GO4Industry

Fundamentals – Report G2

Purpose and Instrumental Scope of Guarantees of Origin

Status quo and prospects for further development

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About the project

GO4Industry

Much of industrial production will soon have to be climate-neutral. This requires an immense increase in the use of renewable energy at all stages of the production process. These efforts require proper emissions accounting along the supply chain, which in turn requires a reliable, cross-border verification system for renewable energy across diverse energy carriers: electricity, gases, heating/cooling. In the Renewable Energy Directive 2018/2001, the EU has instructed the member states to implement this system at the national level. In the "GO4Industry" project, funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the 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 interact across all sectors concerned. The project results are available at https://go4industry.com.

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List of abbreviations

AIB	Association of Issuing Bodies
BImSchG	Federal Immission Control Act (Bundes-Immissionsschutzgesetz)
BImSchV	Ordinance on the Implementation of the Federal Immission Control Act (Bundes-Immissionsschutzverordnung)
RE(S)	renewable energy (sources)
EECS	European Energy Certificate System
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EU	European Union
GHG	greenhouse gas(es)
GO(s)	guarantee(s) of origin
HKNR	German national GO registry (Herkunftsnachweisregister)
kWh	kilowatt hour(s)
MWh	megawatt hour(s)
PPA	power purchase agreement
RED I	Renewable Energy Directive I (2009/28/EC)
RED II	Renewable Energy Directive II (Renewable Energy Directive (EU) 2018/2001)
TWh	terawatt hour(s)
UBA	German Environment Agency (Umweltbundesamt)

1. Introduction: Purpose of guarantees of origin

In the electricity sector, guarantees of origin (GOs) have become a verification tool to **track the renewable nature of electricity and to allocate it to individual consumers**. Besides the increasing demand for green electricity as a market driver, the European Renewable Energy Directive plays a key role in the development of GO systems in the EU member states. The predecessor Directive 2001/77/EC on the promotion of electricity from renewable energy sources (RES) already provided for GOs as a verification instrument, which was further specified and strengthened by Art. 15 of the Renewable Energy Directive 2009/28/EC ("RED I").[1] To implement RED I, the member states had to ensure that producers of renewable electricity receive GOs for their produced energy upon request. In Germany, the GO registry (Herkunftsnachweisregister, HKNR) operated by the German Environment Agency (Umweltbundesamt, UBA) has been responsible for issuing, transferring and cancelling GOs for renewable electricity since 2013. GOs are not issued for renewable electricity from plants that receive support pursuant to the Renewable Energy Sources Act (EEG).

The substantially revised **Renewable Energy Directive (EU) 2018/2001 ("RED II") has significantly expanded the scope of GOs**.[2] While RED I provided for the issuance of GOs for electricity and optionally for heating or cooling from RES, Art. 19 RED II takes a much broader approach, requiring that member states must ensure that producers of renewable energy receive GOs on request. A distinction is made between **GOs for electricity, gas, including hydrogen, and heating or cooling**. This extension to different energy sources requires a further development of the GO systems in the EU member states. In this context, it is important to **clarify the role that GOs should play in the future in different energy sectors**, taking into account interactions with other verification systems for renewable energy characteristics (e.g. mass balancing for gases). However, the **established electricity GOs also face new demands** resulting from the growth of the green electricity market and structural changes in demand. For example, against the backdrop of sustainability and climate neutrality strategies, companies are increasingly driving the growing demand for GOs (AIB 2020, p. 10). Through long-term Power Purchase Agreements (PPAs), consumers secure not only the electricity but also its renewable quality by means of GOs.

An important aspect of the debate is the **question of which purposes GOs should serve**. Depending on the intended use, there are different expectations regarding the instrumental scope of GOs, some of which require further developments of the GO systems and in some cases other energy policy instruments. According to Art. 19 RED II, GOs serve the purpose of

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[1] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

[2] 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).

consumer information. A role in the European expansion target for RES is not envisaged, nor is any impact on the calculation of the share of energy from renewable sources in the individual member states (Art. 19(2) RED II). Nevertheless, GOs already play different roles in the energy policy instrument mix of the member states. For example, in the Netherlands, data collected for the issuance of GOs is also used for verification purposes in the context of national RES support (RES Legal 2019), while in Germany, GOs are only issued for renewable electricity that is not supported by the EEG (Maaß et al. 2019; Kahl and Kahles 2020). In most member states, revenues from the sale of GOs constitute a market-based remuneration component for financially supported RES plants (David and Feng 2019).

Since different instrumental roles necessitate different designs of GO systems, a clear delineation of the aims for which GOs are used is necessary. In particular, the following **roles of GOs** can be distinguished:

- consumer information
- enabling the trading of the renewable or "green" characteristics of energy
- market-driven support for the expansion of RES
- supporting the implementation of other energy policy instruments
- statistical or monitoring purposes

The various possible uses of GOs build on the basic requirements that **accurate, reliable and fraud-resistant verification of the origin of renewable energy** must be provided, and that it must not be possible to sell the renewable energy property of a unit of energy produced more than once (Art. 19(2) and (6) RED II). Also, the benefits of verification must exceed the cost. In addition, different purposes entail different requirements for the **instrumental scope and performance of GOs**. Table 1 summarises key requirements arising from different areas of application.

Table 1: Possible purposes of GOs

<table>
<tr><th>Status quo</th><th colspan="3">Potential additional purposes</th></tr>
<tr><th>Consumer information and enabling the trading of renewable attributes</th><th>Market-driven support for the expansion of RES</th><th>Supporting the implementation of other energy policy instruments</th><th>Statistical or monitoring purposes</th></tr>
<tr><td>Requirements:
Credibility
Qualitative differentiability for expressing consumer preferences (e.g. in terms of additionality, energy sources and technologies)
Needs-based and easily understandable energy disclosure</td><td>Requirements:
Effective incentives for RES expansion – GO price as additional remuneration
Additionality: promotion and acceleration of RES deployment beyond the legal support framework
Contribution to an efficient energy system transformation</td><td>Requirements:
Qualitative differentiability to meet regulatory requirements
If applicable, compatibility with further verification steps</td><td>Requirements:
Contribution to improved data availability
Tracking attributes from production to consumption as completely as possible (e.g. in the context of full disclosure)</td></tr>
<tr><td colspan="4">Overarching Requirements:
prevent multiple marketing of green attributes; accuracy, reliability, fraud-resistance;
benefits exceeding (transaction) costs</td></tr>
</table>

In the following, different **areas of application and further development perspectives for GOs** are presented. The starting points of the analysis are the GO system in Germany and its national and European legal framework. The use of GOs for consumer information and enabling the trading of renewable attributes corresponds to the status quo in Germany (Section 2), while uses beyond this require a further development of the role of GOs (Section 3). In this context, the instrumental scope and performance of GOs is discussed, complemented by examples of interactions with the instrument mix of the German energy transition. Finally, an outlook is given on the synergies and potential conflicts associated with a possible expansion of the scope of GOs (Section 4).

2. Status quo: GOs for consumer information and green attribute trading

According to Art. 19 RED II, GOs serve to prove to final customers the share or quantity of RES in the energy mix of suppliers and in energy products supplied (Art. 19(1) and (2) RED II).[3] In this context, GOs primarily fulfil two functions: For consumers, they provide **consumer information and protection** in connection with energy disclosure rules. At the same time, GOs enable RES producers to **trade the green quality of the energy**, even if energy from renewable versus non-renewable sources does not differ in purely physical terms. These two functions and their associated frameworks are presented in more detail below.

2.1 How GOs work

GOs record key properties of the energy unit produced, such as source, technology, plant age and plant location. The **cancellation of GOs enables the assignment of these attributes to a specific consumer's use of energy** (see Maaß et al. 2019, p. 4 ff.; Figure 1). For example, when electricity suppliers cancel GOs for the electricity consumption of their green electricity customers, the latter are assured that their consumption was covered by the generation of an equivalent amount of renewable electricity and that the **green property of each MWh fed into the grid was marketed only once**.

2.1.1 GOs and the book & claim principle

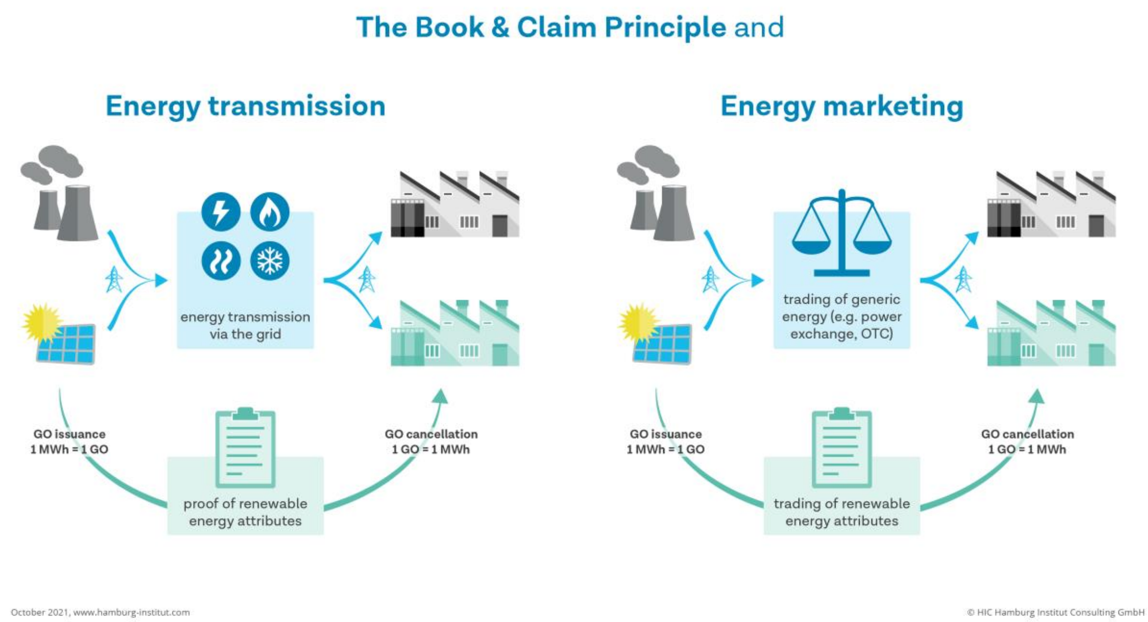
According to the book & claim principle, the transfer of GOs can in principle take place independently of the physical transmission of energy. This is particularly relevant in the case of grid-based supply, where the physical path taken by an energy unit with certain attributes in the grid cannot be traced, let alone controlled. GOs nevertheless allow customers to express their preference for RES by choosing a "green" energy product (see also GO4I Fundamentals Report 1, Bowe and Girbig 2021).

For RES plant operators, GOs are often a prerequisite for marketing the renewable quality of the energy. When electricity is marketed via traders or an exchange, the merit order results from marginal cost-based offers, where the costs of CO_2 emissions according to the European emissions trading system are taken into account. However, the exchange trading of electricity does not differentiate according to the qualitative characteristic of renewable versus non-renewable origin. GOs allow RES producers to sell and deliver the electricity and its green attributes independently, thus generating additional value for the renewable origin attribute, which can tip the scale in favour of renewable investments (see Figure 1). While the electricity and its attributes may be sold to the same buyer, this is not usually the case. The book & claim principle allows the marketing of electricity as generic electricity on the

[3] 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).

electricity exchange and the separate marketing of the green attributes via GOs. When GOs are cancelled for a specific amount of electricity, the volume and properties of the energy are merged again. This facilitates the initiation of transactions and the balancing of supply and demand on both sub-markets – for electricity volume and attributes – and thus increases the efficiency of the marketing processes.

Figure 1: GOs and the book & claim principle



The principles of the GO system that already apply in the electricity sector are transferred to the **new GO applications for heating/cooling and gases.** Thus, here too, energy consumers are assigned the renewable property of the energy unit by cancelling GOs. In principle, the RES property documented by the GO and the physical energy supply are traded independently of each other. However, **member states may define requirements for the use of GOs for disclosure purposes through cancellation and disclosure rules**. Examples are potential requirements regarding the existence of grid connections between producers and consumers for heating/cooling GOs or regarding the separate or joint treatment of hydrogen and other energy gases in the GO system (Verwimp et al. 2020).

When cancelling GOs, the **validity period of the certificates** must be considered. GOs can be used for the purpose of consumer information for twelve months from the end of the period in which the energy was generated (Art. 19(3) RED II). For annual electricity disclosure in Germany, showing the share of RES that was not financed by the EEG surcharge requires the cancellation of GOs whose electricity was generated in the same year that the electricity delivery took place (§ 30(4) HkRNDV; BDEW 2021, p. 44; for more details on electricity disclosure, see Section 2.2). Electricity disclosure statements are prepared for the previous calendar year. For example, in 2021, electricity suppliers can still cancel GOs that are to be used for the electricity disclosure year 2020, provided that the electricity for which a GO was issued was produced in 2020 and the GO is still valid. Under the RED II, GOs must be cancelled no later than 18 months after the end of the generation period (Art. 19(4) RED II). Prior to the implementation deadline of the RED II in mid-2021, a 12-month period applied (Art. 15(3) RED I). After expiry of the cancellation period, the GOs are marked as expired (see for example, § 34 HkRNDV).

2.1.2 GOs and the coupling of energy supply and renewable attribute supply

Besides the book & claim principle, there are several approaches aiming to demonstrate a **coupling of energy supply and green attribute supply**. "Coupling" refers to proving the **temporal and spatial connection** between energy production and consumption, of which different narrow and broad definitions exist. Generally, the following forms of coupling can be distinguished (see GO4I Fundamentals Report 3, Werner 2021):

- In the case of **physical coupling**, GOs are supplied along with an amount of energy transmitted by direct connection between the generation plant and the point of consumption.
- In the case of **balancing group coupling,** an energy flow must take place, or be simulated, from the balancing group of the RES plant for which 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 linked to the underlying energy.
- In the case of **contractual coupling**, the supplier agrees to deliver 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.
- According to physical standards, **temporal coupling of production and consumption** is only possible in the case of a direct line. In the public grid, it is possible to prove the correlation of the time and quantity of a production plants' grid feed-in and the feed-out at a corresponding consumption point or balancing group by means of meter or grid data (**virtual simultaneity**). In between, there can be hundreds of miles of transmission and distribution grid lines. The idea of working with **time stamps** on the GOs is gaining importance thanks to initiatives such as EnergyTag (2021).

The UBA's GO registry (HKNR) permits **optional coupling**, designed as balancing group coupling (§ 16 (3) HkRNDV).[4] However, this procedure only allows certain contract and

[4] Guarantees of Origin and Regional Guarantees Implementation Ordinance (Herkunfts- und Regionalnachweis-Durchführungsverordnung, HkRNDV) of 8 November 2018 (Federal Law Gazette I, p. 1853), last amended by Art. 4 of the Ordinance of 14 July 2021 (Federal Law Gazette I, p. 2860).

supply constellations, and market actors consider it quite costly (Güldenberg et al. 2019, p. 194; Umweltbundesamt 2021, p. 4 f.). In practice, therefore, it is de facto not applied, not even by those suppliers who consider "coupling" important. Instead, suppliers in the green electricity market sometimes implement contractual coupling, where the electricity and the associated GOs are purchased from the same supplier, regardless of how they are handled in the balancing group. This "symbolic" form of coupling entails the least effort. However, information on such a contractual link is not recorded on the GOs.

