GUARANTEES OF ORIGIN FOR GREEN DISTRICT HEATING:

LEGAL FRAMEWORK AND DESIGN OPTIONS

Project report as part of the living labs for the energy transition
'IW³ – Integrierte WärmeWende Wilhelmsburg'

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TABLE OF CONTENTS

ABSTRACT

In the electricity market, Guarantees of Origin (GOs) are an established instrument for tracking energy attributes from production to consumption. The recast Renewable Energy Directive (RED II) from 2018 has extended the scope of GOs to gases and heating and cooling from renewable energy sources. This opens new perspectives for marketing green district heating and cooling (DHC) products – green price premiums could improve the business case of integrating renewables into DHC grids. However, GO systems need to be adapted to the technical, organisational, and regulatory framework of DHC markets. Also, there are uncertainties about what future role GOs could play in the legal framework for transforming DHC grids towards climate neutrality.

Design questions of implementing a DHC GO system and associated legal framework conditions are the focus of the research project 'Green District Heating', which forms part of the living labs for the energy transition 'IW^3 – Integrierte WärmeWende Wilhelmsburg' supported by the German Federal Ministry for Economic Affairs and Climate Action (BMWK). In this context, the Hamburg Institut has implemented a GO registry for green district heating as a pilot project for Germany, in cooperation with Grexel for the technical development, and analysed associated design questions. The project's aim is to generate experiences and recommendations for the design of national DHC GO systems.

This report presents the European and German legal framework conditions for marketing green DHC and introducing DHC GOs as an instrument for proving the green origin of thermal energy. As part of this, the different roles GOs could play in the transition of the heating sector towards climate neutrality are discussed. Moreover, key design options of DHC GO systems are analysed. These include the handling of grid boundaries of DHC supply systems; the treatment of storage and grid losses; the role of DHC customers in the GO registry; GO issuance for self-supplied thermal energy; the cross-sectoral tracking of green attributes in case of energy carrier conversion; verification of plant and measurement data in vertically integrated grids; and the implementation of DHC disclosure rules. For each of these questions, the solutions adopted in the IW^3 pilot registry are documented. An outlook on priorities that can be set during a national implementation of DHC GO systems is provided.

1 INTRODUCTION: NEW PERSPECTIVES FOR THE MARKETING OF GREEN DISTRICT HEATING AND COOLING

District heating and cooling (DHC) from renewable energy and unavoidable waste heat can make an important contribution to the heat transition.[1] Especially in dense and urban areas, the **expansion and decarbonisation of heating grids is** an effective and efficient option for decarbonising the building sector, particularly as heating grids can be used to convert the supply of entire city districts or communities to climate-neutral heat (see e.g. Bacquet et al. 2022; Bürger et al. 2021; Engelmann et al. 2021; Thamling et al. 2020). Heating grids can also play an important role in the climate-neutral supply of process heat. Compared to a decentralised supply with renewable energy, heating grids make it possible to use the cost advantages of large-scale development of heat sources. These include, for example, the use of deep geothermal energy, solar thermal energy, waste heat from industry, commerce, and the tertiary sector as well as thermal waste recycling, or environmental heat in combination with large-scale heat pumps. In combination with large-volume heat storage systems, power-to-heat plants can also absorb excess electricity from wind and solar energy and thus strengthen sector coupling and improve the integration of fluctuating renewable energy into the energy system. Realising cost advantages over decentralised heat generation options also contributes to the social compatibility of the heat transition.

However, the prerequisite for these contributions is both the expansion of existing and new grids for heat supply and the progressive decarbonisation of grids (see Figure 1). In 2022, net heat generation for grid-based district and local heat supply in Germany amounted to approx. 132 TWh (BDEW 2023a, provisional values). Renewable energies accounted for 18.7 % of this and waste heat sources for 6.7 % (BDEW 2023b, provisional values). However, biomass (with a share of 10.1 %) and biogenic municipal waste (7.6 %) have dominated renewable energies so far, with limited sustainable expansion potential available. Geothermal and solar thermal energy have so far accounted for only 1.0 % of net heat generation. Accordingly, there is a **considerable need for investment,** especially in capital-intensive, fuel-independent non-biogenic renewable heat generation options, supplemented by the development of unavoidable waste heat sources and accompanying measures such as the reduction of grid temperatures and the integration of heat storage.

Against this background, **the marketing of specific green district heating products** can contribute to facilitating the refinancing of investments in climate-neutral heat generation sources and to closing the economic gap compared to the continued operation of plants based on fossil energy sources. For district heating customers, the purchase of a green district heating product makes it possible to be supplied with 100% climate-neutral energy today, even if their heating grid is still in the process of transformation. Similar to the green electricity market, this option is not only relevant for ideationally motivated private customers, but also for corporate customers who depend on the purchase of climate-neutral energy to implement climate neutrality strategies. However, a prerequisite for the legally secure marketing of green district heating is a **verification and disclosure system** that ensures the clear allocation of the green attributes of heat quantities generated in renewable energy and waste heat plants to customers.

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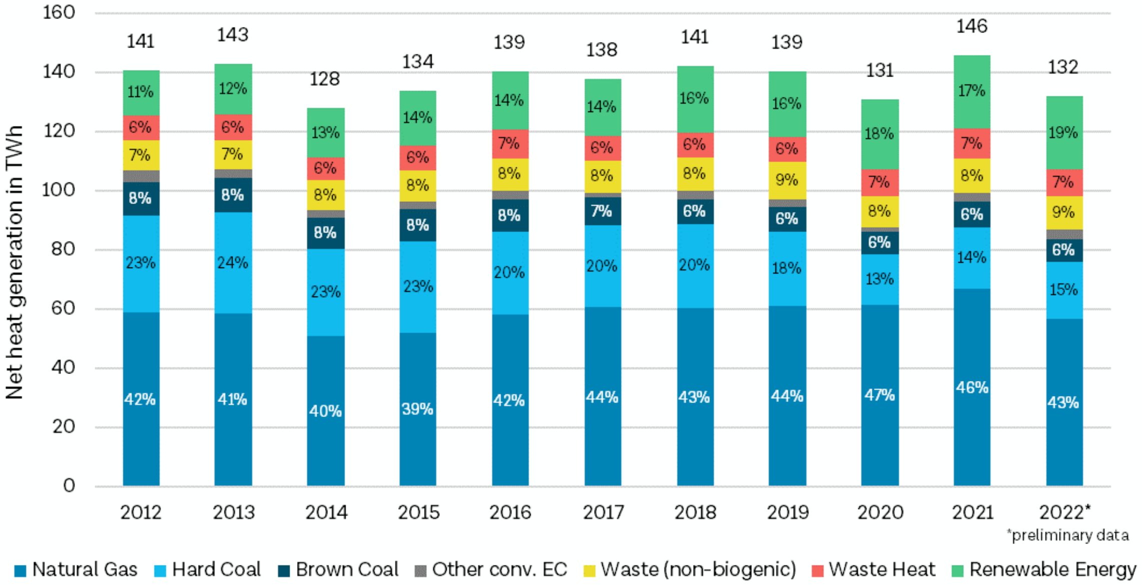
[1] The use of the term "district heating" is independent of distance. According to the draft Heat Planning Act of 1 June 2023, a heat grid can be defined as "a facility for the piped supply of heat that has a horizontal extension beyond the property boundary of the site of the facility that feeds in the heat and is not a building grid within the meaning of section 3(1) number 9a of the Building Energy Act" (section 3 no. 13 WPG draft). According to the draft Building Energy Act of 19.04.2023, a building grid is "a grid for the exclusive supply of heat and cooling to at least two and up to 16 buildings and up to 100 residential units".

Figure 1: Development of net heat generation in Germany by energy source in TWh

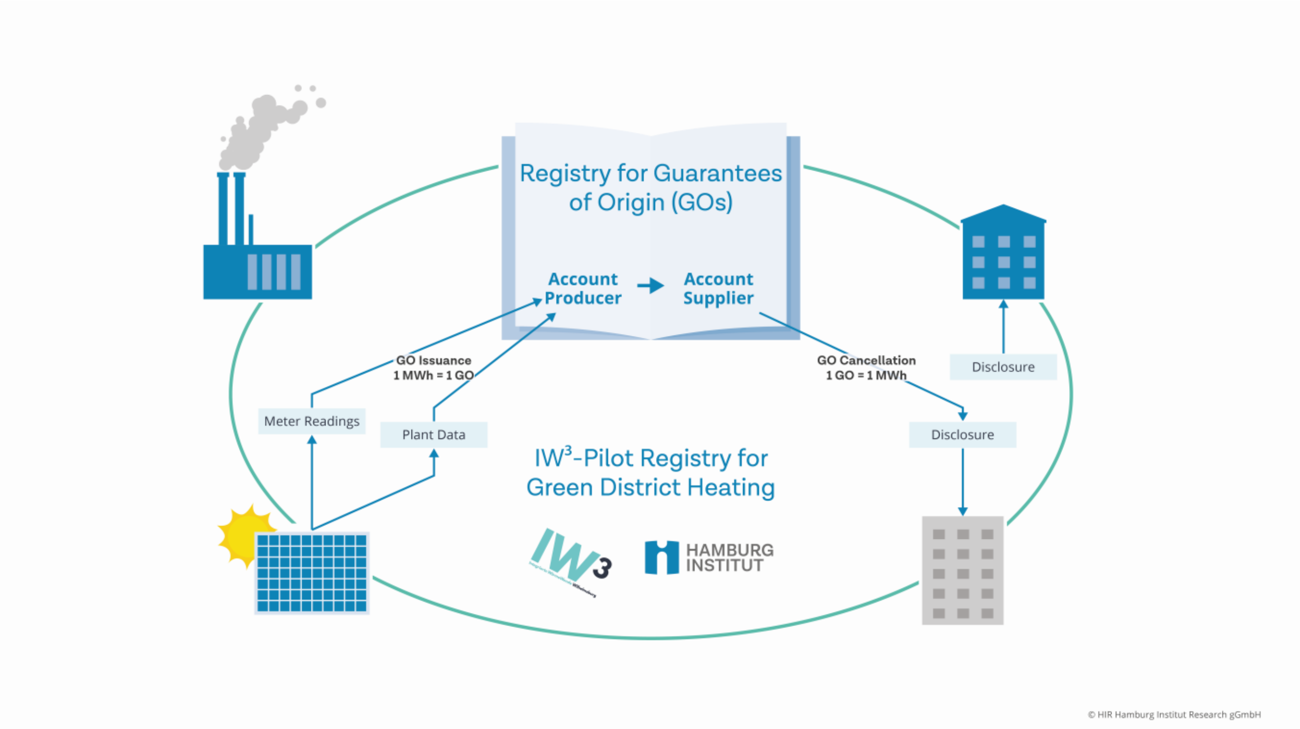


Source: Own presentation based on BDEW 2023a.

In the green electricity market, the clear allocation of green attributes from generation to consumption is ensured by the guarantee of origin system in combination with the electricity disclosure obligation for electricity suppliers. The **first Renewable Energy Directive of 2009 ('RED I')** made the **introduction of guarantee of origin systems for electricity from renewable sources** mandatory. The **second Renewable Energy Directive of 2018 ('RED II')** extended this obligation to **heating and cooling as well as gases, including hydrogen, from renewable energy sources**. In Germany, the legal foundations for the introduction of corresponding verification systems were laid with the **Guarantees of Origin Registry Act (HkNRG) of** 4 January 2023.

The basic **operating principle of Guarantees of Origin (GO)** for electricity remains the same when applied to heating and cooling (see Figure 2): Green attributes are tracked on balance sheet from production to consumption, excluding multiple marketing and multiple use. The balance sheet allocation of attributes enables customers to make demand decisions in favour of certain energy sources and plant technologies, even in the case of energy supply via grids in which the attributes of different generation sources are mixed. GOs are issued after energy generation has taken place and record the attributes of the energy unit produced (standardised as a megawatt hour). This includes, for example, information on the energy source, technology, plant location, plant age or information on whether the plant or the energy produced has received state funding. The application for a GO requires that plant operators have registered their plants in the GO registry. Based on plant and measurement data, GOs are issued to the registry account of plant operators - who can transfer GOs to the account of energy suppliers, traders or - depending on the registry design - consumers. By cancelling a GO, the attributes mapped on it are assigned to a specific energy consumption. **In combination with the disclosure of the heat and cold deliveries, it is ensured that the attributes of a specific energy unit are marketed only once and thus claimed only once**. This is particularly important when it comes to disclosing the origin of green district heating from renewable energy sources or waste heat sources - in principle, however, heating and cooling GOs can be issued for all energy sources and heat generation technologies.

Figure 2: Basic principle of a GO system for heating and cooling



Source: Own representation, Hamburg Institut

Even if the basic principle of heating and cooling GO systems is comparable to the electricity GO system, there are **requirements for adaptation to the specific context of district heating supply,** as the market, technical and regulatory framework conditions are different from those for electricity supply. There is little practical experience available in the heating and cooling context so far: As of 2023, implemented GO systems for heating and cooling are only known from the Netherlands, Finland, and Flanders, even though the introduction in other EU countries is in preparation with the implementation of RED II. **Design questions that need to be answered in the specific context of thermal energy supply** concern for example:

- the handling of heat and cold grid limits in GO systems,
- dealing with storage and grid losses,
- the integration of heat customers into the GO registry,
- a possible GO issuance for self-supply plants,
- the verification of energy carrier conversions when electricity or gases from renewable energy sources are purchased via grids,
- the verification of plant and measurement data in vertically integrated grids, as well as
- the design of heat disclosure.

There are also open questions in determining the **role that heating and cooling GOs can or should play in the future in the context of the heat transition**. While the core function of GOs is to inform consumers and enable the tradability of the green credentials of energy, they can also be used to provide evidence for regulatory requirements, for example in the context of regulatory or funding regulations, or to facilitate the enforcement of reporting obligations.

The theoretical and practical investigation of the open design questions of heat GO systems is the focus of the Hamburg Institut's **'Green District Heating' research project**, which is funded by the Federal Ministry of Economics and Climate Protection (BMWK) as a **sub-project of the project 'IW³ – Integrierte WärmeWende Wilhelmsburg' as part of the living labs for the energy transition** (with a project duration from August 2020 to July 2024). The goal of the IW³ living lab is to establish a climate-friendly decentralised heat supply for the residential quarters on the Hamburg Elbe island of Wilhelmsburg that is CO_2-neutral and, in the long term, works without the use of fossil fuels. IW³ is being implemented under the leadership of Hamburger Energiewerke, supported by a consortium of various partners, including the Hamburg Institut. In addition to the realisation of a geothermal plant (IW_U) and research on the system integration of different heat sources (IW_S), novel trading and marketing mechanisms for climate-friendly district heating are being investigated in the living lab (IW_M , with the participation of Hamburger Energiewerke, the Hamburg University of Applied Sciences (HAW) and Hamburg Institut Research (HIR)). This also includes green district heating marketing based on GO as a verification method. In the IW_M sub-project 'Green district heating' the Hamburg Institut has implemented a **GO registry for green district heating as** a pilot project for Germany, with technical development by Grexel, and researched the associated design issues. The aim is to derive experiences and recommendations for the design of national heating and cooling GO registry.[2] The IW³ pilot registry for heat GOs went into operation in May 2022, with Hamburger Energiewerke as the pilot user. In the further course of the project, experiences from the operation of the registry will be evaluated and selected issues that arise in innovations in the field of green district heating marketing will be examined in more detail. Interested heat suppliers are invited to test the registry. [3]

In this report, the **legal framework conditions for the marketing of green district heating and the introduction of heating and cooling GOs as a verification method are** presented (chapter 2). In particular, the various roles that GOs could play in the heat transition are discussed. Furthermore, **central design options of heating and cooling (H&C) GO systems are analysed and design decisions made in the IW³ pilot registry are justified** (chapter 3). In addition to experiences with GOs in the electricity sector and an analysis of the energy-economic, technical, and regulatory framework conditions of district heating supply, results from the exchange with project partners and stakeholders have also been incorporated into the corresponding specifications. This includes an online stakeholder workshop in April 2021 with around 40 participants from the areas of heat supply, generation, consumption and administration, in the context of which insights into the needs of various market participants on the supply and consumption side could be deepened. Chapter 4 concludes with a summary of the central design options that can be considered for a national implementation of heating and cooling GO systems.

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[2] For more information on the project, see https://www.hamburg-institut.com/projects/forschungsprojekt-iw3/; https://waermeregister.de/; https://www.iw3-hamburg.de/.

[3] https://www.hamburg-institut.com/news/pressemitteilung-waermeversorger-fuer-teilnahme-am-pilot-hkn-register-fuer-gruene-fernwaerme-gesucht/.

2 LEGAL FRAMEWORK FOR THE MARKETING OF GREEN DISTRICT HEATING

This section traces the **development of GOs for renewable energies as a verification instrument within the framework of European legislation** and presents the interaction of GOs with disclosure obligations as the basis of a legally secure marketing system for renewable energies. The implementation of the European requirements was initially carried out at the level of German law for the electricity sector and is presented here as a possible blueprint for the heating sector, whereby some sector-specific peculiarities for heating must be taken into account. The **three main purposes that GOs can fulfil in district heating are presented** and which application potentials are associated with them. On this basis, the status of implementation in German law is then presented and a comparison is made of the extent to which these purposes can be pursued in the existing legal framework or whether there is a need for adaptation/extension.

2.1 Legal framework in Europe

At European level, GOs were introduced with the first Directive on the promotion of the use of energy from renewable sources **RED I (Directive 2009/28/EC)**.[4] In its recitals (52 f.) and in Article 15, the Directive defines the **purpose that GOs are to fulfil** and describes their core elements. According to this, a GO serves to prove to final customers that a certain amount of energy has been produced from renewable sources. To this end, European Member States shall ensure that the origin of electricity produced from renewable energy sources can be guaranteed as such according to objective, transparent and non-discriminatory criteria (para. 1). Member States must therefore ensure that, upon request of a producer of electricity from renewable energy sources, GOs are issued in accordance with the Directive (para. 2 sub-para. 1). Issuing GOs upon request of producers of heating or cooling from renewable energy sources was not yet obligatory for Member States under RED I.

Article 15 of the Directive stipulates as **important core elements** that no more than one GO shall be issued for each unit of energy (para. 2 sub-para. 1) and that Member States shall ensure that each unit of energy from renewable sources is taken into account only once (para. 2 sub-para. 2). In this context, a GO may be transferred regardless of the quantity of energy to which it relates (para. 2 sub-para. 4). The accurate, reliable and fraud-proof electronic issuance, transfer and cancellation of GOs shall be monitored by the Member States or competent bodies designated by them (par. 4 and 5). Article 15(6) specifies the minimum information that a GO must contain. This is information on the energy source from which the energy was produced and on the start and end of production, information on the type of energy to which the GO refers (electricity or heating/cooling), information on the plant in which the energy was produced and on whether the plant has received funding, as well as the date of issue of the GO itself and a unique identification number.

The second Directive on the Promotion of the Use of Energy from Renewable Sources **RED II (Directive (EU) 2018/2001)**, which repealed and recast the previous Directive, introduced important new provisions for GOs (Article 19).[5] The **Directive expands the scope of application of GOs**, which are now mandatory to be issued upon request by producers of energy from renewable sources in general (para. 2 sub-para. 1). Along with this, the types of energy to which the GO refers, have been expanded in the catalogue of mandatory GOs from

[4] 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.

[5] 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.

electricity and heating/cooling to include gas, including hydrogen (para. 7). Furthermore, the mechanisms to be established by the Member States for the electronic issuance, transmission, and cancellation of GOs must now comply with the requirements of the European standard CEN - EN 16325 (para. 6) and the Member States must take due account of the market value of GOs in the context of financial funding mechanisms (para. 2 UA para. 3 and 4).

As a reference document, the European **standard CEN - EN 16325 represents more detailed minimum requirements that are placed on the GO systems to be established in the Member States**.[6] The standard itself has been undergoing a revision process since 2020 in order to map not only electricity but also requirements for GOs for gases, hydrogen and heating and cooling. The revised version has not yet been published. The standard describes requirements for the design of Member State registries, in particular in the areas of registration of registry participants, content of GOs, issuance, transfer and cancellation of GOs, design of user accounts and user authorisations, requirements for installation-related measurement procedures, and rights and obligations of registry operators.

A subchapter of the revised standard will contain specific **requirements for GOs in the heating/cooling sectors**. The revision builds on a draft version prepared in 2020 by the 'FaStGO' consultancy project commissioned by the EU Commission and led by the Association of Issuing Bodies (AIB) (FaStGO 2020). Heating and cooling are treated as part of a uniform GO system for thermal energy. This approach avoids duplication of the administrative burden and costs for Member States and users associated with the establishment and operation of a registry or registration and use of a registry. Moreover, certain technologies such as reversible heat pumps are capable of producing both heating and cooling. Nevertheless, Member State GO cancellation and disclosure rules may distinguish between heating and cooling in order to meet different specific requirements of the heating or cooling market. The mapping of grid identifiers and grid names on GOs is still under discussion. This information is a prerequisite for the possibility of grid-related allocation of GOs in the cancellation and allows leeway in the cancellation rules. This concerns above all the question of cross-grid cancellability for disclosure purposes: Here it is under discussion to grant the Member States the option to only allow GOs for cancellation in a grid that also bear its grid identification, i.e. that were issued for generated thermal energy that was actually distributed in the grid to which the GO cancellation refers (see below under transposition into national law § 6 par. 1 no. 11 HkRNG).

In the new amendment of the Renewable Energy Directive (**RED III**), which was published in a provisional version in June 2023 after the trialogue between the EU Commission, the Council and the Parliament was concluded[7] **, the importance of GOs in the dissemination of contracts on the purchase of renewable electricity is emphasised in addition to the** importance **of GOs as an information tool for consumers** (recital no. 13). In order for GOs to better fulfil this function, RED III requires Member States to ensure that GOs can be transferred to the purchaser of the renewable energy in the context of a renewable electricity purchase contract (Art. 15(8)). However, in order to take the market value of GOs into account, they can still decide not to issue

[6] DIN EN 16325:2016-01. Guarantees of origin related to energy - Guarantees of origin for electricity; German version EN 16325:2013+A1:2015. DIN Deutsches Institut für Normung, Berlin; Working draft EN 16325 CEN/CLC/JTC 14/WG 5 "Guarantees of origin related to energy".

