (through GOs) ensuring the reliable and unambiguous allocation of those attributes and thus of the emissions to specific consumers. In this way, companies can make conscious procurement decisions in favour of climate-friendly electricity products or electricity suppliers, which is in line with the logic of the

[10] A detailed overview of these regulations for industry can be found in the GO4I Industry Report I1 (Hamburg Institut).

[11] This logic is based on the guidelines of the Greenhouse Gas Protocol, which applies to corporate sustainability reporting.

liberalised electricity market (Styles 2022). Here, procurement is mainly done by purchasing electricity and freely traded GOs (AIB 2020) or by means of long-term PPAs through which consumers secure both the electricity and its verifiable renewable origin by means of GOs. Another option is the supply of electricity via a direct line (e.g. company-owned or contracted power plants at or near the place of consumption), with verification by audit.[12]

The choice between the location-based and the market-based approach can lead to a double claim of green attributes. This happens when a company only uses the generation mix in the local grid (location-based approach) but GOs are nevertheless issued for parts of the fed-in RE generation, cancelled and claimed by another company using the market-based approach (Styles 2022). A similar problem arises when GOs from one country (e.g. Norway) are shown in the electricity disclosure of another country (e.g. Germany), but (parts of) the underlying renewable attributes are also included in the national mix of the exporting country, which is used by the local industry under the location-based approach. In order to increase transparency, it is therefore strongly recommendable that **companies present both the location-based approach and the market-based approach,** and that comparisons across companies do not mix the two approaches. Stricter rules on climate reporting would be desirable. Companies that cannot provide evidence of GO cancellation for their electricity consumption or that do not draw their power from RE plants via direct lines should still publish the results of the market-based approach, using the attributes of the residual mix. Unlike the generation mix in the local grid, the residual energy mix is adjusted for explicitly tracked electricity attributes, so that there cannot be multiple claims of green attributes.

[12] In principle, GOs can be used for verification in case of directly connected plants too; in Germany, no GOs are currently issued for self-generated electricity.

4. Further development options for the German renewable power verification system

This chapter examines a number of options for the further development of the existing electricity GO system. As part of this, the challenges described above are addressed in more detail and potential solutions are proposed. Considerations include development options both within and beyond the current legal framework. The premise is that in principle, the GO system is the most effective and efficient system to prove the renewable nature of electricity and prevent multiple marketing of green electricity attributes.

4.1 Stronger differentiation of GO qualities for different purposes

GOs should first and foremost be seen as a neutral verification tool that certifies the authenticity of the renewable energy property and prevents its double marketing. **However, the information on GOs can also be interpreted in terms of the quality or energy transition benefit of the underlying energy**. This perspective can highlight and reinforce the value of certain characteristics of green electricity. Regarding the energy transition benefits of green power, the **criterion of additionality** plays an important role: It posits that the demand for green power should contribute to promoting and accelerating the RE expansion beyond the legal support framework. In this context, five types of green electricity qualities can be differentiated:

- Green electricity from largely depreciated, unsubsidised plants.
- Green electricity from existing subsidised plants, where the GO revenues reduce the required subsidy.
- Green electricity from new subsidised plants, where the GO revenues reduce the required subsidy (especially through lower bids in tenders).
- Green electricity from existing plants whose subsidies have run out and whose operating life can be extended thanks to the GO revenues.
- Green electricity from new, unsubsidised plants (e.g. in conjunction with green PPAs).

A green electricity mix with the highest possible share of new, unsubsidised plants would have a particularly high benefit for the energy transition in this context (see e.g. WWF 2021).[13] **Other quality characteristics** that are not always per se linked to the acceleration of the energy transition in the power sector but can serve individual preferences and/or regulatory requirements include the following:

- Type of renewable energy source, with solar and wind often considered to be more valuable.

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[13] A limiting factor here, however, is the quantity control discussed in chapter 3.2, to the extent that unsubsidised RE expansion volumes are to be deducted from the EEG volumes to be tendered (for wind and photovoltaics). In this case, no additional RE expansion would take place with unsubsidised plants in Germany (see also 4.2.3).

- Spatial proximity of generation and consumption: Regional and national electricity procurement is considered to be of higher quality, as this supports the energy transition locally (at the very least, there should be a physical grid connection to the power plant).
- A connection, at least in abstract terms, between the physical delivery of power and delivery of the renewable property through procurement contracts with green power producers.
- A closer temporal matching of generation and consumption (monthly, hourly or even quarter-hourly), which reflects the actual availability of fluctuating RE generation (see chapter 4.4).

Much of this information can already be accessed or implemented via the existing GO system and does not require any serious structural changes. Only the **transparency regarding different qualities and their accessibility** may not be ensured for third parties. For such quality differentiations to actually generate a benefit for the energy transition (e.g. to accelerate the RE expansion), electricity consumers should be able to understand the different qualities and have access to the corresponding verifications. Consumers' decisions are aided by green electricity labels that mark tariffs that will help consumers support the energy transition beyond the subsidy and that check for further green electricity quality features (Verbraucherzentrale Niedersachsen 2016). However, with the multitude of labels, consumers face a certain lack of clarity, partial inaccuracy or even misleading information. The transparency of green electricity qualities could be increased through requirements to provide further information in the electricity disclosure (as already planned regarding the country of origin, see 3.2). Additional information could also be provided digitally.[14]

However, at least household consumers can so far only choose from prefabricated products, as it would entail prohibitive effort for electricity suppliers to provide individual households with tailored electricity mixes. **Large industrial consumers,** on the other hand, can assume a pioneering role, as their bulk purchases allow them **to negotiate individual agreements with electricity suppliers regarding GO qualities** (Styles 2022). However, as these options are also limited, we are likely to see a pronounced increase in individual PPAs, in which a long-term purchase of GOs of a certain quality can be agreed directly with certain plant operators (Hilpert 2018). Especially for industrial consumers, who must meet reporting obligations and are under public scrutiny, the quality of the green electricity they buy will become increasingly important, e.g. in the context of the market-based climate accounting approach.

Publicly available information on certificate prices would also promote general transparency. Currently, GOs are mostly sold via various over-the-counter channels (with or

[14] See e.g. the "Origin Comparator" in Flanders, https://www.vreg.be/nl/herkomst-stroom.

without their own trading platform, e.g. Montel, greennavigation),[15] with very little price information being publicly available. Another step towards more transparency is the planned GO exchange by EPEX Spot (EPEX 2022), which is to start trading in September 2022. This new offer is intended to provide better qualitative differentiation by production technology (hydro, wind and solar power), country of origin (within the AIB member countries) and subsidy status, as well as better price transparency. However, only large-scale traders will be able to use the platform.

In conjunction with GO quality characteristics, the purposes for which the GOs are to be used will also be relevant. **Different GO qualities will be suited for different purposes**; likewise, different purposes for which green electricity is used will suggest different types of regulation regarding GO quality levels in order to specifically incentivise the production of certain green electricity qualities. For example, the purchase of any electricity GO will to some degree support the energy transition in some country recognised in the system, at least as long as double marketing of the renewable energy property is prevented. However, if the intention is to support the energy transition more locally and with specific energy sources, stronger GO differentiation is necessary. Another example is the production of electricity-based fuels: Since in contrast to the direct use of electricity (e.g. in e-mobility), their production involves several steps and considerable losses, the law should set stricter sustainability and climate protection criteria in this area (cf. dena 2017, ESYS 2017, Öko-Institut/Fraunhofer ISI 2015), including stricter green electricity quality criteria (European Commission 2022). The planned new regulation of electricity disclosure, according to which RE with GOs must in the future indicate the country in which the electricity was generated (the future § 42 (1) no. 3 EnWG), also points to a strengthening of the value of individual green electricity characteristics at the regulatory level.

In sum, the ability of the GO system or an extended verification system for electricity to support the energy transition beyond the state-led growth depends on the **differentiation, availability and demand for different GO qualities.** Demand can develop in the market (e.g. demand from industrial and private consumers) and/or be stimulated by suitable regulation.

4.2 Issuing GOs for electricity from EEG-supported plants

As described in section 2, no GOs may be issued in Germany for electricity whose production is subsidised under the EEG (section 79 (1) in conjunction with section 80 (2) EEG 2021). Until 2021, the "green" characteristic of the EEG-subsidised electricity was distributed to all payers of the EEG levy by displaying the EEG share in electricity disclosure (see GO4I Fundamental Report 2, Styles et al. 2021a). In mid-2021, the electricity disclosure rules in

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[15] e.g. https://montelgroup.com/services/montel-marketplace

Section 42 EnWG were amended to the effect that the **EEG share may only be shown at the product level.**[16] The overall energy source mix of each supplier, on the other hand, is intended to reflect the companies' actual procurement behaviour, so that RE shares shown at this level must be backed by GOs (for the disclosure of non-tracked commercial offers, in which electricity cannot be clearly assigned to an energy source on the generation side, suppliers can also use the residual energy mix, which may also include RE shares).

A further change in the reporting of EEG shares will result from the **switch from levy financing to budget financing in 2022**. In the future, the **share of "renewable energy promoted under the EEG" in electricity generation in Germany** will be shown to all consumers in the product mix of electricity disclosure (or in the company sales mix for single-product suppliers).[17] Up to now, as the EEG share was distributed in parallel with the financial allocation of the levy, the share of RE financed from the EEG levy that a power supplier could report depended on its customer structure (cf. Maaß 2021): Suppliers with a high share of non-privileged consumers such as households, which had to pay the full EEG levy, were able to report a higher EEG share than suppliers whose customers enjoyed a reduction in the EEG levy, such as companies with high electricity bills. In the future, however, the green attributes of subsidised plants will be reported equally vis-à-vis all final consumers (amounting to the share of EEG-subsidised generation in the German electricity mix, e.g. 45% in 2020, according to BDEW (2021b); see BT-Drucksache 20/1630, p. 247).

In principle, the EEG's switch to budget financing removes an important justification for the **EEG double marketing ban,** according to which electricity customers must not be charged twice – both via the EEG levy and the GO price – for the positive environmental characteristics of the renewable electricity (Kahl and Kahles 2020). While showing the green characteristic of EEG electricity in the electricity disclosure could be understood as a "quid pro quo" for the payment of the EEG levy (Kahl and Kahles 2020), the tax financing of the EEG support opens more leeway for allocating the green power characteristics to consumers. The legislator justifies the equal allocation of the EEG share to all final consumers by stating that a budget-financed EEG is ultimately paid for by all final consumers as taxpayers (BT-Drucksache 20/1630, p. 247). It is also argued that the RE share that has already been achieved was made possible in the past by EEG levy payers. A possible alternative would be to allow subsidised EEG plants to issue GOs and to reduce the subsidy costs by subtracting the GO market value from the size of the subsidy.

The discussion on issuing GOs for subsidised EEG plants has also gained momentum due to the **EU Commission's RED III proposal**, which stipulates that member states must allow the

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[16] It should be noted that EEG electricity may not be marketed as green electricity – in the case of green electricity products, the full amount of GOs must therefore be cancelled for the electricity quantities supplied, even though the EEG share must nevertheless be shown in product disclosure (cf. BDEW 2021a).

[17] BT-Drucksache 20/1630, p. 109.

issuance of GOs also for subsidised electricity. Whether this requirement will be reflected in the final RED III is still open as of July 2022 (cf. European Parliament, Committee on Industry, Research and Energy 2022b, pp. 42-46). However, most member states are already using this option (see 4.2): As of 2022, among the AIB member countries, only Germany, Ireland, Lithuania and Serbia do not issue GOs for state-subsidised electricity (cf. David and Feng 2019 and EECS Domain Protocols, AIB 2022a). In addition to greater harmonisation, the Commission's proposal is justified by the aim of **strengthening PPAs** to ensure that RE system operators can transfer both electricity and the associated GOs to consumers (COM(2021) 557 final, p. 19).[18] Even though GO issuance for subsidised plants would require an adjustment of the EEG double marketing ban contained in § 80 para. 2 and § 79 para. 1 EEG 2021, the more general **principle of the European double marketing ban** according to Article 19 para. 2 RED II remains in place: Member States must ensure that a unit of renewable energy is only taken into account once. This means that in the case of GO issuance for supported plants, showing RE shares in electricity disclosure would only be possible via GOs or the residual energy mix, while omitting the EEG share.