2.1.3 GOs and Power Purchase Agreements

GOs can also be transferred under **long-term contracts between RES producers and energy suppliers or consumers** in the form of Power Purchase Agreements (PPAs), especially in the electricity sector (see e.g. Hilpert 2018; Huneke et al. 2018; Section 3.1.2). PPAs come in a wide range of contractual forms. A distinction is made in particular between **physical PPAs** and **financial PPAs** (Hilpert 2018, p. 4 f.). Physical PPAs include **on-site PPAs**, in which generators supply electricity to customers via a direct connection. The generation plant is typically located on or near the consumer's property. By contrast, in physical **off-site PPAs**, generators feed a contractually defined volume of electricity into the public grid, from which the consumer draws the corresponding volume.[5] This requires the handling of electricity supply via balancing groups, which can be outsourced to service providers.

In the case of **financial (or virtual) PPAs**, the focus is on hedging the contracting parties against electricity price risks (Hilpert 2018, p. 5). In this case, no contract is concluded for the supply of electricity, but an individual electricity price is agreed between generators and consumers. Generators sell their electricity via electricity markets, while the consuming party purchases electricity from utilities or other suppliers. The financial PPA involves a contract for difference: The parties agree to make up the difference between the market price of the electricity sold and a contractually fixed reference price. If market prices are below the reference price, the generator receives a payment; in the reverse case, the consumer receives a payment which serves to offset the higher market price of electricity. Although financial PPAs do not involve the supply of electricity, they can be combined with a transfer of GOs. Financial PPAs are also used in particular in cross-border contracts between generators and customers located in different energy markets.

Depending on the contractual constellation, **PPAs can be combined with the above forms of coupling the supply of energy with the supply of energy attributes** – however, none

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[5] For example, off-site PPAs with supply via closed distribution grids are also possible. In the case of feed-in to the public grid, however, the established term "physical PPA" is misleading, as the contract does not specify electricity flows from the feed-in point to the exit point but rather the commercial supply of power, whose billing and quantity control is ensured via balancing groups (for information on balancing group management, see Agora Energiewende 2019, p. 22 ff.).

of the forms of coupling requires a PPA; other contractual arrangements are also possible (especially since PPAs constitute a collective term for various forms of civil law contracts, see Hilpert 2018, p. 1 ff.). In the case of an on-site PPA, there can be a physical coupling of GO transfer and energy delivery, while off-site PPAs can go along with either balancing group coupling (if transfers between the balancing groups of the feed-in and exit points are tracked accordingly) or contractual coupling. The proof of virtual simultaneity of production and consumption can in principle be combined with all forms of PPAs, including financial PPAs.

2.1.4 Industry applications for GOs and standardisation processes

Industrial clients can use GOs as a verification tool in their sustainability reporting (Mundt et al. 2019). Industry and commerce depend on reliable verification systems, and in particular on guarantees of origin, for climate reporting, which is becoming increasingly important. For example, following the internationally accepted guidelines of the Greenhouse Gas Protocol, GOs can be used to ensure a reliable and unambiguous allocation of emissions 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). The **GHG Protocol's market-based approach** complements the location-based approach, which uses the average emissions intensity of electricity for the public grid where a consumer is located. Using GOs, the market-based approach provides proof of the characteristics of the energy supplied so that consumers can make informed purchasing decisions in favour of climate-friendly energy products or suppliers.

In particular, international companies require GO systems for climate accounting that are standardised internationally, or at least across Europe. In this context, the **"European Energy Certificate System" (EECS)** is relevant for the European GO market as a **standardised set of rules for GO systems,** which is used by the member countries and regions of the Association of Issuing Bodies (AIB). Also, the current version of the **European standard CEN - EN 16325** builds on the experience of the EECS system for electricity. The standard is currently undergoing a comprehensive revision process in order to cover not only electricity but also the GO application areas of gases, incl. hydrogen, and heating/cooling (see FaStGO 2020). To support the harmonisation of the EU member states' GO systems, RED II Art. 19(6) requires the member states to comply with EN 16325.

Foreseeably, there will be an increased need for **globally coordinated GO system rules and climate accounting rules,** not only throughout Europe. This results from the increasing interest of legislators and market parties in making green product properties measurable and verifiable. In particular, an international standardisation of rules is required in order to determine the carbon footprint of products which are traded across borders, so embedded GHG emissions can be accounted for in the context of proposed Carbon Border Adjustment Mechanisms.

2.2 Energy disclosure framework

To ensure the reliability of information on the origin of energy supplied and to preclude the multiple marketing of green properties, GO systems must be supplemented by rules for energy disclosure (Van Stein Callenfels et al. 2020, p. 22 ff.). **A European harmonised set of rules already exists for electricity disclosure**. According to the Internal Electricity Market Directive (EU) 2019/944, for product level disclosure, suppliers must indicate in their bills the shares of the individual energy sources in the electricity purchased by the end user in accordance with the supply contract (Annex I No. 5 in conjunction with Art. 18(6) Directive (EU) 2019/944).[6] End users must also be provided with information on the supplier's overall energy mix in the previous year and on the associated environmental impacts (covering at least CO_2 emissions and radioactive waste). National authorities must ensure that such information is reliable and clearly comparable at the national level.

Unlike its predecessor Directive 2009/72/EC, Directive (EU) 2019/944 also specifies, with reference to RED II, the **role of GOs in the disclosure of renewable electricity**.[7] According to Art. 19(8) RED II, **electricity suppliers must use GOs to demonstrate RES shares or quantities in electricity disclosure**, with two exceptions. Where the energy cannot be clearly allocated to a source, suppliers may use the **residual energy mix** – the total annual energy mix of the member state, excluding the attributes of all explicitly traced electricity (see AIB 2021a; Art. 2(13) RED II). That mix may also contain RES components: It contains the attributes of a country's energy production for which no GOs were issued and cancelled (which means that the characteristics of expired GOs also accrue to the residual energy mix). If other methods are used for tracking energy properties from production to consumption, the property pool of the residual mix should be adjusted accordingly.

The second exception for the disclosure of RES shares according to Art. 19(8) RED II applies if the member state does not issue GOs for financially supported RES. This applies to Germany, where the electricity disclosure requirements are implemented by § 42 of the Energy Industry Act (EnWG),[8] which stipulates that **electricity that is financed by the EEG surcharge** must be shown separately. The amount of the EEG share that a supplier can report is determined by a mechanism regulated in § 78 EEG, which distributes EEG electricity to the electricity suppliers in parallel to the financial allocation of the EEG surcharge. Accordingly, in Germany the national ENTSO-E energy mix adjusted for cancelled GOs and EEG electricity

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[6] 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.

[7] See Art. 3(9) of the repealed Directive 2009/72/EC of 13 July 2009 concerning common rules for the internal market in electricity.

[8] Energy Industry Act (Energiewirtschaftsgesetz, EnWG) of 7 July 2005 (Federal Law Gazette I p. 1970, 3621), last amended by Art. 84 of the Act of 10 August 2021 (Federal Law Gazette I p. 3436). For the design of electricity disclosure, see BDEW (2021).

is used to calculate the residual energy mix (§ 42(4) EnWG).

However, this type of electricity disclosure has been criticised for not reflecting the actual procurement behaviour of electricity suppliers (Maaß and Praetorius 2015; Maaß 2016; Seebach et al. 2017). As the expansion of EEG-supported renewables progresses, the electricity mix of all suppliers is becoming greener as per their disclosure, regardless of whether they procure renewable electricity and the corresponding GOs. A partial **adjustment of the electricity disclosure rules** is provided for in the amendment to the EnWG passed by the German parliament in June 2021 (BR-Drucksache 578/21; BT-Drucksache 19/27453, p. 40 f.): The EEG share shall only be shown in product level disclosure, while a supplier's overall energy source mix must reflect its actual procurement. For the overall energy source mix, GO cancellation therefore increases in importance, if suppliers wish to provide evidence of a high renewable energy share. Compared to the earlier version of the regulation, there is no change to the fact that even though the EEG share is shown in product level disclosure, EEG electricity may not be marketed as green electricity – GOs must be cancelled in full for any electricity supplied under a green electricity contract (cf. BDEW 2021, p. 43 f.).

So far, there are **no comparable regulations for disclosing the attributes of heating, cooling, and gases.** If member states use GOs for other types of energy than electricity, the RED II merely stipulates that suppliers use for disclosure the same GO type as the type of energy supplied (Art. 19(8) RED II). This means that electricity GOs are to be used for disclosing the properties of electricity supply, gas GOs for disclosing the properties of gas supply and heating and cooling GOs for disclosing the properties of thermal energy supply.

For the **disclosure of district heating/cooling attributes,** Art. 24 RED II stipulates that member states must ensure that "information on the energy performance and the share of renewable energy in their district heating and cooling systems is provided to final consumers in an easily accessible manner, such as on the suppliers' websites, on annual bills or upon request" (Art. 24 (1) RED II). Moreover, according to the Energy Efficiency Directive (EED), member states shall ensure that information about the fuel mix used and the related annual GHG emissions is made available to final heating and cooling users in or with their bills (Art. 10a para. 2 lit. c EED). However, the method of verification and – in particular – the **role that GOs are to play in the verification process are not specified**. At the German national level, the RED II and EED requirements are implemented by the Ordinance on Metering and Billing in District Heating or Cooling (FFVAV) adopted in June 2021 (BR-Drucksache 310/21, p. 3 f.; BR-Drucksache 310/21 (Beschluss), p. 10 f.).[9] § 5 para. 1 no. 2 FFVAV stipulates that customers must be provided with information on the proportion of energy sources and heating or cooling technologies used in the overall energy mix and on the annual greenhouse gas (GHG) emissions associated with the energy mix. Also, information on the primary energy

[9] Ordinance on Metering and Billing in District Heating or Cooling (Fernwärme- oder Fernkälte-Verbrauchserfassungs- und -Abrechnungsverordnung, FFVAV) of 28 September 2021 (Federal Law Gazette I p. 4591).

factor and the RES share of the district heating or cooling system must be made available to customers on the suppliers' websites and in invoices (§ 5 para. 3 FFVAV). Unlike with electricity disclosure, the FFVAV does not contain any rules on the marketing of differentiated district heating qualities by means of product level disclosure: The information requirements refer to technically interconnected district heating or district cooling systems. Besides the new national disclosure rules for district heating/cooling, there are also individual examples for disclosure obligations under federal state law.[10]

For the **gas sector,** there are **no requirements yet** at the European level for **disclosing the RES share to consumers.** The German legislator has not yet defined any disclosure requirements for the RES share in the supply of gas either. As part of the European Green Deal, the Gas Directive 2009/73/EC and the Gas Regulation (EC) No. 715/2009 are currently being revised to support the market introduction of renewable and low-carbon gas and hydrogen (European Parliament 2021). It remains to be seen to what extent disclosure rules for gases will feature in the revision proposals, which are expected by the end of 2021.

In the absence of regulatory requirements to use GOs for disclosure, GOs for gases or heating/cooling could nevertheless be used **voluntarily to demonstrate RES shares** (if the corresponding GO systems are in place). Especially when several verification systems are in use, however, without binding disclosure rules, it can be a challenge to ensure that no multiple marketing of renewable energy characteristics can occur. At the very least, a **cross-check of the verification systems** that producers could use would be necessary to ensure that the renewable attribute of each unit of energy produced is only marketed once (see also GO4I Fundamentals Report 4, Sakhel and Styles 2021).

2.3 Requirements from the consumer perspective

From the consumer perspective, various **qualitative requirements can be defined regarding information about energy supply characteristics**, such as the information's usefulness, its usability (e.g. in terms of comprehensibility), actual use (driven for instance by accessibility) and credibility (Schudak and Wallbott 2019, p. 240 ff.). One of the criteria of the suitability of GOs is the extent to which the information they contain and the information tools they support facilitate matching the green energy product disclosure obligations with consumer expectations. Empirical findings on **consumers' expectations of green energy products** are so far available mainly for the electricity sector, specifically regarding **households**. In a representative survey on consumer behaviour in the German green electricity market, Schudak and Wallbott (2019, p. 252) for example found the requirement that the electricity is

[10] For example, the Energy Transition and Climate Protection Act of the State of Schleswig-Holstein of 7 March 2017 stipulates that heating/cooling suppliers must publish online information on the energy mix of their heating/ cooling generation and the energy mix in individual heating or cooling grids, as well as information on grid CO_2 emissions and primary energy factors.

not generated in nuclear or coal-fired electricity plants to be important to 64% and 58% of the respondents, respectively. The requirements that green electricity comes exclusively from renewable sources and that electricity suppliers invest in RES plants were similarly important (60% each). The national (55%) and regional (48%) origin of electricity also played an important role.

The **qualitative characteristics of green electricity products can be indicated by means of quality labels**, which may refer either to the properties of the cancelled GOs (e.g. origin from certain energy sources or technologies, plant age, plant location) or other assessment criteria (e.g. the supplier's investment in new RES plants). In particular, labels rely on GOs to demonstrate the green energy attributes that provide "additionality" to accelerate the energy transition (see GO4I Baseline Report 3, Werner 2021). In the survey by Schudak and Wallbott (2019, p. 252), the evaluation of green electricity products on the basis of quality labels played an important role for 40% of the consumers. Another requirement concerns the possibility of a "coupled" supply of electricity and GOs (see 2.1.2). This was relevant for 42% of the respondents. However, a fifth of the respondents gave no answer in this regard, which may indicate problems in assessing the criterion. Also, most respondents (55%) were not aware of electricity disclosure (p. 253). Furthermore, supplementary focus group research indicates that although the disclosure content is appreciated, it is often not fully understood (p. 258 ff.).

Regarding the **credibility of the verification,** the question of system boundaries is relevant. Electricity and gas are traded in the European internal market. Although the EU-wide trade in GOs abstracts from actual grid connections and cross-border transmission capacities, it reflects the relevant market structure. By contrast, district heating/cooling markets are by necessity local, technically self-contained systems, so there is much greater uncertainty as to whether consumers would find the cancellation of GOs from unconnected grids for disclosure purposes credible (Van Stein Callenfels et al. 2020, p. 26 f.; Verwimp et al. 2020, p. 71 ff.). Accordingly, in the heating/cooling context, there is some discussion about whether a grid connection should be required between the GO-issuing plant and the consumer for whom the GOs are cancelled (Purkus 2021; Claas-Reuther 2021).

Differences in consumer expectations may arise between **households and commercial customers as well as public sector organisations** that choose to purchase green electricity products as part of their climate neutrality efforts (see Mundt et al. 2019). In the European GO market, businesses in particular are an important driver of the increasing GO demand (AIB 2020, p. 10). While in electricity disclosure, energy suppliers inform the end users, in climate accounting, companies provide their stakeholders with information on the climate impact of their actions. This can imply different **requirements on verification approaches and information provision**. Besides the expansion of the GO system to other energy carriers, this makes it necessary to also consider a further development of the established system within the electricity sector. For example, self-supply is quickly gaining ground, with more and more companies producing their own electricity on site. In Germany, GOs are not currently issued for self-supply, but this electricity must also be correctly recorded and verified in companies' climate balances. In Germany, as in many other European countries, the GO system, which has been working well so far, was only intended for use in disclosure by electricity suppliers. A growing interest in renewable PPAs is also a relevant trend, as is an increasing interest in shorter reporting periods below a year (ECOHZ 2021; EnergyTag 2021). Further development perspectives for GO systems are discussed in Section 3.1.2.