[7] 2021/0218(COD), Outcome of Proceedings: 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.

GOs for subsidised plants, an option that was to be dropped according to the EU Commission's original amendment proposal to RED III.[8]

2.2 Legal framework for guarantees of origin for electricity in Germany

For the German implementation of RED I and the Electricity Directive, a legal framework for guarantees of origin in the electricity sector was created at the federal level in Germany - albeit with a rather limited scope of use. **Central here are the regulations on electricity disclosure according to § 42 EnWG and §§ 78 ff. EEG**.[9] Within the scope of the mandatory disclosure of the shares of individual energy sources in the energy source mix used, an electricity supplier shall, pursuant to Article 42 (1) and (5) EnWG, disclose to end consumers the use of electricity from renewable energy sources for which either guarantees of origin were cancelled pursuant to Article 79 (4) EEG or which was promoted according to the EEG. For electricity quantities that cannot be clearly allocated to an energy source on the generation side, such as electricity procured via the electricity exchange, the renewable energy share of the ENTSO-E energy source mix adjusted for GO cancellations and EEG quantities can be reported according to section 42 (4) EnWG. No guarantees of origin are issued for EEG-subsidised electricity (§ 79 para. 1 no. 1 EEG), which at the time of EEG levy financing was based on the idea that the green attribute of electricity from plants subsidised under the EEG was already assigned to all levy payers and therefore could not also be assigned to individual consumers (prohibition of double marketing). With the abolition of EEG levy financing, the legislator decided to maintain the ban on double marketing in this way, although the change in the financing of EEG funds would have offered opportunities for modification here (cf. for example Kahl and Kahles 2020). However, since the majority of renewable generation plants in the electricity sector receive EEG funding, only a small proportion of renewable electricity produced in Germany is eligible for the issuance of guarantees of origin.

In the case of electricity marketing, suppliers of green electricity products can only supply 100% green electricity to end consumers if they purchase and cancel guarantees of origin for all the green electricity they supply, including the share of renewably generated electricity from plants that have received EEG funding. On the other hand, electricity suppliers who do not purchase any renewably generated electricity and supply it to end consumers can show their customers the - ever increasing - share of electricity from EEG-subsidised plants for the electricity they supply. On the one hand, this can distort consumers' perception of the green credentials of the electricity. On the other hand, the increased administrative burden associated with the marketing of pure green electricity products may slow down the market mechanisms for the increasing distribution of green electricity.

The **legal basis for the practical operation of the registry in the electricity sector,** according to which the German Environment Agency operates the registry for Guarantees of Origin and Regional Guarantees, is derived from Section 79 (4), Section 79a (4) EEG, the Renewable Energies Ordinance EEV[10] and the

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

[9] Renewable Energy Sources Act of 21 July 2014 (BGBl. I p. 1066), last amended by Article 4 of the Act of 3 July 2023 (BGBl. 2023 I No. 176); Energy Industry Act of 7 July 2005 (BGBl. I p. 1970; 3621), last amended by Article 2 of the Act of 12 July 2023 (BGBl. 2023 I No. 184).

[10] Renewable Energies Ordinance of 17 February 2015 (Federal Law Gazette I p. 146), last amended by Article 7 of the Act of 20 December 2022 (Federal Law Gazette I p. 2512).

Implementing Ordinance on Guarantees of Origin and Regional Guarantees (HkRNDV)[11]. The contents of the GO for electricity from renewable energies in Germany are shown in Table 1.

Table 1: Contents of GOs for electricity from renewable energy sources in Germany

Type of information	Information for the issuance of guarantees of origin
Formal information	• Unique identification number • Date of issue and issuing State • Designation of the registry administration as issuing body • Plant identification number assigned by the registry administration • Designation of the plant

Mandatory information on the attributes of the electricity generated	• Energies used for electricity generation by type and main components
	• Start and end of generation of the electricity for which the GO is issued
	• Location, type, installed capacity and date of commissioning of the plant
	• Information on whether, in what way and to what extent
	  – investment aid has been granted for the plant
	  – a subsidy has been paid or provided in any other way for the electricity quantity

Optional additional information	• Indication that the electricity has been generated in high-efficiency CHP systems (in which case additional information on CHP creation pursuant to section 9(2) EEV). • Information on the way in which electricity is generated in the plant (quality attributes, e.g., fish protection measures in the case of hydropower).

Source: Hamburg Institut's own representation, based on Section 9 (1) EEV and Section 16 HkRNDV.

2.3 Guarantees of origin for district heating

2.3.1 Legal framework for implementation / What is needed?

With regard to the heating/cooling sector, the literal **requirements of RED II** must be implemented **when Member States introduce a GO registry.** Therefore, the registry must ensure that GOs for renewable energy producers can be issued electronically and in accordance with the European standard or - as long as this is not finalised - at least meet the requirements of Article 19 of the Directive. The operation of the registry does not necessarily have to be carried out by an authority - the Directive leaves room for manoeuvre in the design. On the other hand, it is important to **order GOs in the heat sector as a mandatory verification instrument** (cf. § 42 EnWG, §§ 78 ff. EEG). Only in this way can GOs fulfil their purpose of excluding multiple marketing or claiming of green attributes.

As a starting point for the consideration of the implementation of the European requirements into German law, **looking at the purposes and opportunities associated with a registry for heating/cooling will** serve here.

[11] Proof of Origin and Regional Guarantees Implementing Ordinance of 8 November 2018 (Federal Law Gazette I p. 1853), last amended by Article 15 of the Act of 20 July 2022 (Federal Law Gazette I p. 1237).

2.3.2 Purpose 1: Consumer market for green district heating

One purpose of the introduction of heating/cooling GOs and the associated registry is to create a **consumer market for green district heating**. According to the recitals of RED I and II (53 and 56 respectively), this should contribute to the development and expansion of renewable energies. This can work particularly well if **a financing potential can be raised for the heating market by activating similar consumer motivations as in the electricity market.** There, a high level of environmental awareness among consumers and the desire to make one's own contribution to the energy transition and the expansion of renewable energies are recognised as motivations for market behaviour that is characterised on the consumer side by the willingness to pay higher fees for green electricity products specifically linked to these motives (Mundt et al. 2021). In this context, the regionality of electricity products as well as the regional anchoring of energy suppliers are also considered important and have gained in significance in recent years.

In addition to the ideationally motivated purchase of a green energy product by private customers, companies are increasingly becoming an important driver of demand. This can already be observed in the German and European green electricity market (e.g., E&M 2022; ECOHZ 2019; Greenfact 2021; see also in detail Styles et al. 2023). The purchase or own production of renewable energy plays an important role in the implementation of sustainability or climate strategies, which is also emphasised by international initiatives such as the Carbon Disclosure Project (CDP), the Science Based Target Initiative or RE100. Companies also play an important role in district heating sales. Of 135.6 TWh of DHC consumed in 2021, a share of 32 % was accounted for by industrial consumers, 24 % by the commercial, trade and services sector and 44 % by households including housing associations (BDEW 2023c, excluding heat operating consumption and grid losses). **The possibility of being supplied with 100% climate-neutral energy from renewable energy and unavoidable waste heat via a heating grid can be highly relevant for corporate customers** - especially if their own climate neutrality targets are before 2045 or require decarbonisation of their own heat supply before the corresponding transformation process of the respective grid is completed. The verification via GO creates an important prerequisite for the consideration of a green heat product in the climate accounting. In this case, the market-based climate accounting approach for 'Scope 2' emissions from purchased energy can be used, which requires a reliable and clear allocation of emission factors to specific consumers. Without the option of purchasing a green heat product, the only alternative for grids that have not yet completed their decarbonisation would be for corporate customers seeking a fully climate-neutral heat purchase to switch to decentralised heat supply options. However, decoupling large customers could, in the worst case, call into question the economic viability of the entire heating grid - which in turn would call into question the gradual decarbonisation of the heat supply of all other connected customers. In addition to corporate customers from the industrial, commercial, and service sectors, the purchase of a green district heating product can also be of great interest to the housing industry. On the one hand, this is also of interest for the implementation of climate and sustainability strategies, and on the other hand, as proof of the green attributes of purchased energy for municipal stakeholders, lenders, and tenants.

Due to physical limitations, heating grids are spatially limited locally or regionally - unlike the Pan-European connected electricity grid. Therefore, the question arises in particular whether the aforementioned - private as well as company-related - consumer motivations can also be activated if the GOs, which embody the green attribute of energy, can be cancelled across the grid, as is the case with electricity. At least the local/regional motivation factors could be given special emphasis in the case of heat if the Member States made use of the option to only allow GOs issued for locally produced and distributed heat to be cancelled (**Grid identity as a credibility element in GO cancellation**, see also Chapter 3.1). The credibility of green energy procurement is also an important criterion for companies to avoid 'greenwashing' accusations.

From the perspective of European law, the question arises whether such a regulation is objective, transparent and non-discriminatory according to the standards of EU law (cf. Art. 19 para. 1 RED II). The regulation to exclude the cancellation of GOs from other grids on the basis of a grid identifier is not likely to violate the European fundamental freedoms as an internal market restriction within the meaning of Art. 34 TFEU (quantitative import restriction or measure having equivalent effect).[12] As tradable goods, GOs have the status of goods (cf. Art. 19 para. 2 sub-para. 6 sentence 2 RED II).A Member State regulation to exclude the cancellability of GOs includes potential cross-border affairs (namely in the case of cancellability of GOs from other Member States), so that the scope of application of Art. 34 TFEU is opened. Such a cancellation rule would also indirectly hinder cross-border trade, since although the tradability of the GO as such would not be affected, the economic sense of the GO trade would be. For the acquiring agent, the economic purpose of a GO transaction is the usability of the GO for disclosure purposes, which presupposes that the GO can be cancelled, which would potentially be excluded by the cancellation rule. However, such a rule would affect all domestic GO providers equally and would also have the same impact on domestic GOs as on GOs from other Member States. The sale of domestic GOs would therefore be affected in the same way as the sale of GOs from other Member States because they would also be excluded from cross-grid cancellation. This is because it is not the member state origin of the GO that is the connecting factor, but the identity of the grid in the production and distribution of the heat quantities on which the GO is based and in their corresponding cancellation for the heat quantities supplied. This is clearly illustrated by the example of cross-border heating grids (see for example the German-French Energy Platform 2022). Within a cross-border grid, GOs with the same grid identifier would be issued on both sides of the border for heat quantities generated and distributed across the grid, which would also be cancellable on both sides of the border according to the cancellation rule. The cross-border tradability and the obligation to recognise GOs from other Member States result directly from RED II (cf. Art. 19 Para. 2 sub-para. 6 and Para. 9). **Accordingly, a regulation excluding the cancellability of GOs from other grids would not constitute discrimination within the meaning of Article 34 TFEU**.

As GOs enable the legally secure attribution of green attributes in the heat sector, they are a **potentially effective tool for promoting a consumer market for green heat products**. This is especially true if GOs are provided as a mandatory verification tool within the framework of legal requirements for disclosure obligations.

In connection with the consumer market for green district heating, the question of **whether price differentiation can also take place on the basis of balanced products is of** interest to suppliers. Price differentiation of district heating tariffs has already been discussed on the basis of differentiation criteria such as staggering depending on contract periods, application to existing or new customer contracts and different qualitative product attributes. However, as far as can be seen, a final decision on the admissibility of such differentiation by the courts has not yet been made.

Under civil law, price differentiation is generally possible on the basis of contractual freedom. There are no restrictions, for example, due to the Ordinance on General Terms and Conditions for the Supply of District Heating (AVBFernwärmeV)[13] . However, requirements under competition law must be observed, such as the prohibition

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[12] Treaty on the Functioning of the European Union as published on 9 May 2008, as last amended by Art. 2 AmdDec. 2012/419/EU of 11.7.2012 (OJ L 204 p. 131).

[13] Ordinance on General Terms and Conditions for the Supply of District Heating of 20 June 1980 (BGBl. I p. 742), last amended by Article 2 of the Ordinance of 28 September 2021 (BGBl. I p. 4591).

of discrimination under Section 19 GWB.[14] It follows from this that a dominant company may not arbitrarily treat its customers differently from similar customers (Fricke 2018, p. 148 et seq.), unless there is an objective justification for the unequal treatment. This also applies in principle to different prices (Fricke 2018, p. 149). The dominant position of a district heating supplier is generally assumed by the cartel authorities for the respective supply area of the district heating supplier (Bundeskartellamt 2012, p. 80). Objective reasons in the above-mentioned cases of different contract durations include the longer-term plannability of the necessary investments, in the case of new and existing customers the need to procure input materials with short notice and, in the case of the product quality of the heat, the refinancing of the expansion of renewable heat generation plants with cost-intensive development as well as the connection of additional waste heat sources.

2.3.3 Purpose 2: Verification for regulatory requirements

Another possible application of GOs in the heating sector is the **verification of compliance with regulatory requirements**. An example of this is the **use of GOs as a verification instrument to fulfil the obligations of building owners according to the Building Energy Act (GEG)**.[15] According to § 15 GEG, the annual primary energy demand of a newly constructed residential building (§ 18 GEG applies to non-residential buildings) for heating, hot water preparation, ventilation and cooling must not exceed 0.55 times the annual primary energy demand of a reference building. When calculating the annual primary energy demand (according to § 20 GEG for residential buildings, § 21 GEG for non-residential buildings), primary energy factors (PEF) are included to determine those energy carrier-specific amounts of energy that were used outside the building boundary for the production, conversion and distribution of energy (§ 22 GEG in conjunction with Annex 4 GEG). The PEFs to be applied for individual energy sources are specified in the GEG (Annex 4 GEG). However, if the building is supplied via a heating grid, it is possible to use as PEF the value determined and published by the heat supplier in accordance with the provisions of section 22(2) GEG, a grid-specific PEF, so to speak. However, the wording in Article 22(2) of the Act ('may') does not fundamentally prevent a different primary energy allocation method. Accordingly, it would in principle be possible to use product-specific or building-specific PEFs instead of grid-specific PEFs for calculating the primary energy demand of newly constructed (residential) buildings. In this case, building owners could prove the purchase of renewable district heating products by means of the GO or the GO cancellation statement of their heat supplier, which proves to them the heat supply from renewable energy or unavoidable waste heat (cf. § 5 para. 1 no. 7 FFVAV, see chapter 2.3.4). [16]

From an administrative point of view, the **consistent use of GOs by the heat supplier in** the compulsory provision of information according to the District Cooling Consumption Metering and Billing Ordinance (FFVAV) could make things easier for customers if the **proof of the share of renewably generated heat and cooling as well as the (individual) PEF** could be provided by the **same means (GO).** For building owners, it would be advantageous to be able to obtain a PEF that is more favourable for them through the individual decision to purchase a corresponding renewable heat product. Apart from a favourable PEF, customers can activate their individual ecological motivation (see above) in this way by product-specific exertion of their consumer decision. However, in the case of product-related verification it must always be strictly observed that the green attribute assigned to individual customers via the product reference does not also benefit other customers in the verification

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[14] Act against Restraints of Competition in the version published on 26 June 2013 (Federal Law Gazette I p. 1750, 3245), last amended by Article 10(2) of the Act of 27 July 2021 (Federal Law Gazette I p. 3274).

[15] Building Energy Act of 8 August 2020 (BGBl. I p. 1728), as amended by Article 18a of the Act of 20 July 2022 (BGBl. I p. 1237).

[16] District Heating or District Cooling Consumption Metering and Billing Ordinance of 28 September 2021 (BGBl. I p. 4591; 4831), as amended by Article 2 of the Act of 4 January 2023 (BGBl. 2023 I No. 9).

(prohibition of double marketing). Thus, § 5 para. 3 FFVAV provides for the designation of a PEF and renewable energy share for the technically related DHC system. However, a choice of using a product-specific or grid-specific PEF would lead to a double claim of green attributes. **Within the framework of the disclosure rules, it would have to be clarified that all district heating customers (including those who do not use a green district heating product) would have to be informed of their product-specific PEF in addition to the grid-specific PEF**. In the case of regulatory eligibility under the GEG, a cut-off date regulation could be introduced, according to which grid-specific PEFs can be used until the introduction of a national GO registry for heating/cooling or until the introduction of a GO-based product differentiation by suppliers, but thereafter product-specific PEFs would be decisive.

In this context, there are particularities to be considered with regard to existing buildings already supplied from existing plants via a grid (see Styles et al. 2022), which is why it would be simpler in implementation to limit the formation of a product-specific PEF that can be credited under regulatory law to grid-distributed heat from new plants that have not yet been included in the calculation of a grid-specific PEF in the past. This would prevent a pure 'redistribution' of green attributes of existing plants within the grid from leading to a drop in the share of renewable energy and waste heat in the heat supplied to some customers (cf. § 6 para. 1 no. 12 HkNRG).[17] However, with regard to the marketing opportunities for green district heating, this may disadvantage heat suppliers that have already made many investments in plants for the generation of climate-neutral heat in the past, compared to heat suppliers or grids that are still at the beginning of their transformation. Alternatively, a minimum share of green district heating or a minimum PEF could be defined, which must be ensured for customers in the 'basic product' if green district heating is also marketed separately from existing plants (see Styles et al. 2022 for a more detailed analysis of the different options).

The possibility of using GOs in the verification process within the scope of another regulatory requirement of the GEG is currently in flux. According to the current GEG, GO can be used by building owners to disclose the proportional use of renewable energy (§ 10 Para. 2 No. 3 GEG in conjunction with §§ 34-45 GEG), as required by § 44 GEG. These requirements will change considerably according to the Federal Government's draft bill for the 2nd amendment of the GEG dated 19.04.2023 (hereinafter GEG (new)).[18] Accordingly, as of 01.01.2024, every newly installed heating system shall in principle generate at least 65 % of the heat provided from renewable energy or waste heat (section 71 (1) GEG (new)). In June 2023, further proposed amendments were included in the draft version, according to which this obligation initially only applies to new buildings in new development areas. In existing buildings, it is only to take effect when municipalities have drawn up heat plans, which, according to the draft of the Heat Planning Act (WPG), must be done by 2028 at the latest.[19]

For the **connection to a heating grid as a compliance option,** section 71b of the Renewable Energy Sources Act (new) stipulates that at least 65% of the total annual cumulative producer useful heat output distributed in the heating grid must come from renewable energy or unavoidable waste heat (section 71b (1) of the Renewable Energy Sources Act (new) in the case of the connection to a new heating grid with a construction start date after 31 December 2023) or, if the share of renewable energy or unavoidable waste heat is lower than 65% in the case of heating grids with a construction start date before 01.01.2024, a legally compliant transformation

[17] Guarantees of Origin Registry Act of 4 January 2023 (BGBl. 2023 I No. 9).

[18] Draft bill to amend the Building Energy Act, to amend the Heating Costs Ordinance and to amend the Sweeping and Inspection Ordinance. Draft bill of the Federal Government dated 19.04.2023.

[19] Heat Planning and Decarbonisation of Heat Grids Act. Draft bill of the Federal Government dated 01.06.2023.

plan must be in place by 31.12.2026, according to which a share of 50% renewable energy or unavoidable waste heat is achieved by 2030 and complete decarbonisation by 31.12.2044 (section 71b (2) GEG (new)).

Pursuant to § 71 b GEG (new), the heat grid operator must confirm to the connectee that the respective requirements are met when concluding a grid connection contract. This confirmation will serve the customers as proof of compliance with the 65% renewable energy requirement according to § 71 para. 1 GEG (new), so that, in addition, according to the GEG (new), no verification with GO will be required and the competent body for receiving the proof in the case of the heating grid connection will be positioned to check the submitted grid operator certificates by default. For the heating grid operators, in turn, there is basically room to prove the renewable energy share by means of GO, at least in the case of newly built grids according to § 71b para. 1 of the Renewable Energy Sources Act (new). The fulfilment of the obligation for existing grids according to § 71b (2) cannot be verified by means of GO, as it refers to the existence of a corresponding transformation plan, not to the renewable heat actually distributed over the grid - however, GO could be used in a transformation monitoring (see chapter 2.3.4). When providing evidence in connection with transition periods for connections to heating grids according to § 71j GEG (new), the party responsible for the heating system should provide evidence of a contract for the supply of at least 65 % renewable heat, on the basis of which it will be supplied from 01.01.2035 onwards, at the latest. This requires a legally compliant verification of the renewable energy shares and indicates the necessity of a corresponding supply contract design with the inclusion of GO as a verification system - and thus a further application of GO verification.

In addition to these possible applications of verification with GOs in the area of federal regulations, there are **other potential applications, for example, where building owners are confronted with regulatory requirements related to renewable heat generation due to state regulations**. These already affect the large group of owners of existing buildings. According to § 15 of the Hamburg Climate Protection Act (HmbKlischG[20]), owners of existing buildings are obliged to cover 15 % of the heating energy demand from renewable energies from 30.06.2021 in the case of the replacement or subsequent installation of the heating system. As a substitute measure, the connection of the building to a heating grid is permitted (§ 18 HmbKlischG) if this meets the 15 % requirement of § 17 para. 1 HmbKlischG or, in any case, the heat supplier has submitted an audited decarbonisation roadmap for this grid. However, in this area, the provisions of state law will be overlaid or replaced by the provisions of the GEG (new).