Due to the large volume of EEG-subsidised electricity generation in Germany, the potential impact of such a step on the German and European GO market is of great interest. To be able to gauge the effects, an **overview of current GO issuance and cancellation volumes in the German and the European market is given below, as well as an estimate of the maximum additional GO volume that is to be expected from subsidised EEG plants** (4.2.1). Note that the presentation is based on currently available market data, rather than on a model of the GO market, which would be necessary for an analysis of price and volume effects. The market effects of GO issuance for subsidised EEG plants also significantly depend on the design of such a step, as the RED III draft still contains an obligation for member states to duly consider the market value of GOs in their support schemes (see Article 19 para. 2 RED II).

Section 4.2.2 concludes with an overview of how EU Member States that have decided to auction GOs from subsidised plants have designed those **auctions.** Section 4.2.3 discusses whether and under what conditions GOs for subsidised EEG plants could **contribute to the energy transition.**

4.2.1 Possible market impact of GO issuance for supported plants

Figures 1 and 2 show the issuance, cancellation and expiry of GOs in Germany and EECS member countries, respectively, by the year of electricity production. Note that the data for 2021 are not yet complete, as plant operators can still apply for GOs twelve months after the

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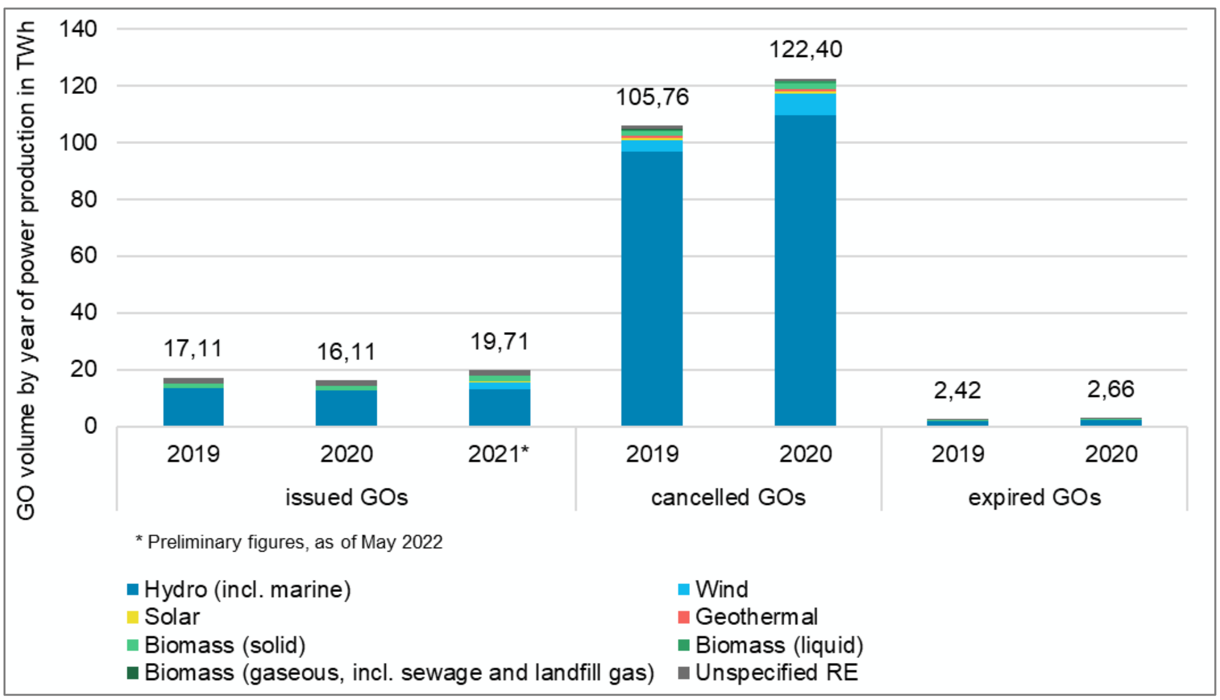
[18] COM (2021) 557 final. Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources and repealing Council Directive (EU) 2015/652.

end of the corresponding electricity generation period (§ 12 para. 1 no. 7 HkRNDV).[19] Also, GOs do not expire until 18 calendar months after the end of the generation period (§ 34 HkRNDV), and the electricity disclosure for 2021 must be published only by 1 November 2022, according to § 42 para. 1 EnWG. **This means that GO issuance, but especially cancellation for 2021, can still be applied for in 2022**. In addition, only few GOs for power generated in 2021 have reached their expiry date. Nevertheless, GO issuance is already shown for 2021, as it already reveals some interesting trends. The data basis is the **AIB activity statistics for GOs in the EECS**. The EECS is a voluntary standard for GO systems used by AIB members. Through the harmonisation of GO systems and the use of the AIB Hub to transfer GOs between registries, membership in the EECS system simplifies GO trading so that the database can be used as an approximation of the European GO market.

Even more current trends could be gleaned from a presentation of the corresponding figures by the year of transaction, for which the 2021 data are already final. However, for better comparability with EEG electricity volumes, we present the data by the year of electricity production. In addition, electricity disclosure for a specific year must rely on GOs whose electricity was produced in the same year, so that the "vintage" of GOs has market relevance.

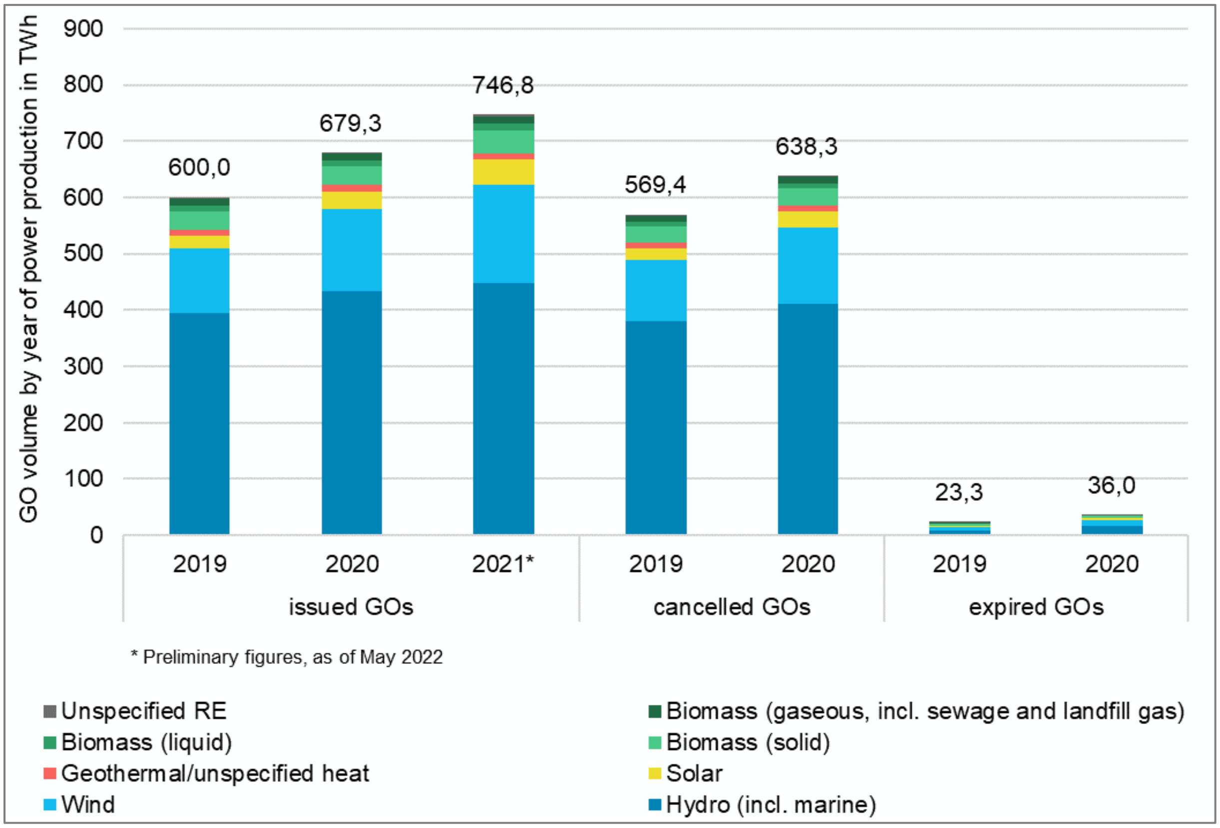
Figure 1: Issuance, cancellation and expiry of EECS GOs from RE in Germany (by year of underlying electricity production)



Source: Hamburg Institut, based on AIB 2022, Activity statistics (Annual Fuel-Level 2, as of May 2022).

[19] Herkunfts- und Regionalnachweis-Durchführungsverordnung of 8 November 2018 (Federal Law Gazette I p. 1853), last amended by Article 4 of the Ordinance of 14 July 2021 (Federal Law Gazette I p. 2860).

Figure 2: Issuance, cancellation and expiry of EECS GOs from RE in AIB member countries (by year of underlying electricity production)



Source: Hamburg Institut, based on AIB 2022, Activity statistics (Annual Fuel-Level 2, as of May 2022).

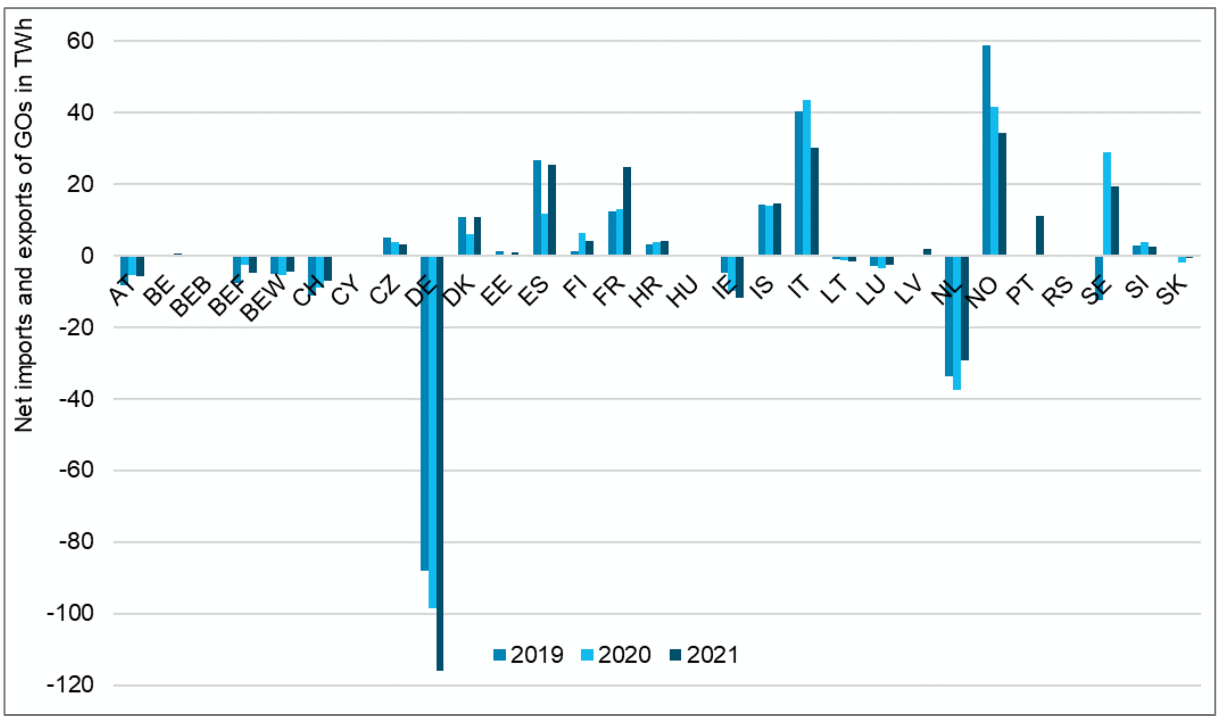
In Germany, the ban on double marketing under the EEG causes a clear imbalance between GO issuance and GO cancellation, as claiming EEG support is generally more attractive than operating unsubsidised plants and selling their GOs. As a result, **only few GOs from domestic RE plants are available on the market**: For 2021, GOs have been issued for 19.7 TWh of renewable power so far, up from 16.1 TWh in 2020. In addition to post-EEG plants whose 20-year support period has expired, high electricity price levels in 2021 (cf. Çam et al. 2022) may have made it increasingly attractive for RE plants to forego support on a monthly basis and switch to unsupported ‘other direct marketing’, where GO issuance is possible. An additional supply of GOs comes from unsubsidised plants that emerged from 0-cent bids or never participated in the EEG auctions.