3. Further prospects for the role of GOs in Germany

This section discusses the further development perspectives for GOs in terms of their purpose and possible applications beyond the established functions of consumer information and enabling the trading of green attributes. In particular, these potential additional roles concern

- **Market-driven support for the expansion of RES**, e.g. by raising the value of the green quality of energy,
- **support for the implementation of other energy policy instruments**, for example as proof of the delivery of RES, to meet legal requirements or to be eligible for financial support,
- **statistical or monitoring purposes**.

3.1 Market-driven support for RES expansion through GOs

As a consumer information instrument, GOs in the electricity sector have so far provided information on the origin of electricity and – in conjunction with electricity disclosure – helped preclude the multiple marketing of green attributes. However, buying a green electricity product is often associated with the additional expectation of contributing to RES expansion, e.g. by investing in new RES plants (see Section 2.3; Schudak and Wallbott 2019, p. 252). **For many consumers, purchasing green electricity is an expression of their active support for the energy transition,** which otherwise offers little room for direct consumer participation. The rising demand for green electricity (Güldenberg et al. 2019; E&M 2021), which increasingly comes not only from households but also from companies, could serve as a **market-based driver for the energy transition.** Increasing demand for GOs, in particular those issued by new plants, could support the acceleration and financing of RES expansion (Maaß et al. 2019). In the context of the German electricity market, three **perspectives for the use of GOs** can be distinguished:

- If **GOs were issued for EEG-supported electricity production**, GO revenues could contribute to the financing of plants and thus reduce the required level of financial support – provided that sufficiently high GO prices can be achieved for electricity from supported plants.
- If no GOs are issued for EEG-supported electricity production, **formerly supported plants could switch to non-supported direct marketing and apply for GOs**. This could be an attractive option if electricity and GO prices are high.
- GO revenues could contribute to the funding of **fully market-financed plants.** Long-term investment security could be achieved by **concluding long-term PPAs** for the delivery of both GOs and electricity.

Overall, the question is to what extent revenues from GOs can play a role in financing supported or even non-supported plants. **Whether the green electricity quality has much value ultimately depends on the supply and demand of the individual GO attributes**. In the European market, GOs from wind and solar power plants tend to achieve higher prices than those from hydropower (Güldenberg et al. 2019, p. 209 ff). However, it is uncertain how GO prices will develop in future, given that the RES capacity in the EU will see significant expansion over the next decade, and that most of this expansion will occur in the realm of wind and solar energy.

Against this background, in the following we discuss **several possible further development perspectives for GO systems in the context of an increasingly market-driven RES expansion** (a more in-depth consideration of selected aspects will be provided in further GO4I project reports). The question of **GO issuance for supported plants** is particularly relevant for the electricity sector, because as of yet it is only here that a GO system exists in Germany and most other EU member states. However, some of the considerations are also relevant for the development of GO systems for other energy carriers. In the German electricity sector, enabling EEG-supported domestic plants to issue and market GOs would require an adjustment of the law. Furthermore, various **approaches** can be identified **to raise the value of green attributes**, including the use of PPAs or greater qualitative differentiation of GO procurement. Another development option, which is also briefly outlined below, is to use GOs not only for consumer information and the generation of additional revenue for RES plants but as a **traded commodity in quota systems**.

3.1.1 Issuance of GOs for electricity from EEG-supported plants

In Germany, **no GOs are issued for electricity production which receives financial support according to the Renewable Energy Sources Act (EEG).** This applies both for plants receiving a fixed feed-in tariff, whose electricity is sold by transmission grid operators on the electricity exchange's spot market (this applies mainly to older or smaller plants), and plants in supported direct marketing which receive a sliding feed-in premium in addition to electricity marketing revenues (the so-called market premium; see §§ 19 - 21c EEG and § 2 EEV for an overview of marketing and support options). Since claiming EEG support is usually more attractive than unsupported direct marketing in combination with GO sales, this rule means that very few GOs from domestic RES plants are available on the market (see Figure 2). Instead, a significant amount of GOs from other European countries is imported to disclose the origin of green electricity – including ones from fully amortised hydropower plants (Güldenberg et al. 2019, p. 199). In the EECS segment of the European GO market, Germany accounted for only about 2% of renewable GO issuance in 2020, but 15% of RES GO cancellation (AIB 2021b). **Under European law, the issuance of GOs for financially supported plants is permissible, provided that the relevant support scheme takes into account the market value of GOs** (Art. 19(2) RED II). According to the RED II, this is assumed to be the case

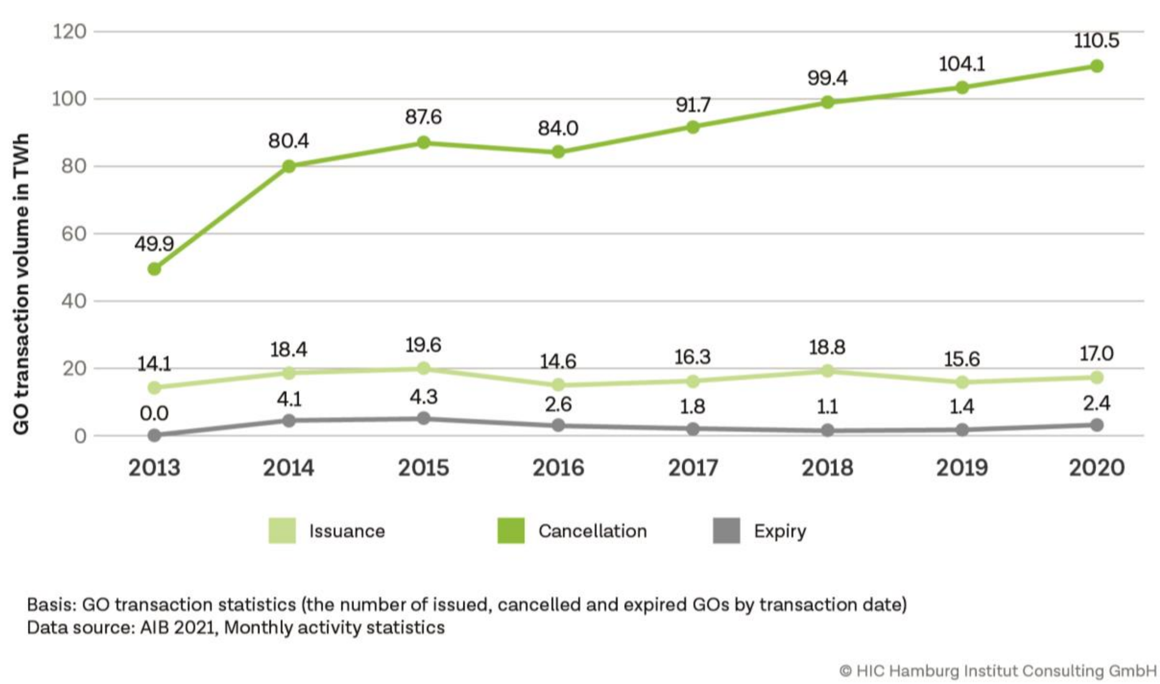
a) "where the financial support is granted by way of a tendering procedure or a tradable green certificate system;

b) where the market value of the guarantees of origin is administratively taken into account in the level of financial support; or

c) where the guarantees of origin are not issued directly to the producer but to a supplier or consumer who buys the energy from renewable sources either in a competitive setting or in a long-term renewables power purchase agreement."

In addition, member states may issue GOs to producers and cancel them immediately to take their market value into account in their support scheme (Art. 19(2) RED II).

Figure 2: Issuance, cancellation and expiry of GOs in Germany



Data source: AIB 2021b.

Most EU member states do issue GOs for financially supported plants and allow electricity from such plants to be marketed as green electricity. As of 2021, only Germany and Ireland do not issue GOs for RES electricity which benefits from national financial support schemes. Until 2019, this also applied to France, Croatia and Portugal (David and Feng 2019, p. 9 ff.). However, France and Croatia have since followed the example of Italy and Luxembourg and introduced auctions for GOs from supported plants (see HROTE 2021; EEX 2021). In Portugal, after a restart of the GO system, GOs have only been issued again since 2020. RES plant operators whose electricity generation is supported by price or investment subsidies must submit the GOs to the competent authority (REN 2020). Such GOs for supported renewable electricity, which account for more than 70% of GO issuance in Portugal, are also marketed through auctions (AIB 2021c; OMIP 2021).

The fact that EEG-supported electricity cannot be marketed as green electricity in Germany is due to the **EEG's interpretation of the European ban on double marketing** (Maaß et al. 2020). Member states must ensure "that the same unit of energy from renewable sources is only taken into account once" (Art. 19(2) RED II) to preserve consumer confidence in the green electricity market. In the EEG, the ban on double marketing is implemented in § 80(1) EEG and supplemented by the further prohibition that plant operators may not be issued GOs for electricity for which EEG payments are claimed (§ 79(1) EEG). Plant operators are also prohibited from passing on GOs or other evidence of the origin of the electricity (§ 80(2) EEG). **This prohibition goes beyond the ban on double marketing**, as EEG-supported electricity is sold as generic "grey" electricity to transmission grid operators or direct marketers. Therefore, no double marketing of green attributes could occur even if GOs were issued and transferred. The German legislator justifies the prohibition of GO issuance for supported electricity by stating that electricity customers should not have to pay twice – via the EEG surcharge and the GO price – for the environmental value of the renewable electricity (Kahl and Kahles 2020). By showing the EEG share in electricity disclosure, the "green" characteristic of EEG-supported electricity is instead distributed among all payers of the EEG surcharge (see Section 2.2). The **ban on issuing and transferring GOs therefore aims to prevent the double reporting of green characteristics in the electricity disclosure** that would result from reporting both the EEG share and GO cancellation.

From 2021 onwards, however, **the EEG support costs will be partly financed by the federal budget** in order to reduce the EEG surcharge and thus to relieve electricity consumers.[11] Following elections in 2021, the coalition parties of the new German federal government announced the abolition of the EEG surcharge in 2023 (SPD, BÜNDNIS 90/DIE GRÜNEN and FDP 2021, p. 62). Even in the case of only a partial abolition, this changes the initial situation in which the designation of the green characteristic of EEG electricity in electricity disclosure

[11] The federal contribution to the EEG support's financing will amount to 10.8 billion euros in 2021, to be financed from the economic stimulus package to deal with the consequences of Covid and from revenues from national CO_2 pricing under the Fuel Emissions Trading Act (BEHG) (BMWi 2020).

is to be understood as "recompense" for paying the EEG surcharge (Kahl and Kahles 2020; Maaß et al. 2020). Since new plants receive much lower levels of support than older ones, one way forward would be to **allow new supported plants to issue and market GOs**. That way, the level of support could be reduced by the market value of the GO. This approach assumes that for plants participating in competitive tenders, the bids would take into account the expected market value of the GOs, so the support level-reducing effect required by RED II would come into play. For plants that receive a market premium or feed-in tariff determined outside of a tender, a suitable flat-rate amount would have to be deducted from financial support to accommodate the GO revenues.

Limiting the issuance of GOs to new EEG-supported plants would minimise the risk of oversupply on the GO market and a corresponding price drop. However, it is difficult to forecast the market outcome as GO prices would ultimately result from supply and demand. Although the demand for GOs is set to increase steeply, especially from industry, the supply will also grow with the continuing RES expansion (including considerably new wind offshore capacities, for instance). The outlined change would allow green electricity customers to establish a more direct connection between their consumption decisions and RES expansion, and to experience this as their effective **contribution to accelerating the energy transition.** Independently of this, co-financing through the sale of GOs would contribute to **harmonising the European internal market for green electricity** and resolve Germany's isolated position (for a more detailed account, see Maaß et al. 2020).

A more far-reaching change could result from the **EU Commission's July 2021 proposal to adapt RED II** to the more stringent climate protection target for 2030, according to which **member states *must* offer GO issuance also for financially supported electricity generation from RES** (European Commission 2021, p. 34 f.). This is justified with the aim of **strengthening PPAs**, which are intended to ensure that RES plant operators can transfer both electricity and the corresponding GOs to consumers (p. 19). PPAs could offer new marketing opportunities for both non-supported and supported plants in direct marketing.

If GOs were issued for all EEG-supported plants, this could have a **significant impact on the domestic and European GO market**, potentially depressing prices.[12] However, under the Commission's proposal, the RED II requirement that member states take into account the market value of GOs when providing support would remain in place. Against this background, one approach to the treatment of existing EEG plants could be to **allow the plant operators to apply for GOs and in return accept a reduction in support** (Kahl and Kahles 2020, p. 11). The extent to which the operators would exercise such an option is currently difficult to gauge. It depends, among other things, on the prices that can be achieved for GOs from

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[12] However, this effect could be offset by Norway's announced withdrawal from the European GO system (Greenfact 2021). In 2013-2017, just under half of the GO cancelled in Germany came from Norway (Güldenberg et al. 2019, p. 201).

EEG-supported plants. Some indication is provided by publicly available auction results for GOs from financially supported plants (see Table 2). However, issuing GOs for supported EEG electricity would **require a revision of the electricity disclosure rules to prevent any double reporting of the green attributes**.

Table 2: Selected auction results for electricity GOs from subsidised RES plants

GO Auction	Hydro	Solar	Wind	Other
France (EEX 2021), June 2021; weighted average price	0.71 €/MWh	0.82 €/MWh	0.82 €/MWh	thermal: 0.66 €/MWh
Italy (GME 2021), June 2021; weighted average price for production in the first half of 2021	0.44 – 0.47 €/MWh	0.33 – 0.37 €/MWh	0.46 – 0.50 €/MWh	other: 0.35 – 0.42 €/MWh
Luxembourg (ILR 2021), July 2021; weighted average price	–	1.25 €/MWh	0.52 €/MWh	solid biomass: 0.53 €/MWh
Portugal (OMIP 2021), July 2021; marginal price for production in April 2021	0.43 €/MWh	0.43 €/MWh	0.43 €/MWh	thermal: 0.41 €/MWh
Croatia (Cropex 2021), July 2021; marginal price for production in May/June 2021	–	–	commissioned in 2010–2014: 0.43 €/MWh 2015–2020: 0.49 €/MWh	biomass < 5 MW: 3.25 €/MWh ≥ 5 MW: 0.45 €/MWh

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), different levels of supply and demand, and different numbers of suppliers and bidders.

If GOs were to be issued for supported plants, the combination of financial support and GO marketing as a market-based remuneration component will tend to **reduce the required level of support**: EEG surcharge payers or the federal budget would be relieved by the premium which green electricity customers voluntarily pay for the green characteristics. In EEG tenders, for example, which are used to competitively determine the market premium amount, plant operators would reduce their bids by the expected extra revenue from the marketing of GOs. This reduces the support costs for the EEG. However, as the tender volume is fixed, GO revenues do not lead directly to additional RES expansion in this case. In auctions for GOs from publicly supported RES plants elsewhere in Europe, the revenues are generally used to reduce support costs (e.g. AIB 2021c). However, **an additional RES expansion effect can arise indirectly** if falling support costs promote social acceptance of the energy transition and thus support the political feasibility of more ambitious RES expansion targets.