In addition to providing evidence to meet regulatory requirements, heat GOs could also be used to provide **evidence in the context of subsidy programmes**. Furthermore, they could play a role in the **distribution of CO_2 cost components in district heating tariffs.**

For example, **in the funding of buildings, requirements for ecological quality indicators such as renewable energy and unavoidable waste heat shares as well as primary energy and emission factors** generally play an important role in achieving efficiency house and subsidy classes. However, in the **federal funding for efficient buildings (BEG),** analogous to the current amendment to the GEG, the rule has been established for heating grids that a flat-rate fulfilment of requirements can be assumed in the case of a heating grid connection (cf. BMWK 2023). This presupposes that decarbonisation of heating grids is effectively ensured by other instruments - first and foremost the draft of the Heat Planning Act (WPG) and the Federal Funding for Efficient Heating grids (BEW) should be mentioned here (see 2.3.4). For example, in the first version of the newly drafted BEG, a connection to heat or building grids only fulfilled the eligibility requirement for the renewable energy

[20] Hamburg Climate Protection Act (Hamburgisches Klimaschutzgesetz - HmbKliSchG) of 20 February 2020.

subsidy class if grids were fed to more than 55 % by types of renewable energy or waste heat-based heat generation specified in the directive (see BEG WG and BEG NWG of 20 May 2021). With the amendment of the BEG WG and BEG NWG of 16 September 2021, the possibility was created to be able to apply a default renewable share of 55 % for heating grids, provided that a BEW-funded transformation plan is available, or the primary energy factor of the heating grid is 0.25 or less. The update of the funding guidelines of 9 December 2022 envisages that a share of 65 % of renewable energies may be applied across the board for heating grids to fulfil the renewable energy subsidy class (without further requirements for the existence of a transformation plan, whereby the WPG will introduce regulatory requirements for renewable energy and unavoidable waste heat shares). [21]

Actual shares of renewable energy and unavoidable waste heat in heating grids, on the other hand, can be relevant for achieving the sustainability class of the BEG (for refurbishments) or the requirements of the **'climate-friendly new construction' funding.** In both cases - in addition to other requirements - at least requirements for greenhouse gas emissions of the 'Sustainable Building Plus Quality Seal' must be met (BEG WG and BEG NWG of 9 December 2022; KfW 2023). For the life cycle analysis, standard factors are to be used for the assessment of heat from heating grids, which differentiate between heat from fossil heating plants or CHP plants and heat from heating plants or CHP plants operated with renewable energy (BMWSB 2023a,b). In the case of a proportional supply from fossil and renewable energy sources, 'a calculated value must be formed from the corresponding ratio of the two shares. The assumed ratio must be justified and documented' (BMWSB 2023a, p. 8). The calculation of greenhouse gas emissions from the district heating used could potentially be carried out on the basis of a product-specific accounting instead of grid-specific ratios of renewable and fossil heat generation. In order to avoid multiple use of green district heating quantities, it should be made clear that product-based accounting is to be carried out if product differentiation has been introduced in the respective heating grid.

The accounting of CO_2 and other greenhouse gas (GHG) emissions could also play a role in the **distribution of CO_2 cost components in district heating tariffs.** Corresponding cost components result from the **European emissions trading system** (especially for CHP plants) or from the **national emissions trading system according to the Fuel Emissions Trading Act** (whereby the replacement by a European emissions trading system for buildings, road transport and fuels in certain industrial sectors is planned from 2027, see DEHSt 2023). Rising CO_2 price paths lead to an increase in the competitiveness of district heating generation based on renewable energy and unavoidable waste heat in the long run. For customers, concluding a long-term supply contract for green district heating from renewable energy or waste heat plants could offer an opportunity to hedge against future rising CO_2 prices (see also Styles and Claas-Reuther 2022). In return, a surcharge would already be paid today for a green district heating product to drive the expansion of renewable energy and waste heat use in the grid. Such 'Green Heat Purchase Agreements' could lead to the decarbonisation of heating grids taking place faster than required by regulatory requirements of the WPG. In this way, additional emission savings could be realised. Another application of product-specific emission factors would be the **Carbon Dioxide Cost Allocation Act (CO2KostAufG).**[22] Here, emissions from heat deliveries are included in the calculation of CO_2 emissions from rented buildings, which in turn determines the cost allocation between landlords and tenants. Currently, however, it is stipulated that for heat deliveries from heating grids, emission factors uniform to the grid are to be used (§ 3 para. 4 no. 3 CO2KostAufG).

[21] Smaller building grids, on the other hand, must actually meet requirements for renewable energy and waste heat shares under the Federal Support for Efficient Buildings (BEG), see BEG WG and BEG NWG of 9 December 2022.

[22] Carbon Dioxide Cost Sharing Act of 5 December 2022 (BGBl. I p. 2154).

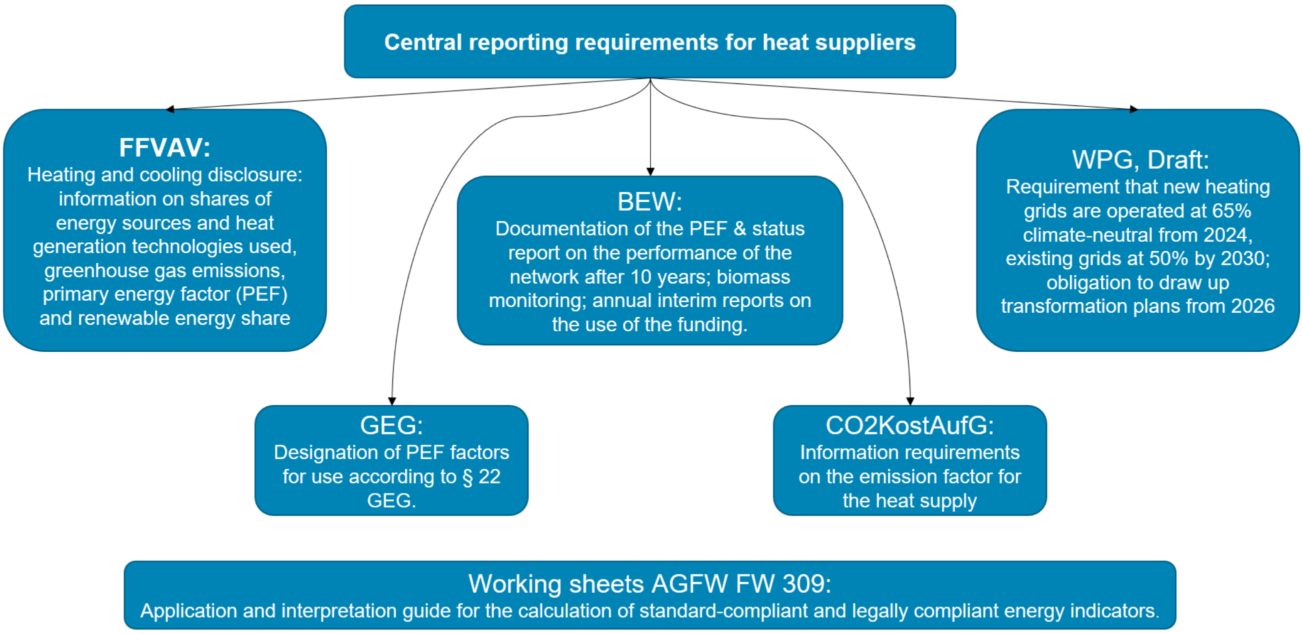
Similar to the regulatory role of product-specific primary energy factors, if product-specific emission factors are relevant for the allocation of CO_2 costs, it must be **ensured that customers are not placed in a worse position by a mere redistribution of green attributes from existing plants in the grid**. Since the connection to a heating grid is usually a long-term purchasing decision, it must also be ensured that the decarbonisation of the heating grid progresses for all connected customers. In order **to ensure that a 'Green Heat Purchase Agreement' contributes to an acceleration of the decarbonisation of heating grids, this application could be limited to heat from unsubsidised new plants**. If, on the other hand, a subsidy under the BEW were to be claimed for the realisation of new plants, corresponding attributes could be distributed evenly among all customers. **Since GOs contain information on the subsidy status of plants, the GO evaluation could be used to achieve transparent verification of the allocation of green district heating quantities to customers in different contract forms**.

2.3.4 Purpose 3: Enforcement facilitation

District heating suppliers have to deal with various - voluntary or mandatory - reporting requirements, which are increasing and becoming more diverse with a growing political role of heating grids for the decarbonisation of the building sector (see Figure 3). These include the already mentioned heat disclosure according to the FFVAV, the designation of grid-specific PEFs, which can be used in the context of the primary energy demand calculation of buildings, and the information obligation for the supply of heat according to the CO2KostAufG. Further reporting requirements will arise if the federal funding for efficient heating grids(BEW) is used and in the future probably through the implementation of the Heat Planning Act (WPG), which is currently in draft form. The AGFW provides application and design aids for calculating energy indicators in the AGFW FW 309 worksheet series.[23] Against this background, a guarantee of origin registry for heating and cooling could make a **possible contribution to the standardisation and digitalisation of verification processes** through a central collection of plant data and data on generation quantities, which could be made available digitally for various purposes. In implementation, heat suppliers could, for example, provide competent authorities or agencies with access to relevant data via monitoring accounts. Potentially, it would also be possible to calculate relevant key figures (e.g., renewable energy and waste heat shares) through the registry software itself, although this would generally require a complete recording of the plants and generation quantities connected to a grid as part of full disclosure (see Chapter 3.7.2).

[23] Arbeitsblattreihe FW 309 Energetische Bewertung von Fernwärme und Fernkälte. AGFW | Der Energieeffizienzverband für Wärme, Kälte und KWK e. V., Frankfurt am Main.

Figure 3: Reporting requirements for heat suppliers



Source: Own representation, Hamburg Institut

The **District Heating or District Cooling Consumption Metering and Billing Ordinance (FFVAV),** which entered into force on 4 October 2021, implements, among other things, information obligations for heating and cooling suppliers imposed by the EU Energy Efficiency Directive 2018/2002/EU (Art. 10a Para. 2 lit. c in conjunction with Annex VIIa No. 3 EED)[24] and by Art. 24 Para. 1 RED II. In addition to other information, suppliers must provide customers with information on the share of energy sources and heat generation technologies used in the overall energy mix and the associated greenhouse gas emissions (§ 5 par. 1), as well as information on the primary energy factor of the technically connected DHC system and the percentage share of renewables used (§ 5 par. 3). According to the newly introduced § 5 para. 1 no. 7 FFVAV of 4 January 2023, in cases where a utility commits to supplying customers with heat or cooling that has been generated to a certain extent from or on the basis of renewable energy or unavoidable waste heat, the share or amount of renewable energy sources and heating or cooling technologies used must be proven by means of guarantees of origin issued by the competent authority pursuant to § 5 HkNRG.

The use of GOs as proof is already mandatory for the disclosure of green district heating supplies (§ 5 para. 1 no. 7 FFVAV). Within the scope of a **full disclosure of all energy sources used in the** grid **with GOs** - also voluntarily possible **-,** energy carrier and technology shares according to § 5 para. 1 no. 2 lit. a could be calculated and verified on the basis of the information available in the H&C GO registry. GHG emissions could be calculated on this basis if information on the energy source mix is combined with emission factors for corresponding energy sources. When reporting PEF and renewable energy shares according to § 5 para. 3, the definitional reference to renewable energies in the sense of § 3 para. 2 GEG must be taken into account. This definition does not necessarily have to be the same as the one on which an issuance of heating/cooling GOs is based (e.g. the GEG definition for electricity-based heating and cooling is limited to solar energy systems or building-

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

integrated wind power systems that are in direct spatial connection with the building, whereas for power-to-heat systems in heating grids, the grid purchase of renewable electricity is also a relevant application, see Chapter 3.5). From the point of view of transparency and comprehensibility for customers, it would be desirable to **harmonise definitions across different reporting obligations.** This also applies to the definition of unavoidable waste heat, whereby the handling of waste heat from thermal waste treatment in particular needs to be clarified (see Styles and Claas-Reuther 2022 for more details).

Pursuant to Section 92 (1) of the GEG, the developer or owner must prove compliance with the **requirements of the GEG** (see Chapter 2.3.3) to the competent authority under Land law by **submitting a declaration of compliance.** The regional governments are authorised to regulate the details of the procedure for the declaration of compliance, the entitlement to issue it, the compulsory information to be provided and the evidence to be supplied in detail by ordinance (Article 94 GEG). In the course of the respective design of the implementation of the law, **implementation could be facilitated where the provision of evidence could be carried out directly by the competent regional authority by querying data from the GO registry**. This could initially be created as an additional option, starting with those who obtain green heat products deposited with the GO registry and whose GO disposal protocols and proofs from the registry could be directly viewed by the competent authority via a digital interface, which would make a chain of evidence or transmission steps obsolete. This is because the information necessary to verify compliance with the law would already be available for retrieval in the GO registry. In the practical design of the GO registry as well as in the procedural regulations, corresponding possibilities for the competent regional authorities to participate in the registry would have to be created to facilitate such a direct retrieval.

The direct retrieval of data from the GO registry could also facilitate the enforcement of state authorities' **compliance with state law requirements**. As described above, these can arise with regard to minimum shares of renewable heat for owners of existing buildings when replacing heating systems or for heating grid operators.

The draft bill for the new Renewable Energy Sources Act does not provide for any changes with regard to the enforcement responsibility of the German Federal States (§§ 92-94 Renewable Energy Sources Act). Here, it would be conceivable to facilitate enforcement by opening up the currently envisaged chain of evidence within the framework of § 71 b GEG (new) for the renewables share of the cumulative useful heat output. Here, too, instead of a confirmation from the heating grid operator to the connectee, which the connectee (as well as the issuer) must keep for 10 years and submit to the competent authority for verification if required (§ 71 para. 2 GEG (new)), **a direct retrieval by the authority from the GO registry would be conceivable, from which the share of the renewable heat supplied to the connectee could be traced on the basis of the cancellation records**.

The information obligations under the **CO2KostAufG** include the requirement that heat suppliers must show a uniform calorific value-related emission factor of the heating grid on invoices in the case of heat supplies from grids with several plants. This factor is intended to balance the emission quantities of individual plants in proportion to the total amount of heat fed into the grid, whereby the calculation of fuel emissions is subject to the provisions of the ordinance pursuant to section 7 (4) nos. 2 and 4 of the Fuel Emissions Trading Act (BEHG), which specifies the standard values to be used.[25] At this point, a heating/cooling GO registry could facilitate the verification of the shares of individual plants in the total amount of heat to be fed in and form the **basis for a**

[25] Fuel Emissions Trading Act of 12 December 2019 (BGBl. I p. 2728), last amended by Article 2 of the Act of 9 November 2022 (BGBl. I p. 2006); Emissions Reporting Ordinance 2030 of 21 December 2022 (BGBl. I p. 2868).

customer-specific allocation of emission factors. It should be noted, however, that the calculation of emission factors is based on fuel quantities used for heat generation, whereas the GO registry would record net heat generation quantities fed into the grid. A GO-based calculation of emission factors would nevertheless be possible, taking into account auxiliary energy use and transport losses, if plant-specific emission factors based on fuel use were first determined (cf. Styles et al. 2022).

Further facilitation of implementation could result from verification processes within the framework of the **federal funding for efficient heating grids(BEW).**[26] Under the BEW, funding is provided for transformation plans and feasibility studies for heating grids, the construction of new heating grids with a share of renewable energy and waste heat of at least 75 %, the transformation of existing heating grids into greenhouse gas-neutral supply systems, and individual measures for existing heating grids. In addition, the BEW includes an operating cost subsidy for the production of renewable heat from solar thermal systems and electricity-driven heat pumps that feed into new heating grids or heating grids to be transformed (BAFA 2023). In the case of new grids to be constructed, grant recipients must submit annual confirmations for ten years from initiation to the Federal Office of Economics and Export Control (BAFA) as the granting agency, confirming that minimum requirements for eligible grids and information on the share of renewable energy and waste heat on which the calculation of the amount of funding is based are met (see BEW guideline of 01.08.2022, section 8.4). In the case of existing grids and new grids, the PEF of the grid must also be documented. Ten years after the starting up of subsidised plants, a status report on the actual performance of the grid must be submitted to BAFA. BAFA also carries out continuous monitoring of the funding of biomass as a heat source, for which the biomass shares of the annually promoted plant output is evaluated. A **comprehensive evaluation system is to be implemented for success control and monitoring**, whereby BAFA is responsible for checking the data required for this. In compliance with data protection regulations, funding recipients are obliged to 'provide all data required for the performance review and evaluation of this guideline and designated to the funding recipient by the approval authority, and to participate in surveys, interviews and other data collection planned by the approval authority for the performance review and evaluation' (Guideline for the BEW of 01.08.2022, section 8.4). **Corresponding data collections could be simplified and digitalised by integrating the H&C GO registry into the evaluation process** by granting BAFA as the approval authority access to relevant plant and generation data via a monitoring account. **With full disclosure of the heat generation quantities fed into a grid, the GO registry could also be used to verify** renewable energy and waste heat **shares**. In addition, the GO registry could be used for the **digital transmission of generation data for operating cost subsidies.** Here, BAFA is responsible for checking the measurement data on the quantities of heat fed into the heating grid, which must be transmitted annually by the system operator in the form of an interim certificate. Corresponding data transmissions and checks are also required for the issuance of heat GOs, so that cross-authority synergies can be used here and a duplication of verification and checking processes can be avoided.

Finally, there could be synergies with the implementation of the **Heat Planning Act (WPG)**, which is available as a draft bill from the federal government. The WPG obliges the German Federal States to ensure that heat plans have been drawn up for all municipal areas with more than 10,000 inhabitants by the end of 2028 at the latest (§ 5). In line with the amendment to the Renewable Energy Sources Act (see 2.3.3), it is mandatory for new heating grids with construction starting after 31 December 2023 to be supplied with at least 65% heat from renewable energy, unavoidable waste heat or a combination thereof (§ 26). For existing grids, there is an obligation to achieve a corresponding minimum share of 50 % by 2030 (§ 25). The draft bill of 1 June 2023 provides for extensions of the deadline for grids with transformation plans. For grids fed with at least 50 % from fossil-fuel

[26] Guideline for federal funding for efficient heat grids- BEW of 01.08.2022, BAnz AT 18.08.2022 B1.

CHP plants promoted under the Combined Heat and Power Act (KWKG), only the remaining heat fed into the heating grid must be generated from renewable energy and/or unavoidable waste heat by the end of 2035. All heating grids must be operated in a climate-neutral manner by 2045, whereby the biomass share of the annually generated heat volume is to be limited to a maximum of 25 % or 15 %, depending on the length of the grid (§ 27). For new grids, the biomass share shall be limited to a maximum of 35 % or 25 % as early as 2024 (§ 26). For the monitoring of the obligations, Federal State governments are to be empowered to designate a competent authority (Article 30, No. 5). Here, too, the **use of the H&C GO registry as a central database** could **reduce the burden of verification procedures**. Furthermore, operators of heating grid are obliged to provide information to the authorities responsible for the preparation of heat plans with regard to data required for inventory and potential analyses (§ 11 par. 1 no. 5). Via a national H&C GO registry, heating grid operators could make data on heat generation plants and quantities available digitally.

2.3.5 Status of implementation in Germany

The implementation of the RED II requirements regarding the heat registry took place in Germany through the **Guarantees of Origin Registry Act (HkNRG)**[27] and **amendments to the District Heating or District Cooling Consumption Metering and Billing Ordinance (FFVAV)**[28].

The **HkNRG** entered into force on 14.01.2023 and is intended to create the **framework conditions for the establishment and operation of guarantees of origin registries for gaseous energy sources as well as heating and cooling from renewable energy or unavoidable waste** heat (§ 1) and thus implements the extended scope of application for GOs under RED II. In addition to definitions (§ 2), the Act contains general regulations such as the basic assignment of tasks to the competent authority regarding the issuing, transfer, and cancellation of GOs and basic GO principles (§§ 3 and 5, reference unit megawatt hour, exclusion of double marketing). The Act then contains ordinances on the content and sub-delegation of GOs and GO registries for gaseous energy sources (§ 4) and for heating and cooling (§ 6). It also contains ordinances on data reconciliation and data exchange between the new registries to be introduced and the existing registries in the electricity sector, as well as on the operation of all GO registries in a database (§ 8) and provisions on fines (§ 9).

For heat GOs and H&C GO registries, § 5 HkNRG sets the framework known from RED II. Paragraph 1 stipulates that the competent authority, which has yet to be determined, issues GOs for renewable heat or heat from unavoidable waste heat to operators of installations for the production of heat and cooling in accordance with § 6 HkNRG, is responsible for cancelling and transferring GOs, operates the corresponding electronic database in accordance with DIN EN 16325 (the European GO standard) and prevents misuse of GOs in the heat sector. § Section 5 (3) HkNRG further stipulates that a GO (and only one GO) shall be issued for a quantity of heat or cooling from renewable energy or unavoidable waste heat of one megawatt hour generated and delivered to customers. For electricity-based heating or cooling from renewable energy or unavoidable waste heat, § 5 par. 4 HkNRG stipulates that GOs are only issued if GOs have been cancelled for the electricity consumption from a grid on which the generation is based in accordance with § 79 EEG and the Implementing ordinance on guarantees of origin and regional guarantees for electricity from renewable energies (HkRNDV). According to section 5 subsection 5 HkNRG, the issuance of GOs for heating and cooling or unavoidable waste heat is excluded if electricity was consumed in their generation (also via the diversions of gaseous energy carriers), which receives

[27] Guarantees of Origin Registry Act of 4 January 2023 (BGBl. 2023 I No. 9).

[28] District Heating or District Cooling Consumption Metering and Billing Ordinance of 28 September 2021 (BGBl. I p. 4591; 4831), as amended by Article 2 of the Act of 4 January 2023 (BGBl. 2023 I No. 9).