2021 saw a significant increase in GO issuance from domestic wind and solar plants (starting from a low level), while GOs from hydropower (especially run-of-the-river plants) continue to dominate. Overall, **however, German GOs accounted for only 2.6% of the total EECS GO supply in 2021,** compared to 2.4% in 2020. By contrast, **cancellations for electricity delivered in Germany amounted to 122.4 TWh for 2020, or 19.2% of EECS GO demand**

in that year. A large share of the cancelled GOs comes from hydropower (almost 90% in 2020), although cancellation of GOs from wind, solar and bioenergy is increasing.

In view of the comparatively low domestic issuance of GOs in Germany, GOs are **imported to a considerable extent from other European countries for the purpose of disclosing the attributes of green power products**. Germany is the largest net importer of GOs in Europe, followed at some distance by the Netherlands (see Fig. 3). Norway is the largest net exporter, followed by Italy. According to an analysis of where the GOs originated as part of the Market Analysis Green Electricity II for the German Environment Agency, just under half of the annual GOs cancelled in Germany came from Norway in the period 2013-2017 (Güldenberg et al. 2019). An important criterion for imported GOs was that the plants did not receive any subsidies (this was the case for at least 95% of the cancelled GOs in 2013-2017). However, in 2017, 95% of the cancelled GOs without subsidies came from plants that were at least ten years old at the time of cancellation (partly with expansion investments).

Figure 3: GO trade balances of guarantee of origin systems in AIB member countries (by transaction date)



Source: Hamburg Institut, based on AIB 2022, Activity statistics (Annual Fuel-Level 2, as of May 2022). Note: BEB, BEF and BEW represent regions within Belgium (BE). Cyprus and Hungary are not listed because their values were zero in each year.

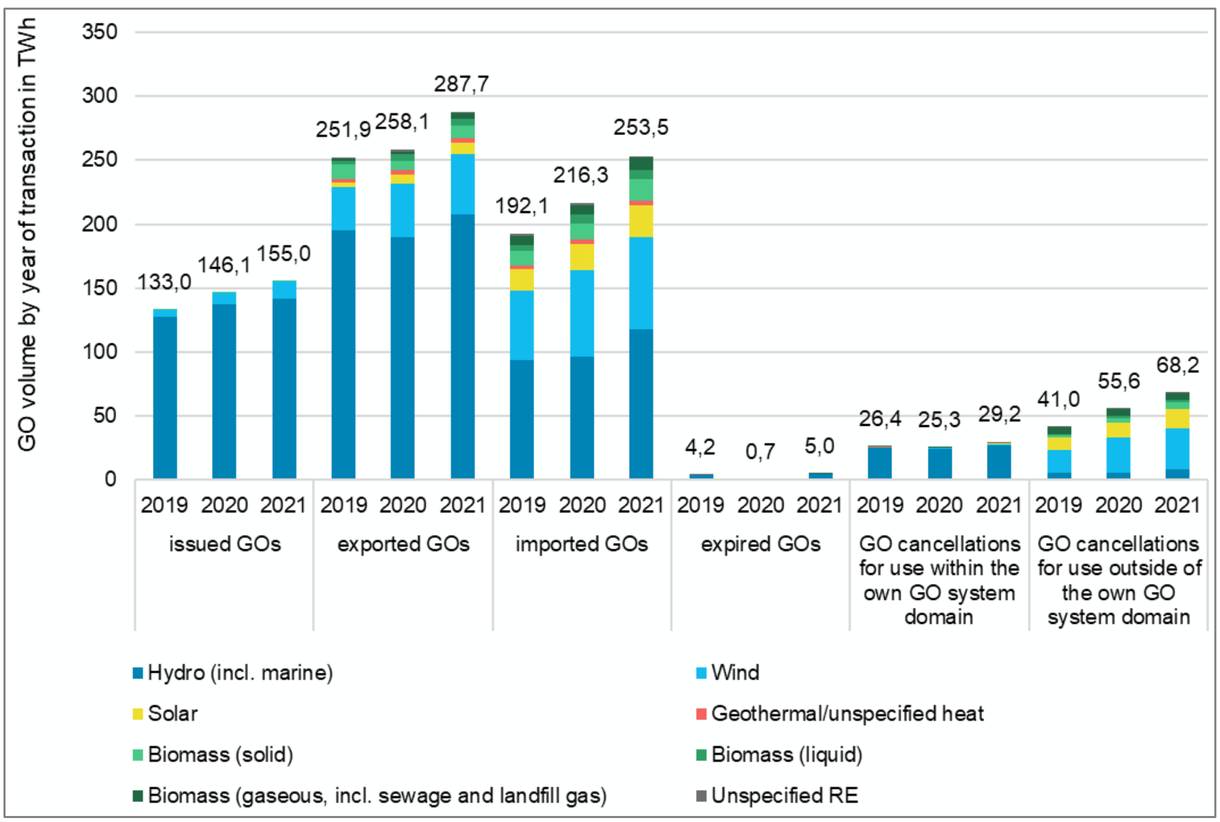
Norwegian GOs (especially those from hydropower) thus currently play a major role in the German GO market. Against this background, the Norwegian government's announcement in the autumn of 2021 that it would consider withdrawing from the European GO system in order to prioritise the green power needs of its own industry (Greenfact 2021) caused a stir.

However, such a step would face significant legal obstacles as Norway, being an EEA member, is obliged to implement the RED. However, even a Norwegian exit from the AIB and the EECS system could significantly reduce the supply on the European GO market (Montel Weekly 2021).

The **net effect of a hypothetical withdrawal of Norway from the GO system** is the difference between the GOs issued and the GOs cancelled for the national domain (unlike in Germany, cancellations for other domains can also be carried out in Norway in certain cases). GO cancellations for the Norwegian domain correspond to the demand for GOs by Norwegian consumers, which would be eliminated if Norway left the GO market, as would the issuance of Norwegian GOs.

The corresponding data are available from the AIB transaction statistics (see Fig. 4). **In 2020, 120.9 TWh less would have been available to the European GO market if Norway had withdrawn,** and 125.8 TWh less in 2021.

Figure 4: GO transactions for guarantees of origin from RE in Norway (by transaction date)



Source: Hamburg Institut, based on AIB 2022, Activity statistics (Annual Fuel-Level 2, as of May 2022).

In addition, there would be **organisational effects on European GO trading**: Currently, Norway is a central trading place for GOs with high import and export volumes, as transaction costs in the Norwegian registry NECS are low (Greenfact 2021). Whether Norway will actually withdraw from the GO or EECS system is uncertain as of July 2022 – but the Norwegian export in GOs could also decline due to higher local demand for green electricity products backed by GOs. In particular, increased GO procurement may become relevant for Norwegian industrial companies if market-based climate accounting with verifiable allocation of green properties via GO cancellation should become the market standard, rather than location-based climate accounting (see GO4I Industry Report I1, Sakhel et al. 2022). Any such shifts in the GO supply would necessitate a **restructuring of GO procurement for green power in Germany**.

Against this background, **GO issuance for subsidised plants could contribute to a more neutral GO trade balance in Germany**. This is also relevant insofar as a better balance of supply and demand has been emerging in the EECS market in recent years, following excess supply of GOs in the past (AIB 2021; RECS 2021).[20] A GO shortage – e.g. due to an increase in domestic GO demand in Norway or the country's exit from the EECS system – would trigger price increases on the European GO market unless the demand also declines.

A **rough estimate of the maximum number of GOs that could come onto the market in the event of GO issuance for subsidised EEG plants** can be made on the basis of the EEG volume statistics and the EEG medium-term forecast (see Fig. 5). **The increase in expansion targets due to the coalition agreement and the EEG amendment 2022** (BT-Drucksache 20/1630; BMWK 2022b) **as well as current electricity price developments have not yet been taken into account.** A robust estimate of the GOs for subsidised plants would also require modelling, which is beyond the scope of this project.

In 2020, 180.6 TWh of grid feed-in from RE was marketed under the market premium model, with the remuneration being determined either competitively in tenders or set administratively. 41.2 TWh were purchased by the transmission system operators and received a feed-in tariff. The volume of **other, unsubsidised 'direct marketing'** was negligible in 2020. This indicates that non-EEG plants contributed a significant share to domestic GO issuance in 2020 (e.g. older hydropower plants, energy generation from biogenic waste, plants realised outside of the EEG). In the future, the importance of "other direct marketing" – which is already eligible for GO issuance – will increase, as the EEG subsidy period expires for ever more plants and offshore wind farms are realised with "0-cent bids" (cf. r2b energy consulting 2021). Moreover, plants can decide on a monthly basis to switch to this unsubsidised form of marketing when electricity and/or GO prices are high. However, all things considered, the additional volume of GOs from other direct marketing is unlikely to exceed 25 TWh by 2026 – a relatively small amount compared to the domestic GO demand.

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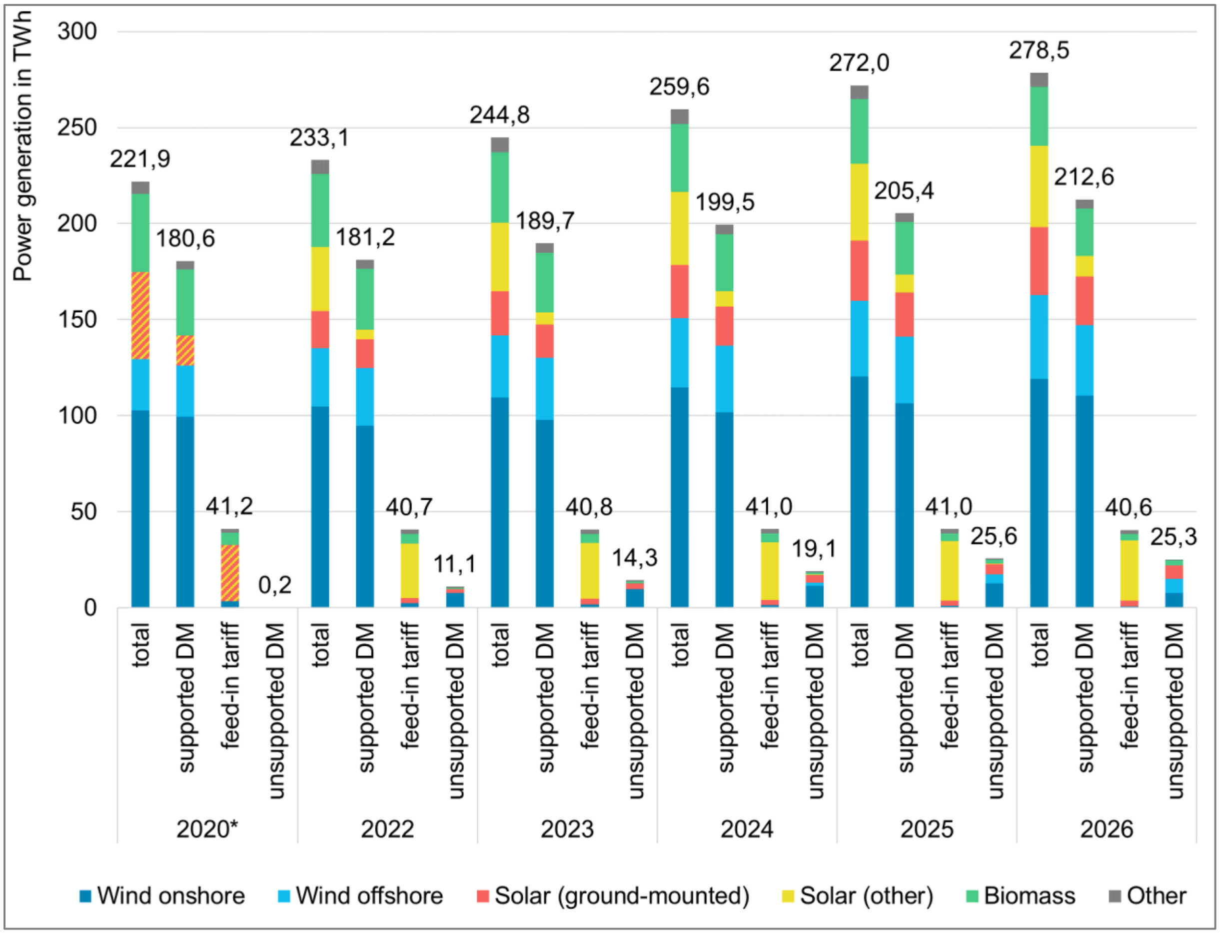
[20] When comparing supply and demand in Fig. 2, it should be noted that cancellations of exported GOs to non-EECS regions without central statistics are not shown. Furthermore, some AIB member countries report cancellations not by the year of electricity disclosure but by the transaction year (AIB 2022d).