Alternatively, funds that are not needed to support electricity generation from RES become available to support the energy transition in other sectors.

3.1.2 Strengthening the value of green attributes

As shown in Section 2.1, GOs are the prerequisite for making green attributes tradable even if the energy is procured via grids or other forms of supply in which energy from different sources is mixed – that is, in cases where attributes cannot be physically tracked. Whether the marketing of GOs can make a relevant contribution to financing investments in RES plants depends on the market value of the green attributes. However, **prices on the GO market are subject to strong fluctuations** and therefore difficult to be predict (Güldenberg et al. 2019, p. 217 ff.; Hulshof et al. 2019). For example, prices for "Nordic Hydro" GOs have ranged from €0.1/MWh to €2.5/MWh in recent years. A price spike in 2018 was triggered by low water levels in Scandinavian reservoirs (Kuronen 2021; Güldenberg et al. 2019, p. 213 ff.). In the GO market, the price of GOs from Scandinavian hydropower plants with no age criterion serves as a base price. **GOs with special quality characteristics achieve a premium** over the base price. Such characteristics include, for example, the age and financial support status of plants, the renewable energy source and technology used, and the country of origin (see Table 3; for a detailed analysis of GO price drivers, see Güldenberg et al. 2019, p. 209 ff; Styles et al. 2021a, p. 25 ff.). Beyond that, there are also broader influences such as progress in RES expansion and the development of demand for green electricity.

In general, however, GO proceeds currently constitute only a small – and very volatile – contribution to the total proceeds of RES plants, so that they have not yet been a significant driver of RES investment. An important factor here is that the European GO market has so far been characterised by oversupply, with more GOs issued than cancelled. However, after peaking in 2016/17, this **oversupply in the GO market has been steadily declining**. Demand and supply in the GO market were balanced for the first time in the 2019/2020 reporting period (RECS 2021a). **If this trend continues, GO prices could stabilise in the future** and become more relevant as a revenue component for plants. However, due to the ongoing RES expansion – and potentially the market entry of additional GO volumes from supported plants – **prices remain very difficult to forecast**.

Table 3: Key GO price drivers in the German green electricity market

Energy source	In the European market, price premia exist in particular for GOs from wind and solar power relative to hydropower: However, technology preferences are country-specific.
Plant age	The younger a non-supported plant, the higher the value of its GOs. "New plants" are priced separately.
Country of origin	In the German green electricity market, domestic plants can achieve price premia, but their GOs are currently very scarce. Price premia for domestic plants are also achieved in several other countries.
Funding status	Any GO for supported electricity production so far had to be imported to Germany due to the EEG's double marketing ban, and there has been little interest in such imports.
Procurement quantity	When procuring large quantities of GOs, lower prices can be achieved. In some cases, this can make it worthwhile to over-procure GOs; "surplus" GOs can be sold on or used to disclose the origin of other electricity products.
Delivery period	Slight price differences may occur depending on the year of delivery.
Ownership of the GO provider	Some green electricity suppliers avoid buying GOs from suppliers with ties to nuclear or fossil energy.
Environmental influences	Weather conditions can have a major impact on production volume. Dry years tend to be associated with GO shortages and thus higher prices.
Risk behaviour	Supply fluctuations (e.g. due to precipitation) lead to cautious supply behaviour on the part of producers and traders of wind and hydropower GOs.
Market tactics	There may be indications of "intentional" supply shortages in the middle and at the end of a year to increase GO prices.

Source: Styles et al. 2021a, p. 27; based on Güldenberg et al. 2019, p. 209 ff.

Changes in the group of countries that participate in the European GO market also affect future price developments. According to RED II, member states may only accept third-country GOs if the Union has concluded an agreement on the mutual recognition of GOs with this third country and if the energy is directly imported (Art. 19(11) RED II). Following the end of the implementation period of RED II in mid-2021, Switzerland and the United Kingdom will therefore have to conclude such an agreement if they are to export GOs to the EU. However, both countries have decided to continue to recognise GOs from the EU (RECS 2021b). Furthermore, the **Norwegian government** has **announced that it is considering opting out of the European GO system** (Greenfact 2021). As Norway currently exports large amounts of GOs, the aim of that step would be to increase the share of RES in the national electricity disclosure so as to be able to achieve climate neutrality when exporting Norwegian products. However, Norway is part of the European Economic Area (EEA). The EEA Agreement extends the European internal market and related EU legislation to the participating states and ensures equal rights and obligations for all individuals and market participants within its scope. As the RED has been incorporated into the EEA Agreement, the legal admissibility of such a step is uncertain. Norway accounted for 19% of RES GO issuance in active AIB member countries in 2020 (AIB 2021b). An exit from the GO system or even just an increase in domestic cancellation could cause a significant shortage in the European GO market.

Besides such overarching developments, several perspectives for the **further development of the electricity GO market emerge** that could raise the value of green attributes. Some of these approaches may also prove relevant for the still nascent markets for green gases and green heating/cooling. On the one hand, the market is showing a growing interest in PPAs for RES. Concluding a long-term PPA, for example with electricity suppliers or industrial end users, could offer plant operators significantly greater planning certainty than marketing their electricity on the wholesale market (e.g. Huneke et al. 2018; see Section 2.1.3). Industrial customers in particular will look to PPAs to procure electricity supply from RES at stable conditions. So far, the United States has been the leader in corporate PPAs, but in recent years there has also been significant growth in Europe and other regions (BloombergNEF 2021). However, challenges arise, among other factors, from complex contract negotiations and uncertainty in managing risks (e.g. regarding the allocation of price and volume risks; see Hilpert 2018). The EU Commission's proposal to adapt RED II also envisages strengthening PPAs in the marketing of RES (European Commission 2021, p. 19). However, if more PPAs are to be concluded directly between plant operators and end consumers, this would require an adjustment of the German system for electricity GOs, which may currently only be cancelled by electricity suppliers for electricity disclosure (see § 30 (1) HkRNDV), but not by final consumers. By contrast, in some other EU member states, such as the Netherlands and Finland, **end consumers can in principle cancel GOs** (CertiQ 2021; Fingrid 2021).

Besides PPAs, predictable revenue streams for plant operators could also result from **long-term GO supply contracts between plant operators and consumers or utilities.** These could be concluded independently of electricity supply contracts or contracts for difference to hedge against electricity price risks (cf. Section 2.1.3). The focus here would be on hedging against GO price risks for plant operators and GO purchasers.

Even beyond PPAs, **unsupported new RES plants are likely to play a greater role in the electricity sector in future**. In addition to the cost degression of RES technologies, rising CO_2 prices in the EU Emissions Trading Scheme will be reflected in higher electricity prices, improving the financing options of RES plants on the electricity market (Maaß et al. 2019, p. 23 ff.). Besides unsupported new plants, the electricity and GO supply from old plants whose support periods have expired will also increase in the medium term. The GO market may see increased price differentiation, with unsupported new plants as the premium segment (cf. also Seebach and Timpe 2020). The **criterion of additionality**, an important qualitative differentiating factor for GOs on the green electricity market, plays a special role here. Additionality, which is the focus of GO4I Fundamentals Report 3 (Werner 2021), means that buying green electricity should accelerate RES expansion beyond the public support framework. Green electricity certification providers evaluate the share of new, unsupported plants in the electricity supply mix, which already leads to higher GO prices for such plants. The recognised maximum age for new plants is mainly determined by green electricity labels and sometimes depends on the energy source (e.g. ok-power label: 8 years for hydropower, 4 years for wind power).

In future, new **developments in trading mechanisms** could improve transparency regarding the quality factors that affect GO prices. Currently, GO transactions are primarily conducted over the counter (OTC). Price information can be requested for a fee from service providers or from traders, but price transparency is lower than, for example, in the electricity spot market (Güldenberg et al. 2019, p. 195). Until 2018, the European Energy Exchange (EEX) operated a trading segment for GOs which, however, had not seen any transactions since 2015 (Güldenberg et al. 2019, p. 188). Since multiple characteristics of GOs affect their price, more diverse transactions with lower trading volume must be processed than in the electricity market, which makes it difficult for trading platforms to operate efficiently (Oslo Economics 2018). For RES GOs from selected EECS countries, Epex Spot is currently developing a new solution for European spot auctions, which will allow either the purchase of "generic" GOs or differentiation according to various GO characteristics (Lehtovaara et al. 2021, p. 15).

As a special form of the qualitative differentiation of the GO market, the **temporal dimension of GO issuance and cancellation** could also gain importance (cf. the above discussion on coupling in Section 2.1.2). Granular GOs with higher temporal (i.e. hourly or quarter-hourly) resolution on a kWh basis could be used, for example, to demonstrate a temporal link between RES generation and electricity consumption. This is of interest e.g. to companies that formulate daily or even hourly climate neutrality targets or optimise their product carbon footprints by scheduling their production for times when RES abound in the generation mix. The design of rules for a granular GO market and its interaction with the established GO market structures are currently investigated, for example, by the EnergyTag initiative (EnergyTag 2021).

The value of green energy can also be increased by indicating its **regionality**. In the electricity sector, regionality plays an increasingly important role, especially for households (Wallbott et al. 2021; Mundt et al. 2021). Besides the GO registry, the UBA also operates a registry of regional guarantees, which 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 RES plants financed by the EEG surcharge (Mundt et al. 2021, p. 15; Maaß et al. 2017). The aim is to promote the acceptance of regional RES expansion. However, the renewable characteristic of EEG-supported electricity is still shown as the EEG share in the electricity disclosure and distributed among the electricity supply companies in parallel to the allocation of the EEG surcharge (see Section 2.2) – this EEG share cannot be marketed as green electricity. In order to market a **regional green electricity product**, it is therefore necessary to cancel GOs in addition to regional certificates in order to disclose the RES characteristics of the entire electricity supply. As outlined in Section 3.1.1, a further development perspective for the GO system would be to also issue GOs for supported plants and to allocate RES characteristics in electricity disclosure no longer via EEG shares but only via GO cancellation or the residual energy mix. This would allow the joint marketing of GOs and regional certificates that originate from the same RES plant. Furthermore, it would also be conceivable to market regional green electricity products based on non-supported renewable electricity. GOs already contain information on the plant location. For a more extensive indication of regionality, the issuing of regional certificates could also be allowed for non-supported RES electricity, or corresponding, additional information could be integrated into GOs (in particular information on the area of consumption within which the GOs can be considered a regional certificate, cf. § 19 HkRNDV). To what extent the joint marketing of regionality and renewable properties would indeed raise the value of green energy remains to be examined.

Furthermore, an increase in the value of green attributes can also result if the intended use of GOs were to expand beyond their current roles to **supporting the implementation of energy policy instruments** (see Section 3.2). If regulatory requirements, subsidy frameworks or rules on exemptions from levies and surcharges were to recognise GOs that meet certain quality requirements as a verification tool for the green quality of procured energy, demand for such GOs would rise. One example is the amendment to the Renewable Energy Ordinance (EEV) adopted by the Bundestag in June 2021, which defines requirements for an EEG surcharge exemption for electricity used in hydrogen production.[13] Besides a number of other criteria, it is envisaged that the cancellation of GOs will play a role in demonstrating the green quality of hydrogen production, with various requirements for the origin of the electricity (GO4I Fundamentals Report 4, Sakhel and Styles 2021).

3.1.3 GOs as a commodity in quota systems

Tradable certificates to control RES expansion through verifiable quotas for electricity procurement are used in particular in Scandinavia and the USA (CEER 2021; NCSL 2021). Suppliers must demonstrate certain quotas in their portfolio by means of certificates for RES production or pay penalties. This system depends on the smooth trading of the RES certificates and free price formation. If the certificates become scarce, their prices rise, which should incentivise additional RES expansion. Although RES certificates also indicate the origin of the energy, in EU member states with quota systems, a clear distinction is made between disclosure GOs according to Art. 19 RED II and the RES certificates used in the quota system (cf. e.g. Energimyndigheten 2021; CEER 2015), so pricing will differ. In Germany, a quota system for GHG reduction contributions based on mass balancing has been introduced in the transport sector for fuels (additionally, compliance with sustainability criteria must be demonstrated for biofuels).

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[13] Ordinance on the Implementation of the Renewable Energy Sources Act and the Wind Energy at Sea Act (Renewable Energy Sources Ordinance – Erneuerbare-Energien-Verordnung, EEV) of 17 February 2015 (Federal Law Gazette I, p. 146), last amended by Art. 87 of the Act of 10 August 2021 (Federal Law Gazette I, p. 3436).

The quota model has been discussed by experts for many years. Possible combinations with the GO system were recently investigated by the Florence School of Regulation (Pototschnig and Conti 2021) on behalf of the European Commission. A **combination of the quota model and the GOs envisioned in RED II** would fundamentally change the established system: Rather than a mere tool for consumer information, GOs would become a tool for steering and enforcing RED II target compliance and the calculation of RES shares in member states. A RES quota with tradable certificates could be implemented at the European level, but also at the national or regional level. The principle could be applied separately to different sectors (e.g. electricity, heating/cooling, transport, industry) and energy carriers (e.g. electricity, gases, heating/cooling); alternatively, it would be conceivable to enable trade in GOs to achieve emissions targets across different sectors and energy carriers (Pototschnig and Conti 2021, p. 10 f.). The latter approach aims at cost efficiency and would allow achieving the overall RED II target (RES share of 32% of EU final energy consumption by 2030) at minimal cost. The importance of cost efficiency is emphasised in light of the fact that an increase in the target level is necessary to realize climate neutrality by 2050 – for example, the EU Commission proposal for an adaptation of the RED II envisages a RES share of at least 40% in 2030 (European Commission 2021, p. 29). The broader the scope of the quota system, according to the proposal, the more likely the marginal costs of meeting the target are to converge across sectors and countries (Pototschnig and Conti 2021, p. 9 f.).

Like any funding mechanism, the quota model reaches its limits when the incentivised RES expansion faces infrastructural bottlenecks. This applies to grid expansion, the development of storage capacities and sector coupling capabilities, for instance. A cost-efficient expansion of RES capacity is realized when the cheapest technologies are deployed at the most profitable locations. For the decarbonisation of the energy system, however, it must be ensured that **energy from renewable sources is available in spatial and temporal terms in such a way that the actual energy demand is met**. In this respect, the cost efficiency of the overall system for maintaining an uninterrupted energy supply is more important than cost-efficient generation alone. A wholistic economic analysis would furthermore have to incorporate additional aspects such as external (e.g. environmental) costs. Cost differences resulting from the different technological maturity of the various technologies should also be considered (Azar and Sandén 2011; Jacobsson and Bergek 2011; Gawel et al. 2017). A focus on the cheapest options at a given point in time need not yield a cost-effective solution in a dynamic perspective, as it neglects potential cost reductions in innovative technologies through learning curve and scale effects. **Especially in the case of a cross-sectoral quota, which would cover electricity, gas and heating/cooling, optimising the overall system would be a challenge,** as the various RES-based technology options are at different stages of development.