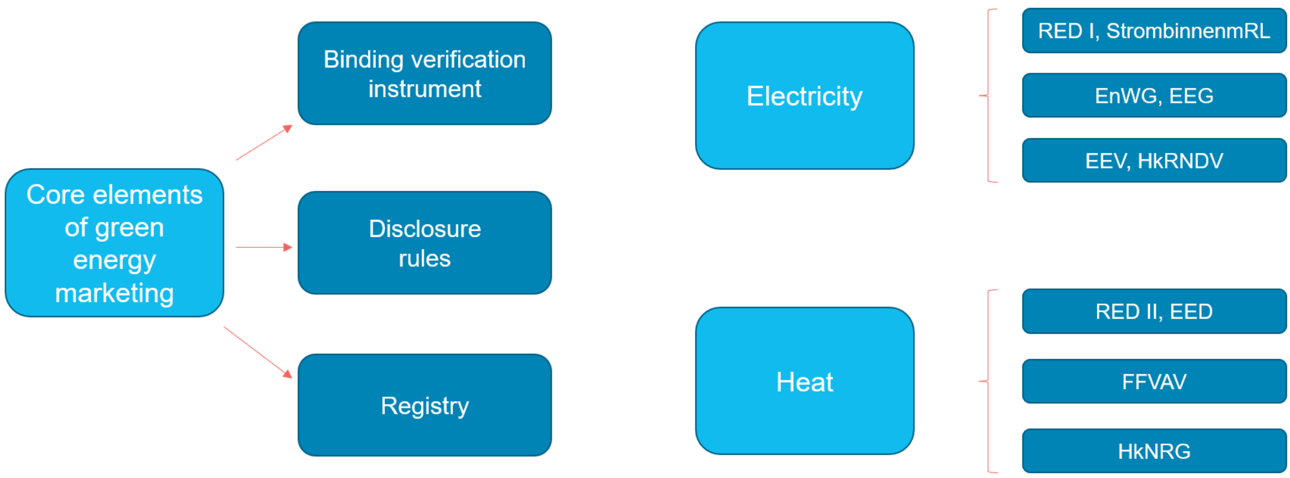
financial support according to the EEG (according to section 19 or 50 EEG with the exception of cases of electricity consumption at the request of the grid operator according to section 13 subsection 6b or section 13a EnWG, especially to avoid the curtailment of renewable energy installations). Here, the HkNRG reflects the status of the EEG (cf. § 79 par. 1 no. 1 and § 80 par. 2 EEG), which is to be continued via these provisions for electricity-based heating and cooling. Section 6 para. 1 no. 11 HkNRG contains the authorisation to limit the cancellation of GOs for heat and cooling from renewable energy or unavoidable waste heat to consumption in the DHC grid in which the generation plant on which the GO is based is located. This authorisation reflects the idea of grid identity as a credibility element (see chapter 2.3.2).

Pursuant to § 5 para. 1 no. 7 **FFVAV,** utilities that undertake to supply customers with heat or cooling that has been generated to a certain extent from or on the basis of renewable energy or unavoidable waste heat must provide evidence of the proportion or quantity of renewable energies and technologies used by means of GOs issued for the heat or cooling supplied to the customer. This provision thus designates the GO as the mandatory verification instrument for disclosure of renewable heat and cooling. According to the wording, the provision also requires a link between the GO and the quantity of heat or cooling supplied, as the verification must be carried out with the GOs issued for the heat supplied to the customer.

2.3.6 Adaptation/Extension options regarding the legal framework

With the HkNRG and the amendment to the FFVAV, essential elements for the implementation of the European legal requirements and the introduction of the GO system for heating and cooling are already in place in Germany (referred to in short as the heat GO system in the following). Figure 1 summarises the **core elements of the marketing of green energy:** the creation of a binding verification instrument, the implementation of a disclosure rule and the implementation of a registry- for the application cases of electricity and heat.

Figure 4: Core elements of green energy marketing and implementation for electricity/heat



Source: Own representation, Hamburg Institut

As illustrated above, there are **still a few more steps to be taken to complete the heat** GO **system including the registry, for which the** foundations have already been laid with the far-reaching ordinance authorisations in the HkNRG. The concrete design of the registry and its procedural rules will lead to further completion in the near future. The practical commissioning of the national H&C GO registry will then actually bring the heat GO system to life for all actors. The implementation of the grid identity in the GO evaluation appears to be particularly important as a credibility element.

In addition, further stages of integration and digitisation potential are conceivable, which would require changes to or extensions of the legal framework to a considerable extent. The presentation of the required basic elements of the heat GO system, the possible purposes it is suited to serve and the current state of implementation in Germany reveal various stages of possible further development.

On the one hand, the **heat GO system** could be **further strengthened by extending the mandatory use of GOs as a verification instrument to other areas**. Currently, the FFVAV only requires the use of GOs as a verification instrument for the supply of renewable heat to end customers if special renewable heat products are sold. However, if heating grid operators/heat suppliers do not sell special renewable heat products, they are not subject to this disclosure obligation by means of GOs and can also carry out the grid transformation completely independently of the heat GO system. This is because the principle laid down in European law applies here that GOs are only issued upon application. The only way to broaden the scope of application of GOs would be to introduce full disclosure by means of GOs, which would also be issued for energy from non-renewable sources (see Chapter 3.7.2).

In addition to the possibility of the extended obligation to use GOs in the context of disclosure, it would be possible to advance the **recognition of GO-backed** renewable **heat products in the context of verification for regulatory requirements.** This could initially also be done as an additional option to the existing verification pathways. Since this approach has the incentive of simplification, it could also contribute to a strengthening of the heat GO system.

The registry role of authorities and their authorisations with regard to data access and data reconciliation play an essential role for the **possible facilitation of enforcement through the heat GO system.** Here, the existing ordinance powers of the HkNRG would have to be explored and the provisions for law enforcement by the German Federal States in the GEG (new) or WPG (draft) would have to be concretised.

From a legal perspective, however, it seems sensible not to take the second step before the first here, but to **incorporate future experience based on an ongoing national heat registry as well as the resulting needs of the market players and the digitalisation capacities of the authorities**.

3 KEY DESIGN ISSUES FOR A GUARANTEES OF ORIGIN SYSTEM FOR HEATING AND COOLING

Different technical, economic, and institutional framework conditions apply to the supply of DHC compared to the supply of electricity. This implies that the **established electricity GO system** cannot be **transferred to the heating and cooling application without modifications.** Even though Article 19 of RED II and EN 16325, which is currently being revised, provide a framework for the design of heating and cooling GO systems (see chapter 2.1), there is still significant scope for design. In particular, states or regions that establish corresponding systems can use **cancellation rules to** define which requirements a GO must meet in order to be used for a specific purpose. The question of whether a **grid connection between producers and consumers** a prerequisite for cancelling GOs for disclosure purposes should be, or whether cross- grid cancellability of GOs should be permitted, is the subject of particularly intense debate (see Verwimp et al. 2020a; Van Stein Callenfels et al. 2020).

Other design options, such as the **integration of end consumers in GO registries**, the **handling of self-supply** or the **treatment of storage and grid losses,** are already handled differently in the electricity GO systems of different countries. This raises the question of the advantages and disadvantages of different options in the heating and cooling context. If heating and cooling plants obtain electricity or gas via grids, it must also be clarified which verification requirements are placed on the attributes of these energy inputs so that the heat generated can be considered green. This requires rules for the transfer of **green attributes** across sectors or energy carriers in **the context of energy conversion processes.** Another special feature is the **verification of plant and measurement data**. Especially in the verification of measurement data, independent grid operators play a central role in electricity GO systems. DHC grids, on the other hand, are usually vertically integrated systems in which grids are operated by the utility itself, as are at least some of the generation plants. Finally, the **design of disclosure rules is of** central importance so that GOs can fulfil their information function vis-à-vis consumers.

In the following, the central design options for heating and cooling GO systems are examined in more detail. Reasons are given as to which option was selected for the IW^3 pilot registry in each case. In addition, it describes how design decisions were implemented in concrete terms. **Methodologically, the analysis is based on various foundations**. On the one hand, the scientific literature on the design of GO systems was evaluated and supplemented by an analysis of the legal framework conditions for electricity GOs in Germany and for heat GOs in the Netherlands and Flanders, where corresponding systems were already established before 2021. Significant input for design decisions was also developed in the context of a stakeholder workshop with actors from the areas of heat supply, generation, consumption, and administration, which was conducted online in April 2021 with approx. 40 participants. In addition, Grexel provided technical advice on the implementation of design options in the registry software and coordinated design decisions with the IW$_M$ project partners Hamburger Energiewerke and the Hamburg University of Applied Sciences (HAW).

For better readability, the term heat GO is used in the following, but results also apply analogously to the area of cooling supply.

3.1 Cross-grid cancellability of GOs

The definition of the system boundary for characterising the attributes of supplied district heating is a fundamental decision for GO systems for thermal energy. Heating and cooling grids are closed, usually local systems, across whose boundaries no quantities of heat or cool are supplied. On average across Germany, district heating water grids have a mean grid length of 20.1 km per grid (with significant differences between several German Federal States, from 4.3 km mean grid length in Hesse to 285.5 km in Hamburg, see AGFW 2022). Steam grids have a mean grid length of 16.2 km per grid throughout Germany; district cooling grids, which have been much less widespread to date, tend to be smaller with a mean grid length of 2.9 km per grid. Although in some cases there are regional interconnected systems in which individual grids are technically coupled with each other, there are also clearly defined limits to the supply system here (e.g., the district heating grid in the Ruhr area or the Saar district heating grid in Saarland, see Engelmann et al. 2021, p. 342 and 252). The ecological quality attributes of supplied district heating are defined in accordance with the applicable legal framework in relation to technically interconnected DHC systems of suppliers (see chapter 2.3; cf. e.g., § 5 para. 3 FFVAV as well as § 22 para. 2 GEG).

The case appears to differ in the electricity sector with widely branched distribution and transmission grids in which electricity is transported at different voltage levels connected by substations. In 2021, the length of the low-voltage, medium-voltage and high- and extra-high-voltage grids in Germany totalled 1.90 million km (BDEW 2023d). There are connections to the electricity grids of neighbouring countries via cross-border interconnectors and thus an integration into the European interconnected grid (see e.g., BDEW 2023e for an overview of cross-border electricity exchange in 2022). Tracing grid connections between electricity generation and consumption points to prove that electricity can at least theoretically be supplied would involve a great deal of effort. **Accordingly, electricity GO systems abstract from grid connections within the system boundary of the European internal market**. In principle, all GOs from the EU and the EEA that comply with the requirements of Art. 19 RED II can be used for electricity disclosure. The German Environment Agency verifies the recognition of foreign certificates in Germany. According to Art. 19 para. 11 RED II, GOs issued by third countries can only be recognised if an agreement on the mutual recognition of GOs exists between the EU and the third country and energy is directly imported or exported.

The abstraction of grid connections in the electricity GO system follows the ideal image of a European 'copper plate' even if in reality cross-border transmission capacities are limited or - in the case of Iceland and Cyprus - currently non-existent. Domestically, too, grid bottlenecks have to be taken into account when transporting electricity. **However, a stricter consideration of the spatial connection between generation and consumption can be done on a voluntary basis**, taking into account the plant location information on GO. In part, a limitation of the spatial correlation is also laid out in criteria of green electricity labels or initiatives such as RE100, which formulate requirements for the quality of green electricity used. For example, the update of the RE100 criteria published in autumn 2022 stipulates that, in order to meet their green electricity targets, companies participating in the initiative may only use green electricity or GO from countries that are part of the European internal market and a member of the Association of Issuing Bodies (AIB), and are thus connected via the AIB registry hub and follow the standardised rules of the European Energy Certificate System (EECS) (RE100 2022). In addition, countries of origin must have a grid connection to a country that meets the first two requirements. Green power labels also sometimes specify the European interconnected grid as the relevant system boundary for GO procurement, which excludes Iceland and Cyprus as GO procurement countries (see OK Power 2018). **According to RED II**, **green hydrogen should also be subject to requirements regarding the spatial and temporal connection of production and consumption in order to count towards renewable energy targets for the transport sector** (cf. Art. 27 para. 3 RED II). The RED III draft extends the application of the criteria to further areas of application of 'renewable fuels of non-biological origin' (RFNBOs). The Delegated Act of the EU Commission on the specification of these criteria, which was finally adopted in June 2023, focuses in particular on the location of the electrolyser and the electricity generation plant in the same or neighbouring price bidding zones with regard to the spatial connection (see chapter 3.5.2.3). Even beyond the Delegated Act, increased consideration of spatial correlations in the electricity sector is being discussed, with the aim of creating signals for improved coordination of renewable energy generation and consumption, taking transmission capacities into account, and preventing an increase in electricity consumption from locally leading to an expansion of electricity generation from fossil sources (e.g. EnergyTag 2022a, p. 8 ff.). Strengthening the credibility of statements to consumers also plays an important role in this discussion.

Accordingly, the question arises for heating and cooling GO systems whether grid boundaries should be abstracted from when using GO for disclosure purposes, or whether a grid connection between generation and consumption should be assumed to ensure that thermal energy quantities can be supplied, at least in principle. In this case, concrete heat flows within technically connected grids are also abstracted from - since these follow thermodynamic laws, the attempt to control them to meet the demand of certain customers in the grid for green energy is not appropriate. The few GO systems for heating and cooling that have already been implemented have taken different approaches with regard to the consideration of grid boundaries. The Dutch GO system for thermal energy excludes a cross-grid GO evaluation for disclosure purposes (Verwimp et al. 2020a, p. 71 f.). GOs may only be used as proof of delivery to final customers connected to the same heating grid into which the heat was injected.[29] In Finland, however, cross- grid cancellation is allowed.[30] The Flemish system also allows GO cancellation across grid boundaries, at least in the Flemish region (Verwimp et al. 2020a, p. 71 f.).[31] The draft version of the GO standard EN 16325 provides that national or regional GO systems for heating and cooling can define cancellation rules with regard to grid boundaries themselves, although the revision of the standard has not yet been completed (FaStGO 2020, p. 56). Advantages and disadvantages can be identified for the different approaches, which are discussed in more detail below. The results of the IW^3 stakeholder workshop in April 2021, at which the question of cross-grid cancellability of GOs was an intensively discussed topic, are also included.

3.1.1 Arguments promoting a cross-grid cancellability of GOs

The creation of a single European market for heating and cooling GOs would lead to **significantly higher liquidity in the GO market** than would be the case if cancellation for disclosure purposes were restricted to technically interconnected grids. In this context, higher market liquidity can lead to lower prices for GOs, so it is to be expected that trading GOs between grids would allow the offer of cheaper green district heating products than would be the case if green district heating marketing were restricted to plants actually present in the grid. For utilities, resilience to unplanned plant outages would also increase. In such cases, GOs could be used from outside the company-owned grid in order to be able to fulfil supply obligations regarding green attributes to customers. Otherwise, backup capacities based on renewable energies would have to be set up in the own grid to compensate for possible plant failures, or it would have to be contractually agreed that in the case of unplanned plant failures, a supply with heat of non-renewable origin is permissible.

For both district heating customers and suppliers, it may also be beneficial to **decouple the supply and demand for green energy in their own grid**. Customers would be given the opportunity to purchase a district heating product with green attributes regardless of the investment behaviour of their local district heating

[29] See Art. 25a, lit. b Regeling garanties van oorsprong en certificaten van oorsprong, https://wetten.overheid.nl/BWBR0035971/2020-01-01#Paragraaf6_Artikel25.

[30] See Act on Guarantees of Origin for Energy (Translation from Finnish), https://www.finlex.fi/en/laki/kaannokset/2021/en20211050.pdf.

[31] Decree of 8 May 2009 containing general provisions on energy policy; Flemish Government Decree of 19 November 2010 containing general provisions on energy policy, https://www.vreg.be/sites/default/files/wetgeving_inzake_gos.pdf.

supplier. It should be noted that district heating grids are natural monopolies and utilities are usually vertically integrated (see Engelmann et al. 2021, p. 342). The opening of grids to additional suppliers is possible, but a prerequisite, since, with constant demand, the integration of additional plants into the supply system would necessitate production reductions in existing plants which can impair their economic viability and possibly the economic viability of the heat supply system as a whole. In Germany, district heating customers are therefore usually not able to choose between different suppliers within a grid. If there were only limited investments in renewables in the company-owned grid, and customer requests for higher renewable energy shares were not met or only at high surcharges, the only alternative would be to disconnect from the grid and invest in own, decentralised renewable energy plants. However, this would often not be cost-efficient for customers who have decided in the past to connect to a heating grid with the associated investments.

To what extent the cancellation of GOs from a grid other than one's own leads to an extended choice for district heating customers depends, however, on the design of the GO cancellation right (see chapter 3.3). Independence from one's own supplier would be given if customers were able to withdraw GOs themselves. In the electricity sector in Germany, GOs can currently only be cancelled by electricity suppliers for their customers (see Styles et al. 2023). If this approach were to be transferred to the DHC sector, customers would have to negotiate the attributes of the district heating product they purchase with their district heating supplier (or agree on provision contracts in which GOs they purchase themselves are devalued by the district heating supplier). It follows that opening up the disclosure for off-grid GOs would not necessarily result in greater competition in the marketing of green district heating.

For district heating suppliers, on the other hand, the establishment of a cross-grid GO market can create incentives to invest more in the expansion of renewable energy and to generate revenues through trading in GOs, even if there is no demand for green thermal energy in their own grid. However, this presupposes that customers of other district heating grids are sufficiently **willing to pay for the corresponding GOs.**

The argument of cost efficiency can also speak in favour of a cross-grid cancellability of GO: **Similar to the logic of renewable energy quota systems with tradable fulfilment contributions, incentives for renewable energy expansion are first set where generation and system integration costs are lowest** (Pototschnig and Conti 2021). Heat suppliers with comparatively high renewable energy expansion costs could thus initially purchase GOs for disclosure purposes from supply systems that were already able to realise higher renewable energy shares due to lower specific expansion costs. With regards to the shortening of the timeframe to reach the climate neutrality target of 2045, however, the scope for corresponding shifts is gradually becoming smaller, so that a balance must be struck **between the economic cost-efficiency concept and the risk of delaying necessary transformation processes in individual grids** (see 3.1.2). The respective balance here also depends on the framework conditions of district heating supply, which show significant differences in different EU Member States. For example, district heating systems in Finland already have a comparatively high renewable energy share with an average of 44 % in 2020 (Statistics Finland 2021). In grids with high renewable energy shares, a cancellation of off-grid GOs could make it easier for heat suppliers to achieve a renewable energy share of 100 % for their entire grid.

Meanwhile, whether GO cancellation across grid boundaries leads to cost savings or an increase in the price of green district heating products for individual customers depends on the marketing contexts in the respective grid. While higher market liquidity tends to lead to lower GO prices, in the own grid the scarcity of green attributes may increase when suppliers export attributes of their renewable energy-based heat generation from the grid. Provided that there is transparency about the origin of the grid, there could also be **price differentiation between on-grid and off-grid GOs,** reflecting the preferences of district heating customers.

3.1.2 Arguments for restricting the cancellability of GOs to technically interconnected grids

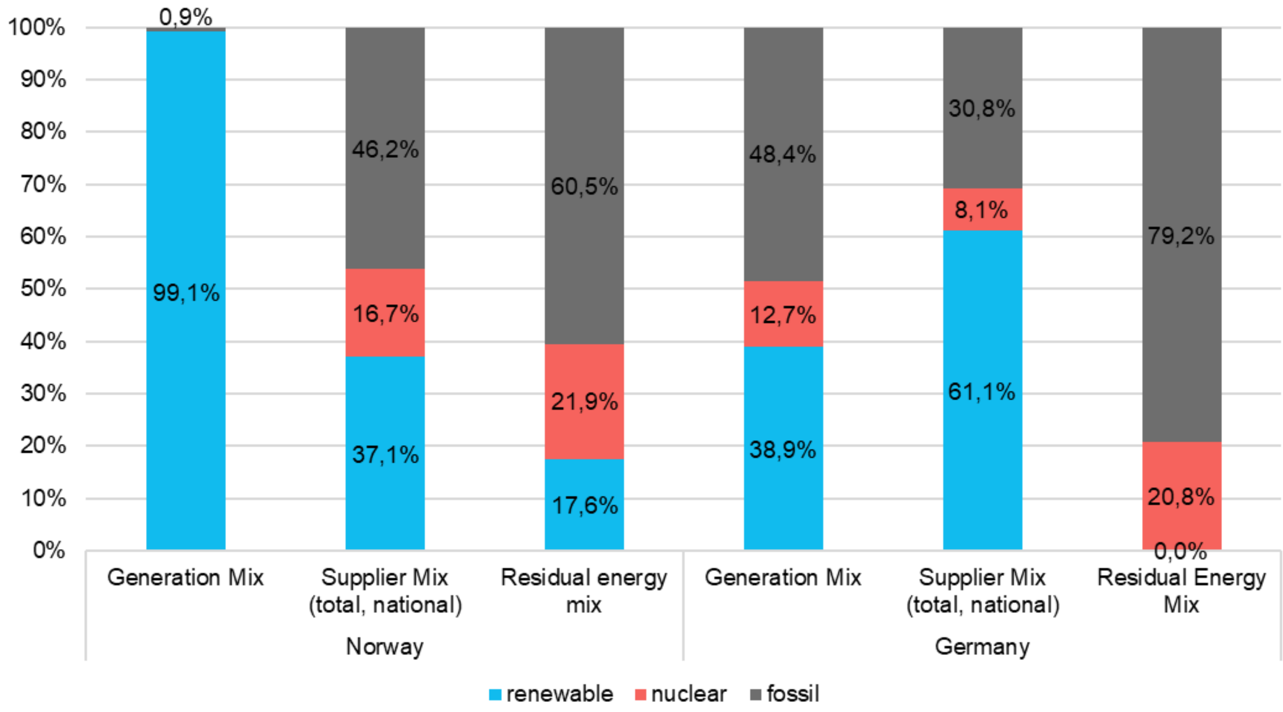
The main argument against heating and cooling disclosure with GOs from unconnected grids is that **credibility for consumers** is **extremely uncertain. In** addition, there are **challenges in excluding multiple marketing and multiple claims of green attributes**. For grids with a low share of renewable energy and unavoidable waste heat , there is also a **risk that the transformation process of one's own grid could be slowed down by the purchase of GOs from other grids**.

Heating and cooling grids are, as described in the introduction in 3.1, local or at most regional systems. It is not possible to supply thermal energy from technically unconnected grids. **This characterisation of heating and cooling grids as closed systems represents a fundamentally different framework condition than the widely branched grid structure of the electricity system with a European interconnected grid.** If a GO from a Spanish PV plant, for example, is cancelled for electricity disclosure in Germany, it cannot be assumed that the megawatt hour fed into the grid is physically delivered to Germany, but in principle there are electricity exports and imports between Germany and France and France and Spain that are handled via border interconnection points. For a building connected to a Hamburg heating grid, however, there is no possibility of exchanging thermal energy with a heating grid in Munich or in other EU Member States. **Unlike in the electricity and gas sectors, there is no single European market - and no national market - for thermal energy.** Accordingly, there are doubts as to whether, for example, Hamburg district heating customers would consider a heat label with GO from a geothermal plant in Munich or a biomass plant in Sweden to be credible. Corresponding concerns were also raised in the consultation on EN 16325 carried out in the FaStGO project, with stakeholders partly fearing that the **purely virtual nature of a GO trade between grids for thermal energy could damage consumer confidence in the GO system as a whole** (e.g., also for electricity and gases, see Van Stein Callenfels et al. 2020, p. 25 f.).