Figure 5: Electricity generation by subsidised and unsubsidised EEG plants (excluding on-site consumption)



***2020: EEG electricity generation with grid feed-in according to the EEG annual accounts; 2022-2026: Forecast EEG electricity generation with grid feed-in.**
Source: Hamburg Institut, based on data from r2b energy consulting 2021, EEG medium-term forecast 2022 to 2026; 50Hertz, Amprion, Tennet, Transnet BW, 2021, EEG volume statistics 2020. DM: direct marketing; "Other" includes geothermal, hydropower, landfill, sewage and mine gas. Not included is renewable electricity from non-EEG plants (e.g. older hydropower plants; corresponding electricity volumes are already represented on the GO market today).

By contrast, GO **issuance for all subsidised EEG electricity volumes** would significantly expand the GO supply from Germany – by a maximum of 222 TWh in 2020, rising to 253 TWh in 2026 (again without taking into account the adjusted RE expansion targets and current electricity price developments). In 2020, this would have increased the supply of GOs in the European market by almost one third (cf. Fig. 2). However, **the demand for GOs would also be likely to increase in Germany**: the elimination of the EEG share in product disclosure would drastically reduce the reported RE share of conventional electricity products (there would be no change for green electricity products, since such power must already be fully covered by GOs, regardless of the EEG share). It is to be expected that power suppliers would therefore procure more GOs in order to offset a deterioration in the ecological properties of their electricity products caused by the elimination of the EEG share.

Furthermore, the market impact of GO issuance for subsidised EEG plants crucially depends on how such a step is designed. According to Article 19 (2) RED II, **member states must take due account of the market value of GOs in their support schemes**. This is assumed to be the case if:

- the financial support is granted within the framework of a tender or a system of tradable green certificates;
- the market value of the GOs is taken into account when administratively determining the amount of financial support; or
- the GOs are not issued directly to the producer but to a supplier or consumer who purchases the renewable energy either under competitive conditions or under a long-term contract for the purchase of renewable electricity.

The third option could be implemented by **auctioning GOs from subsidised plants** to suppliers or consumers. The greatest impact on the GO market can be expected from auctioning all GOs for EEG-subsidised plants. But even here, the market effects can be controlled via the auction design (see 4.2.2) – for example, setting a minimum price for the bids can serve to prevent a price decline due to oversupply on the GO markets.

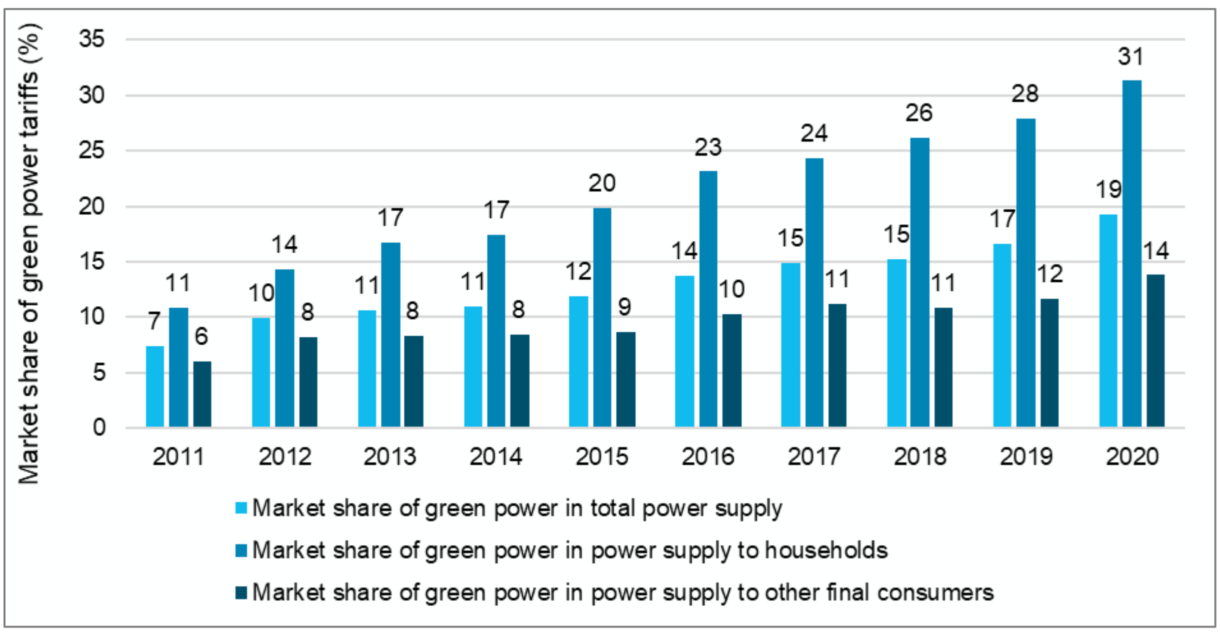
In the case of **optional GO issuance to plant operators,** on the other hand, it is to be expected that the GO issuance rate will differ depending on the marketing segment. For new plants that participate in EEG tenders, the GO revenues will likely be priced into the bids. This would presumably be reflected in high GO issuance rates. For existing plants in subsidised direct marketing, the GO issuance rate would depend on how much the subsidy is reduced to take account of the market value. For regional certificates, which EEG-subsidised plants can apply for, § 53b EEG 2021 already contains a corresponding regulation: When a plant receives regional certificates for its power, the subsidy is reduced by €1 per MWh. The decision whether to apply for GOs and accept the subsidy deduction will then depend on the GO market prices.

For **existing plants in the feed-in tariff**, their participation in the GO market if GO issuance were made optional is associated with even greater uncertainty. Since the power produced by such plants is marketed via the transmission system operators, plant operators would have to establish new marketing channels for participation in the GO market. Especially for small solar plants, the transaction costs could make market participation with GOs of a few MWh per year unattractive (even though new roles for aggregators could emerge). With approx. 41 TWh of annual renewable power in the period 2020-2026, the influence of electricity with feed-in tariffs on the GO market would remain limited in any case; directly marketed power in the market premium model is more relevant.

The increase in the RE expansion targets established by the 2022 amendment to the EEG will lead to more renewable power being generated by subsidised plants, which in turn raises the supply of GOs. However, **the demand for GOs – and especially domestic GOs – is also likely to further increase**. In 2020, green power products already accounted for 31% of the electricity supplied to households, and 14% for other consumers (incl. industry, trade and services, public sector) (see Fig. 6).

However, there is **increasing pressure on companies in particular to implement climate neutrality strategies**, which includes the verifiable procurement of green power when buying electricity from the grid. Besides the share of green electricity, a **significant increase in the overall demand for electricity can also be expected** in the course of the decarbonisation of the heating/cooling, transport and industrial sectors: In scenario calculations for a 'Climate-Neutral Germany 2045', Prognos et al. (2021), for example, assume an increase in gross electricity consumption from 595 TWh in 2018 to 643 TWh in 2030 and 1017 TWh in 2045 (e.g. due to the electrification of industrial processes, the expansion of e-mobility and the production of hydrogen and synthetic fuels, the expansion of heat pumps and power-to-heat in general, and advancing digitisation). An **expansion of the GO supply due to GO issuance for subsidised EEG plants must therefore be assessed in the context of an expected expansion of the demand for GOs**, both in Germany and in Europe.

Figure 6: Share of green electricity in electricity sales to German consumers



Source: Hamburg Institut, based on data from Bundesnetzagentur/Bundeskartellamt, Monitoring Reports 2010-2021. The calculation of the market shares of green electricity is based on survey data from utilities on the volume of power marketed in dedicated green electricity tariffs (2020: 73.4 TWh) and on the total volume of electricity sold to final consumers (2020: 380.9 TWh). In 2020, the respondents sold 37.2 TWh of green electricity to households (total: 118.8 TWh) and 36.3 TWh to other consumers (total: 262.2 TWh).

4.2.2 Design of GO auctions in EU member states

As described in the previous section, auctioning off all GOs for EEG-subsidised plants could have the greatest impact on the European GO market. However, this impact can to some extent be managed by choosing a suitable auction design. Furthermore, a state GO auction could generate revenues that could be used to partially refinance the subsidy costs (alternatively, these can be reduced with an optional issuance of GOs to plant operators, who will price the expected revenues into their tender bids). Since various countries that have in the past not issued GOs for subsidised plants have opted for auctions, key design options will be presented in more detail here.

Until 2019, France, Croatia, Slovakia and Portugal, like Germany, did not issue GOs for subsidised plants (David and Feng 2019, p. 9 ff.). However, like Italy and Luxembourg before, these countries subsequently introduced auctions for GOs from subsidised plants (see EEX 2022; HROTE 2022; OKTE 2022a). In Portugal, following a relaunch of the GO system, GOs have only been issued again since 2020. RE system operators who receive a subsidy must submit GOs to the competent authority (REN 2020). GOs for subsidised renewable power account for more than 70% of the GO issuance in Portugal and are marketed through auctions (AIB 2021b; OMIP 2022). In June 2022, the first auction of GOs from subsidised plants also took place on the Hungarian power exchange, and general GO trading is to begin in the second half of the year (AIB 2021c; HUPX 2022a). While only non-EECS GOs were sold in the first auction, this will change in the next auctions (HUPX 2022a).

In the following, we provide a brief overview of central characteristics of GO auctions in different countries. Similarities as well as clear differences in the auction designs can be identified. **Proceeds from the auctions for GOs from subsidised plants are generally used to reduce the subsidy costs**, i.e. they flow back into the subsidies for RE plants (e.g. REN 2020; HROTE 2022; ILR 2022a; Article 4, Chapter 2, RGD 31/03/2010 - A59[21]).

In Luxembourg, France and Slovakia, the auctions of GOs from subsidised plants are conducted by the same entity that is responsible for the national GO registry (EEX 2022; ILR 2022a; OKTE 2022a). In Croatia, Italy, Portugal and Hungary, on the other hand, different entities operate the GO registry and provide the auction platform and conduct GO auctions. Here, the auctions are mostly managed by the national power exchanges (OMIP 2022; CROPEX 2022a; Article 3.4, GSE 2013; HUPX 2022a). GO auctions take place monthly (France & Hungary), quarterly (Luxembourg, Slovakia) or 5-7 times a year (Italy, Croatia) depending on the country (EEX 2022; HUPX 2022a; Art. 3.4, GSE 2013; CROPEX 2022b; OKTE 2022b; ILR 2022a). Portugal currently holds 5 auctions per year, but the short-term

[21] Règlement grand-ducal du 31 mars 2010 relatif au mécanisme de compensation dans le cadre de l'organisation du marché de l'électricité. - Mémorial A n° 59 de 2010, p. 1023 - Le Gouvernement du Grand-Douché de Luxembourg (https://legilux.public.lu/eli/etat/leg/rgd/2010/03/31/n2/jo).

goal is to offer monthly auctions (OMIP 2022 & 2021a). The same aim applies in Hungary (HUPX 2022d).

In each of the countries considered, all members of the national registry can participate in the auctions, once they have signed an agreement with the auction platform, confirming they will comply with the auction rules and trading agreements. In most cases, a financial guarantee is also required, with details varying (e.g. EEX 2020; Article 1.4, GSE 2013; OMIP 2022; Article 8.6, Number 5, OKTE 2021). **Croatia, Luxembourg and Hungary even open the auctions of GOs from supported plants to all members of the GO registries connected to the AIB hub** (CROPEX 2022a; ILR 2022b; HUPX 2022a).

Depending on the country, the **GOs to be marketed via auctions are differentiated by various quality characteristics.** While most countries only differentiate by production period and technology, France, for example, also differentiates by region (EEX 2022). In Croatia, the various GO auctions are differentiated according to old versus new plants, and the plants are listed by name (CROPEX 2022b). While in Luxembourg, the auctions for GOs from subsidised plants do not differentiate by plant age, information is provided on the identity of the plants as well as their commissioning date and capacity (ILR 2022c).