Currently, **tradable quota obligations are mainly used to promote sector-specific RES expansion in national contexts.** In Germany, this is the case in the transport sector, where the GHG reduction quota obliges suppliers of transport fuels to achieve increasing GHG savings (Generalzolldirektion 2021a). For cost efficiency reasons, the fulfilment of the quota may be passed on to third parties. The **GHG quota implements the RED II target on the RES**

share in the transport sector (Art. 25(1) RED II). For verification, RED II currently provides for **mass balancing of fuels** to prevent double counting and to demonstrate compliance with sustainability and GHG savings criteria (Art. 30(1) RED II).[14]

With the **introduction of GOs for renewable gases**, it must be clarified whether and under what conditions GOs can also be used as part of the verification for the GHG reduction quota. Since RED II requires the transport sector to use mass balancing verification, GOs alone would not suffice for verification. Potentially, it could be examined whether GOs could be combined with a mass balance method of verification. **If GOs and mass balancing for gases were to run alongside each other, coordination between the systems would be necessary** to rule out any multiple use of the green attributes.

In Germany, **quota schemes for GHG reduction or RES shares are also discussed for other energy carriers and sectors, such as gases or district heating** (e.g. Daniel-Gromke et al. 2020, p. 147 f.; Engelmann et al. 2021, p. 407 ff.). If GOs were to be used as evidence for this purpose, the question of system boundaries arises. For example, Art. 24(4) RED II provides that member states must implement measures that are expected to increase the share of RES and waste heat/cold in district heating/cooling grids by an average of 1% per year (alternatively, they must grant third-party RES and waste heat/cold producers access to the heating/cooling grids). Member states that decide to increase the share of RES and waste heat/cold are free regarding their choice of instrument by which to achieve the target. In the case of a quota, applying the annual increase to each grid would not achieve the target at the lowest cost, as RES expansion costs vary from grid to grid and strongly depend on local circumstances (e.g. due to the available RES potential). If GOs were used as a verification method for a district heating/cooling quota scheme, it would make sense to allow GOs to be cancelled independently of a grid connection between the points of generation and consumption. However, to be counted towards national RES targets, the energy must be proven to have been produced in the member state's territory (Art. 7 RED II).[15]

3.2 Supporting the implementation of energy policy instruments

The issuance of GOs is linked to the **collection and verification of data on RES plants and their energy production**. The verification of such information by accredited testing and measurement bodies is an important prerequisite to ensure that GOs are "accurate, reliable and fraud-resistant" (Art. 19(6) RED II; see also Verwimp et al. 2020, p. 13 ff.). **Such data can be used not only for energy disclosure purposes and the trading of RES attributes**

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[14] The tracking of sustainability-certified biomass used for the production of bioenergy also relies on mass balancing (BLE 2010, p. 26 ff.).

[15] Exceptions are statistical transfers, joint projects or joint support schemes (Art. 8 - 13 RED II). According to Art. 19(2) RED II, the transfer of GO does not affect the use of corresponding measures by member states.

but also to support other policy instruments, such as the verification of eligibility for RES support or compliance with regulatory requirements on RES shares.

In the case of consumption-side instruments that impose requirements on the use of RES, it is necessary to decide whether, and if so under what conditions, the **purchase of a green energy product for whose consumption GOs are cancelled is recognised for regulatory compliance**. As an example, the suitability of GOs as evidence of the **purchase of green gas or green district heating** is discussed below, complemented by an outlook on the role that GOs could play in proving the charging of **electric vehicles with electricity from RES.** In addition to the options discussed here, GOs can also play a role in tracking the transfer of renewable attributes in energy conversion processes (e.g. Power-to-Gas, Power-to-Heat, but also gas-based electricity and heat production). In particular, this raises the question of what evidence is required for an energy input drawn from the grid to be recognised as originating entirely from RES. To prove the green property of hydrogen production, for example, the amendment to the Renewable Energy Ordinance of July 2021 stipulates that GOs for electricity inputs obtained from the grid must be cancelled in order to claim an EEG surcharge exemption (alongside further requirements; see Section 3b EEV). The **use of GOs in energy conversion processes, which requires interfaces between verification systems**, is the focus of GO4I Fundamentals Report 4 (Sakhel and Styles 2021) and is therefore not discussed in detail here.

3.2.1 Support for the verification of production-side support instruments

In the Netherlands, for example, data collected for the issuance of GOs is also used for verification purposes within the framework of the national RES support programme, SDE++. The use of GOs for disclosure purposes and the payment of support to producers are independent of each other (CertiQ 2018, p. 10). However, support payments for wind and photovoltaic plants are adjusted by the average market value of GOs (Netherlands Enterprise Agency 2020, p. 4).

In Germany, RES GOs have so far only been used as evidence within the electricity disclosure framework but not for other energy policy instruments. In the electricity sector, the strict separation between the options of either receiving GOs or receiving financial EEG support must be taken into account. With the prospective introduction of GO systems for gases as well as renewable heating/cooling, however, the question arises to what extent GOs could also be used here as proof of RES production beyond disclosure rules. **In the case of production-side support instruments, synergies in data collection can be exploited in the case of a national GO registry,** similarly to the Dutch SDE++ programme. In the heating sector, there could be links, for example, to the planned funding of operating costs as part of the federal funding of efficient heating grids (Bundesförderung effiziente Wärmenetze, BEW) (for the concept of the new BEW programme, see Pehnt 2020; BMWi 2021a).

3.2.2 Purchase of green gas products as a regulatory compliance option

The German **Building Energy Act (Gebäudeenergiegesetz, GEG)** makes it possible to apply a reduced **primary energy factor** compared to natural gas **when using biomethane from the gas grid** (§ 22(1) No. 2 GEG).[16] Such procurement may also count towards RES consumption requirements (§ 40(3) GEG). However, both benefits depend on **verification by means of a mass balance system, which must document the entire transmission and distribution chain of biomethane.** This form of verification covers the following intermediate steps (BMU 2012, p. 7 ff.):

- production and feed-in into the gas grid;
- any transfer of the right to withdraw a quantity of gas from the grid equivalent to the quantity of biomethane transmitted via the natural gas grid;
- withdrawal from the gas grid.[17]

At the end of a calendar year, the quantity of biomethane withdrawn must correspond in heat equivalent to the quantity of gas from biomass that was fed into the grid elsewhere. According to the explanatory memorandum to the Act, these requirements are intended to "ensure a **real relationship between the production and purchase of biogas**" (BT-Drucksache 19/16716, p. 121). Mass balancing is also required under the GEG for the use of biogenic liquefied gas (§§ 22(1) No. 3 and 40(4) GEG). The EEG, too, requires mass balancing so that gas that EEG plants withdraw from the grid can be recognised as landfill gas, sewage gas, mine gas, biomethane or storage gas (§ 44b(5) EEG). Furthermore, for energy generated from such gas to be eligible under the EEG, the gas must have been fed into the grid within the Federal Republic of Germany, including the German exclusive economic zone (BMU 2012, p. 5).

Requirements are thus stricter than for Book & Claim GOs, where only the production (for GO issuance) and consumption (for GO cancellation) of energy are considered, but not transmission and distribution (BMU 2012; Bowe 2013). The separate marketing of energy and renewable attributes via GOs in principle allows for an abstraction from actual grid connections **– the cancellation of GOs for renewable gas would initially mean that a corresponding amount of energy was produced in the European internal market**, regardless of whether a transfer to the German gas grid has taken place. In principle, GOs enable consumers to express a preference for energy properties, even if the available infrastructure does not allow

[16] Act on the Saving of Energy and the Use of Renewable Energy for Heating and Cooling in Buildings (Building Energy Act – Gebäudeenergiegesetz, GEG) of 8 August 2020 (Federal Law Gazette I, p. 1728).

[17] A further documentation step is required if consumers receive a gas product that contains a share of biogas.

them to physically receive that same unit of energy.[18] However, the **extent to which infrastructural conditions are abstracted from can be influenced by cancellation and disclosure rules.** For example, to disclose the properties of gas withdrawn from public gas grids, GOs could be used that were issued for gas that was demonstrably fed into such a grid at some point within the European internal market. The feed-in would be verified by the gas system operators. In this case, GOs for gases transported by vehicle could not be used for disclosure of grid-based gas supply. **Differentiation between different gas types** is also possible (Verwimp et al. 2020, p. 30 ff.). French legislation on hydrogen GOs, for example, distinguishes between "normal" GOs and guarantees of traceability (Ministère de la Transition écologique 2021). The latter require that the GOs and the hydrogen were sold jointly. Also, there is a requirement that the hydrogen supplied has not been mixed with other types of hydrogen or other gases between production and consumption.

To prove a **"real relationship" between energy generation and supply** within the meaning of the GEG requires further verification steps beyond a pure book & claim consideration of energy generation and consumption, including accounting for transmission and distribution. However, gas GOs that meet the relevant requirements could form part of mass balancing certificates in future, namely as proof of generation and, if applicable, feed-in. To prove procurement of green gas as a regulatory compliance option, the **requirement** could be **to prove a coupled transfer of GOs and the corresponding energy, in the form of the transfer of withdrawal rights** (BMU 2012, p. 10). For the necessary linking of GOs and mass balance registries, implementation issues would have to be clarified. Alternatively, a simplified requirement could relate to **GOs issued for gases fed into a gas grid connected to the German grid**. The **creation of interfaces between mass balancing and GO systems** for gases would have the advantage of preventing any multiple marketing of the renewable properties. If, on the other hand, the two systems exist independently of each other, there is a risk of the renewable property of a given MWh being marketed to different consumers – once via a GO and again via mass balancing. A cross-check between the two systems is necessary to prevent this scenario.

3.2.3 Purchase of green district heating products for regulatory compliance

For district heating (and cooling), it would also be conceivable in principle to use GOs to prove the **fulfilment of RES usage obligations or to calculate the primary energy factor of differentiated district heating products.** For example, it may be more cost-efficient to support the expansion of renewable generation capacity in a district heating grid by paying a

[18] In the case of electricity GOs, for example, cancelling Norwegian hydropower GOs does not depend on the availability of interconnector capacity between the electricity grids involved. In any case, cross-border grid connections are being reinforced, for example the NordLink power line between Germany and Norway commissioned in May 2021 (Bundesregierung 2021).

price premium for a green district heating product than to install a decentral RES heating system in one's own building.

Regarding **RES usage obligations under the GEG, district heating can already be used as a substitute** for the proportionate coverage of energy demand from RES **if at least 50% of it comes from combined heat and power plants** (§ 44(2) GEG). Alternatively, a significant proportion of the overall heat distributed in the grid must come from RES, or at least 50 per cent must come from waste heat plants (it is also possible for at least 50 per cent to come from a combination of these three sources). The Hamburg Climate Protection Act, on the other hand, requires a **minimum RES share in a heating grid** for that grid connection to be eligible as a substitute measure for RES usage obligations for existing buildings (see e.g. § 18(2) in conjunction with § 17(1) HmbKliSchG; the usage obligation arises when a heating system is replaced or retrofitted).[19] The federal subsidy for energy-efficient buildings (Bundesförderung für effiziente Gebäude, BEG) makes stricter demands: at least 55% of the energy required to supply a building with heating/cooling must come from RES for the building to be eligible for the "efficient building RES" subsidy class (BMWi 2021b). If the heat is drawn from a grid, at least 55% of the energy in that grid must be from RES. According to the amendment to the BEG coming into force on 21 October 2021, a RES share of 55% may be summarily assumed for a heating grid if the primary energy factor of the grid does not exceed 0.25 or if a transformation plan endorsed by the Federal Subsidy for Efficient Heat Networks (BEW) exists. However, as of December 2021, the BEW has not yet come into force.

The requirement of minimum RES shares could support local grid transformation processes if the building owners concerned facilitate the refinancing of RES heat generation plants via their purchase of a green district heating product. The **calculation of building- or heating-product specific primary energy factors** could likewise make the purchase of green district heating economically attractive for building owners, thus generating extra income for RES plants in heating grids (Maaß and Pehnt 2019). **However, the current practice is to calculate a uniform primary energy factor for the heating or cooling grid to which a building is connected** (see § 22 GEG, DIN V 18599-1: 2018-09, worksheet AGFW FW 309 Part 1). The legal framework for a product-specific calculation of primary energy factors is the subject of ongoing research (see Claas-Reuther 2021; Hamburg Institute 2021).

Of importance is the **requirement of a real relationship between production and purchase,** which the GEG's explanatory memorandum places on the use of grid-supplied biomethane for regulatory compliance (BT-Drucksache 19/16716, p. 121). Regarding district heating, this could mean that **only GOs that originate from the grid to which consumers are connected could be considered in terms of meeting regulatory requirements**.

[19] The Hamburg Climate Protection Act (HmbKliSchG) of 20 February 2020 also recognises the connection to heating grids as a substitute measure if the required RES minimum share of 15% of the annual heating energy demand has not yet been met but the heating supplier has submitted an audited decarbonisation roadmap.

3.2.4 Proof of green electricity procurement in e-mobility

For the expected expansion of e-mobility, it must be **ensured that the resulting electricity demand can be covered from RES**. **Certified green electricity based on GOs** could play a role here. Some funding programmes by German federal states for charging infrastructure already require the purchase of certified green electricity. However, such a requirement is not included in the European transport sector target for RES according to Art. 25(1) RED II or its national implementation, the GHG reduction quota.[20]

As shown in Section 1, Art. 19(2) RED II excludes a role of GOs for EU member states' compliance with the binding overall RES target for 2030 under Art. 3 RED II. GOs also have no effect on the calculation of the gross final consumption of RES in the member states under Art. 7 RED II. On the other hand, a role in the verification of the **transport sector target under Art. 25 RED II, which is calculated independently of the overall RES target under Art. 3 RED II** (see Hoffmann 2020), is at least not explicitly excluded.

When calculating the share of RES in the transport sector, the renewable electricity provided for rail and road transport must be taken into account according to the methodology formulated in RED II. Member states may use the **average share of renewable electricity in their electricity mix**, measured two years previously (Art. 27(3) RED II; Hoffmann 2020). Art. 27(3) RED II formulates **narrowly defined conditions under which electricity can be fully counted as renewable**. In the case of e-mobility, there is an option to demonstrate that the electricity used to charge road vehicles is supplied by **direct connection from a RES plant.**

For **electricity-based fuels such as hydrogen or synthetic fuels,** electricity from a direct connection to a RES plant can also be fully counted as renewable if various additional criteria are met. For electricity-based fuels, Art. 27(3) RED II provides that **electricity taken from the grid can be fully counted as renewable** "if it is produced exclusively by means of renewable energy sources and demonstrably has the characteristics of renewable energy and meets any other relevant criteria, so that it is ensured that its characteristics as renewable energy are claimed only once and only in one end-use sector" (Art. 27(3.6) RED II). "Other criteria" include geographical and temporal correlation between the production of the renewable electricity and the fuel. Furthermore, fuel producers should additionally contribute to the use of renewable sources or to their financing (Art. 27(3) and Recital 90 RED II). **A methodology for the verification of these criteria is to be introduced by delegated act of the EU Commission** (originally expected by the end of 2021). According to the current state of discussion, the EU Commission is planning strict requirements for the definition of "green" electricity-based fuels (Stiftung Umweltenergierecht 2021; see GO4I Fundamentals Report 4, Sakhel and Styles 2021). PPAs between the RES plants and the fuel production facilities are among

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[20] According to the EU Commission's proposal for a further development of RED II, Art. 25 RED II is to be revised to the effect that the target for the RES share in final energy consumption in the transport sector is replaced at the EU level by a target for GHG intensity reduction through the use of RES (European Commission 2021, p. 41).

the requirements. It is **still unclear to what degree the cancellation of GOs with certain qualities will form part of the verification process**. It is also not yet clear whether these requirements will eventually be extended to the grid-based electricity supply of rail and road transport.