In addition to the missing grid connections, it is also relevant for the credibility of a cross-grid cancellation of heating and cooling GOs for disclosure purposes that **grids can have clearly heterogeneous attributes**. This starts with the **distinction between heating and cooling grids**, but **differences in temperature levels** are also relevant within both categories (Verwimp et al. 2020a, p. 73). Heat supplied at several hundred degrees Celsius via process heat grids has a different economic value than heat at 90°C used to supply buildings. Accordingly, credibility would be reduced if GOs issued for supply to a grid with a significantly lower temperature level could be used to mark a demand for high-temperature process heat. In the case of cross-grid cancellation, this can be addressed by displaying on the GO the temperature level into which it is fed, and only GOs of the same temperature level may be used for marking (FastGO 2020, p. 53 ff.). However, in addition to challenges in the design of the temperature level limits, this can result in innovation barriers for the transformation of heating and cooling grids to systems with a large number of decentralised feeders of thermal energy from renewable energy and waste heat, as well as barriers for the technical coupling of grids. In the case of cancellation rules that are linked to temperature levels, the question arises, for example, of how to deal with a solar thermal system that feeds into the cold return flow of the grid and thereby relieves the primary heat source. The supply temperature of buildings could be at a different temperature level than the grid feed-in of the renewable energy system. It would also have to be clarified how GO from plants in coupled grids with different temperature levels would have to be treated, e.g., in the case of a process heating grid whose return flow is used for a heating grid to supply buildings. On the other hand, limiting the GO evaluation to technically connected grids eliminates the need to distinguish between temperature levels (in hybrid grids that can switch between heating and cooling supply, a fundamental distinction between heating and cooling may nevertheless be useful).

Of particular importance, which also influences the credibility of heating and cooling GO systems, is the **problem of possible multiple marketing or multiple claims of green attributes by producers or customers**. This can arise for several reasons in the case of a cross-grid GO evaluation for disclosure purposes. For example, district heating plants are often strongly anchored in the municipal context. This includes the visibility of e.g., coal-fired power plants or solar thermal plants in the city or community image, but also local media coverage of new renewable energy or waste heat recovery plants or, for example, stakeholder participation processes to accompany geothermal drilling. Here, there may already be a **perceptual double claim of green attributes** - for example, if consumers know that their heating grid is supplied by a geothermal plant, and on this basis assume that their heat deliveries also come from geothermal energy, even if corresponding attributes are exported from the grid via GO sales and are not included in the heat label. A similar challenge in perception arises for Norwegian electricity consumers, as Norway's generation mix is dominated by hydropower, but a large part of the green attributes is exported to other countries via GO. As a result of this, the Norwegian electricity mix has relevant shares of nuclear and fossil energy sources, even though the domestic generation mix in 2021 was 99.1 % renewable (of which 91.4 % hydropower, see AIB 2022). Figure 5 compares the generation mix, supplier mix and residual energy mix of Norway, which is a net exporter of energy attributes, with Germany as a net importer of energy attributes (cf. AIB 2022; AIB 2023a).

Figure 5: Generation mix, total supplier mix and residual energy mix in the electricity sector: The examples of Norway and Germany in 2021 (shares of different energy sources in percent)



Note: The generation mix corresponds to the total annual supply of energy attributes generated in a country (based on electricity generation statistics). The supplier mix includes both explicitly tracked attributes (energy quantities for which GOs have been cancelled, as well as electricity quantities subsidised under the Renewable Energy Sources Act in Germany) and electricity quantities that are not explicitly tracked (in the case of the reporting of non-traced trade offers, for which the residual energy mix can be used). (Individual) supplier mixes are shown in the electricity disclosure.

The national residual energy mix is calculated by adjusting the generation mix of the respective country for the attributes of explicitly tracked energy quantities (e.g., energy quantities for which GOs have been cancelled and, in Germany, also EEG-subsidised electricity quantities). The cross-border trade of electricity quantities and GOs means that countries can have surpluses or deficits of attributes (attribute surpluses occur, for example, in Germany as a net importer of energy attributes, while attribute deficits result in Norway as a net exporting country). Attribute surpluses are included in the 'European Attribute Mix', which is used by countries with attribute deficits to 'fill up' the national residual energy mix.

Source: Own representation, based on AIB 2022.

Even though electricity exports are currently much smaller than attribute exports, there are connections to the European interconnected grid, whereas a **larger abstraction** would be required for a **attribute export from heating and cooling grids.** Double marketing would occur if heat suppliers advertised the attributes of their plant park locally to customers (e.g., for connection to a heat grid), but the attributes of the corresponding heat generation were marketed outside the grid.

Multiple marketing or claiming of green attributes can also result from different disclosure rules in different countries. For electricity disclosure, the use of GOs for the disclosure of renewable energy shares or quantities in electricity supplies is harmonised and mandatory at European level, through RED II and the Internal Electricity Market Directive (see chapter 2.1). **For the heating and cooling sector, however, the link between GO and disclosure rules is less clearly formulated** (see also Verwimp et al. 2020a, p. 71). Art. 19 (8) RED II only states that utilities must use the GO provided for the type of energy supplied for disclosure purposes if Member States have also provided GOs for energy types other than electricity. **However, basic disclosure rules are formulated in Article 24 (1) RED II and the Energy Efficiency Directive EED** (see also Chapter 2.3.4). Accordingly, Member States must ensure that end-users are provided with easily accessible information on the energy performance and the share of renewable energy of their DHC systems (Art. 24 para. 1 RED II). In addition, end-users must be provided with information on the fuel mix used and the associated annual greenhouse gas emissions (Art. 10a para. 2 lit. c in connection with Annex VIIa No. 3 EED). The **form of the verification of renewable energy shares is not defined in more detail**. However, the wording 'share of renewable energy in **their** DHC systems' makes it clear that this must be information on the generation mix in the heating grid in which the point of consumption is located. At national level, this is also reflected in the **FFVAV**, where Art. 5 para. 3 FFVAV explicitly requires suppliers to provide information on the share of renewable energy used in their **technically connected DHC system.** Assuming the continuation of corresponding disclosure rules, **two labels** would have to be **prepared in the case of a cross-grid GO evaluation**: one with information on the attributes of the supplier's own DHC system, and one on the attribute mix after taking into account imports and exports of GO across the supplier's own grid boundaries. This is likely to reduce the comprehensibility of the disclosure and may lead to multiple marketing and claims if customers can choose between both statements. **In this case, it would therefore have to be clearly and bindingly defined for which purpose which statement applies, and this in a harmonised European form** (e.g. GO-based disclosure for statements about the attributes of heat deliveries for consumer information and climate assessment purposes on the one hand and renewable energy share in the specific, technically connected heating grid as a key figure for offsetting against regulatory requirements or building subsidies on the other).

In the case of a cross-grid cancellation of GOs for disclosure purposes, the following question also arises: **If attributes are exported from the grid, which attributes are applied instead?** For the electricity sector, a harmonised European methodology for calculating the residual energy mix exists - at least among the AIB Member States (AIB 2022, see Figure 5). Member States calculate national residual energy mixes by adjusting the annual generation mix (based on electricity generation statistics) of the respective state for the attributes of explicitly tracked energy quantities (e.g., energy quantities for which GOs were cancelled or, in Germany, also EEG-subsidised electricity quantities) (see AIB 2022; Art. 2 No. 13 RED II). However, deficits or surpluses in energy attributes can occur due to the trading of electricity quantities and GOs between member countries. To compensate for these, a European Attribute Mix is calculated, which is fed by countries with attribute surpluses and used by countries with attribute deficits to fill national residual energy mixes (AIB 2022).

For the heating and cooling sector, no corresponding, harmonised residual energy mix calculation methodology exists so far. Possible approaches were proposed by the FaStGO project (see Verwimp et al. 2020b). In the case of a cross-grid GO evaluation, the question thus arises as to whether residual energy mixes should be determined on a grid-specific basis, with balancing of attribute surpluses and deficits via a national residual energy mix, which would itself have to be balanced via a European attribute mix. This would create transparency about the attribute import and export of grids, but the calculation effort would probably be significantly higher than for the electricity residual energy mix calculation. Another option would be to match grid-specific residual energy mixes directly with a European attribute mix for heating or cooling without calculating a national residual energy mix. As a third option, grid-specific residual energy mixes could be dispensed with. In this case, a national residual energy mix would be calculated directly based on national DHC generating statistics as well as heating and cooling GO statistics, which could be used by all grids with attribute deficits. It is recommended to distinguish between residual energy mixes for district heating and district cooling for all options (Verwimp et al. 2020b, p. 24).

In any case, it would be important to **establish a harmonised European methodology, as otherwise double counting of green attributes cannot be ruled out**. As a transitional solution, the FaStGO project, for example, proposes to consider only fossil attributes for residual energy mixes (Verwimp et al. 2020b, p. 6 and 24). To compensate for attribute deficits in grids resulting from the export of GO outside the grid boundaries, only fossil attributes could be applied in this case (and not the attributes of e.g., renewable energy plants that forego GO issuance). However, as different fossil energy sources differ significantly in terms of their GHG balance (e.g., coal with or without CHP, gas, fuel oil), a reliable statistical recording of fossil attributes would be a prerequisite for this approach. If this is not given, the attributes of the fossil energy source with the highest emission factor represented in the national heat generation mix could be applied by default.

It should be noted that the need for a residual energy mix calculation arises from the fact that in most countries only a part of the (usually renewable) energy production attributes are explicitly tracked. **In the case of full disclosure, where GOs would be issued for all energy sources and cancelled for each energy consumption, the residual energy mix would be zero** (AIB 2022; Verwimp et al. 2020b). With a pan-European full disclosure in the heating and cooling sector, attributes of grids trading GOs with each other could be directly swapped (e.g., coal CHP attributes for geothermal attributes). However, as full disclosure is possible on a voluntary basis but not mandatory across Europe, this option for dealing with attribute deficits or surpluses remains theoretical so far.

If the GO evaluation for disclosure purposes is limited to technically interconnected grids, the challenges in dealing with attribute deficits or surpluses do not arise. Although GO cancellation determines the allocation of attributes to certain customers (in the context of product disclosure), the attributes of the overall energy mix within the technically interconnected grid do not change. The attributes of the different products marketed in the grid must add up to the attributes of the entire technically connected heating or cooling system (provided that losses are taken into account in the balancing, see Styles et al. 2022). **Residual energy mixes are thus determined purely in relation to the grid. This ensures the robustness of the balancing system without requiring a harmonised methodology for the residual energy mix calculation across Europe**.

Finally, the question arises **how GO can best support the ecological transformation of heating and cooling grids instrumentally. This question has to be answered against the background of specific national framework conditions of DHC supply**. A cross-grid GO cancellation can bring additional transformation incentives for suppliers, especially if there is only limited demand or willingness to purchase green district heating in their own grid. From a consumer protection point of view, however, precautions would have to be taken to ensure that a lack of willingness (or ability) to increase demand does not lead to a deterioration of the attribute mix compared to the status quo (through attribute export, but also redistribution of green attributes in the own grid). For customers, the purchase of off-grid GO offers the possibility to accelerate the expansion of green district heating, especially if a corresponding expansion in their own heating grid does not seem feasible. **In Germany, however, the long-term decarbonisation of heating grids is stimulated by various instruments** (such as, in particular, the planned Heat Planning Act, but also the federal funding for efficient heating grids with the requirement that systemically funded grids must achieve greenhouse gas neutrality by 2045 at the latest; national certificate trading for fuel emissions with an increasing price path; or the phase-out of coal-fired power generation by 2038 at the latest).[32] At the same time, current renewable energy and unavoidable waste heat shares in heating grids are above average for the heating and cooling sector as a whole, but still in need of significant expansion (see Chapter 1). In this context, it may make sense to **focus heating and cooling GOs primarily on supporting and accelerating transformation processes in the customer's own grid** (whereby accelerating the expansion of climate-neutral generation options leads to additional GHG savings over time). This could be achieved by limiting the GO cancellation for disclosure purposes to technically connected grids.

In the case of a cancellation of GO across grid boundaries, on the other hand, there would be the risk that the transformation of one's own grid could be postponed if the demand for green district heating in the grid could be met, at least temporarily, by purchased GO from outside the grid. With regard to the climate protection effect, it would be particularly problematic if fossil generation in one's own grid were not reduced and instead green district heating products were backed with GO from existing plants in other grids, which had already been realised in the past and independently of GO marketing. In this case, green district heating marketing would have no benefit for the energy transition in the company's own grid or in other grids in Germany or abroad.

3.1.3 Design decision in the IW³ pilot registry

In the stakeholder workshop on the design of the IW³ pilot registry for green district heating, the topic of the cross-grid value of heat and cooling GOs was discussed in a controversial and differentiated manner. In an anonymous online survey following the discussion on the question of whether it should be possible to label the heat origin by means of GOs that originate from unconnected grids, 14 participants were against this (of 27 responses received in total, see Figure 6). The position that only GOs from plants connected to the same grid as consumers should be used to label the origin of heat was justified in particular with a higher credibility and ecological integrity of the evidence. However, the question associated with the residual energy mix calculation, which attributes should be applied instead of renewable energy attributes exported from the grid, was also problematised.

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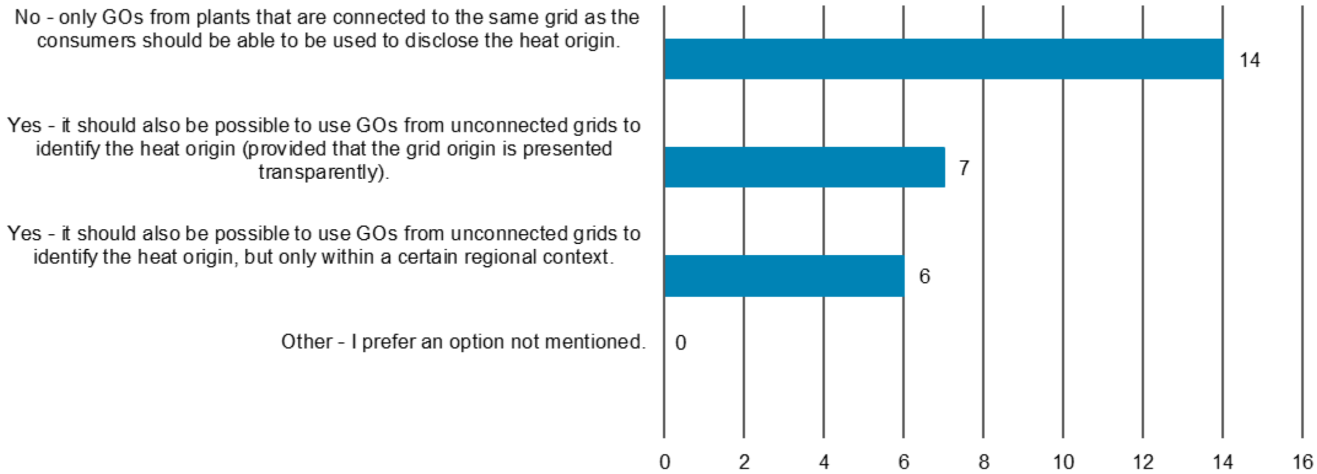
[32] See Chap. 2.3 or Coal-fired Power Generation Termination Act (KVBG) of 8 August 2020 (BGBl. I p. 1818), last amended by Article 1 of the Act of 19 December 2022 (BGBl. I p. 2479).

Seven participants were in favour of making it possible for GOs from unconnected grids to be used to identify the origin of the heat. A central argument was the higher market liquidity with better resilience to system failures, lower costs for GOs and better availability of green district heating products for customers. In the discussion, the need for **transparent information on the origin of the grid** was emphasised in order to enable customers to make informed decisions. Provided that there are binding rules for disclosure and consumer information, it was seen as the decision of suppliers and customers whether green district heating products with off-grid GOs would be offered or demanded. Six participants took the intermediate position that GOs from unconnected grids should also be able to be used for disclosure, but only within a certain spatial context. Various options were discussed, such as trading heat GOs within a municipality or within companies, e.g., if a supplier operates several heating grids in a municipality. In this case, the spatial connection of the district heating supply would be reflected by 'virtual grids', even if individual grids were not technically connected to each other. Here, too, the transparency of evidence and disclosure rules was seen as an important prerequisite.

Figure 6: Survey results on the cross-grid cancellability of GO

Should heat disclosure be made possible using GOs originating from unconnected grids? (One answer option, n = 27)



Note: 11 out of 38 participants did not give an answer.

Source: Own representation, based on online survey at IW³ -Stakeholder Workshop on 13.04.2021

Based on the discussion in the stakeholder workshop and the considerations presented in this chapter, the decision was made in the IW³ pilot registry to **focus on the balance sheet delivery of green heat within technically connected grids.** A grid connection between the generation plant and the consumption point is required in order to cancel GOs for disclosure purposes. The possibility of product differentiation in the ecological heat quality within interconnected grids represents an innovation compared to grid-uniform ecological indicators, which can be expected to provide more effective demand-side impulses for local transformation processes compared to cross-grid GO cancellability. At the same time, a high credibility of the verification system is ensured, which was assessed as particularly significant for the pilot context of the IW project. [3]

The use of GOs from unconnected grids in a spatial context for disclosure purposes could be an option to combine the advantages of higher credibility and transformation effectiveness of the certificates with an extended market liquidity. However, the definition of the relevant spatial context is a challenge. The question here would be whether drawing a municipal boundary, for example, could be considered discrimination against actors beyond this system boundary and, especially in the European context, could be classified as an impairment of the internal market within the meaning of Article 34 TFEU (see Chapter 2.3.2). **In the case of interconnected grids, on the other hand, there is a technical and commercial justification for the system boundary of heat and cold disclosure** (basically given deliverability of heat quantities), which moreover affects the sales of domestic GOs and GOs from other Member States in the same way. In the case of cross-border grids, GOs from both Member States would be eligible for disclosure in the same way. Excluding the cancellability of GOs from other, unconnected grids therefore does not constitute discrimination.

In order to differentiate between grids, the IW³ pilot registry includes the GO information fields 'network identity' and 'network name'. This follows the FaStGO proposal for a draft of EN 16325 (FaStGO 2020, p. 54 f.). If available, suppliers can use the AGFW identification number of the grid for the grid identifier, as this is often already shown to customers on invoices and is therefore known, as is the grid name. When registering a system, suppliers can state whether the system's grid is technically connected to another grid (by submitting suitable documents as proof). This information is currently kept outside the registry but could also be anchored in the registry as an additional information field (e.g., as an identifier for interconnected grids, which is assigned by the body operating the registry). It would also be possible to use the information field 'grid name' for information on interconnected grids. When cancellation requests for GOs are made in the IW³ pilot registry, the identifier of the grid in which a customer is located must be specified as the location of the beneficiary. Before releasing the cancellation, the HIR as operator of the pilot registry checks whether the grid identifier of the customer and the plant from which a GO originates match. This check is carried out manually but could in principle also be automated. The name and identifier of the grid to which the generation plant is connected and the grid identifier of the beneficiary of the GO cancellation are also shown in the GO cancellation statement (see Figure 15 in Chapter 3.7.1).

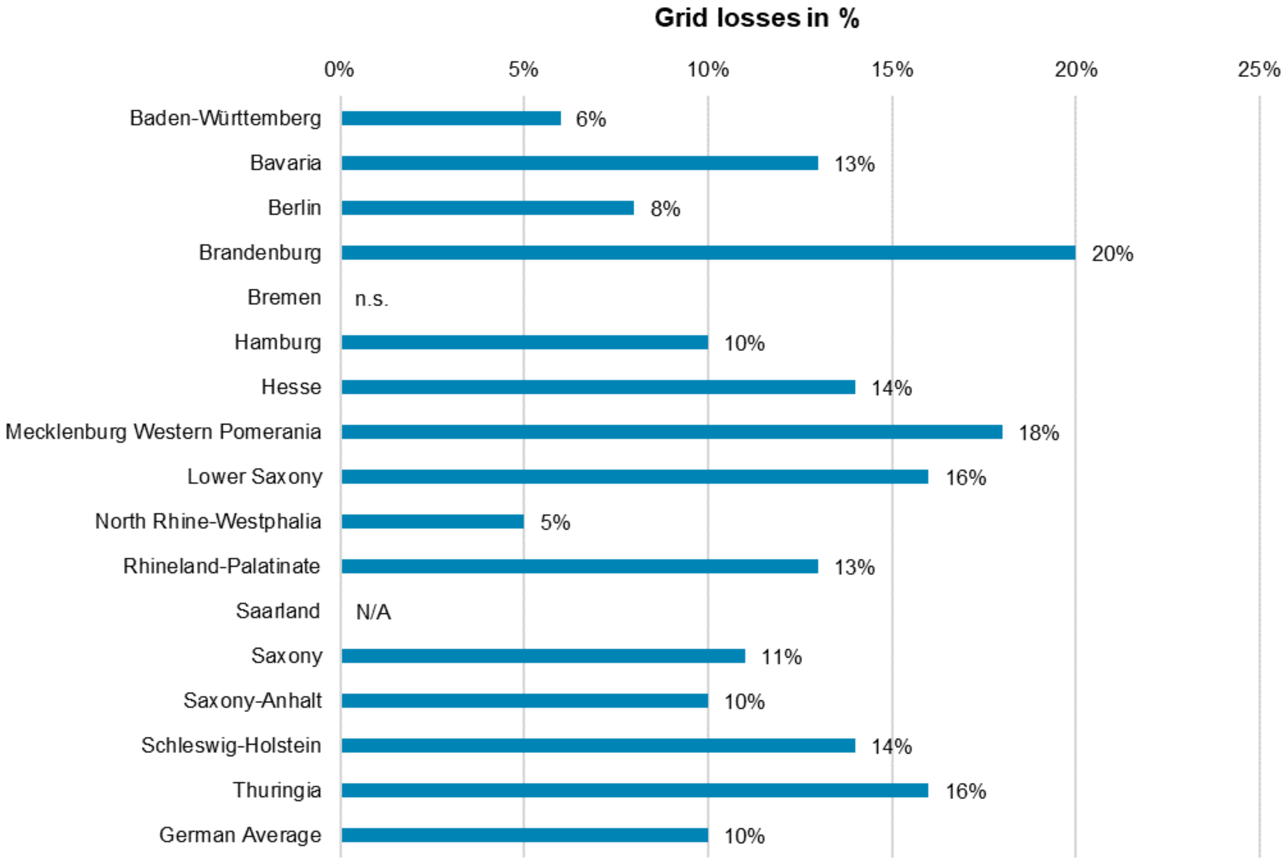
3.2 Dealing with storage and grid losses

Another issue that influences the credibility of a GO system for heating and cooling is how energy losses are dealt with in heating and cooling supply systems. In the electricity sector, losses in grid transport and intermediate energy storage are neglected in most European GO systems (Cornélis and Lenzen 2020). Unless explicitly assigned attributes by the GO cancellation, deliveries of grid and storage electricity losses are implicitly assigned the attributes of the residual energy mix, which also applies to the disclosure of non-traced trade offers (such as electricity purchased via the power exchange). In Germany, however, deliveries of grid and storage electricity losses to electricity grid operators are not considered to be deliveries to end-consumers that require electricity disclosure (Styles et al. 2021). Since GOs may only be cancelled by electricity suppliers within the scope of electricity disclosure, it is currently not possible for grid operators to cancel GOs for grid losses and assign renewable energy attributes to them in the process. In some other countries, voluntary cancellation by grid operators is possible in principle (see Styles et al. 2023), although no data is available on the extent to which this is used. A special case is the Netherlands, where the disclosure of energy loss deliveries falls under the full disclosure obligation (Styles et al. 2021). GO cancellation by grid operators is actively practised here.