Information regarding quality characteristics and – if applicable – **minimum auction prices** is published prior to each GO auction. Minimum prices are usually chosen to cover the costs of the auction (e.g. Article R314-69-5, Book III, Title I, Chapter 4, Section 2, Subsection 6, Code de l'énergie[22]) and vary greatly by country. In France and Portugal, the minimum price for auctions in 2022 has so far been €0.15 (EEX 2022; OMIP 2022). In Croatia, by contrast, it is between €0.60 and €1, depending on the GO quality (CROPEX 2022b). In Slovakia, the minimum price for GOs from subsidised plants in 2022 is between €0.35 and €0.75 (OKTE, 2022b). In Hungary, the minimum prices in 2022 are between €0.22 and €0.32 (HUPX 2022c). For Luxembourg and Italy, that information is only available to registered users.

In all countries, **GOs from supported plants are allocated in accordance with the bid prices in descending oder** (pay-as-bid) (IRL 2022b; EEX2020; Article 3.4, GSE 2013; Article 8.6, Number 14 c, OKTE 2021). In Hungary, only the highest bids additionally receive GOs from new plants (HUPX 2022d). Portugal and Croatia are exceptions. In Croatia, the allocation is based on the marginal cost price (CROPEX 2019). In Portugal, the GOs are also allocated at marginal cost price, but this only happens after several auction rounds that start with different entry prices (OMIP 2021b). Table 3 shows the results of various auctions in 2022.

[22] Code de l'énergie: LIVRE III, TITRE IER, Chapitre IV: Les dispositions particulières à l'électricité produite à partir d'énergies renouvelables (Articles L314-1 A à L314-35), version of 25 August 2021 - République Francaise (https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000036783207).

Table 3: Examples of auction results for electricity GOs from state-subsidised renewable energy plants (auction rounds in 1st half of 2022)

GO Auction	Auction result by RE technology			
	Water	Solar	Wind	Other
France (EEX 2022), March 2022, weighted average price	1.90 €/MWh	1.92 €/MWh	1.89 €/MWh	Thermal: 1.81 €/MWh
Italy (GME 2022), June 2022, weighted average price for various production months in 2022	1.90 - 2.07 €/MWh	1.75 - 2.47 €/MWh	1.72 - 2.08 €/MWh	Other: 1.70 - 2.16 €/MWh
Luxembourg (ILR 2022a), April 2022, weighted average price	-	2.26 €/MWh	1.68 €/MWh	Solid biomass: 1.72 €/MWh
Portugal (OMIP 2022), May 2022, Marginal price for production months January / February 2022	1.80 €/MWh	1.95 €/MWh	1.76 €/MWh	Thermal: 1.74 €/MWh
Croatia (CROPEX 2022c), April 2022, marginal price for production months February/ March 2022	-	-	Commissioned 2010-2014: 1.66 €/MWh Commissioned 2015-2020: 1.69 €/MWh	Biomass < 5 MW: 2.58 €/MWh
Slovakia (OKTE 2022b), May 2022, weighted average price	1.16 €/MWh	1.16 €/MWh	-	-
Hungary (HUPX 2022b), June 2022, weighted average price for Q4 2021	-	0.40 €/MWh	0.40 €/MWh	-

Source: Hamburg Institut.
Note: The comparability of the results is limited by differences in auction design (e.g. minimum prices, differentiation by technologies, regions, production periods, plant capacity or age), as well as by the different levels of supply and demand and numbers of suppliers and bidders.

In cases where information on this is available, **GOs may not be issued directly to subsidised plants that sell their power via a PPA** (e.g. Article 9, Number 6, Decreto-Lei n. º39/2013[23]). However, the issuance of GOs is a prerequisite for the verification of renewable electricity, which is of increasing importance not only for energy suppliers but also for

[23] Decreto-Lei n. º39/2013, de 18 de marco Procede à primeira alteração ao Decreto-Lei n.°141/2010 de 31 de decembro, que estabelece as metas nacionais de utilização de energia renovável no consumo final e transpõe parcialmente a Diretiva n.º 2009/28/CE, do Parlamento Europeu e do Conselho, de 23 de abril - República Eletrónico (https://dre.pt/dre/detalhe/decreto-lei/39-2013-259898).

industrial customers. The draft RED III also proposes under Article 15(8) that it must be possible to transfer GOs under PPAs, including those concluded with subsidised plants.

France addresses these challenges in its GO legislation. **Here, plant operators can reacquire the GOs issued for their plant** in order to market them together with the electricity, e.g. pursuant to a PPA. They therefore have a pre-emptive right to their own GOs (L314-14, Book 3, Title I, Chapter 4, Section 2, Code de l'énergie[24]). However, municipalities, a group of municipalities or metropolitan areas also have a pre-emptive right to GOs from subsidised plants in their territory (L314-14, Book 3, Title I, Chapter 4, Section 2, Code de l'énergie). **GOs from subsidised plants in the territory of a municipality can be claimed partly or entirely free of charge** and are intended to enable municipalities to demonstrate the renewable and local characteristics of their electricity consumption. The municipalities may not sell those GOs to third parties (L314-14, Book 3, Title I, Chapter 4, Section 2, Code de l'énergie), as they are intended to promote renewable energy acceptance in the region.

Given the changes proposed in the draft RED III (2021) regarding the issuance of GOs for subsidised plants, which would mean an end to the German ban on double marketing, **GO auctions are an option for adapting the German GO system.** Table 4 summarises key aspects and issues that would need to be considered with regard to the auction design:

Table 4: Central design aspects for auctions of GOs from subsidised plants in Germany

Design aspect	Central issues
Responsibilities & division of tasks	• Who is responsible for conducting the auctions? • Who provides the auction platform, and how? • Who is responsible for the physical settlement of the auction result? • Who deals with the financial processing and invoicing of the proceeds from the auction?
Auction frequency	• How often should the auctions take place? Quarterly or even monthly?
Eligibility	• What are the criteria for eligibility to participate in an auction set? • For example, should participation be limited to members of the GO registry or should members of other registries that are integrated in the AIB hub also be eligible?

[24] Code de l'énergie : LIVRE III, TITRE IER, Chapitre IV : Les dispositions particulières à l'électricité produite à partir d'énergies renouvelables (Articles L314-1 A à L314-35), version of 25 August 2021 - République Francaise (https://www.legifrance.gouv.fr/codes/section_lc/LEGITEXT000023983208/LEGISCTA000023986396/#LEGISCTA000023986396).

Conditions of participation	• What additional conditions of participation need to be set? • Participation conditions could, for example, relate to signing appropriate agreements with the auction platforms, submitting key documents, passing a clearing procedure, depositing financial guarantees or deadlines for timely registration on the auction platform.
Differentiation of the GO offer	• Which quality features differentiate the GOs offered in an auction? • Is differentiation by technology and production period sufficient? • Might the market benefit from differentiation by other quality characteristics, such as plant age, plant capacity, location, etc.? What effects could this have on the expansion of RE plants?
Minimum price	• What is a good minimum auction price? • According to what rules should the minimum price be set?
Selecting the winner(s)	• According to what ranking are the winners selected? • By what criteria are equal bids ranked? • Is the winner selected immediately after evaluating the bids or should there be several auction rounds?
Auction price	• At what prices are winners picked within an auction? • Should a pay-as-bid procedure be introduced or is the auction price based on the marginal cost price determined within an auction?
Auction proceeds	• How are the proceeds from the auctions used to reduce the costs of the financial support schemes? • What adjustments would have to be made within the current regulatory framework in this regard?
Pre-emption rights	• Are RE system operators granted pre-emptive rights to their own GOs, e.g. in order to sell them together with the physical power pursuant to PPAs? • How would such a pre-emption right be designed?
Promoting public acceptance	• Should municipalities and cities be given priority access to GOs from RE plants located within their territory in order to promote acceptance? • How would such a mechanism be designed? Should the municipalities for example receive GOs from RE plants in their territory, in whole or in part, free of charge? May these GOs also be used for other purposes than marking the electricity consumption of the municipality?

Source: Hamburg Institut.

4.2.3 GOs for supported EEG plants as a contribution to the energy transition?

In the discussion about the **energy transition benefits of green electricity,** the **criterion of additionality** often plays a special role (see GO4I report G3, Werner 2022; section 4.1). The question is whether the demand for green electricity serves to accelerate the RE expansion beyond the legal support framework. It has been argued that a green power mix with the largest possible share of new, unsubsidised plants has a particularly beneficial effect on the energy transition.

The extent to which the marketing of GOs yields relevant revenue for plant operators depends primarily on the GO prices. As a rule, GO revenues only account for a few percentage points of the total revenues of the plants, and these small revenues are furthermore subject to price fluctuations on the GO markets (Güldenberg et al. 2019; Hulshof et al. 2019). In the electricity sector, GO revenues are therefore not yet considered a measurable driver of investment decisions. Electricity GO prices in 2022 are indeed at a significantly higher level than in 2021 - GOs from hydropower, wind and solar energy at times traded at over €2/MWh in the first half of 2022 (Greenfact 2022; Commerg 2022). However, this compares to average monthly electricity prices above €100 or even €200 per MWh on the power exchange (Statista 2022). If prices for electricity GOs stabilise at a high level in the future, a stronger, market-driven incentive effect could result. In this context, an increasing interest in electricity from unsubsidised plants that are **financed purely on the basis of demand via PPAs** could also prove effective. GOs from green PPAs are usually transferred to the contractual partner and are thus not traded on the GO market (unless unused GOs are resold). Instead, the value of such GOs is reflected in the PPA terms and conditions.

In the case of subsidised plants, green electricity demand can at best serve to accelerate the RE expansion indirectly: The investment decision is primarily determined by the subsidy (for plants in the feed-in tariff) or the combination of the subsidy and market revenues (for plants in the market premium model). **However, GO revenues can reduce the subsidy requirements of plants**, and thus lead to stronger RE growth with a given subsidy volume. In particular for **new plants** that participate in tenders, it can be assumed that the expected GO revenues would be priced into the bids. However, in the case of quantity-based tenders, as currently established in the EEG, while the subsidy costs would be reduced, the total capacity per tender round remains fixed. In budget tenders, by contrast, lower bids would lead to an increase in realised capacity. However, this comes at the cost of greater uncertainty regarding the quantity of realised RE expansion.

If GOs are issued for **existing plants** in return for a subsidy reduction, this also leads to a reduction in support costs. The proceeds from auctions of GOs from state-subsidised plants can be used to finance part of the subsidy costs. While GO revenues do not affect the (past) investment decisions for existing plants, an indirect benefit for the energy transition can also arise here in the case of budget-financed subsidies: Lower subsidy costs can promote political support for faster RE growth. However, this also depends on sufficient prices for GOs from subsidised plants. It is interesting to note that in the first half of 2022, prices of over €2/MWh also emerged in auctions for GOs from subsidised plants (with regional and temporal differences, see Table 3 in 4.2.2).

With regard to a direct additionality effect of green electricity demand, a highly relevant development is the amendment introduced in the EEG 2023 according to which unsubsidised, purely market-financed RE will also be deducted from the tender quantities for wind and solar plants (§§ 28, 28a, 28b EEG 2023; see Müller et al. 2022; BT-Drucksache 20/2580). Revenues from GOs for unsubsidised new plants will then also no longer have a net additionality effect if any positive impact on the growth of unsubsidised RE capacity means that fewer subsidised plants are realised in return.

Besides the discussion about direct or indirect additionality in relation to the expansion of RE, it is therefore advisable to assess GOs primarily in relation to their core function of consumer information: In a liberalised electricity market, they make it possible to clearly allocate the characteristics of the generated energy to consumers and to prevent multiple marketing (see GO4I report G2, Styles et al. 2021a). **If RE were shown in electricity disclosure exclusively via GO cancellation and the use of the residual energy mix in the case of non-tracked commercial offers, this could strengthen the consumer information function of GOs**. If the EEG share were not shown in product disclosure, consumers would have a clearer picture of the extent to which green electricity properties were actively procured for their products. Greater transparency regarding the procurement decisions of companies already results from the omission of the EEG share in the disclosure of the overall energy source mix. It remains to be empirically investigated how consumers assess the differentiation of information in the overall energy mix and product disclosure.