In the German **GHG reduction quota,** which is anchored in the Federal Immission Control Act (Bundes-Immissionsschutzgesetz, BImSchG), the **origin or renewable property of the electricity used in e-mobility does not play a role for its eligibility for the quota**. To determine the GHG emissions of the electricity, the energy consumed in electric road vehicles is multiplied by the average GHG emissions per energy unit of electricity in Germany, plus an efficiency adjustment factor (§ 5(2) 38th BImSchV).[21] The GHG reduction contribution of electromobility improves as the share of RES in the German electricity mix increases. However, no verification procedure is envisaged that could be used to demonstrate fully RES-based electricity procurement for vehicle charging. Such a **verification procedure would, however, be a prerequisite for providing incentives for charging point operators to contribute to RES expansion via direct connection-based or grid-based RES purchase**. For selected electricity-based fuels mentioned in the 37th BImSchV, specific GHG emission values for renewable fuels can be used if only electricity from non-biogenic RES was used in producing the fuel (especially if the electricity is bought from off-grid power plants; see § 3 37th BImSchV; Generalzolldirektion 2021b).[22] An ordinance shall define in more detail how proof of the RES property of the electricity is to be provided for the production of hydrogen and other electricity-based fuels (cf. BT-Drucksache 19/29850; BT-Drucksache 19/27435).

The **role of GOs could be expanded to demonstrate a higher share of RES than contained in the national electricity mix when electricity for e-mobility is purchased from the grid**. However, in order to count towards the RES expansion target for the transport sector or the GHG reduction quota, it would make sense to impose additional qualitative requirements on the GOs used. In particular, it is important to **avoid merely shifting the attribution of RES from the electricity sector to the transport sector** (see also Timpe et al. 2017). To this end, the **criterion of additionality** should be observed to ensure that increasing electricity use for e-mobility contributes to RES expansion. Additionality requirements have already been formulated, for example, by labels that certify green electricity products (for a detailed discussion, see GO4I Fundamentals Report 3, Werner 2021). For instance, based on the information contained in GOs, eligibility could be limited to electricity from relatively new and

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[21] Ordinance on the Establishment of Further Provisions for the Reduction of Greenhouse Gas Emissions from Fuels (38th Bundes-Immissionsschutzverordnung, BImSchV) of 8 December 2017 (Federal Law Gazette I, p. 3892), last amended by Art. 1 of the Ordinance of 21 May 2019 (Federal Law Gazette I, p. 742).

[22] Thirty-seventh Ordinance on the Implementation of the Federal Immission Control Act (Ordinance on the Crediting of Electricity-Based Fuels and Co-Processed Biogenic Oils to the Greenhouse Gas Quota, 37th BImSchV) of 15 May 2017 (Federal Law Gazette I, p. 1195), last amended by Art. 20 of the Act of 21 December 2020 (Federal Law Gazette I, p. 3138).

unsupported plants. Regarding contributions to the national transport sector RES target, it would also make sense to restrict eligibility to GOs from domestic plants.

In principle, the **delegated act on the methodological implementation of Art. 27(3) RED II for hydrogen and other electricity-based fuels** could also form a basis for formulating requirements for the verification of renewable electricity supply to charging points via the grid. Information on plant location could support the verification of a spatial connection between electricity generation and consumption for the charging of electric vehicles. Similarly, hourly or quarter-hourly time stamps for GOs could demonstrate a temporal connection between generation and consumption. However, it is necessary to **weigh up the benefits against the administrative effort of providing such proof. In e-mobility, electricity consumption is much more dispersed than with the production of electricity-based fuels**. Also, the latter entails considerable conversion losses (see e.g. IRENA 2020), so that from an **energy efficiency point of view, the direct use of electricity in final consumption applications is preferable** wherever it is technically and economically possible. To ensure that fuel production plants are located and operated in a manner that is energy transition-compatible, it can therefore make sense to impose stricter requirements on the production of electricity-based fuels with regard to the temporal and spatial correlation of RES production and consumption than on the direct use of electricity in e-mobility. Nevertheless, the increasing electricity demand for e-mobility must also promote the expansion of RES. **GOs that meet the additionality criterion could be an option for verification here**.

3.3 Statistical or monitoring purposes

Art. 19(2) RED II clarifies that GOs have no impact on compliance with the EU RES target under Art. 3 or on the calculation of gross final consumption of RES under Art. 7 (see Section 3.2.4). **However, data on GO issuance can support national RES statistics and the monitoring of RES expansion**. Yet this function is limited by the fact that member states only have to issue GOs at the request of RES producers (Art. 19(2) RED II). Thus, GOs do not provide a complete picture of RES production. In particular, if member states decide not to issue GOs for state-supported RES production, only a comparatively small section is covered. Therefore, as a rule, **GOs can at most provide additional information for statistical assessments.** For example, issuing non-transferable GOs for the self-supply of electricity, where data availability is poorer than for grid supply, could facilitate estimates. **GO systems can play a larger role in supporting RES statistics and energy transition monitoring processes in a full disclosure framework.** This option is briefly presented below, along with the **question of dealing with storage and grid losses in the GO system** for a transparent tracking of energy origins.

3.3.1 Full disclosure of energy origins

Austria, Switzerland and the Netherlands require a **mandatory full disclosure of electricity origins.** Electricity suppliers must use GOs to demonstrate to their customers the composition of their energy sources (Güldenberg et al. 2019, p. 204 ff.; RECS 2020).[23] In these countries, GOs are issued for both renewable and non-renewable energy sources. The data thus generated can be used for national energy statistics. Basically, three types of full disclosure can be distinguished (according to RECS 2020): (1) In the case of **full disclosure of energy production,** every producer, regardless of the energy source and production technology, is issued a GO for each MWh produced. (2) In the case of **full disclosure of energy consumption,** a GO must be cancelled for each MWh consumed, thus establishing full transparency regarding the renewable or non-renewable origin of the energy purchased. The GO can be cancelled by the consumers themselves or by their energy suppliers on their behalf. A sub-form of full disclosure of consumption is (3) **full disclosure of energy supply**, where energy suppliers must disclose the origin of all energy deliveries by cancelling GOs.

Maximum transparency of energy origins could be achieved if **mandatory full disclosure of production and consumption** were combined (Laven 2019). Besides these **transparency gains,** however, the **administrative costs** of implementing such a system must also be considered. Further developments in the IT infrastructure of the energy sector may help to reduce the implementation effort (e.g. through the use of smart meters in combination with automated GO issuance). Market observers estimate that full disclosure in the Netherlands, Austria and Switzerland is contributing to an increasing demand for RES GOs (ECOHZ 2021).

3.3.2 Treatment of storage and transmission losses in the GO system

If GOs are used for statistical or RES expansion monitoring purposes, the treatment of storage and transmission losses in the GO system must be clarified. This issue is also relevant when GOs are merely used for consumer information. According to the "book and claim" principle, GOs are issued for energy production and cancelled for final consumption. **Transmission and storage processes are not by default taken into account in the verification system.** However, as the share of GO-certified RES increases, the handling of losses in the GO system becomes more relevant (Cornélis and Lenzen 2020, p. 6). Losses incurred during transmission and storage mean that a MWh generated from RES is not fully available for withdrawal from the grid. In the marketing of electricity, for example, transmission system operators must procure loss energy to compensate for grid losses. By contrast, grid losses are frequently not taken into account when marketing green attributes via GOs (Cornélis and

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[23] GOs can also be issued for non-renewable energy independently of full disclosure. In Sweden, 95% of the electricity generation capacity is voluntarily registered for GO issuance without full disclosure being mandatory (RECS 2020).

Lenzen 2020, p. 6). The German electricity GO system for instance does not currently support a GO cancellation for grid losses (Styles et al. 2021b).

The consequence of this omission can be illustrated by the thought experiment of an EU-wide full disclosure system. If GOs were issued for every – renewable or non-renewable – MWh of electricity fed into the grid and GOs were cancelled for every MWh delivered to end customers, GO issuance would exceed cancellation. Surplus GOs with the least valued characteristics would likely expire – their characteristics would be absorbed into the residual energy mix. This **"residual" of properties not explicitly tracked from generation to consumption would be implicitly allocated to the transmission and storage losses**. To avoid the creation of a residual energy mix, the Dutch full disclosure system for example generally requires electricity suppliers to prove the origin of their supply by cancelling GOs for renewable or non-renewable energy sources, including the delivery of electricity to cover the loss energy of electricity grid operators (see Styles et al. 2021b, p. 12 f.). Similarly to other consumers, Dutch grid operators can likewise procure and cancel GOs themselves.

As the share of explicitly tracked RES in the energy mix increases, even without full disclosure, the challenge arises that the residual energy mix of properties not explicitly tracked becomes smaller and increasingly dominated by non-renewable energy. Disclosing the properties of grid and storage losses could therefore help to strengthen the **transparency of the GO and electricity disclosure system,** as it would ensure a clear allocation of RES attributes to energy consumption. Particularly in the case of energy carriers with comparatively high transmission and storage loss rates, such as heating or cooling, taking losses into account in GO systems can be important to ensure a high credibility of consumer information (Klimscheffskij et a. 2020, p. 45).

One **possibility for taking transmission and storage losses into account in the GO system** is to treat losses as consumption and to allow the origin of that energy to be disclosed by GO cancellation (see Verwimp et al. 2020, p. 28; Klimscheffskij et a. 2020, p. 26). In Germany, the cancellation of GOs for the loss energy of electricity grid operators would require an adjustment of the regulatory framework (Styles et al. 2021b). A topic for further analysis is whether disclosure obligations should be extended to transmission and storage losses in a further development of disclosure rules, or whether the disclosure of RES shares through GO cancellation should be allowed on a voluntary basis. In the case of full disclosure, taking losses into account becomes necessary in order to prevent the calculation of a residual mix and to enable a comprehensive tracking of energy attributes.

4. Conclusion: Challenges and opportunities from expanding the scope of GOs

Both RED II and the German electricity GO scheme emphasise the role of GOs as a consumer information tool. This will become highly relevant for industry in its **efforts towards verified climate neutrality.** In the electricity sector, the development of the EEG towards budget-financed support raises the question of **whether GOs and the marketing of green electricity should play a stronger role in driving RES expansion in the future** – not just as a source of income for post-EEG plants and in the context of non-supported direct marketing, but also as a market-based remuneration component for supported new plants. With the wider application of GOs as envisaged in RED II, the **question of how GOs fit into the energy policy instrument mix also arises for the energy carriers gas and heating/cooling**. Here, as with electricity, policy decisions must be made as to whether the focus of GOs should continue to be merely to inform consumers and to enable the trade in green attributes, or whether additional purposes should be pursued. One may conceive in particular of supporting roles for the promotion of RES expansion, the implementation of other energy policy instruments, and the generation of data for monitoring the energy transition.

It should be noted that **these different applications each entail different requirements for the instrumental scope of GOs and the design of GO systems**. Synergies, as well as trade-offs, may exist between different uses and purposes of GOs. Synergies, for example, can arise with regard to using a common data basis for GO issuance and promotion systems. Different requirements for the instrumental performance of GOs are particularly evident regarding the **extent to which certain purposes imply certain qualitative demands on GOs, particularly with regard to a coupling of the delivery of GOs and energy**. Tracking the actual physical path that the energy takes through grids is not feasible. On the other hand, balancing group coupling, temporal coupling of production and consumption, or the inclusion of grid information on GOs (e.g. for heating/cooling GOs) would be possible and may serve to better reflect the spatial and temporal connection between energy production and consumption. While balancing group coupling of the delivery of energy and its green attributes is already offered as "optional coupling" for electricity GOs in the UBA’s HKNR, this option has not been used much so far. Other options, e.g. the integration of hourly or quarter-hourly time stamps, would require a further development of the GO system. GOs with time stamps could, for example, serve as a verification tool for companies that aim to optimise their product carbon footprints by scheduling their production when the availability of RES is high.

The example of heating/cooling can illustrate the **conflicts of objectives that may arise in the instrumental design of GO systems**. For example, the objective of ensuring credibility for consumers could argue for not allowing the cancellation of GOs from unconnected heating/cooling grids for disclosure purposes. While in the case of gas and electricity grids, the cancellation of GOs from the European internal market also represents an abstraction from actual grid connections, heating/cooling is only traded locally.[24] If regulatory or subsidy rules require a physical connection between generation and consumption, this would result in a similar requirement for proof of grid connections between production devices and consumers. If, on the other hand, the cost-efficient expansion of RES is the primary objective, this would suggest also allowing the cancellation of GOs from unconnected heating/cooling grids: Not only do the costs of RES expansion differ in individual grids, but the demand and additional willingness to pay of the connected users can also be expected to differ. If GOs can be sold without a physical connection to the place of consumption, district heating suppliers that invest in RES generation could reap refinancing contributions even if there is no significant demand for green heat in their grid. In this case, renewable district heating capacities would be incentivised to grow most rapidly where the costs are at their lowest. This could be driven, for example, by a quota system in which GOs are used as a commodity. However, if GOs were simultaneously to be used as a consumer information tool, a high degree of transparency would have to be ensured in communicating the origin of the heat to consumers in order to convey what proportion of the renewable attributes originates from their own grid. Otherwise the credibility of the system would be jeopardised.[25]

Such trade-offs also arise for other objectives. A coupling of the delivery of electricity and GOs can for example strengthen the credibility of GOs for consumers but at the same time weaken the financing function of GOs for RES plants. For plant operators, the option to sell GOs separately from the electricity means a potential income stream that is independent of the electricity market, which contributes to risk diversification. On the other hand, the **increased use of long-term supply contracts such as PPAs opens up new perspectives for a contractual coupling of the supply of energy and GOs**, which could yield more stable revenues from the sale of green attributes.

Going forward, a possibility would be to **define a set of requirements regarding the properties of GOs for each of their intended use cases** – with regard to the coupling of energy and GO delivery, but also, for example, with regard to properties such as plant age or support status. In the example of district heating, there could for instance be a rule that for disclosure purposes only GOs could be used where a grid connection between producers and consumers exists, while GOs from unconnected grids could be accepted as evidence of meeting a RES quota. However, this increases the complexity of the verification system, which necessitates a high degree of transparency in explaining the use of GOs for various purposes (or the introduction of different types of GOs). Alternatively, **different verification systems may be devised for different regulatory purposes** – e.g. for gases, mass balancing for the recognition of grid-based supply as a regulatory compliance option and GOs as a pure consumer

[24] At the local level, there may nevertheless be grid interconnections, including cross-border ones.

[25] In particular, credibility would suffer if in grids dominated by fossil heat generation plants, the disclosure heavily relies on GOs from pre-existing RES plants from unconnected grids. Then the demand for green district heating would not incentivise the expansion of RES in any grid.

information tool. However, **any such parallel systems require coordination**. On the one hand, there is the **practical requirement to keep the cost of verification through multiple systems low**. For example, it would be costly if plants had to undergo several audit processes for different systems. On the other hand, avoiding any double marketing of green properties would require reconciliation between the different verification registries.