Compared to electricity grids, heating and cooling supply systems have some special features that make it advisable to consider grid and storage losses from the outset when designing GO systems. As far as grid losses are concerned, in heating and cooling grids, unlike electricity grids, no independent grid operator is responsible for balancing. In electricity grids, energy producers can market the full amount of electricity fed into the grid - in the liberalised electricity market, the procurement of lost energy is the responsibility of the transmission and distribution grid operators. Heating and cooling systems, on the other hand, are usually vertically integrated, e.g., heat suppliers operate both grids and at least part of the generation plants. As a result, losses are directly taken into account in the production planning of the plant fleet. Furthermore, losses in the transport of thermal energy are much more significant in terms of volume than losses in electricity grids. The latter were 5.4 % for Germany as a whole in 2021 (27.7 TWh of 508.6 TWh net electricity generation volume fed into general supply grids), and 5.3 % in 2020 (Bundesnetzagentur and Bundeskartellamt 2022). Heating grid losses, on the other hand, averaged 13 % of the heating grid feed-in in 2020, which corresponded to about 7 % of the primary energy input of all generation plants (AGFW 2022, p. 19, data based on AGFW member survey). In 2021, average district heating grid losses were 10 % (AGFW 2022, p. 40). There can be significant differences between individual grids. For example, state-specific average values in 2021 varied between 5 % in North Rhine-Westphalia and 20 % in Brandenburg (AGFW 2022, p. 38, see Figure 7).

The combination of quantitatively significant heating grid losses and the consideration of grid losses in production planning can result in a credibility problem if losses were not taken into account in the disclosure and verification of DHC (see also Klimscheffskij et al. 2020, p. 45). With a heating grid loss of 10 %, every tenth MWh that a renewable energy plant feeds into a heating grid would not be available for heat delivery to customers but would be lost in heat distribution. In individual grids, this value can even be higher. Regardless of whether the GO cancellation is limited to connected grids for disclosure purposes or whether a cross-grid GO cancellation is made possible, the neglect of losses would lead to more green attributes being marketed than are actually available for energy delivery to customers. Since losses in this case would probably be assigned to fossil attributes, not taking losses into account in the heating and cooling disclosure would lead to renewable energy and waste heat shares in heat deliveries being overstated.

Figure 7: Average heat grid losses by Federal State in Germany in 2021



Basis: AGFW member survey with data from 165 district heating.

Source: Own representation, based on data from AGFW 2022, p. 38

A similar problem arises with losses in storage facilities located in heating or cooling grids. These can also be considerable, especially in the case of longer-term storage, e.g., in seasonal storage facilities (the extent of losses depends on the type of storage and, depending on the technology, also on the storage duration, see IRENA 2020a; Engelmann et al. 2021, p. 120). Similar to grid losses, storage losses are covered by the quantities of thermal energy generated that are not available for delivery to customers. However, storage increases the amount of energy from renewable energy or unavoidable waste heat that can be integrated into grids, as intermediate storage can take place at times when energy supply exceeds demand (up to seasonal storage of e.g., solar thermal in summer with withdrawal in winter). In the case of storage facilities upstream of the grid (for example in combination with a power-to-heat facility or geothermal facility that releases heat directly to the storage facility instead of to the heating grid during periods of low heat demand), storage losses are already taken into account in the GO system: The basis for the GO issue would be the net heat production that the storage facility feeds into the heating grid (see FaStGO 2020, p. 31; the prerequisite is that the generating facility itself does not receive an GO issue). **On the other hand, there are several options for dealing with storage facilities that take heat from the grid for storage**.

On the one hand, storage operators could cancel GOs because of storage losses (as the deviation between stored and withdrawn thermal energy). It would also be possible to cancel GOs **for stored heat and**

reissue GOs for withdrawn heat. Since the amount of energy stored out is less than the amount stored in, losses are also taken into account here, whereby attributes of the cancelled GOs could be inherited proportional to the GOs issued (see Verwimp et al. 2020, p. 27). **However, in the case that storage facilities are not operated as part of a vertically integrated utility, both options would impose a one-sided economic burden on storage operators**. If accounted for on an annual basis, the time-shifting effect of storage would not be visible in the heat label, so it would not receive a separate value in the course of green district heating marketing. Since storage increases the amount of green attributes that can be integrated into heating grids, it therefore seems reasonable in an annual heat disclosure to share the costs for the GO cancellation for storage losses among the actors of the supply system. If heat disclosure is not done on an annual basis, but e.g., on a monthly or quarterly basis, the model 'GO cancellation for stored energy quantities, GO issuance for withdrawn energy quantities' could become interesting for storage operators, provided that GO from storage would be assigned a higher value as a result. In this case, GOs could be used to make visible that, for example, a withdrawal of solar thermal heat in winter was used to cover a demand for heat in winter.

In the evaluation of options for dealing with storage losses, an annual heating and cooling disclosure is initially assumed here, as prescribed by the FFVAV (even if suppliers are free to voluntarily use supplementary disclosure with a higher granularity). In an annual balancing, the sum of grid and storage losses is the difference between the energy fed into the grid and the energy delivered to customers (with meters for the net energy production fed into the grid and the energy delivered to customers). Storage losses from storage facilities located in the grid can be separated from grid losses with the help of meters for the storage and withdrawal of thermal energy. However, due to the systemic role of storage in the integration of renewable energy and unavoidable waste heat into heating grids, two approaches are examined in more detail in 3.2.1 and 3.2.2, in which **grid and storage losses are treated analogously.**

Finally, it should be noted that a consideration of grid and storage losses in the GO and disclosure system for heating and cooling would help to establish **consistency between different regulatory requirements for the calculation of** renewable energy and waste heat **shares** (see also Styles and Claas-Reuther 2022). Art. 24(1) of the provisional final version of RED III after the trilogue procedure has been completed provides that **information on the renewable energy share must be expressed at least as a percentage of the gross final energy consumption of heating and cooling allocated to customers of a given DHC system,** including information on how much energy was consumed to deliver a unit of heat to the customer or end consumer (Art. 24(1) RED III). What is meant by gross final energy consumption from renewable sources in the heating and cooling sector is defined in more detail in Art. 7 para. 3 RED II (without change in RED III). This is calculated as 'the amount of DHC produced from renewable sources in a member state plus the consumption of other energy from renewable sources in industry, households, the service sector and agriculture, forestry and fisheries for heating, cooling and process purposes'. As the renewable energy share refers to produced quantities of thermal energy, quantities of energy lost in deliveries to customers due to grid transport and intermediate storage are included.

At the national level, section 22 (2) of the **GEG also requires losses to be taken into account when calculating grid-specific PEFs.** According to this, the PEF determined and published by a DHC supplier can be used for calculating the total energy demand of buildings if the company 'has determined the fuels and electricity, including auxiliary energies, used to generate and distribute heat in a heating grid, weighted them with the primary energy factors of Annex 4 and related them to the quantity of heat supplied, and has stated the application of this calculation method in the publication' (Section 22 (2) sentence 2 GEG). Since fuels used are set in relation to quantities of heat delivered, the calculation methodology takes into account not only losses from energy conversion but also grid and storage losses. **Losses are also included in the calculation of coverage shares of DHC deliveries to GEG utilisation obligations for renewable energy** (as a substitute measure according to § 44 GEG). The AGFW worksheet FW 309 Part 5 provides a calculation method for this, according to which the heat quantities fed into the heating grid from renewable energy, waste heat or CHP are set in relation to the total heat quantity fed into the heating grid. The GEG specifications and the calculation approaches based on them currently refer to grid-uniform key figures. If the balancing of green district heating products on a GO basis is to be consistent with regulatory requirements, the corresponding specifications must be transferred to this.

In the following, two alternative approaches are considered to integrate grid and storage losses into a GO system for heating and cooling.

3.2.1 Deduction of a loss factor in GO issuance

One option would be to **already take grid and storage losses into account when issuing GOs** and thus only issue GOs for quantities of thermal energy that are available for delivery to customers. If, for example, 10,000 MWh per year were fed into a grid from renewable energy plants and average losses totalled 20 % (e.g., as the sum of grid losses and storage losses), a GO would only be issued for 8,000 MWh. Practically, loss factors could be stored in the GO registry, which would be automatically deducted when the GO is issued. However, challenges arise when determining the loss factor, as the volume of the actual losses would only be known at the end of the balancing period, e.g., after the end of the year of identification. Especially in the case of heating grids in transformation, grid losses can change from year to year when new generation plants or consumption points are connected or systemic measures such as a change in the temperature level are implemented. Storage losses in turn depend on actual storage use, which can vary from year to year. The use of a loss factor based on previous years can therefore result in inaccuracies in the annual balancing. Even greater inaccuracies would result if a national average value were used to determine the loss factor. This results from the considerable differences that individual grids have in terms of their grid losses (see Figure 7), as well as differences in the use of storage facilities located in the grid.

If a cross-grid GO cancellation is made possible (see 3.1), it should also be noted that a different treatment of losses in national GO systems could lead to unequal treatment of renewable energy producers. In this case, producers in some Member States could receive a GO for a MWh of net thermal energy production fed into the grid, while in others they would only receive a value reduced by the loss factor. In a European GO market, corresponding producers would compete with each other, even though independent producers in particular, who are not vertically integrated with the grid operator, would have little possibility to influence transport losses in their feed-in grid.

3.2.2 Proportional consideration of grid and storage losses in GO cancellation

As an alternative to the deduction of a loss factor in the GO issue, **grid and storage losses can** be **taken into account proportional in the cancellation of GOs**. Since disclosure rules according to § 5 FFVAV or § 42 EnWG are based on the energy carrier mix of the previous year, the cancellation of GOs can still take place after the end of the balancing year - the decisive factor is that the energy production on which the GOs are based took place in the same year as the energy supply to which the disclosure refers (cf. § 30 para. 4 HkRNDV for electricity GOs; in addition, the lifetime of the GOs must be taken into account). After the end of the balancing year, transport and storage losses in the grid can be determined by comparing the energy quantities fed in and delivered to customers**. Taking grid and storage losses into account in the cancellation thus allows a**

significantly more accurate balancing than deducting average loss factors in the GO issuance. In addition, it can be made transparent in the heating and cooling disclosure which GOs were cancelled for losses and which for energy quantities delivered to customers. If GOs were cancelled across grids, the amount of GOs to be cancelled for losses would result from the specific grid and storage losses of the grid in which green thermal energy is marketed, so that there would be no unequal treatment of producers in the GO issuance.

If grid and storage losses were taken into account in the GO cancellation, 10,000 GOs with a unit of 1 MWh would be issued for a heat feed-in from renewable energy plants of 10,000 MWh per year. At the end of the balancing year, the actual losses would be determined (e.g., 20 % as the sum of grid and storage losses). In this case, 2,000 GOs would have to be cancelled for grid and storage losses, 8,000 GOs would be available for cancellation for the thermal energy supplied to customers.

However, the question arises as to **which actor should be responsible for the cancellation of GO for grid and storage losses**. In grids with an independent grid operator, this role could be filled by the grid operator, with allocation of the costs incurred for GO procurement to the different actors in the heat supply system. A challenge, however, would be that at the end of the balancing period, the required amount of GO may no longer be available or may be sold at a high price (unless GO from non-contiguous grids can be used for disclosure and high market liquidity would be ensured). There is also the question of the legal basis on which an independent system operator could be obliged to cancel GOs for losses on a pro rata basis (except in a full disclosure system that includes the disclosure of losses). In Germany, however, this case is primarily theoretical, as district heating systems are usually vertically integrated.

If customers can cancel heat GOs themselves, there are also challenges in taking grid and storage losses into account on the cancellation side. As part of the rules for consumption disclosure, it could be stipulated that GOs must be cancelled proportional for losses during the transport and intermediate storage of heat. For corporate customers using GOs as evidence in their carbon accounting, this could be verified, provided that such companies submit their carbon accounting to an independent audit (either as part of non-financial reporting audit obligations under the Corporate Sustainability Reporting Directive (CSRD), see Styles et al. 2023, p. 55 ff., or voluntarily). In the case of corporate customers without a climate accounting audit or private customers, checking whether the necessary amount of GOs for storage and grid losses has been cancelled would involve a great deal of effort. In addition, even in the case of pro rata GO cancellation for grid and storage losses by end consumers, it must be noted that information on the extent of the losses is needed promptly at the end of the accounting period in order to be able to procure GOs in the necessary amount. If the GO cancellation is limited to technically interconnected grids and end consumers compete for available GO from renewable energy and waste heat plants, the availability and price of GO at the end of the accounting period can be associated with considerable uncertainties. This problem is less relevant in the case of a cross-grid GO cancellation with higher market liquidity.

In the event that, analogous to the current regulations for electricity GOs, only heat suppliers are allowed to cancel GOs, it is recommended that supply companies cancel GOs for grid and storage losses on a pro rata basis due to the challenges described above. In the case of vertically integrated companies, these are responsible for grid operation and often also storage operation and thus not only have the best and most up-to-date information on the extent of losses, but also the possibility to influence losses. An obligation to cancel a proportion of the GO for losses could thus increase incentives to reduce grid losses if technically and economically feasible, e.g., through investment measures. In addition, information on losses is continuously taken into account in production planning, so that district heating suppliers can estimate how many GOs can be used to disclose the heat quantities supplied to customers and how many must be planned for the disclosure of losses.

3.2.3 Design decision in the IW^3 pilot registry

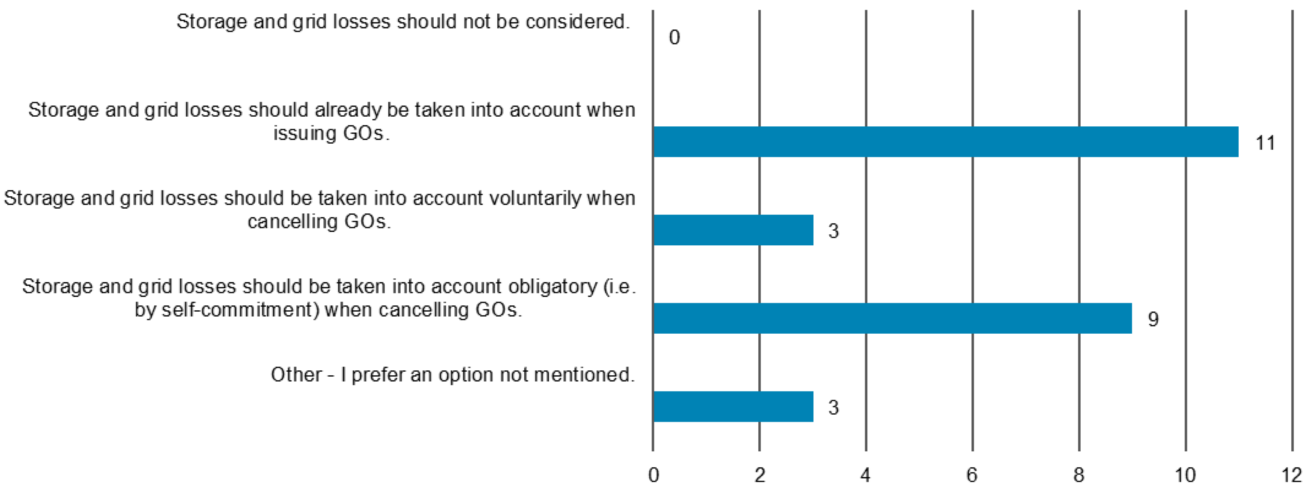
Discussions in the stakeholder workshop on the design of the IW^3 pilot registry confirmed that a consideration of grid and storage losses in the heating context is considered highly relevant. None of the stakeholders participating in the online survey opposed the consideration of grid and storage losses (see Figure 8). With regard to the form of consideration, however, the participants were divided. 11 out of 26 respondents preferred consideration in GO issuance, 12 in GO cancellation, three of which were voluntary and nine mandatory (or self-mandatory in the context of IW^3 pilot registry participation). Three respondents preferred options not mentioned.

Based on the considerations in 3.2.1 and 3.2.2, **the system rules of the IW^3 pilot registry recommend that suppliers who supply green district heating products cancel additional GO on a pro rata basis in order to take losses into account** (see Hamburg Institut 2022). Table 2 shows an example of a green district heating product that takes losses into account. In the example, for a heat quantity of 30,000 MWh per year supplied to customers, 34,091 GOs would have to be cancelled in the green district heating product (with a loss factor of 14 %) in order to prove the origin of the product from renewable energy and unavoidable waste heat (see also Chapter 3.7.2).

This product-based approach to dealing with losses enables accurate balancing of heat attributes on an annual basis and takes into account that supply companies have the best information availability regarding the extent of losses. This makes it possible to include grid and storage losses not only in production planning, but also in planning the marketing of green district heating products. If future legal frameworks allow, this approach will also allow supply companies to calculate **product-specific primary energy and emission factors taking losses into account,** consistent with existing regulations for calculating grid-uniform PEFs and renewable energy shares. A proposal for such a product balancing methodology has been developed by the Hamburg Institut on behalf of BDEW (Styles et al. 2022).

Figure 8: Survey results on the consideration of storage and grid losses

Should storage and grid losses be taken into account in the heat GO system - and if so, in what form? (One answer option, n = 26)



Note: 10 out of 36 participants did not give an answer.

Source: Own representation, based on online survey at IW³ stakeholder workshop on 13.04.2021

Table 2: Exemplary product cut taking into account grid and storage losses for a large model grid

	Product 1: Green district heating (GDH)	Product 2: Basic product (BASIC)
Quantity of heat supplied $Q_{out,j}$ [MWh/a]	30.000,00	322.000,00
Required heat generation $Q_{pr,j}$ [MWh/a] taking into account transport losses with a loss factor of $\boldsymbol{\delta}$ of 0.14. The following applies: $\boldsymbol{Q_{pr,j} = Q_{out,j} * (1+\delta)}$	34.090,91	365.909,09
Contribution $X_{i,j}$ [MWh/a]		
Plant 1: Natural gas CHP	0,00	320.000,00
Appendix 2: Unavoidable waste heat	17.045,45	22.954,55
Plant 3: Power to Heat (with electricity from RE)	17.045,45	22.954,55

Source: Styles et al. 2022, p. 54, Product balancing for green district heating, study commissioned by BDEW.

The presentation of losses in the heat label is not specified in the system rules in order to be able to investigate different possible solutions. **However, a separate display of losses is recommended for reasons of transparency**. In the registry itself, when applying for a GO cancellation, it can be indicated whether the cancellation is in favour of a district heating product or specific customers (this is also established in the electricity GO registry, see § 30 para. 3 HkRNDV). In addition, there is a free text field 'cancellation purpose' in which suppliers can enter that it is a cancellation for losses.

3.3 Integration of heat customers in the guarantees of origin registry

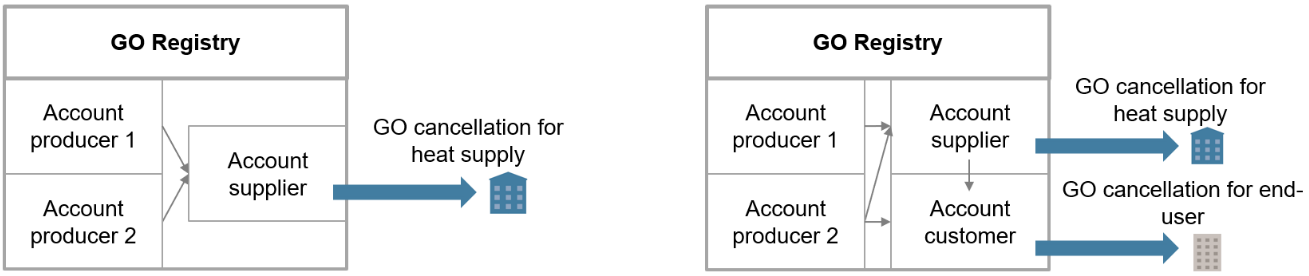
In Germany, electricity GOs may only be used for electricity disclosure by an electricity supplier (§ 30 para. 1 HkRNDV; see Styles et al. 2023). **Accordingly, only electricity producers are entitled to apply for the**

cancellation of electricity GOs in the GO registry, and only for their own electricity supply and electricity disclosure. The legal electricity disclosure obligation according to § 42 EnWG refers to the provision of information to end consumers. Electricity supply companies that apply for a GO cancellation may specify a certain electricity product or a certain electricity customer in favour of which the GO is cancelled (§ 30 para. 3 HkRNDV). As proof of this allocation of green attributes, a certificate of cancellation can be created in the GO registry, which can be made available to electricity customers.