Not showing the EEG share would involve a trade-off between the possible impact on the acceptance of the energy transition and the boost to the consumer information function. In the justification of the law to adapt the electricity disclosure rules to the abolition of the EEG levy, one of the reasons mentioned for showing the EEG share in the product mix is that the significance and effectiveness of the EEG support must be visible to the consumers. It should also be noted that the EEG electricity share achieved by 2021 was made possible financially by the EEG levy payers. With the abolition of the levy, consumers continue to contribute to the RE expansion as taxpayers, even though their claim to be allocated the corresponding RE attributes becomes weaker. However, the claim to RE attributes in return for levy or tax payments can also be examined critically. **The 2000 draft of the EEG justified the levy with the polluter-pays principle**: electricity suppliers (and, through cost shifting, consumers who purchase electricity from public grids) were to be held **responsible for the ecological costs of conventional electricity generation** through price regulation (BT-Drucksache 14/2776, p. 20).[25] The electricity consumers were in turn to

[25] BT-Drucksache 14/2776, v. 23.2.2000. Resolution recommendation and report of the Committee on Economics and Technology (9th Committee) on the bill of the parliamentary groups SPD and BÜNDNIS 90/DIE GRÜNEN - Drucksache 14/2341 - Entwurf eines Gesetzes zur Förderung der Stromerzeugung aus erneuerbaren Energien (Erneuerbare-Energien-Gesetz - EEG) sowie zur Änderung des Mineralölsteuergesetzes.

benefit from the cost degression in RE generation technologies and from avoided climate change damage.

The possibility to actively purchase more green electricity from domestic plants could also increase the acceptance of the energy transition. The desire to contribute to the energy transition at home is an important motivation for green power consumers (Schudak and Wallbott 2019). Given the low level of GO issuance from German RE plants, this desire can currently hardly be met. A relevant change could result from another adjustment to the electricity disclosure rules that was also introduced with the Easter Package: For the share of (unsubsidised) RE with GOs, **the country of origin of the renewable power must in the future be indicated as part of electricity disclosure**. On the one hand, this could increase the demand for GOs from unsubsidised plants in Germany – however, given the current and continuing shortage of such electricity in the coming years (see Fig. 5), green power products based on such electricity could become a high-price premium product. By contrast, buying GOs from subsidised domestic plants could be an attractive option, especially for private customers.

It should be noted that, **with rising CO_2 prices and costs of fossil fuels, a green electricity product does not need to be more expensive than a conventional product**. As "grey electricity", electricity bought from the power exchange is featureless and not price-differentiated in terms of origin – the marginal power plant whose bid is the last to be used to meet demand sets the price. However, among other factors, the suppliers' price structure also depends on their own generation capacity and the conclusion of utility PPAs (electricity supply contracts between electricity producers and electricity suppliers) (for an overview of various electricity procurement options, see Lenz et al. 2019). PPAs can also be concluded with EEG plants in subsidised direct marketing – issuing GOs for these plants would also enable the transfer of green power properties to contract partners. **A focus on GOs for showing RE shares in product disclosure could strengthen the transparency of supplier competition**, as both the price and the characteristics of the delivery of electricity would be directly influenced by the energy suppliers' procurement choices.

With **increasing RE shares in the overall energy generation mix in Germany,** a focus on GOs to show RE shares in electricity disclosure could also strengthen the **quality competition among electricity suppliers**: Electricity disclosure could provide information not only on the GOs' country of origin but also on subsidy status of the power plants, the type of renewable energy source or RE technology, or aggregate information on plant age (as quality factors that already influence pricing today, see Güldenberg et al. 2019). Other differentiating features could be regionality or increased temporal matching (e.g. monthly or hourly) (cf. 4.1). **Even with a targeted RE share of 80% of gross electricity consumption in 2030, GOs could thus support consumer choice in electricity purchasing decisions**. With an increasing share of renewable energy in the generation mix, the characteristics of fossil energy generation are also of growing interest: Here, full disclosure models with GO issuance and cancellation could also improve transparency for non-renewable energy sources (e.g. RECS 2020). The possibility of using residual energy mix properties for the disclosure of non-tracked commercial offers would then be eliminated.

To honour the consumers' contribution to financing the RE growth, alternatives to the designation of EEG shares could be tested. In Spain, for example, if GOs from subsidised plants are exported, the electricity producer must forego the subsidy.[26] This ensures that the green properties of subsidised power remain available for domestic electricity disclosure ("national GOs" are not considered EECS GOs, see AIB 2022c). Another approach to be examined in more detail would be the French model, in which municipalities can use auctioned GOs from subsidised plants located within their territory partially or even entirely free of charge (see 4.2.2). It would be interesting to assess whether this raises the regional acceptance of RE development. In disclosing renewable power characteristics, a differentiation between new and existing plants could also be examined: For existing plants financed by the EEG levy, the EEG share could continue to be reported. This share will decline as more and more plants drop out of the subsidy. That way, a larger share of the displayed renewable power would reflect procurement decisions. One advantage of issuing GOs only for supported new plants is that a potential supply shock on GO markets caused by GO issuance for supported RE generation from existing EEG plants would be avoided. However, the price effects of GO issuance for supported existing plants could also be controlled by the design of such a step (e.g. minimum prices in auctions or the amount of support reductions in the case of optional GO issuance). Moreover, combining information on EEG shares, the share of GOs from supported new plants and the share of GOs from unsupported plants in disclosure statements would increase the complexity of the information provided.

4.3 Further development options for the design of the GO registry

In this section, the focus is less on what the GO system can do but rather on the operational design of the organisation and administration of GOs, the registry and GO transactions. In particular, the scope for digitisation of the GO system and the integration of new actors will be addressed.

4.3.1 Digitisation and automation in the context of electricity GO verification

As described in chapter 2, in Germany the administration of GOs and their transactions (issuance, cancellation, etc.) is organised via a central official registry, the HKNR. With the rapid development of information technology, the energy sector, too, is discussing digital

[26] Article 11.2 of Decision ITC/1522/2007 of 24 May 2007, Last update published on 22.05.2015: Orden ITC/1522/2007, por la que se establece la regulación de la garantía del origen de la electricidad procedente de fuentes de energía renovables y de cogeneración de alta eficiencia. https://www.boe.es/eli/es/o/2007/05/24/itc1522/con.

solutions that could replace or supplement existing structures. Among the issues under discussion are more decentralised approaches to organising RE certificates that allow for the involvement of smaller actors, higher granularity and simultaneity. A potentially promising solution in this context is distributed ledger technology, better known as blockchain (BC) technology, where all transactions take place directly between the participants (i.e. peer-to-peer), eliminating the need for a central registry or a superordinate control authority.[27] The question is, however, whether this would be possible from a technical and regulatory point of view in the electricity sector.

Table 5: Different types and proof concepts of Blockchain

Types	
Permissionless	Access to the BC is open to all
Permissioned - public	Editing access is restricted; viewing the BC is unrestricted
Permissioned - private	Access for editing and viewing is controlled
Proof concepts	
Proof of Work	Consensus mechanism: solving a mathematical/cryptographic problem with high computational effort
Proof of Stake	Consensus mechanism, especially in the case of public, freely accessible BC: random selection with varying stakes, depending e.g. on the length of participation.
Proof of Authority	Consensus mechanism, especially in the case of private BCs with restricted access: prior allocation of the validation right
Zero-Knowledge-Proofs	The BC does not contain the underlying data but only its properties. Certain facts can be verified via the BC without disclosing the actual data (e.g. confirming whether someone is underage without disclosing their date of birth).
Smart Contracts	Automated, decentralised and redundant execution of transactions using a BC

Source: Hamburg Institut, based on Andoni et al. 2019, Bogensperger et al. 2021, Strüker et al. 2021a, Wüst and Gervais 2017.

Technically, BCs are spreadsheets (ledgers) that are kept, replicated and synchronised on different nodes (computers). The BC consists of several blocks that are connected to each

[27] An overview of operational design options for verification systems, especially with regard to international transfers, can be found in Chapter 4 of GO4I Fundamentals Report 4, Sakhel and Styles 2021.

other via unique cryptographic hashes (chains). Each block stores a list of transactions. The BC is stored locally with all participants, which means that it can be verified by any number of parties. This redundancy makes the BC immutable (e.g. Wüst and Gervais 2017). There are various BC systems that differ in the way they deal with participant access and proof procedures (see Table 5).

BC technology works without a superordinate, central control instance, as it is highly resistant to manipulation due to the immutability and reliable (redundant) storage of data on multiple servers. Third parties can easily verify all transactions as all blocks can be viewed by all participants (Andoni et al. 2019, Bogensperger et al. 2021, Strüker et al. 2021a, Wüst and Gervais 2017, Zeiselmair et al. 2018). It also simplifies the automated execution of transactions, which reduces the associated risks and complexity (Strüker et al. 2021a, Andoni et al. 2019). The technology is therefore well suited to transactions between non-trusting parties (Wüst and Gervais 2017, Andoni et al. 2019). However, BC technology also has some disadvantages: for example, personal data cannot be deleted (Bogensperger et al. 2021, Andoni et al. 2019) and it is difficult to correct incorrect entries or transactions (Moody et al. 2020, Van Evercooren 2019). Also, especially in the case of BCs with unrestricted access and many participants, the redundant storage of blocks/transactions causes a high storage and energy overhead (Bogensperger et al. 2021, Andoni et al. 2019, Moody et al. 2020). Applications that require government control usually cannot be organised via a BC per se (Moody et al. 2020, RECS 2019, Van Evercooren 2019). In sum, the application of BC technology is often not necessary or too burdensome; existing solutions will in many cases achieve the same aim at less effort (Wüst and Gervais 2017, Bogensperger et al. 2021, Moody et al. 2020, Van Evercooren 2019). This is especially true if a control authority can or must always be online and/or all participants trust each other. Centralised solutions are preferable in many cases, as they allow for more simultaneous transactions (Wüst and Gervais 2017). BCs generally have lower efficiency due to the high (computing) effort (e.g. due to redundant storage) (Strüker et al. 2021a), which is why, for example, processing of microtransactions via the BC is not worthwhile (Bogensperger et al. 2021).

These characteristics of BC technology also have implications for its applicability in the GO context. **In the current legal framework, the HKNR cannot be substituted by BC technology, as a higher-level control authority is required** (Moody et al. 2020) **and BC technology cannot ensure the avoidance of double marketing of the renewable energy property** (Bogensperger et al. 2021, Van Evercooren 2019). In addition, the technical implementation would be very costly (Moody et al. 2020), plenty of energy would be required to maintain the system (Andoni et al. 2019, Bogensperger et al. 2021, Moody et al. 2020) and the efficiency or speed of transactions would not necessarily be improved (Bogensperger et al. 2021, Strüker et al. 2021a Wüst and Gervais 2017).

Nevertheless, the **increasing digitisation and process automation through innovative information technologies** (potentially including BC) can also benefit the HKNR system. For example, communication between the HKNR and other data platforms could be established or improved and automated to better exploit synergies. For example, (automated) data reconciliation with the Market Master Data Registry[28] could take place in order to facilitate the feeding of data into the HKNR (e.g. if GOs are also issued for subsidised plants) and to constantly confirm that the plants are still operating. Then the (manual) entry of (possibly deviating) data and their confirmation by the grid operators could be dispensed with. As soon as further registries for heating/cooling, gas and possibly buildings are added, this sort of automation would create even more synergies. In non-automated processes, data processing for a biogas CHP unit, for example, would be very complex, since biogas is partly processed into biomethane and fed into the natural gas grid and partly converted into electricity in CHP plants. In this case, various registries would have to be reconciled with each other: the master data registry and a GO registry each for electricity, heating/cooling and gas. In addition, BC technology in particular may facilitate the tracking of specific energy attributes, e.g. granularity and real time (RECS 2019), which serve as proof in connection with GOs (see section 454.4).

BC and other technologies, possibly in combination with each other, could also drive the decarbonisation of the energy industry in other areas. Such technologies could, for example, support greater decentralisation, i.e. **greater integration of small producers and prosumers** (e.g. small solar plants with storage) into the system (Kett and Strauß 2019, Moody et al. 2020, Van Evercooren 2019), and thus support the short-term balancing of electricity supply and demand, relieve the burden on the transmission grids and ultimately reduce costs. An example of this is the BC-based crowd balancing platform "Equigy"[29], a collaboration between European transmission system operators TenneT, Swissgrid, Terna, and APG. The platform enables European prosumers to provide flexible capacities of their electric vehicles, heat pumps or home battery storage via aggregators for system services. A similar example concerns the switch of a generation plant from power consumption to the provision of system services or to participation in electricity trading, which is still very time-consuming as some of the processes involved are still carried out on paper (Strüker et al. 2021b). In order to digitise and automate such processes, digital proof of identity is needed at the device or machine level. In a decentrally organised system, these are known as self-sovereign identities (SSIs) (Strüker et al. 2021c). The Blockchain Machine Identity Ledger project is testing the use of SSIs to digitally establish a chain of trust, for example between a PV system, a smart meter and the market master data registry. That way, devices can automatically switch between consuming power and providing system services (Strüker et al. 2021b).