Moreover, to properly define the requirements for GO properties is not just crucial when GOs are increasingly used for the market-driven support of RES expansion or to promote the enforcement of energy policy instruments. **A qualitative differentiation of GO demand** will also be helpful in the context of the established GO functions of consumer information and enabling the trading of renewable attributes. An increased differentiation of demand by GO quality is likely to help strengthen the value of green characteristics, thereby providing additional demand-side impetus for the energy transition. Such differentiation will also allow industrial renewable electricity consumers to choose their desired bundle of green attributes, e.g. regarding the energy sources and technologies or the age and support status of the plants. For example, the UBA's HKNR offers electricity suppliers the option of receiving cancellation certificates that provide information on which GOs with which properties have been cancelled for a specific electricity product or customer (§ 30 (3) HkRNDV). For industrial consumers, it may be of increasing interest to note the quality of the green electricity they procure in their climate reporting. Finally, potential for further development also exists in the context of electricity disclosure rules in order to increase transparency for private and industrial consumers.

In sum, expanding the scope of GOs as part of the renewable energy policy mix entails both **new opportunities and challenges**. While additional purposes can harbour synergies, strengthening one function can weaken another, which is why **the purpose for which GOs are to be used must be clearly defined**. Instrumentally incompatible objectives should be avoided wherever possible.

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Agora Energiewende, 2019. The liberalisation of electricity markets in Germany – history, development and current status. Berlin. https://static.agora-energiewende.de/fileadmin/Projekte/2019/Liberalisation_Power_Market/Liberalisation_Electricity_Markets_Germany_V1-0.pdf.

AIB (Association of Issuing Bodies), 2020. Transforming. Annual Report 2019. Brussels. www.aib-net.org/sites/default/files/assets/news-events/annual-reports/AIB%20Annual%20Report%202019%20web.pdf.

AIB, 2021a. European Residual Mixes. Results of the calculation of Residual Mixes for the calendar year 2020. Brussels. www.aib-net.org/sites/default/files/assets/facts/residual-mix/2020/AIB_2020_Residual_Mix_Results.pdf.

AIB, 2021b. Activity statistics. AIB Monthly Statistics, completed on 8 April 2021. www.aib-net.org/facts/market-information/statistics/activity-statistics-all-aib-members.

AIB, 2021c. Auctions for Guarantees of Origin (GOs) in Portugal. AIB NEWS – 19 August 2021. www.aib-net.org/newsletter/web.html?n2g=exu6l9s3-iic2tv37-1cg2#Portugal.

Azar, C., Sandén, B.A., 2011. The elusive quest for technology-neutral policies. Environmental Innovation and Societal Transitions, 1(1), 135–139.

BDEW (Bundesverband der Energie- und Wasserwirtschaft), 2021. Leitfaden Stromkennzeichnung. Umsetzungshilfe für Elektrizitätsversorgungsunternehmen, Erzeuger und Lieferanten von Strom zu den Bestimmungen über die Stromkennzeichnung (§ 42 Abs. 1-8 EnWG i. V. m. §§ 78 und 79 EEG). Gültig ab dem Bilanzierungsjahr 2020. Berlin. www.bdew.de/media/documents/210801_Leitfaden_Stromkennzeichnung_2021.pdf.

BLE (Bundesanstalt für Landwirtschaft und Ernährung), 2010. Leitfaden Nachhaltige Biomasseherstellung. Bonn. www.ble.de/SharedDocs/Downloads/DE/Klima-Energie/Nachhaltige-Biomasseherstellung/LeitfadenNachhaltigeBiomasseherstellung.pdf?__blob=publicationFile&v=1.

BloombergNEF, 2021. Corporate clean energy buying grew 18% in 2020, despite mountain of adversity. Post of 26.01.2021. https://about.bnef.com/blog/corporate-clean-energy-buying-grew-18-in-2020-despite-mountain-of-adversity.

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit), 2012. Auslegungshilfe zur Massenbilanzierung nach § 27c Absatz 1 Nummer 2 EEG 2012. Zugleich: Anwendungshinweis zum Vollzug des EEWärmeG, hier: Massenbilanzierung von Biomethan. www.clearingstelle-eeg-kwkg.de/sites/default/files/BMU_Auslegunghilfe_Massenbilanzierung.pdf.

BMWi (Bundesministerium für Wirtschaft und Energie), 2020. EEG-Umlage 2021: Fakten & Hintergründe. www.bmwi.de/Redaktion/DE/Downloads/E/zahlen-und-fakten-eeg-umlage.pdf?__blob=publicationFile&v=4.

BMWi, 2021a. Entwurf Förderrichtlinie BEW, Stand 16.07.2021: Richtlinie für die Bundesförderung für effiziente Wärmenetze. Entwurf des Bundesministeriums für Wirtschaft und Energie (BMWi).

BMWi, 2021b. Richtlinien zur Bundesförderung für effiziente Gebäude (BEG). www.deutschland-machts-effizient.de/KAENEF/Redaktion/DE/FAQ/FAQ-Uebersicht/Richtlinien/bundesfoerderung-fuer-effiziente-gebaeude-beg.html.

Bowe, S., 2013. 19 – Market development and certification schemes for biomethane. In: A. Wellinger, J. Murphy, D. Baxter (eds.). The Biogas Handbook. Woodhead Publishing, 444–462.

Bowe, S., Girbig, P., 2021. Verification systems for renewable energy. GO4Industry project report (Fundamentals, Part 1), sponsored by BMU (FKZ: UM20DC003). GreenGasAdvisors, Berlin. https://go4industry.com.

BR-Drucksache 310/21 vom 15.04.21. Verordnung des Bundesministeriums für Wirtschaft und Energie. Verordnung zur Umsetzung der Vorgaben zu Fernwärme und Fernkälte in der Richtlinie (EU) 2018/2002 sowie in der Richtlinie (EU) 2018/2001. https://dserver.bundestag.de/brd/2021/0310-21.pdf.

BR-Drucksache 310/21 (Beschluss) vom 25.06.21. Beschluss des Bundesrates. Verordnung zur Umsetzung der Vorgaben zu Fernwärme und Fernkälte in der Richtlinie (EU) 2018/2002 sowie in der Richtlinie (EU) 2018/2001. www.bundesrat.de/SharedDocs/drucksachen/2021/0301-0400/310-21(B).pdf?__blob=publicationFile&v=1.

BR-Drucksache 578/21 vom 25.06.21. Gesetzesbeschluss des Deutschen Bundestages. Gesetz zur Umsetzung unionsrechtlicher Vorgaben und zur Regelung reiner Wasserstoffnetze im Energiewirtschaftsrecht. www.clearingstelle-eeg-kwkg.de/sites/default/files/2021-06/210625_BR_Entwurf_Gesetzesbeschluss_Wasserstoff_BR-Drs_578-21.pdf.

BT-Drucksache 19/16716 vom 22.01.2020. Gesetzentwurf der Bundesregierung. Entwurf eines Gesetzes zur Vereinheitlichung des Energieeinsparrechts für Gebäude. https://dserver.bundestag.de/btd/19/167/1916716.pdf.

BT-Drucksache 19/27435 vom 09.03.2021. Gesetzentwurf der Bundesregierung. Entwurf eines Gesetzes zur Weiterentwicklung der Treibhausgasminderungs-Quote. https://dserver.bundestag.de/btd/19/274/1927435.pdf.

BT-Drucksache 19/27453 vom 09.03.2021. Gesetzentwurf der Bundesregierung. Entwurf eines Gesetzes zur Umsetzung unionsrechtlicher Vorgaben und zur Regelung reiner Wasserstoffnetze im Energiewirtschaftsrecht. www.clearingstelle-eeg-kwkg.de/sites/default/files/2021-04/Gesetzentwurf_BReg_210309.pdf.

BT-Drucksache 19/29850 vom 19.05.2021. Beschlussempfehlung und Bericht des Ausschusses für Umwelt, Naturschutz und nukleare Sicherheit. https://dserver.bundestag.de/btd/19/298/1929850.pdf.

Bundesregierung, 2021. Für eine sichere Stromversorgung: Neues Kabel verbindet Deutschland und Norwegen. www.bundesregierung.de/breg-de/suche/nordlink-1917818.

CEER (Council of European Energy Regulators), 2015. CEER Advice on customer information on sources of electricity. Brussels. www.ceer.eu/documents/104400/-/-/8207e038-1312-a790-c1c1-8b2fd7ac58c9.

CEER, 2021. Status review of renewable support schemes in Europe for 2018 and 2019. Brussels. www.ceer.eu/documents/104400/-/-/ffe624d4-8fbb-ff3b-7b4b-1f637f42070a.

CertiQ, 2018. EECS Electricity Domain Protocol for the Netherlands. Arnhem. www.aib-net.org/sites/default/files/assets/facts/domain-protocols/Netherlands%2025-05-2018%20v3.4.pdf.

CertiQ, 2021. Trading in certificates. www.certiq.nl/faq.

Claas-Reuther, J., 2021. Rechtliche Rahmenbedingungen für die Vermarktung Grüner Fernwärme. Präsentation bei den Berliner ENERGIETAGEN 2021, 28.04.2021. www.energietage.de/event/702-herkunftsnachweise-fuer-gruene-fernwaerme.html.

Cropex (Croation Power Exchange), 2021. Guarantees of Origin: GOs Auction Results. www.cropex.hr/en/guarantees-of-origin/rezultati-drazbi-jamstava-podrijetla.html.

Daniel-Gromke, J., Rensberg, N., Denysenko, V., Barchmann, T., Oehmichen, K., Beil, M., Beyrich, W., Krautkremer, B., Trommler, M., Reinholz, T., Vollprecht, J., Rühr, C., 2020. Optionen für Biogas-Bestandsanlagen bis 2030 aus ökonomischer und energiewirtschaftlicher Sicht. Abschlussbericht im Auftrag des Umweltbundesamtes. Texte 24/2020. Umweltbundesamt, Dessau-Roßlau. www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-01-30_texte_24-2020_biogas2030.pdf.

David, L., Feng, C., 2019. GO Monitoring 2018 Report: Development of the Guarantees of Origin Market 2009-2018. RECS, VaasaETT. https://recs.org/download/?file=go-monitoring-2018-report.pdf&file_type=documents.

ECOHZ, 2021. A paradigm shift in the making for renewable energy demand? Post of 29.04.2021. www.ecohz.com/press-releases/a-paradigm-shift-in-the-making-for-renewable-energy-demand.

EEX (European Energy Exchange), 2021. French Auctions for Guarantees of Origin. www.eex.com/en/services/registry-services/french-auctions-for-guarantees-of-origin.

E&M, 2021. 16. Ökostromumfrage. Energie & Management, July 1st, 2021, 9–19.

Energimyndigheten, 2021. CESAR: Information – Om Elcertifikatssystemet – Om Ursprungsgarantisystemet. https://cesar.energimyndigheten.se/Lists/PublicPages/Info.aspx.

EnergyTag, 2021. EnergyTag and granular energy certificates: Accelerating the transition to 24/7 clean power. The EnergyTag Initiative, London. www.energytag.org/wp-content/uploads/2021/05/EnergyTag-and-granular-energy-certificates.pdf.

Engelmann, P., Köhler, B., Meyer, R., Dengler, J., Herkel, S., Kießling, L., Quast, A., Berneiser, J., Bär, C., Sterchele, P., Heilig, J., Bürger, V., Köhler, B., Braungardt, S., Hesse, T., Sandrock, M., Maaß, C., Strodel, N., 2021. Systemische Herausforderung der Wärmewende. Abschlussbericht im Auftrag des Umweltbundesamtes. Climate Change 18/2021. Umweltbundesamt, Dessau-Roßlau. www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-04-26_cc_18-2021_waermewende.pdf.

European Commission, 2021. 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. COM(2021) 557 final. Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0557.

European Parliament, 2021. Legislative train schedule: A European Green Deal. Revised regulatory framework for competitive decarbonised gas markets/before 2022-01. www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revised-regulatory-framework-for-competitive-decarbonised-gas-markets.

FaStGO, 2020. Draft revision proposal for the EN16325 standard on guarantees of origin related to energy based on the original text: EN 16325 (2013+A1:2015) (Task 2.2). Technical support for RES policy development and implementation for the European Commission. FaStGO – Facilitating Standards for Guarantees of Origin. www.aib-net.org/news-events/aib-projects-and-consultations/fastgo/project-deliverables.

Fingrid, 2021. Guarantees of Origin: Frequently asked questions. www.fingrid.fi/en/electricity-market/guarantees-of-origin/frequently-asked-questions.

Gawel, E., Lehmann, P., Purkus, A., Söderholm, P., Witte, K., 2017. Rationales for technology-specific RES support and their relevance for German policy. Energy Policy, 102, 16–26.

Generalzolldirektion, 2021a. Treibhausgasquote (THG-Quote). www.zoll.de/DE/Fachthemen/Steuern/Verbrauchsteuern/Treibhausgasquote-THG-Quote/treibhausgasquote_thg_quote_node.html.

Generalzolldirektion, 2021b: Anrechnung von Elektromobilität und strombasierten Kraftstoffen. www.zoll.de/DE/Fachthemen/Steuern/Verbrauchsteuern/Treibhausgasquote-THG-Quote/Quotenverpflichtung/Erfuellung-Quotenverpflichtung/Anrechnung-Elektromobilitaet-strombasierte-Kraftstoffe/anrechnung-elektromobilitaet-strombasierte-kraftstoffe.html?nn=294356.

GME (Gestore dei Mercati Energetici), 2021. GSE GO auctions. Session date 21 June 2021. www.mercatoelettrico.org/En/Tools/Accessodati.aspx?ReturnUrl=%2fEn%2fEsiti%2fGO%2fEsitiGOAste.aspx.

Greenfact, 2021. New Norwegian government proposes the removal of the GO system. Post of Oktober 14, 2021. www.greenfact.com/News/1643/New-Norwegian-government-proposes-the-removal-of-the-GO-system.

Güldenberg, J., Maaß, C., Mundt, J., Werner, R., 2019. AP 2: Analyse des HKN-Handels und der Preise. In: E. Hauser, S. Heib, J. Hildebrand, I. Rau, A. Weber, J. Welling, J. Güldenberg, C. Maaß, J. Mundt, R. Werner, A. Schudak, T. Wallbott (eds.), Marktanalyse Ökostrom II – Marktanalyse Ökostrom und HKN, Weiterentwicklung des Herkunftsnachweissystems und der Stromkennzeichnung. Abschlussbericht im Auftrag des Umweltbundesamtes. Umweltbundesamt, Dessau-Roßlau, 181–228. www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-08-15_cc_30-2019_marktanalyse_oekostrom_ii.pdf.

Hamburg Institut, 2021. Ziel des Teilvorhabens „Grüne Fernwärme“. www.iw3-hamburg.de/projektpartner/#HIR.

Hilpert, J., 2018. Rechtliche Bewertung von Power Purchase Agreements (PPAs) mit erneuerbaren Energien. Würzburger Studien zum Umweltenergierecht Nr. 12. Stiftung Umweltenergierecht, Würzburg. https://stiftung-umweltenergierecht.de/wp-content/uploads/2019/02/Stiftung_Umweltenergierecht_WueStudien_12_PPA.pdf.

Hoffmann, B., 2020. Grüner Strom im Kraftstoffmarkt – Was bringt die RED II?, Zeitschrift für Neues Energierecht, 24(4), 300–306.