In several EU and EEA countries, GO cancellation is also possible for other actors, such as GO traders or end consumers themselves. In Germany, too, corporate electricity customers in particular are expressing interest in being allowed to cancel GOs themselves for the electricity they purchase via grids. Motives are manifold (see Styles et al. 2023 for an analysis) and include an expectedly more direct control over GO procurement and cancellation (both in terms of cost and quality) or an improved coordination of sustainability reporting and electricity disclosure periods (as electricity disclosure for an electricity supply year according to § 42 para. 1 no. 1 EnWG does not have to be published until 1 November of the following year, while deadlines for sustainability reports are often earlier).

For the heat supply sector, the question also arises as to whether GO cancellation should take place exclusively through supply companies, as established in the electricity sector, or whether GO cancellation should also be made possible for heat customers (see Figure 9). In the first case, GOs would be transferred in the registry from producer accounts to supplier accounts (possibly via merchant accounts as an intermediate step) and cancelled by suppliers for their heat deliveries. In the second case, this option would be supplemented by the possibility to register with a heat customer account in the registry, in order to obtain GOs directly from producers, traders or suppliers and to cancel them for one's own heat consumption. Trading with GOs takes place separately from the registry (e.g., as an over-the-counter transaction). **It should be noted that in the area of district heating supply**, **the role of the customer and the role of the end consumer may differ.** In the case of rented flats, building owners or the housing industry act as customers, while the final consumption of heat takes place through the tenants. Since registration in the registry and the processing of GO transactions is associated with effort (and, in the case of a national registry outside the research context, with fees), it can be assumed that, as a rule, private individuals would not make use of a GO cancellation right. This is also evident from the experience of electricity GO registry operators in countries with a right of cancellation for end-users, where it is primarily used by companies with high electricity consumption (see Styles et al. 2023). In the heating sector, it can therefore be assumed that the right to cancel GOs is primarily used by building owners or the housing industry, who report the attributes of the heat they purchase to tenants or take them into account in their climate accounting, as well as by industrial or other corporate customers.

Figure 9: Options for cancelling heat GOs in the registry design



Source: Own representation, Hamburg Institut

3.3.1 Chances and challenges of a GO cancellation right for heat customers

Both enabling a GO cancellation by heat customers and limiting the GO cancellation to heat suppliers offer specific advantages. For example, a GO cancellation by heat customers can facilitate the **individual compilation of GO portfolios**. In this case, customers with a preference for certain energy sources or technologies could purchase GOs directly from the corresponding plant operators. **However, if plants are operated by a vertically integrated utilities, concluding a contract for GO deliveries from specific plants would be largely equivalent to concluding a green district heating supply contract with specific attributes** (with allocation of heat production from specific plants by cancellation of corresponding GOs in favour of the customer by the supplier). A GO cancellation by heat customers could be of particular interest if GOs from other than the own, vertically integrated grid can be used for heat disclosure, or if several suppliers are active in the own grid or if heat is fed in by independent heat producers.

Another advantage, which also comes into play in the case of vertically integrated grids and the requirement to only use GOs from one's own grid for disclosure purposes, is the **digital, direct access to all information fields contained on GOs**, which heat customers would receive by participating in the GO registry. This can facilitate the use of information e.g., in sustainability reporting and climate accounting of companies. Another option in this context would be **transparency accounts with access to digital cancellation statements for consumers** who are not themselves endowed with cancellation rights. Such accounts are offered in the Dutch electricity GO registry and are used extensively (a GO cancellation by end consumers is also possible, but via merchant accounts, see Styles et al. 2023).

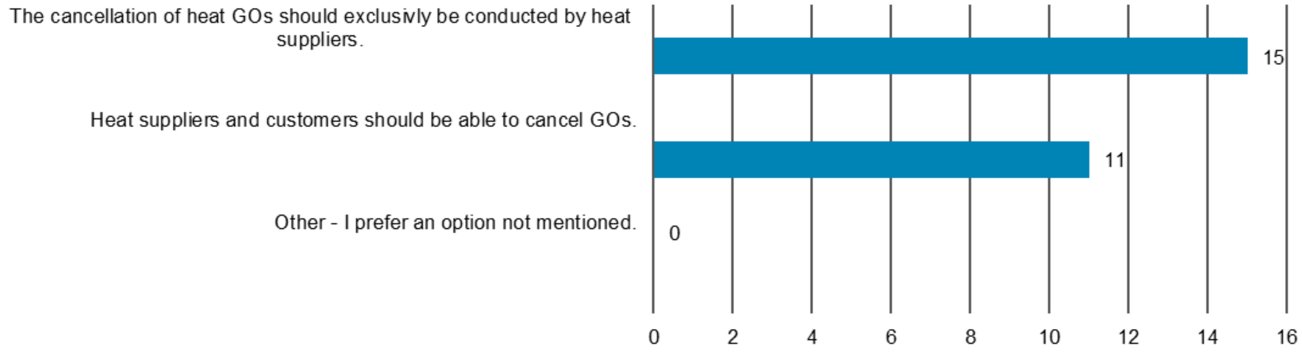
On the other hand, an advantage of a GO cancellation only by heat suppliers is the lower complexity of the resulting disclosure system. In this case, responsibilities for the reporting of renewable energy and waste heat shares and further information of a heat label would be clearly located with the heat suppliers, which facilitates the verification of corresponding information. Due to the vertically integrated nature of heat supply systems, an independent verification of information on renewable energy shares in heat supply would probably require audits to support an authority responsible for disclosure supervision (see chapter 3.6). Audits could also be used to verify the information provided by heat customers on the attributes of their heat consumption in their own GO cancellation; this would be particularly practicable if their own GO cancellation was not carried out by private customers, but by corporate customers, e.g., from industry or the housing sector. Since in this case consumption disclosure by heat customers would occur alongside heat supply disclosure by suppliers, which would also have to be verified in parallel, the overall verification costs of the disclosure could be higher than in a system in which only suppliers cancel GOs. If the corresponding audit costs are borne by customers who wish to have their own GO cancellation, they could, however, decide for themselves whether the individual advantages of their own participation in the GO registry outweigh the resulting costs.

If a cancellability of heat GOs for disclosure purposes is limited to interconnected grids, a restriction of the GO cancellation to heat suppliers may result in a better plannability of GO availabilities and prices. This is due to the fact that heat suppliers have the best availability of information about the heat production to be expected from individual plants over the course of the year as well as the total heat sales. This makes it possible to estimate the amount of green district heating that can be marketed in a year, taking safety buffers into account. Since heat customers have worse information about the annual supply of GOs to be expected, a high demand for green district heating could result in price peaks for the GOs available in the grid that are difficult to plan, or it might only be possible to realise strongly fluctuating shares of green district heating in one's own heat consumption year after year given the willingness to pay. If the proof of green district heating shares via GO cancellation would be necessary to fulfil regulatory requirements or if certain decarbonisation targets for the own district heating consumption were communicated within the framework of climate strategies, this could prove to be problematic for consumers. In the case of a cross-grid GO cancellation with greater market liquidity, this challenge would only be relevant if there is a strong preference for GO from one's own grid.

In summary, it can be stated that **both enabling GO cancellation by heat customers and limiting GO cancellation to heat suppliers, the transparency of GO information, customisability of green district heating products and planning security with regard to GO availability and prices strongly depend on the concrete contract design and the disclosure rules in the heat GO system.** A high degree of planning security for customers can be achieved, for example, by concluding a long-term supply contract with green district heating with GO cancellation by the supplier, or by concluding long-term GO supply contracts (with a separate contract for heat supply). Also, on-balance supply of district heating from specific renewable or waste heat plants could be agreed with suppliers as an alternative to compiling an individual GO portfolio. Transparency of GO information can be established through detailed cancellation statements or the creation of transparency accounts in the registry, as an alternative to the implementation of GO cancellation in the registry by heat customers themselves. In the IW³ stakeholder workshop, there was a slight preference among participants for a GO cancellation exclusively by heat suppliers (15 out of 26 votes cast, see Figure 10), which may, however, be influenced by the composition of the participants (with a higher number of representatives of heat suppliers than consumer associations). Moreover, the preference is not clear.

Figure 10: Survey results on actors with GO cancellation rights

Should the cancellation of GOs for a specific end-use be carried out by heat suppliers only or by suppliers and consumers? (One answer option, n = 26)



Note: 12 out of 38 participants did not give an answer.

Source: Own representation, based on online survey at IW³ stakeholder workshop on 13.04.2021

However, the challenges of a GO cancellation by heat customers are intensified if grid and storage losses are to be taken into account on the cancellation side (and not by deducting an average value when issuing the GO, which would be less accurate with regard to the balancing methodology). In this case, the plannability of the GO purchase becomes complicated for heat customers, as they would have to take into account losses in their GO cancellations with an amount that is only determined at the end of the year (see chapter 3.2). However, the availability of corresponding GOs in the grid may no longer be guaranteed at that time, or only at high prices. The proportional GO cancellation for grid and storage losses would also have to be taken into account when checking the heat labels of heat customers.

3.3.2 Design decision in the IW³ pilot registry

From a technical point of view, it would have been feasible to enable GO cancellations by both suppliers and consumers in the IW³ pilot registry. **However, the aforementioned challenges in the treatment of grid and storage losses justify the decision to limit the GO cancellation to heat suppliers** (or GO cancellation is also possible by system operators, to identify self-supply (see chapter 3.4), or if system operators independent of the heating grid operator supply customers directly within the framework of pass-through models). When cancelling GOs for their customers, suppliers can indicate in the IW³ pilot registry whether the cancellation is for the benefit of a district heating product or specific customers. **In order to create transparency for customers, the registry allows the export of detailed cancellation statements that** summarise the content of all information fields on GOs (see figure 15 in chapter 3.7.1). Cancellation statement can be provided to clients, e.g., with invoice documents or online.

Not included in the IW³ pilot registry, but technically possible, would be the **creation of monitoring accounts that would allow digital access to cancellation statements**. This could be an option for larger heat customers, e.g., from industry or the housing sector. However, registration with a monitoring account could also be relevant for regulators to facilitate the verification of heat labels. If heat GOs should play a role in the future in fulfilling regulatory or subsidy requirements (e.g., in proving renewable energy shares in heat supply by heat customers, or in proving annual shares of renewable energy and unavoidable waste heat by suppliers in the context of BEW), competent authorities could also use digital access to cancellation statements for monitoring purposes here. This could replace the decentralised submission of proofs by heat suppliers or heat customers and thus reduce the monitoring effort.

3.4 GO issuance for self-supply

In the area of electricity GOs, different EU Member States deal differently with the question of whether GOs are issued only for electricity supplied to customers or also for electricity consumed by the operator of the energy generation plant itself (see Verwimp et al. 2020a, p. 58; Van Stein Callenfels et al. 2020, p. 7 ff.; Styles et al. 2023). What is meant here is **self-consumption in the sense of self-supply of energy**; quantities of energy used as auxiliary energy for energy production cannot receive a GO, as the GO issuance according to EN 16325 is for net energy production.

A non-differentiated issuance of certificates for energy used for self-supply and energy supplied to customers should be viewed critically, as transparency is lost for consumers. If GOs issued for self-supply can be used to identify the attributes of electricity deliveries to customers, a possible multiple claim or multiple marketing of green attributes cannot be safely ruled out - unless there is a disclosure obligation not only for electricity deliveries but also for self-supply, with the requirement that GOs must be cancelled to identify attributes in both cases (Verwimp et al. 2020a, p. 58; Van Stein Callenfels et al. 2020, p. 7 ff.). For example, in the case of an industrial company that operates a PV system on its own premises and sells GO from this to third parties, it would have to be ensured that appropriately marketed green attributes of the PV system are not used by the company itself within the scope 1 climate accounting and also not in other statements by the company regarding the attributes of its electricity supply. The use of self-supply GOs to disclose energy supplies to third parties or the use of purchased GOs to change the attributes of own generation facilities on the company's premises (esp. to green fossil self-supply facilities) also represents a **mixing of climate accounting scopes 1 (direct emissions from company-owned sources) and 2 (purchased energy).** Emission sources in the different scopes must be accounted for separately according to the internationally recognised rules of the Greenhouse Gas Protocol (WRI and WBCSD 2004).

On the other hand, it may make sense to issue GOs for self-supply plants, which may only be used to identify the self-consumed energy from the corresponding plants. In the electricity sector, this is particularly the case if **plants both generate electricity for the plant operator's own supply and feed electricity into a grid and sell it to third parties**. In this case, by cancelling self-supply GOs for self-consumed electricity, a plant operator could prove that only those electricity quantities whose green attributes were not marketed to anyone else are counted in the scope 1 accounting. Otherwise, proof would be required that no GOs were issued for self-consumed electricity quantities that could be cancelled in favour of other end consumers (e.g., through a comparison of grid feed-in and consumption profiles with requested GO quantities and electricity quantities applied for in the Scope 1 climate accounting by independent auditors). Since the proof that a GO has not been issued for self-consumed electricity quantities can be more time-consuming than the clear assignment of green attributes to self-consumption and electricity deliveries by means of GO cancellation, the use of self-supply GOs can offer advantages here (see also Sakhel et al. 2022). In contrast, the added value of issuing and cancelling GOs for self-supply is lower for electricity generation plants without grid connection that exclusively supply the plant operator with electricity. An audit as proof of generated electricity quantities and their attributes can usually be assessed as sufficient here (Sakhel and Styles 2021).

3.4.1 Heating grids with prosumers as a use case for H&C GOs for self-supply plants

These considerations on the issuing of electricity GOs for self-supply can also be transferred to heat supply. **Relevant here are grids with an integration of prosumers that use energy from their own heat generation plants for self-supply but can also feed energy into the heating grid and draw energy from the heating grid**. A correspondingly open design of heating grids can offer opportunities for the integration of decentralised renewable energy and unavoidable waste heat sources into heating grids. By feeding in heat that is not consumed by themselves, the share of climate-neutral generation sources in the grid increases, while owners of building systems do not have to design their systems to supply individual buildings (with complete coverage of the building-specific peak load). Instead, they can choose a broader optimisation approach that includes costs of a grid purchase of heat and revenues from a grid feed-in. In such constellations, a transparently distinguishable GO issuance for self-consumed and grid-fed heat quantities can facilitate the clear allocation of green attributes.

One example of a heat supply system with prosumers is the ‘Energieverbund Wilhelmsburg’ heat grid, which is to become part of the future interconnected system of Hamburger Energiewerke in the IW^3 project area (Hamburger Energiewerke 2023). It was built from 2011 to 2013 as part of the International Building Exhibition (IBA) Hamburg and offers connected customers both the opportunity to purchase heat and to feed heat they have generated themselves from renewable sources into the grid (IBA Hamburg 2023). Generation systems in different buildings (e.g., solar thermal systems on roofs and façades) can be interconnected to form a ‘virtual power plant’ and coordinated by the grid operator via remote monitoring. The majority of the heat supply in the grid is covered by a biomethane CHP unit from Hamburger Energiewerke, which also secures the basic supply (IBA Hamburg 2023).

3.4.2 Design decision in the IW^3 pilot registry

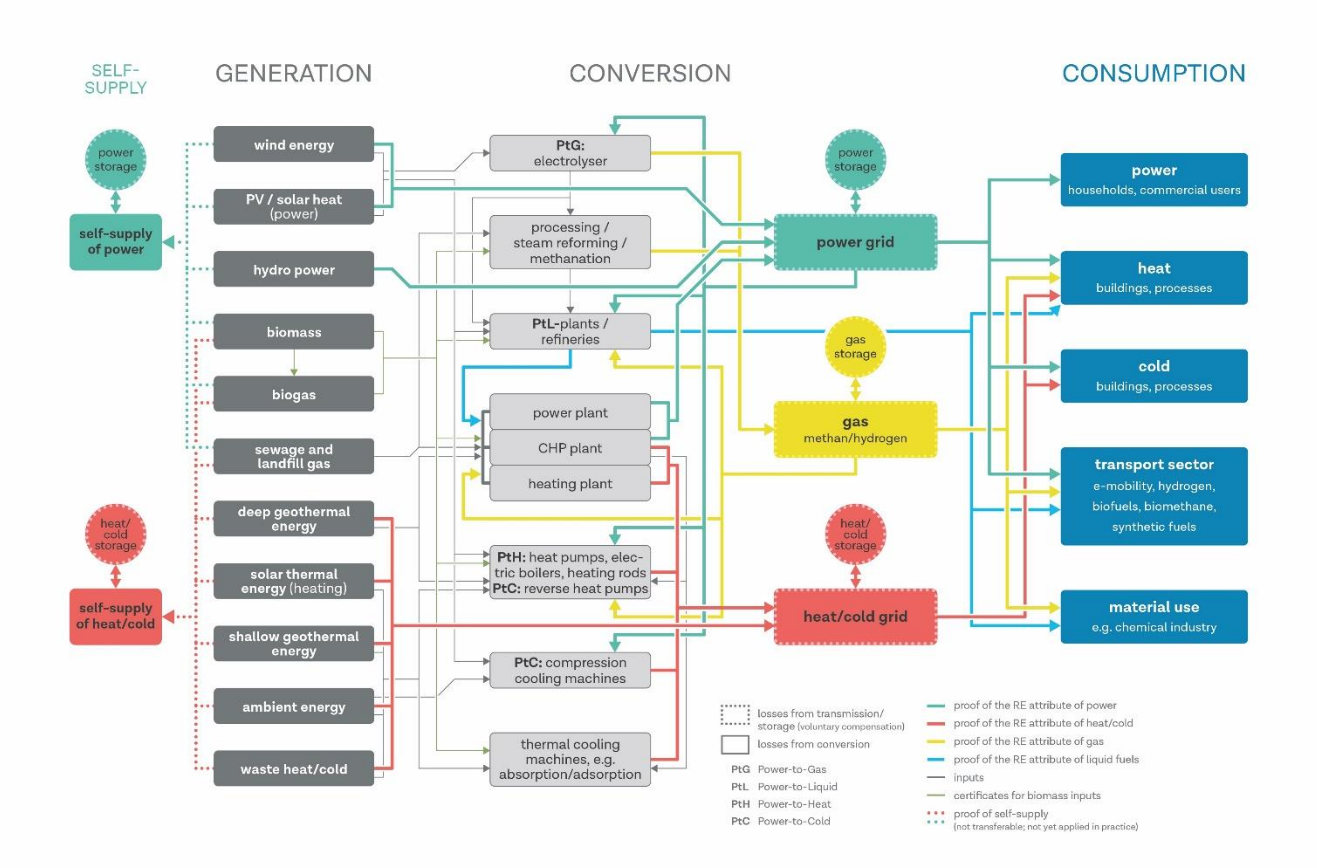
Due to the potential relevance of prosumers in the IW^3 project area, the decision was made in the IW^3 pilot registry to **allow GO issuance for self-supply** (accordingly, the topic was not among the design issues discussed at the IW[3] stakeholder workshop). Producers can apply for GOs for heat production used for self-supply; however, these can only be used to disclose one's own heat consumption.

In order to transparently distinguish between GOs issued for heat quantities consumed by the producer or fed into grids, a proposal of the FaStGO project was implemented for the EN 16325 draft version: **the introduction of a GO information field on the 'dissemination level' of the energy produced** (Van Stein Callenfels et al. 2020, p. 7 ff.). In the IW[3] pilot registry, producers declare what percentage of their energy production was fed into a heating or cooling grid in a given period and what percentage was consumed by the plant operator for self-supply. If there is no self-supply, the percentage of energy fed into the grid is set to 100 %. The period to which the declaration refers can be selected flexibly (from permanently valid to monthly or even daily, if the ratio between self-supply and grid feed-in changes). The correctness of the information would have to be confirmed by a measurement data audit, provided that GO assessments in the IW[3] pilot registry are used to make statements to customers for disclosure or marketing purposes (and the registry is not only used for test purposes, see chapter 3.6, Hamburg Institut 2022).

3.5 Verification of energy carrier conversions

Decarbonised district heating generation can be based on the use of renewable energy and waste heat sources in the immediate spatial context of the heating grid (such as geothermal energy, solar thermal energy, ambient energy or unavoidable waste heat e.g., from industrial processes or data centres). The power supply of heat pumps or power-to-heat plants in the narrower sense, such as electric boilers and heating rods, can also be based on the use of renewable electricity generation sources whose plant location is in the immediate vicinity of the heating grid and which are connected to corresponding plants via direct lines. However, it is equally possible to **purchase electricity from renewable sources via the grid, which expands the range of applications of electricity-based, large-scale heat generation options in heating grids** (for example, through greater independence from local renewable electricity generation potentials, especially in urban areas, and local availability of fluctuating renewable electricity sources). Progressive sector coupling makes it possible, through electrification of processes and the use of Power to X technologies, to tap into climate protection and generation cost benefits of wind and solar energy in the heating and cooling, transport, and industrial sectors as well (see Figure 11). In addition, the cross-sectoral use of gases from renewable sources is relevant (especially biomethane and green hydrogen). **Energy conversion processes that are based on a balanced supply of green electricity or green gases from grids must therefore also be mapped in the verification of green district heating**. The central question here is what proof must be provided in each case so that energy inputs taken from grids can be considered fully renewable (see also Sakhel and Styles 2021).

Figure 11: Verification at sector coupling interfaces



Source: Sakhel and Styles 2021, p. 10.

3.5.1 Framework conditions for energy carrier conversions in the HkNRG

The basic framework for verification at sector coupling interfaces is provided by the HkNRG of 4 January 2023. **According to this, GOs for electricity-based heating or cooling from renewable energy or unavoidable waste heat are only issued for electricity taken from grids if the GOs on which the electricity consumption is based have been cancelled** (§ 5 para. 4 HkNRG). This is an important prerequisite to prevent double counting of renewable energy volumes (see also Verwimp et al. 2020, p. 35 ff.; FaStGO 2020, p. 30 f). Without such a regulation, it could not be ruled out that the green attribute of a MWh of electricity generation from renewable sources would be marketed both to electricity customers (in the case of cancellation of the electricity GO for a green electricity product) and to heat customers (in the case of crediting of the green attribute of electricity generation in the heat GO issuance to a power-to-heat (PtH) plant and cancellation of the heat GO for a green heat product). Such multiple claims of green attributes would occur, for example, if heat GOs were issued for electricity-based heat generation based on average renewable energy shares in the national electricity generation mix. In contrast, if GOs are cancelled for electricity inputs and GOs are issued for heat outputs, key attributes of the cancelled electricity GOs can be inherited by the heat GOs, excluding multiple counting (e.g., on energy source or funding status, Verwimp et al. 2020; FaStGO 2020, p. 30 f.). Since GOs must be cancelled for the entire renewable energy used and heat GOs are issued for the net heat generation fed into the grid, conversion losses are also taken into account here.