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[28] The Market Master Data Registry is a registry operated by the Federal Network Agency for master data (e.g. contact information, technical plant data, company form, etc.) of the electricity and gas market. See https://www.bundesnetzagentur.de/DE/Fachthemen/ElektrizitaetundGas/Monitoringberichte/Marktstammdatenregister/MaStR_node.html.

[29] https://equigy.com/about

In sum, emerging solutions such as BC technology could support the decarbonisation of the energy system and could become valuable to the GO system (e.g. for data reconciliation and real-time verification). However, they cannot yet replace the existing central GO verification registries from a regulatory and technical point of view.

4.3.2 Access to the GO registry for new actors

In Germany, only electricity suppliers may cancel GOs for electricity disclosure in order to show the share of "renewable energy with guarantees of origin that is not financed from the EEG levy" in their electricity delivery to consumers. A corresponding definition of the purpose of GOs and cancellation rights results from regulations of the EEG and the Ordinance on the Implementation of Guarantees of Origin and Regional Guarantees of Origin (HkRNDV) in conjunction with the Energy Industry Act (EnWG) (see Styles et al. 2021b). However, the set of actors who can cancel GOs and keep GO accounts at GO registries is not uniformly regulated throughout the EU, and is handled differently by various member states of the AIB and EECS system (cf. AIB 2022a). The obligation to use GOs for electricity disclosure in Article 19 (8) RED II is directed at electricity suppliers, but the cancellation of GOs by other actors (e.g. to voluntarily disclose the characteristics of their own electricity consumption) is at least not explicitly excluded.

In particular, industrial companies and other large consumers of electricity sometimes express interest in also being allowed to cancel GOs in the HKNR (e.g. BDEW 2021c). The envisaged use cases are complex and were discussed during a workshop held by the German Environment Agency (2022b) and in a GO4Industry project workshop with industry representatives. For industrial companies, **buying GOs to reduce their emissions according to the market-based approach of the Greenhouse Gas Protocol** is a particularly relevant use case (see 3.3). At present, the corresponding GOs must be cancelled by electricity suppliers, who may provide their customers with detailed proof of cancellation. An evaluation of the advantages and disadvantages of companies cancelling GOs for themselves, rather than having the GOs cancelled for them by their electricity suppliers requires more detailed, empirical investigations. At this point, therefore, only a conceptual classification is made.

In the context of **corporate sustainability reporting**, the following three GO cancellation paths are emerging. Each would imply some degree of change to the current GO system in Germany:

- Cancellation of GOs for the companies' own electricity consumption covered by electricity purchases (Scope 2 accounting): currently, GO cancellation is only possible through electricity suppliers.
- Cancellation of GOs for third-party electricity consumption (e.g. to reduce electricity-related emissions along the supply chain in Scope 3 accounting): not possible at present.

- GO issuance and cancellation for renewable power that the companies produce and consume themselves (Scope 1 accounting), as proof to stakeholders: currently not possible.

Further specific use cases are the **cancelling of GOs for the energy losses of grid operators** (see e.g. 50Hertz et al. 2021; Styles et al. 2021b) or **GO cancellation by the operators of storage facilities or energy conversion plants** (e.g. power-to-gas, power-to-heat). In the case of storage, GO cancellation could become relevant especially in connection with time stamps on GOs (see 4.4.1): Through GO cancellation for stored electricity and GO issuance for withdrawn electricity (with a new time stamp), the fact that storage enables a temporal shift in the supply of power could be rendered more visible and possibly more valuable (EnergyTag 2022a). In the case of conversion plants, a relevant use case could be that the operators specifically want to procure GOs of a certain quality on the market or through PPAs, and that quality could then be "inherited" by the generated energy (e.g. hydrogen, heating/cooling) and corresponding verification (cf. Verwimp et al. 2020, p. 35 ff.).

PPAs can be an example for a relevant use case for the cancellation of GOs for a company's own electricity consumption (for Scope 2 accounting). In the case of utility PPAs between generators and electricity suppliers, the latter can cancel GOs and, if desired, provide their customers with proof of cancellation. In the case of corporate PPAs, however, only companies that have founded their own legally independent energy supplier can currently cancel GOs. Otherwise, contracts with energy suppliers are necessary for the cancellation of GOs from PPAs, or producers need to cancel GOs as energy suppliers. GO cancellation by companies themselves could simplify the handling of such PPAs.

GO cancellation for third-party electricity consumption (Scope 3 accounting) would have to be examined in more detail. Notably, such a practice would break the existing close link between GO cancellation and the supply of electricity. Particularly in the case of GO cancellation for upstream suppliers, the risk would increase that several GOs are cancelled for the same electricity consumption and different actors report different properties. This would increase the complexity of electricity disclosure and could reduce the transparency of statements on the ecological quality of the purchased or supplied electricity.

Finally, another aspect of giving companies access to the HKNR is the possibility to **issue GOs for self-produced electricity**. This would correspond to demands of some energy-intensive market participants that claiming the green electricity property of the renewable power produced by their own plants could be facilitated in this manner (for Scope 1 accounting). In Germany, no GOs have been issued so far for electricity used for self-supply, whereas this is common practice in some other EU countries (e.g. in Sweden). Issuing self-supply GOs would have the advantage that the renewable property of the electricity generated for self-consumption by plants that are connected to the public grid (and can therefore also feed into the grid) cannot be claimed multiple times, e.g. by the operator of the installation itself and by another party to whom GOs for exactly this amount of electricity could be sold. **Self-supply GOs would clearly indicate that the self-consumer is claiming the green electricity status** and prevent resale, which would also enable self-consumers to make a firm statement about the green electricity they produced. However, when issuing self-consumption certificates, some rules should be adopted to avoid double marketing or claiming of the green electricity property. Van Stein Callenfels et al. (2020) suggest adding an identifier to the GOs that indicates the dissemination level of the physical energy for which the GO was issued (e.g. on-site consumption or grid feed-in). The authors also suggest that GOs issued for energy that is not available for open trading could, for example, be cancelled immediately after issuance to prevent their marketing. Furthermore, suitable disclosure rules should stipulate that self-supply GOs can only be used to label the company's own consumption.

Having listed these conceivable use cases of GOs for Scope 1, 2 or 3 accounting of emissions from energy consumption, it should be noted that the **use of GOs to offset greenhouse gas emissions is not permitted.** The reason is that double counting of emission reductions must be prevented according to Article 6.2 of the Paris Agreement. Emission reductions from renewable energy projects in the EU are already taken into account in the member states' national GHG reporting, so using GOs for offset purposes would lead to double counting. For the same reason, German or European projects whose emission reduction contributions are counted towards European or national climate protection targets cannot participate in the voluntary carbon market for emission credits (DEHSt 2021).[30]

4.4 Possible extensions of the energy attributes displayed on GOs

This section presents potential extensions of the electricity GO system that enable the transmission of additional information or energy attributes via GOs. These considerations at times go beyond the system's current scope.

4.4.1 Granular real-time evidence

Green electricity is more likely to be a credible product for consumers it can be proven that the **RE plant from which the electricity is purchased has indeed produced and fed in electricity during the time of consumption, ideally the same amount that is being consumed**. Through the temporal correlation of production and consumption, i.e. by coupling the time interval of consumption with the time interval of green electricity production, it can thus be shown, albeit abstractly, that renewable power was purchased in a period when such power was actually produced, rather than in a situation where it was physically impossible to produce the energy (e.g. during a 'Dunkelflaute' or 'dark lull'). Proving such a correlation and

[30] Article 6.4 of the Paris Agreement could allow for the issuance of authorised emission credits that go hand in hand with an adjustment of national GHG emission balances. However, no mechanisms of that sort have been envisaged for Germany or the EU yet (DEHSt 2021).

the necessary integration of smaller RE plants into this methodology furthermore require measuring the renewable energy in smaller units than the current GO unit of 1 MWh, so that real-time proof also becomes possible for time intervals shorter than one hour and for smaller generation quantities.

Besides meeting potential future legal requirements (e.g. regulation on hydrogen production according to Article 27 (3) of RED II), some stakeholders have been calling for granular real-time certificates due to other advantages or energy transition benefits (e.g. European Parliament 2022a,b). For example, it has been emphasised that proof of a temporal alignment of renewable power generation and consumption not only **increases consumer trust** but also serves to **relieve the grid infrastructure,** as power is taken from the grid when it is actually fed in. Aligning feed-in and (flexible) consumption serves to reduce grid congestion and/or the curtailment of RE plants (EnergyTag 2021). Higher granularity also enables the **inclusion of smaller RE plants, and thus more renewable power, in the verification methodology** (Strüker et al. 2021b, RECS 2019). Another advantage of granular real-time electricity certificates is the possibility to **improve emission calculations** (EnergyTag 2021). For example, in an industrial context, such certificates could be used to calculate electricity-induced emissions more accurately at a specific point in time, compared to when using the location-based approach (see chapter 3.3). The calculation would no longer have to rely on average (annual) national (or at best regional) RE shares in the electricity mix or complicated calculation procedures (e.g. based on grid operator data). In the market-based approach, more accurate calculations would be possible with real-time verification, as this allows market-based Scope 2 emissions to be calculated on an hourly basis (or even more granularly, if necessary), rather than only on a monthly or annual basis (EnergyTag 2021). Real-time certificates also provide a more accurate basis for calculating emissions beyond electricity, such as product carbon footprints (see Sakhel et al. 2022, GO4I industry report).

Granular real-time certificates could also **incentivise investment in certain technologies and flexible capacities** (EnergyTag 2021). The hourly procurement of energy attribute certificates could encourage consumers and energy suppliers to consider which RE technologies are best suited to meet their needs. The resulting demand for certain types of certificates (e.g. solar, wind, etc.) could in turn lead to greater geographical and technological diversity of generation technologies or counteract a technology shortage or surplus. Also, the existing verification systems currently do not provide an incentive to adjust renewable power consumption to generation or vice versa, as the certificate price applies to the entire period (year or month). The switch to shorter verification periods could increase incentives to provide flexibility, such as flexible demand or storage capacity.

In the absence of official, legally compliant, granular real-time certificates, **various initiatives and pilot projects** have been formed, not least because of the great interest of certain actors, especially industry. One of the most prominent initiatives in this context is EnergyTag. Devoted to real-time verification, it is led by a group of industry representatives and nongovernmental organisations (EnergyTag 2022a,b). The initiative was founded in 2020 with the aim of creating a framework for at least hourly certificates that fits into existing verification systems, rather than defining a new independent standard. Since then, various papers have been published that define use cases and standards for granular real-time certificates (see https://energytag.org/publications). But there has also been increasing momentum in the emergence of individual pilot projects and service providers over the last 5 years. Google, for example, has been working since 2017 on an hour-by-hour reconciliation of green power generation and consumption, mainly through the purchase of wind and solar power (Google 2020). In cooperation with Microsoft, Vattenfall has developed a solution to enable customers to reconcile green electricity consumption and generation on an hourly basis (Vattenfall 2020). In Germany, Statkraft has been supplying Daimler Mercedes Benz with 100 per cent green power on an industrial scale around the clock via a so-called "24/7 PPA" (Statkraft 2021). The service provider FlexiDAO offers a platform on which users can compare the previous annual to the previous hourly renewable power share to present the deviation of these two calculation methods. Also they can generate an hourly proof of green electricity production and the corresponding time-based comparison with electricity consumption (FlexiDAO 2021).[31] In this way, FlexiDAO supplies 100% renewable electricity to a data centre in the Netherlands, which has concluded a PPA with a wind farm for this purpose. Along with several other providers,[32] Flexidao uses blockchain technology to verify hourly production and consumption. While many actors regard blockchain as a technical solution for the operational implementation of such verification, EnergyTag (2022b) proposes the development of an API (Application Programming Interface) standard (see also 4.3.1).

Disadvantages of the establishment or integration of a granular real-time system relate in particular to the necessary **technical and administrative development effort**. In addition, the real-time certificates may be scarce due to time and space constraints. Thus, hourly procurement could lead to higher overall certificate prices if consumers aim for a high or full share of hourly reconciliation and the price is ultimately determined by the cost of additional generation in hours when certificates are scarce (EnergyTag 2021, PV Magazine 2021).