HROTE (Croatian Energy Market Operator), 2021. Guarantees of Origin auctions. www.hrote.hr/guarantees-of-origin-auctions.

Hulshof, D., Jepma, C., Mulder, M., 2019. Performance of markets for European renewable energy certificates. Energy Policy, 128, 697–710.

ILR (Institut Luxembourgeois de Régulation), 2021. ILR auctioning platform for guarantees of origin (GOs): Auction Results. https://auction.grexel.com/ilr/sv/public/auctionResults.

IRENA (International Renewable Energy Agency), 2020. Green Hydrogen: A guide to policy making. Abu Dhabi. www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Green_hydrogen_policy_2020.pdf.

Jacobsson, S., Bergek, A., 2011. Innovation system analyses and sustainability transitions: Contributions and suggestions for research. Environmental Innovation and Societal Transitions, 1(1), 41–57.

Kahl, H., Kahles, M., 2020. Das Doppelvermarktungsverbot zwischen Verbraucherschutz und Grünstrombedarf der Industrie. Neue Rechtslage und Reformoptionen. Würzburger Berichte zum Umweltenergierecht Nr. 50. Stiftung Umweltenergierecht, Würzburg. https://stiftung-umweltenergierecht.de/wp-content/uploads/2020/08/Stiftung_Umweltenergierecht_WueBerichte_50_Doppelvermarktungsverbot.pdf.

Klimscheffskij, M., White, A., Verwimp, K., Moody, P., Desaulniers, A., Timlin-de Vicente, M., Matosic, M., Standera, M., Switten, L., 2020. The development of systems for EU based market supervision statistics (Task 4.1). Technical support for RES policy development and implementation for the European Commission. FaStGO – Facilitating Standards for Guarantees of Origin. www.aib-net.org/news-events/aib-projects-and-consultations/fastgo/project-deliverables.

Kuronen, A., 2021. Does GO system add value to energy transition? Post from 17.03.2021. https://grexel.com/does-go-system-add-value.

Lehtovaara, M., Morvan, M., Mohammedi, M., Strunski, D., 2021. Auctioning Guarantees of Origin: Bringing transparency and liquidity together. Presentation at EEX Group Digital Conference 2021, Building Markets Together, 15.04.21. https://eex.weblive.events/pdf/1_Auctioning%20GOs_Bringing%20Transparency%20and%20Liquidity%20Together.pdf

Maaß, C., 2016. Kurzfristig umsetzbare Option zur Verbesserung der Stromkennzeichnung. Kurzgutachten für LichtBlick SE. Hamburg Institut, Hamburg. www.hamburg-institut.com/wp-content/uploads/2021/07/Lichtblick-Stromkennzeichnung_2016.pdf.

Maaß, C., Claas-Reuther, J., Purkus, A., 2020. Herkunftsnachweise für Strom aus neuen EEG-finanzierten Anlagen. Gesetzentwurf im Auftrag von LichtBlick SE. Hamburg Institut, Hamburg. www.hamburg-institut.com/wp-content/uploads/2021/06/Herkunftsnachweise_fuer_Strom_aus_neuen_EEG-Anlagen.pdf.

Maaß, C., Pehnt, M., 2019. Neue politische Instrumente zur Dekarbonisierung der Fernwärme. In: Agora Energiewende (ed.). Wie werden Wärmenetze grün? Dokumentation zur Diskussionsveranstaltung am 21. Mai 2019 auf den Berliner Energietagen 2019. Agora Energiewende, Berlin, 21–29. https://static.agora-energiewende.de/fileadmin/Projekte/2019/Waermenetze/155_Waermenetze_WEB.pdf.

Maaß, C., Praetorius, B., 2015. Wie kommt Ökostrom zum Verbraucher? Eine Analyse von Stand und Perspektiven des Direktvertriebs von gefördertem Erneuerbare-Energien-Strom. Agora Energiewende, Berlin. https://static.agora-energiewende.de/fileadmin/Projekte/2014/direktvermarktung-von-gruenstrom/Agora_Oekostrom_zum_Verbraucher_web.pdf.

Maaß, C., Güldenberg, J., Mundt, J., Werner, R., Kahles, M., 2017. Theoretische Fundierung der Regionalen Grünstromkennzeichnung. Studie im Auftrag des Umweltbundesamtes. CLIMATE CHANGE 17/2017. Umweltbundesamt, Dessau-Roßlau. www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2017-06-19_climate-change_17-2017_gruenstromkennzeichnung.pdf.

Maaß, C., Werner, R., Häseler, S., Mundt, J., Güldenberg, J., 2019. Ökostrommarkt 2025. Wie eine intelligente Steuerung des Ökostrommarktes die Energiewende beschleunigt. Im Auftrag von LichtBlick SE. Hamburg Institut, Hamburg. www.hamburg-institut.com/wp-content/uploads/2021/06/1904_Studie_HAMBURG_INSTITUT_Oekostrommarkt_2025.pdf.

Ministère de la Transition écologique, 2021. Ordonnance n° 2021-167 du 17 février 2021 relative à l'hydrogène (NOR : TRER2018536R). Journal officiel électronique authentifié n° 0042 du 18/02/2021, Texte n° 2. www.legifrance.gouv.fr/jorf/id/JORFTEXT000043148001.

Mundt, J., Werner, R., Maaß, C., 2019. AP 4: Ausweisung der Umweltwirkung durch Strombezug von Unternehmen und öffentlicher Hand. In: E. Hauser, S. Heib, J. Hildebrand, I. Rau, A. Weber, J. Welling, J. Güldenberg, C. Maaß, J. Mundt, R. Werner, A. Schudak, T. Wallbott (eds.). Marktanalyse Ökostrom II – Marktanalyse Ökostrom und HKN, Weiterentwicklung des Herkunftsnachweissystems und der Stromkennzeichnung. Abschlussbericht im Auftrag des Umweltbundesamtes. Umweltbundesamt, Dessau-Roßlau, 317–383. www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-08-15_cc_30-2019_marktanalyse_oekostrom_ii.pdf.

Mundt, J., Claas-Reuther, J., Maaß, C., Wallbott, T., Dohles, N., Pospiech, M., Rüter, T., 2021. Ausweisung von regionalem Grünstrom in der Stromkennzeichnung. Abschlussbericht im Auftrag des Umweltbundesamtes. CLIMATE CHANGE 50/2021, Umweltbundesamt, Dessau-Roßlau. www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-06-30_cc_50-2021_ausweisung_regionaler_gruenstrom.pdf.

NCSL (National Conference of State Legislatures), 2021. State renewable portfolio standards and goals. Denver, CO/Washington, DC. www.ncsl.org/research/energy/renewable-portfolio-standards.aspx.

Netherlands Enterprise Agency, 2020. SDE++ 2020. Stimulation of sustainable energy production and climate transition. Commissioned by the Ministry of Economic Affairs and Climate Policy. Zwolle. https://english.rvo.nl/sites/default/files/2020/11/Brochure%20SDE%20plus%20plus%202020.pdf.

OMIP (Operador do Mercado Ibérico de Energia – Pólo Português), 2021. Auctions for Guarantees of Origin. www.omip.pt/en/auctions-GO.

Oslo Economics, 2018. Analysis of the trade in Guarantees of Origin. Economic Analysis for Energy Norway, OE-report 2017-58, Oslo.

Pehnt, M., 2020. Bundesförderprogramm Effiziente Wärmenetze (BEW). Präsentation beim 25. Dresdner Fernwärme-Kolloquium, Dresden, 27 Oktober 2020. www.ifeu.de/fileadmin/uploads/Pehnt-2020-BEW-AGFW.pdf.

Pototschnig, A., Conti, I., 2021. Upgrading Guarantees of Origin to promote the achievement of the EU renewable energy target at least cost. Research Project Report. European University Institute/Florence School of Regulation, Fiesole (FI). https://cadmus.eui.eu/bitstream/handle/1814/69776/QM-03-21-034-EN-N.pdf?sequence=3.

Purkus, A., 2021. Ausgestaltungsoptionen für ein Pilot-Herkunftsnachweissystem für Wärme und Kälte. Präsentation bei den Berliner ENERGIETAGEN 2021, 28.04.2021. www.energietage.de/event/702-herkunftsnachweise-fuer-gruene-fernwaerme.html.

RECS, 2021a. The supply & demand of certified European renewable electricity. RECS International Secretariat. https://recs.org/download/?file=The-supply-demand-of-European-renewable-energy_FINAL.pdf&file_type=documents.

RECS, 2021b. Swiss and UK GOs no longer eligible for export to the EU. https://recs.org/news/swiss-and-uk-gos-no-longer-eligible-for-export-to-the-eu.

REN (Rede Eléctrica Nacional), 2020. EECS Electricity Domain Protocol for Portugal. www.aib-net.org/facts/aib-member-countries-regions/domain-protocols.

RES Legal, 2019. Netherlands: Premium tariff (SDE+), Procedure. www.res-legal.eu/search-by-country/netherlands/single/s/res-e/t/promotion/aid/premium-tariff-sde/lastp/171.

Sakhel, A., Styles, A., 2021. Sectoral, legal and transnational interfaces in renewable energy verification systems. GO4Industry project report (Fundamentals, Part 4), sponsored by BMU (FKZ: UM20DC003). Hamburg Institut, Hamburg. https://go4industry.com.

Schudak, A., Wallbott, T., 2019. AP 3: Kundenerwartungen und Wirkung der Stromkennzeichnung. In: E. Hauser, S. Heib, J. Hildebrand, I. Rau, A. Weber, J. Welling, J. Güldenberg, C. Maaß, J. Mundt, R. Werner, A. Schudak, T. Wallbott (eds.). Marktanalyse Ökostrom II – Marktanalyse Ökostrom und HKN, Weiterentwicklung des Herkunftsnachweissystems und der Stromkennzeichnung. Abschlussbericht im Auftrag des Umweltbundesamtes. Umweltbundesamt, Dessau-Roßlau, 229–316. www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-08-15_cc_30-2019_marktanalyse_oekostrom_ii.pdf.

Seebach, D., Timpe, C., 2020. Echter Einfluss für Ökostromverbraucher. "Harte Zusätzlichkeit" in Märkten für erneuerbare Energie über die bestehenden politischen Ausbauziele hinaus. Diskussionspapier für den EnergieVision e.V., Deutsche Zusammenfassung. Öko-Institut, Freiburg. www.oeko.de/fileadmin/oekodoc/Harte-Zusaetzlichkeit-Kurzfassung.pdf.

Seebach, D., Timpe, C., Lucha, C., Prahl, A., Lehnert, W., Rühr, C., 2017. Verbesserte Ausweisung geförderter Strommengen aus erneuerbaren Energien im Rahmen der Stromkennzeichnung. Arbeitspapier im Auftrag des BMWi. Öko-Institut, Freiburg/Berlin. www.oeko.de/fileadmin/oekodoc/Weiterentwicklung-SKZ-EEG-2017.pdf.

SPD, BÜNDNIS 90/DIE GRÜNEN, FDP 2021. Mehr Fortschritt wagen. Koalitionsvertrag zwischen SPD, Bündnis 90/Die Grünen und FDP. https://www.bundesregierung.de/breg-de/service/gesetzesvorhaben/koalitionsvertrag-2021-1990800.

Stiftung Umweltenergierecht, 2021. Anforderung an die Produktion von grünem Wasserstoff. Ein Vergleich des Delegierten Rechtsakts und der Erneuerbare-Energien-Verordnung (EEV). Stand: 9. Juli 2021. Würzburg. https://stiftung-umweltenergierecht.de/wp-content/uploads/2021/07/Stiftung_Umweltenergierecht_Vergleich-del.-RA-und-EEV_Stand_2021-07-09.pdf.

Styles, A., Mundt, J., Gerlach, M.-J., Werner, R., 2021a. Entwertung von Herkunftsnachweisen für die Verlustenergie von Netzbetreibern: Auswirkungen auf den Herkunftsnachweismarkt. Gutachten im Auftrag der Schleswig-Holstein Netz AG und TenneT TSO GmbH. Hamburg Institut, Hamburg. www.hamburg-institut.com/projects/entwertung-von-herkunftsnachweisen-fuer-die-verlustenergie-von-netzbetreibern.

Styles, A., Claas-Reuther, J., Maaß, C, 2021b. Entwertung von Herkunftsnachweisen für die Verlustenergie von Netzbetreibern: Rechtliche und regulatorische Rahmenbedingungen. Gutachten im Auftrag der Schleswig-Holstein Netz AG und TenneT TSO GmbH. Hamburg Institut, Hamburg. www.hamburg-institut.com/projects/entwertung-von-herkunftsnachweisen-fuer-die-verlustenergie-von-netzbetreibern.

Timpe, C., Seebach, D., Bracker, J., Kasten, P., 2017. Improving the accounting of renewable electricity in transport within the new EU Renewable Energy Directive. Policy paper for Transport & Environment. Öko-Institut, Freiburg/Berlin. www.oeko.de/fileadmin/oekodoc/Improving-accounting-of-renewable-electricity-in-transport.pdf.

Umweltbundesamt, 2021. Bericht vom HKNR-Workshop zur optionalen Kopplung. HKNR-Newsletter 2/2021, 03.08.2021. Dessau-Roßlau. www.umweltbundesamt.de/sites/default/files/medien/376/dokumente/20210730_hknr_newsletter_2_2021_final.pdf.

Van Stein Callenfels, R., Verwimp, K., Moody, P., White, A., Klimscheffskij, M., Matosic, M., 2020. Takeaways from a consultation on text proposals for a revised CEN – EN 16325 standard on guarantees of origin (Task 2.3). Technical support for RES policy development and implementation for the European Commission. FaStGO – Facilitating Standards for Guarantees of Origin. www.aib-net.org/news-events/aib-projects-and-consultations/fastgo/project-deliverables.

Verwimp, K., Moody, P., Van Stein Callenfels, R., Kovacs, A., Vanhoudt, W., Barth, F., Pedraza, S., Lehtovaara, M., Klimscheffskij, M., White, A., 2020. Identification of the main challenges which currently exist in the management of guarantee of origin system (Task 1.3). Technical support for RES policy development and implementation for the European Commission. FaStGO – Facilitating Standards for Guarantees of Origin. www.aib-net.org/news-events/aib-projects-and-consultations/fastgo/project-deliverables.

Wallbott, T., Dohles, N., Mundt, J., 2021. Regionaler Grünstrom – Interesse und Ansprüche von Verbraucher*innen. Ergebnisse einer repräsentativen Verbraucherbefragung im Rahmen des Forschungsprojekts „Ausweisung von regionalem Grünstrom in der Stromkennzeichnung“. CLIMATE CHANGE 17/2021. Umweltbundesamt, Dessau-Roßlau. www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021-04-21_cc_17-2021_gruenstrom-verbraucherbefragung.pdf.

Werner, R. 2021. How guarantees of origin can accelerate the energy transition. GO4Industry project report (Fundamentals, Part 3), sponsored by BMU (FKZ: UM20DC003). Hamburg Institut, Hamburg. https://go4industry.com.

WRI (World Resources Institute), WBCSD (World Business Council for Sustainable Development), 2015. GHG Protocol Scope 2 Guidance – An amendment to the GHG Protocol Corporate Standard. Washington, DC/Geneva. https://ghgprotocol.org/sites/default/files/standards/Scope%202%20Guidance_Final_Sept26.pdf.