4.4.2 Geographical correlation

The draft delegated act (Article 27(3) RED II) for the first time formulates **legal requirements regarding the geographical correlation of electricity production and consumption**. Such geographical correlation serves to reproduce physically more likely or at least possible energy flows (within an interconnected grid but excluding unconnected grids, such as isolated island grids). On the one hand, this can help to take into account local conditions and grid constraints, for example when energy users concentrate their procurement in that part of the

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[31] For a summarised explanation of this product, see https://www.youtube.com/watch?v=h3hlsAQcTJE.

[32] e.g. https://www.powerledger.io, https://www.greentechmedia.com/articles/read/iberdrola-uses-blockchain-to-authenticate-green-energy#gs.LFRE8Vr8

grid where they operate (EnergyTag 2022a). In addition, the proximity between consumption and production can strengthen user trust in the "authenticity" of green electricity. The definition of an appropriate boundary of geographical correlation depends on consumer preferences or the legal framework. In principle, however, boundaries can be defined purely geographically (local, regional, national) or on the basis of the electricity market (bidding zones).[33]

GOs already contain information on the geographical location of a power plant. To verify the required correlation, a reconciliation between the locations of production and consumption must also be set up. At the regional level, such a comparison already takes place in Germany when **regional certificates** are used. Regional certificates are only issued for electricity that is eligible for the EEG market premium (§ 18 HkRNDV). Regional electricity products backed by regional certificates enable consumers to purchase electricity from regional RE plants financed by the EEG levy, which is intended, among other things, to strengthen the acceptance of regional RE growth (Mundt et al. 2021). However, the renewable property of EEG-subsidised electricity will continue to be shown as an EEG share in power disclosure (see 4.2). The marketing of regional green electricity products therefore requires cancelling both GOs and regional certificates in order to show the renewable energy properties of the entire electricity supply.

For regional certificates, a region is defined by a radius of 50km around the place of consumption (as a municipality or postcode area) (Umweltbundesamt 2022b). The regional certificates issued for a plant contain information on the area in which that power may be used as regional electricity (§ 19 HkRNDV).

If GOs are also issued for subsidised plants (see 4.2), they could optionally also contain information on regional verification. This would enable the marketing of electricity from both subsidised and unsubsidised plants as regional green electricity and could reinforce the value of the GOs and the acceptance-promoting effect of green power products that combine regional and renewable properties.

To support the verification of green hydrogen (see 3.2, Table 2), GOs could also be supplemented with **information on the price bidding zone** in which a plant has fed the electricity into the grid (cf. European Parliament 2022b, pp. 42-46). Germany currently has only one bidding zone, so this information corresponds to the country of origin, but to prove that GOs originate from neighbouring price bidding zones, such information could nevertheless also be relevant for Germany.

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[33] According to the draft delegated act of Article 27(3) REDII, a geographical correlation exists not only if electricity production and consumption can be shown to be close to each other (in the same, adjacent or contiguous offshore bidding zone(s)), but also if production and consumption take place before a grid congestion (i.e. if due to the consumption, a RE plant needs not be curtailed, so there is less grid congestion and less need for redispatch).

4.4.3 GHG footprint

In principle, it is both possible and of interest to add a data field to GOs that indicates the **carbon or GHG footprint of the certified unit of energy.** However, calculating the footprint can be problematic. For example, there are very different views on the calculation of life-cycle emissions from the construction and decommissioning of power plants (Van Stein Callenfels et al. 2020, Verwimp et al. 2020). Accordingly, authors of FaStGO[34] documents recommend a voluntary GHG footprint field on the GOs, with the associated calculation methodology also being indicated. This approach would accommodate the use of alternative methodologies developed by legislators or other parties. A statutory methodology could be introduced at a later stage. For comparability, it would be advisable to define a uniform methodology (including default values to be used if no specific footprint is calculated). Any data provided in a voluntary field would also have to be verified by some suitable mechanism, e.g. through independent experts.

4.5 Dealing with non-issued GOs

The **curtailment of renewable power feed-in by grid operators in the course of redispatch measures** gives rise to certain obligations under the Energy Industry Act. GOs are affected by redispatch measures in that they are not issued if no energy is generated due to interventions for grid stability purposes. In the following, we briefly present the relevant legal regulations on redispatch and, taking into account the basic European legal requirements for GOs and PPA contract practice, those framework conditions that must be observed when **dealing with GOs in connection with redispatch measures.**

Pursuant to Section 13a (1) EnWG, operators of plants for the generation or storage of electric energy with a capacity of 100 kilowatts or more must adjust the plant's power generation or absorption or tolerate an adjustment at the request of a transmission system operator. Such interventions are called redispatch measures. They serve to prevent bottlenecks in the electricity grid and to protect line sections from overload. Section 13a (1a) and (2) EnWG regulates the **balancing and financial consequences of redispatch measures** and stipulates compensation. Pursuant to section 13a (2), compensation for redispatch measures is deemed appropriate if it puts plant operators in the same economic position as they would have been in without the measure.

However, **as yet there is no methodology for the compensation of GOs that are not issued due to redispatch measures** (cf. BDEW 2021d, BDEW 2020, 4.3). Any such methodology must take into account that GOs are only issued for energy that is actually

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[34] Facilitating Standards for Guarantees of Origin: This project provided 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."

produced (cf. article 19 para. 2 of Directive 2018/2001 EC, section 79 para. 1 no. 1, section 12 para. 1 HkRNDV). **This means that there can be no "registry solution", according to which GOs would be issued as compensation for plant curtailment due to redispatch**.

By contrast, a solution by way of in rem restitution would be conceivable in principle: The transmission system operator could buy GOs in the amount of the curtailed energy production on the market and give them to the plant operator as compensation for the redispatch measure. **However, Section 13a (2) EnWG provides only for financial compensation for non-issued GOs, but not compensation in kind**, in that Section 13a (2) sentence 3 no. 5 EnWG lists lost revenue as a component of appropriate financial compensation. Non-issued GOs qualify as lost revenue, being immediately caused by the redispatch measure. The amount of compensation is calculated as revenue lost during the redispatch measure plus any additional expenses minus any expenses saved (BDEW 2020).

The amount of lost revenue from non-issued GOs as a result of a redispatch measure will differ in each individual case, depending on individual agreements by which the plant operators market the GOs from their plants. These agreements also determine whether the redispatch measure causes the plant operator any additional expenses.[35] Depending on the individual arrangement, the plant operator may be obliged to procure replacement GOs or to provide financial compensation, or – if redispatch measures are considered cases of force majeure – he may be free of any such obligations.

In principle, compensation for non-issued GOs could follow the model of the compensation for lost revenue from cogenerated heat supply, which applies in comparable circumstances (BDEW 2020). In both cases, the redispatch measure potentially entails a second component of lost revenue: lost revenue from heat sales if a cogeneration plant is curtailed vs lost revenue from GO sales if a renewable power plant is curtailed. The exact amount of the loss in revenue depends on the individual contracts for heat and GO delivery, respectively.

Compensation for the non-issuance of GOs due to redispatch measures in particular concerns plant operators who sell electricity and GOs through PPAs ('other direct marketing'). Since the EU Commission attaches increasing importance to PPAs for RE expansion, the question of how to deal with the consequences of redispatch measures can be expected to also grow in importance. In this respect, a regulation that is as coherent and manageable as possible would be desirable.

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[35] The model contract of the European Federation of Energy Traders (https://data.efet-d.org//Files/Rahmenvertrage%20-%20Strom/210317%20EFET%20PPA%20Deutsch.pdf) provides an example of the various options regarding the obligations with regard to GO delivery in a PPA.

5. Conclusion: Promoting GOs as a versatile verification instrument for renewable electricity

In sum, this report recommends **recognising GOs as a system that efficiently verifies the renewable nature of electricity and, thanks to its monopoly position in the EU, is able to prevent multiple marketing of green electricity**. This monopoly position is not least due to a lack of reliable and abuse-proof alternatives. Technological approaches such as blockchain could potentially facilitate the international transmission of green energy properties, but even from a purely legal point of view, they cannot replace a comprehensive cross-border system (e.g. in the form of one or more connected central registry/registries).

The common association of electricity GOs with greenwashing, fraud and relabelling only hampers the debate on renewable electricity, being a binary view that does not do justice to the functional capabilities of GOs. GOs as such are neither "good" nor "bad". Their merits depend on the specific use case at hand, rather than on the system itself. Accordingly, the credibility and ability of GOs to support the energy transition rather depends on the **quality of GOs used in a specific situation (e.g. new or old plant, regional/national or international) and the applicable regulation** (requirements on GOs to fulfil a specific purpose). Suitable regulation can increase the often (and rightly) criticised marginal benefit of GOs for the energy transition.

The counter-narratives to greenwashing – "direct delivery from the generation plant" via a PPA[36] or "coupling"[37], e.g. through the balancing group system – are not necessarily more convincing. At worst, they even compromise the ban on multiple marketing. It should therefore be clear to all users that in a system that still contains a proportion of fossil electricity, any type of renewable electricity purchase (except for direct purchase from a RE plant that is not connected to the public grid) automatically entails buying grey electricity. As a result, any modification of the electricity GO system, which aims to increase the pursuit of green power, remains an abstraction and would not enable a "pure" green electricity supply. **Thus, the credibility debate should not revolve around the question of whether GOs are the right instrument, but rather around the question of which GO qualities are available, which purposes GOs serve in each case and what effect the use of a certain GO quality for a certain purpose actually has on the energy transition.**

Assuming that GOs are the right instrument to guarantee the origin of power and to prevent the double marketing of its renewable property, **it makes sense to expand the functions of GOs to support their credibility and to pursue specific purposes in a more targeted**

[36] A RE plant operator who under a PPA sells the power but not the GOs can market the green power property elsewhere.

[37] Even fully renewable balancing groups cannot manage without indirectly balancing with electricity of unknown origin, which mars the "purity" of the green electricity thus delivered.

manner, first and foremost the acceleration of RE expansion. The following suggestions are made to strengthen the existing system or to expand its capabilities:

1) **GOs should be used to disclose every transfer of renewable power to prevent double marketing (this includes PPAs)**. For example, this could be provided for in a national implementation of the RFNBO criteria of the delegated act (Article 27(3) RED II) – in analogy to the requirements formulated by the 2021 version of the Renewable Energy Ordinance (EEV) for green hydrogen production to be exempt from the EEG levy.[38]

2) **Different GO qualities should be made more recognisable and accessible in order to increase transparency and awareness of the capabilities of GOs**. This would increase credibility for consumers and help to tap into the willingness to pay for certain qualities. It would also allow consumers to more specifically support technologies, locations, new plants, etc.

3) **To strengthen GOs as a neutral information tool, their issuance for subsidised plants is also recommended – with a clear distinction between subsidised and unsubsidised plants in electricity disclosure.** If renewable power were shown in electricity disclosure exclusively via GO cancellation and using the residual energy mix for non-tracked commercial offers, this could strengthen the consumer information function of GOs: Consumers could get a clearer picture of the extent to which electricity suppliers have actively procured green electricity properties for their products. **Even with increasing shares of renewable energy in the overall energy mix in Germany, GOs could thus serve to strengthen quality competition among electricity suppliers**. If the RE properties of supported existing plants, which were financed by the EEG levy in the past, are to continue to be allocated to electricity consumers as an average share, GO issuance for subsidised plants could focus on new plants with budget-financed support.

4) **The advancing digitisation in the energy sector could facilitate the decarbonisation of the energy system and support the GO system** (e.g. in data reconciliation and real-time verification, e.g. using blockchain technology). However, given the current legal framework, central GO registries cannot be replaced with decentral technologies. In addition, multiple marketing must continue to be prevented.

[38] Section 3b EEV; Renewable Energy Ordinance of 17 February 2015 (BGBl. I p. 146), version cited here: last amended by Article 87 G of 10.8.2021 I 3436; current version: last amended by Article 14 of the Act of 20 July 2022 (BGBl. I p. 1237).

5) **New GO features such as higher granularity and time stamps (and possibly GHG footprints if a consistent methodology can be devised) should be tested**. Reconciliation of electricity generation and consumption could serve to meet (potential) regulatory requirements, but also promote the credibility of the verification system, ease the strain on the electricity system and help to further decarbonise it. However, since the necessary information flows and in particular the reconciliation of generation and consumption information entail increased verification costs, an optional design would be advisable – these verification costs can be worthwhile for certain applications (e.g. verification for green hydrogen), but less so for others (e.g. electricity disclosure for households, where reconciling consumption profiles with feed-in profiles would create high transaction costs). Real-time verification could potentially also be carried out by third-party providers outside of the central HKNR (cf. EnergyTag 2022b), as long as it is ensured that corresponding GOs are cancelled.

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