Energy conversion processes are also relevant for heat generation plants that draw green gas from the natural gas grid (e.g., CHP units or boilers that use biomethane, and in the future possibly also green hydrogen to cover peak loads). **Mass balancing is currently established as means of demonstrating the green credentials of biomethane supplied via grids.** The Renewable Energy Directive generally specifies mass balancing as a verification system for gaseous and liquid fuels in order to demonstrate compliance with sustainability and GHG reduction criteria (Art. 30 RED II). Mass balancing procedures can also be used to prove that each delivery of gaseous and liquid fuels is only taken into account once in the calculation of the renewable energy share of gross final energy consumption in the individual Member States according to Art. 7 para. 1 RED II. Mass balancing is also required in the GEG and EEG in the case of a balanced purchase of biomethane (GEG) or landfill gas, sewage gas, mine gas, biomethane or storage gas (EEG) from the natural gas grid as proof so that corresponding energy quantities can be counted towards regulatory requirements of the GEG or are eligible for funding under the EEG (§ 40 para. 3 GEG; § 22 para. 1 no. 2 GEG; § 44b para. 4 EEG; see Styles and Claas Reuther 2022 for more details). Mass balancing is not explicitly mentioned in the HkNRG, but at least until gas GO registries are established and the relationship between gas GO registries and mass balancing is clarified, it offers itself as a verification method to issue district heating GOs on the basis of a balance-based reference of green gases. A GO registry for green gases such as biomethane and hydrogen produced on the basis of renewable energies should also be established with the implementation of the Guarantees of Origin Registry Act. **Similar to the use of electricity, the verification of green attributes could also be carried out through GO cancellation** (whereby it must be ensured through a reconciliation or integration of the registries for mass balancing and gas GO that no double counting of green attributes occurs through the parallel use of both verification systems).

3.5.2 Challenges in the verification of energy carrier conversions and possible solutions

Despite the provisions made within the framework of the HkNRG, challenges remain in the verification of energy carrier conversions, which are outlined below. These include, in particular, the handling of **electricity quantities from EEG-subsidised plants**, the handling of **self-supply plants that are not connected to electricity-based heat generation plants via direct lines but via grids,** and the implementation of possible **additional requirements for the spatial and temporal connection of electricity generation and consumption**.

3.5.2.1 Dealing with electricity volumes from EEG-subsidised plants

GOs offer the possibility to show not only information on the funding status of the heat produced (in case of production funding) or heat generation plant (in case of investment funding). An additional information field can provide information on **whether electricity or gas inputs used for heat generation were subsidised by the state or not, and which funding scheme was used**. Section 6 (1) no. 7 HkNRG contains an ordinance authorising the inclusion of corresponding information in heat GOs. **Information on the funding status of the energy inputs used creates transparency and enables customers to differentiate their demand for green district heating**. Analogous to the green electricity market, green district heating from unsubsidised new plants, for example, could establish itself as a premium product, whereby in the case of electricity-based heat generation, the use of unsubsidised electricity would also have to be proven. **Information fields on the funding status of energy inputs can also form a basis for a corresponding qualitative differentiation within the framework of verification for regulatory requirements**.

In Germany, however, there are challenges in dealing with electricity for which EEG funding is claimed, as no GOs may be issued for this (§ 79 para. 1 in conjunction with § 80 para. 2 EEG). Since 2022, EEG financing has been changed to household financing, the share of ‘renewable energies promoted under the EEG’ must be shown to all end consumers in the product mix of the electricity disclosure (or in the company sales mix, if suppliers do not sell differentiated electricity products, see § 42 para. 3 EnWG). Although electricity-based heat generation plants also count as final electricity consumers, showing the share of EEG-subsidised electricity to all final electricity consumers in the same amount and additionally showing renewable heat generated from EEG-subsidised electricity in the context of heat disclosure could represent a double claim on the green attributes of the corresponding EEG-subsidised electricity quantities. The HkNRG clarifies that no heat GOs from renewable energy or unavoidable waste heat can be issued on the basis of EEG-subsidised electricity (or gases generated with EEG-subsidised electricity) (§ 5 para. 5 HkNRG). A possible exception is provided for electricity consumed at the request of the transmission system operator (TSO) within the framework of measures pursuant to Article 13(6b) or Article 13a EnWG (in particular to avoid the curtailment of renewable energy plants). If no GOs are issued for such electricity quantities, however, an alternative verification procedure would have to be provided that ensures clear allocation and exclusion of multiple consideration of green attributes.

Apart from **electricity quantities that** were **consumed at the TSO's request, it** would therefore only be possible to issue GOs for electricity-based heat if GOs were cancelled that were issued either for **unsubsidised electricity from domestic renewable electricity generation plants** (incl. EEG-subsidised plants that temporarily switch to unsubsidised other direct marketing) or **for renewable electricity generated abroad**. The use of imported GOs issued for subsidised electricity or subsidised installations would also be permissible.

Against the background that **a spatial correlation between electricity generation and consumption** can **strengthen the credibility of a corresponding verification**, the handling of EEG-subsidised electricity quantities in the cross-sectoral tracking of green attributes turns out to be unsatisfactory. Electricity use in large-scale heat pumps and PtH plants plays an important role in studies and scenarios on decarbonisation of district heating supply (see e.g., Engelmann et al. 2021; Bürger et al. 2021; Bacquet et al. 2022; Copernicus project Ariadne 2021, 2022). **The purchase of renewable electricity via grids can be a more cost-efficient decarbonisation option for electricity-based heat generation than the use of local renewable electricity generation plants connected via direct lines**, if the latter is at all reasonably possible at the location of the heating grid (e.g., in an urban context). Thus, grid-connected electricity supply allows for greater flexibility in the spatial location of renewable electricity generation plants. Compared to direct supply, the realisation of larger plants and plant parks that make their electricity available to various applications via grids allows for economies of scale. In addition, PtH plants and large heat pumps can absorb electricity surpluses from the grid and, in combination with heat storage systems, contribute to the system integration of the fluctuating renewable electricity sources wind and photovoltaics. This contribution goes beyond the avoidance of grid bottlenecks or curtailment of renewable energy plants. Especially in combination with thermal storage, targeted electricity-based heat generation in times of low electricity prices could, on the one hand, reduce the costs of a climate-neutral heat supply, but on the other hand also stabilise the revenues for wind and PV plants (by increasing demand in times of low electricity prices, but also by purchasing corresponding GO). In the case of plants that are subsidised with the sliding market premium, a corresponding stabilisation of electricity prices could in turn reduce the state subsidy costs.

Against this backdrop, **issuing GOs for subsidised plants, as originally called for in the EU Commission's RED III draft, would allow for a more uniform and simpler tracking of green attributes across sector borders** (in the preliminary final version of RED III following the conclusion of the trilogue procedure, however, Member States are still allowed to forego issuing GOs for subsidised plants). The increased use of Power to X plants, also in combination with EEG-subsidised electricity, could contribute to increasing the amount of electricity from wind and PV that can be integrated into grids. In order to avoid a supply shock on European GO markets, a restriction of GO issuance for EEG-subsidised electricity to new plants would also be an option (see Sakhel et al. 2022).

In principle, it would also be advisable to **harmonise the definition of electricity-based renewable heat across different laws and ordinances**. For example, the GEG limits the definition of renewable energies that are eligible for heat generation within the meaning of the Act to solar energy systems or building-integrated wind power systems that are in direct spatial connection with the building (§ 3 para. 2 GEG; although default values for PEF and emission factors also include renewable energy quantities contained in the electricity mix, cf. Annexes 4 and 9 GEG). However, this does not adequately reflect the role that large-scale electricity-based solutions can play in the decarbonisation of heating grids. In addition, different definitions result in discrepancies in the reporting of renewable energy shares under different laws (e.g., GEG and WPG). The uniform use of GOs to track green attributes across sectors could contribute to better comparability and traceability of corresponding information and would also be a prerequisite to leverage the potentials of GOs to facilitate the enforcement of different laws or funding schemes (see 2.3.4).

3.5.2.2 Dealing with self-supply plants with grid feed-through

In addition to the exclusion of issuing GOs for EEG-subsidised electricity, it should be noted that, in Germany, GOs are only issued for electricity quantities supplied to end consumers (§ 79 para. 5 EEG). In addition, electricity GOs may only be used for electricity disclosure by an electricity supplier as stipulated in the EnWG (§ 3 no. 29 EEG; § 30 par. 1 HkRNDV), whereby the electricity disclosure obligation refers to the provision of information to end consumers (§ 42 par. 1 EnWG). **The current legal situation therefore excludes the issuing of electricity GOs for self-supply**. In other EU countries, on the other hand, it is sometimes possible to apply for GOs for one's own generation of electricity and to cancel them for one's own electricity consumption, such as in Finland or Sweden (see Styles et al. 2023).

Against this background, a **challenge** arises in the verification of energy carrier conversions if **heat suppliers themselves operate renewable electricity generation plants whose electricity is fed into grids and is used at least proportional to supply their own large heat pumps and PtH plants**. This can be a relevant case, for example, for municipal supply companies or other energy suppliers that operate both electricity generation plants and heating grids (likewise, this constellation is relevant for the supply of electrolysers with electricity from company-owned plants via the electricity grid). The issuance and use of GOs for verification would require that the operator of the electricity and heat generation plant are different legal entities - in this case it would be a matter of supplies subject to electricity disclosure. However, a corresponding organisational division of the company may involve costs or be impracticable for other reasons. The **issuing of self-supply GOs for electricity generation plants with grid feed-in - in connection with a disclosure rule that restricts the use to the disclosure of self-supply** - would be a solution for this case of sector-linked verification (see also chapter 3.4).

3.5.2.3 Requirements for the spatial and/or temporal connection of electricity generation and consumption

A uniform definition of heat generation from renewable energies that includes the use of renewable electricity from the grid does not exclude that **in different application contexts differentiated quality requirements can be placed on the electricity used and the GOs used for verification**. Depending on their preferences and willingness to pay, customers could choose between **products with subsidised and unsubsidised plants, different technologies or shares of new plants.** It would also be possible, for example, to impose requirements on the quality of the green electricity used in the case of regulatory eligibility within the framework of the PEF calculation for the GEG or a subsidy for electricity-based heat generation plants under the BEW.

In addition, the **spatial and temporal correlation of electricity generation and consumption is** a relevant criterion that provides information on whether electricity from renewable sources was available in the grid at the time of electricity-based energy generation and, in view of grid bottlenecks and limited capacities at border interconnection points, could at least theoretically have contributed to meeting a certain demand. **The political discussion on the design of corresponding requirements has so far focused on green hydrogen and other renewable fuels of non-biogenic origin (RFNBOs)**. A corresponding delegated act of the EU Commission was finally adopted in June 2023.[33] As a concretisation of Article 27 para. 3 RED II, it describes under which conditions liquid and gaseous RFNBOs can be counted as fully renewable towards the transport sector target of RED II. RED III extends the scope of the criteria to the use of RFNBOs in other consumption sectors. Specifically for **electricity purchased from the grid,** the following criteria apply to be considered fully renewable:

- If the RFNBO-generating plant (usually an electrolyser) is located in an electricity price bidding zone in which the **average renewable electricity share in the previous year was more than 90 %** and the RFNBO production does not exceed a maximum number of hours calculated depending on the renewables share in the bidding zone.
- If the RFNBO-generating plant is located in a bidding zone where the **emission intensity of the electricity is lower than 18 gCO_2-eq/MJ**, provided other criteria are met:
    - **Power Purchase Agreements (PPAs)** must be concluded with power generation plants (directly or via intermediaries), in equivalent amounts to the renewable electricity input.
    - Requirements for **spatial and temporal correlation** must be met (see below).
- If electricity was consumed in a balancing period in which the need for **redispatch of renewable electricity generation plants** could be reduced by electricity consumption to generate RFNBOs.
- If criteria of **additionality and temporal and spatial correlation** are met:
    - **Additionality** is given if RFNBO producers produce renewable electricity in their own plants, or if PPAs are concluded with power generation plants (directly or via intermediaries), in equivalent amounts to the renewable electricity input, provided that:
        - the renewable electricity generation plant has not been commissioned earlier than 36 months before the RFNBO plant (with exemptions for electricity generation plants with terminated PPAs and capacity expansions at RFNBO plants);
        - the renewable electricity generation plant has not received investment or operating cost funding (with exceptions, e.g., for funding prior to repowering, plants for research, development and demonstration purposes, or a repayment of funding received).
        - For RFNBO plants that start operation before 2028, additionality requirements only apply from 2038.
    - **Temporal correlation:**

[33] Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin. Official Journal of the European Union, 20.6.2023, L 157/11-19.

- Until the end of 2029: RFNBO production must take place during the same calendar month as renewable electricity generation from PPA plants, unless electricity is used from a new storage facility located behind the same grid connection point as the electrolyser or renewable electricity generation plant and charged in the same calendar month as the renewable electricity generation covered by the PPA took place.
- From 2030 onwards, an hourly correlation must be demonstrated instead of a monthly one. Member States may implement this requirement for RFNBOs generated in their territory as early as mid-2027.
- Alternatively, the temporal correlation requirement is considered to be met if RFNBOs were produced in a period of one hour in which the electricity price on the day-ahead market of the bidding zone was at most 20 euros/MWh or lower than 0.36 times the EU ETS price for an emission allowance of one tonne of CO equivalents.$_2$

○ **Spatial correlation:**
- The renewable electricity generation plant with PPA is located in the same bidding zone as the electrolyser.
- The renewable electricity generation plant is located in a linked bidding zone (which may be in another Member State) and day-ahead electricity prices in the relevant time period were equal to or higher than in the bidding zone of the RFNBO plant.
- The renewable electricity generation plant with PPA is located in an offshore bidding zone that is connected to the bidding zone of the electrolyser.
- Member States may impose additional spatial context requirements to ensure compatibility with national planning for electricity and hydrogen grids.

Preamble 15 of the Delegated Act clarifies that multiple consideration of green attributes in the GO issuance is to be ruled out by cancelling GOs issued for the renewable electricity used. **In order to increase the efficiency of the verification process, it is advisable to use certificates as evidence for as many of the criteria mentioned as possible, provided that they can be mapped by the certificate system**. Information on the plant location can be used for matching the bidding zone (as there are several bidding zones in some countries, this matching could be simplified by including bidding zones as a GO information field). Information on additionality (subsidy status and commissioning dates) can be covered by already existing GO information fields (except possibly in exceptional cases, such as a repayment of subsidy after GO issuance or the additional information that the installations are for research, development and demonstration purposes). The proof of the monthly temporal correlation can also already be mapped via the GO system. In order to prove hourly correlation, however, further development towards granular GOs would be necessary (see e.g., EnergyTag 2022b, Energy Track & Trace 2023).

Corresponding criteria could in principle be applied not only to electricity-based renewable fuels of non-biogenic origin as a prerequisite for counting towards national or European targets and consideration in regulatory or funding law, but also for other Power to X applications, including PtH. However, it should be noted that RFNBO production is associated with comparatively high conversion losses (e.g., IRENA 2020b). **A direct use of electricity for heat generation or in e-mobility turns out to be more energy efficient than a use of RFNBOs**. For RFNBO production, it is therefore of particular importance to ensure that an associated increase in electricity consumption does not lead to an increase in fossil-based electricity generation but is accompanied by an expansion of renewable electricity generation capacity in the electricity sector. **Against this background, it seems sensible to develop a lower-threshold and administratively leaner set of criteria for the recognition of electricity-based heat generation from renewable energy in the context of regulation**

requirements or funding. For example, the cancellation of electricity GOs with certain qualitative attributes could be required (see Styles and Claas-Reuther 2022):

- Requirement that a minimum share of electricity GO comes from photovoltaics or wind power as fluctuating renewable electricity sources (to strengthen the role of sector coupling for system integration of fluctuating renewable energy production);
- Requirement that a certain share of the electricity GO comes from plants located in the bidding zone for Germany or connected bidding zones;
- Requirement that electricity GOs come from unsubsidised plants (to avoid possible double subsidisation of electricity and heat generation);
- In the case of PtH plants such as electric boilers or heating rods, requirements could also be imposed on the grid-serving use or the temporal connection between renewable electricity generation and consumption (initially monthly, later hourly, following the Delegated Act).

3.5.3 Design decision in the IW³ pilot registry

The question of what requirements should be placed on an electricity purchase in order for an electricity input in heat generation to be considered renewable was also discussed at the IW³ stakeholder workshop in April 2021. However, almost three quarters of the participants did not give an answer (see Figure 12), which indicates that at least at the time of the workshop there was still greater uncertainty regarding the topic or that a more detailed discussion would have been necessary to form an opinion. Since the challenges described in 3.5.2 would have to be addressed at the level of the national electricity CCN system or would require adjustments in the legal framework, **a solution as simple as possible was chosen for the IW³ pilot registry for the verification of green energy inputs obtained via grids, with a focus on excluding multiple marketing or multiple claims of green attributes**.

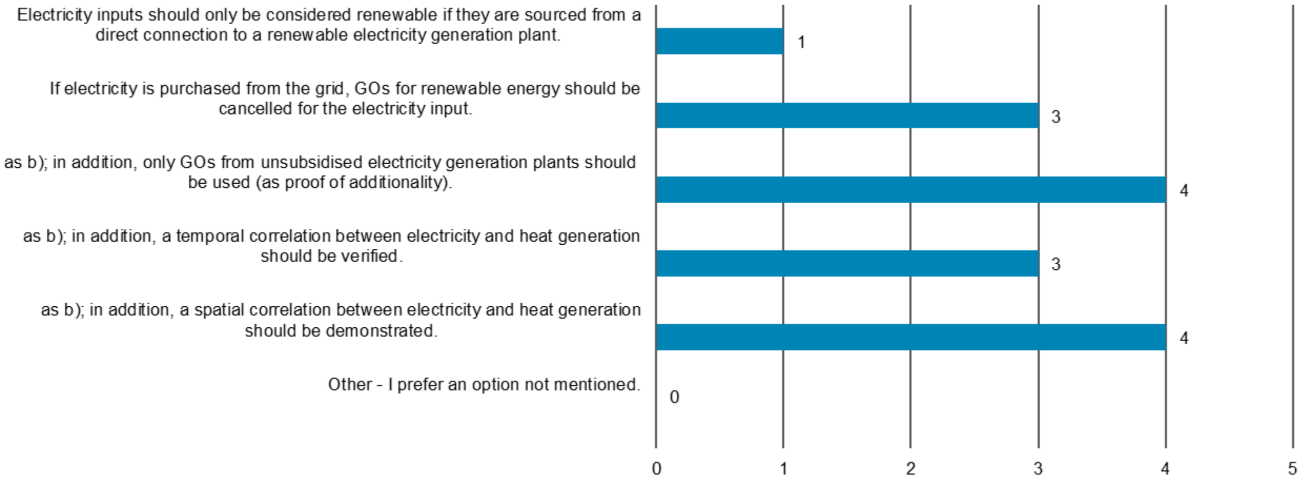
For example, the system rules of the registry stipulate that for heat pumps or power-to-heat plants that draw electricity from general supply grids, **proof of the green attributes of the electricity used** can be provided by **submitting a GO certificate of cancellation from the German Environment Agency's electricity GO registry** (Hamburg Institut 2022). Since the pilot registry enables full disclosure of heat quantities, heat GOs can also be issued if no proof of the attributes of the electricity used is provided. In this case, however, they are not heat GOs for renewable energies. Instead, heat GOs for non-renewable energy with an energy source marked as ‘unspecified’ are issued for the share of the output that is due to electricity as an input. For heat pumps, on the basis of consumption declarations specifying the energy input factors of ambient heat and electricity, RE-GOs can in any case be issued proportional for the energy output attributable to ambient heat.

Plants that balance biomethane or other renewable gases via the natural gas grid can prove the green attributes of the energy inputs by submitting a mass balance certificate (as a national gas GO was not yet in place when the IW³ pilot registry was implemented).

In the pilot registry context, the verification of cancelled electricity GOs or mass balancing certificates is carried out manually. **In the case of the implementation of national registries, interfaces between heat, electricity, and gas GOs or even the integration of the registries in a database offer considerable simplifications for the verification of conversion processes**. In this case, ‘inheritable’ information from cancelled GOs for energy inputs, such as energy source and production status, could be automatically transferred to newly issued heat GOs. For gases, an interface to the mass balance-based biogas registry of the German Energy Agency (dena) would also be conceivable.[34] In the case of biomethane (as well as other biomasses used for heat generation), interfaces to the sustainable biomass systems database (Nabisy) of the Federal Agency for Agriculture and Food (BLE) could also facilitate the transfer of sustainability information.[35] The HkNRG provides for the detailed regulation of data reconciliation and exchange of a national H&C GO registry with electricity and gas GO registries as well as other national and international registries and databases (according to § 6 no. 13-15 HkNRG).

Figure 12: Survey results on requirements for proof of renewable origin of electricity

What requirements should be placed on an electricity purchase in order for an electricity input in heat generation to be considered renewable? (Multiple answers possible, n = 10)



Note: 26 out of 36 participants did not give an answer.

Source: Own representation, based on online survey at IW³ stakeholder workshop on 13.04.2021

3.6 Verification of plant and measurement data

In GO systems, three types of data with verification requirements can generally be distinguished (cf. EN 16325; AIB 2023b):

- **Plant data** (e.g., information on capacity, commissioning date, technology, energy source, funding status).
- **Measurement data** (for net heat generation fed into the heating grid or net heat generation used for own supply)
- **Consumption declarations** (especially for biomass plants, plants with more than one energy input, and for plants with energy carrier conversion, e.g., biomethane CHP or power to heat plants).

Harmonised requirements for data verification are currently formulated for electricity GO systems by the EN 16325 standard and the European Energy Certificate System (EECS) for electricity GOs and gas GOs. Within the framework of the ongoing revision of EN 16325, corresponding rules for gases, hydrogen, heating, and cooling are being developed. **The FaStGO draft for EN 16325 of 2020 established the following framework**

[34] See https://www.biogasregister.de/.

[35] See https://nabisy.ble.de/.

conditions for data verification, which were taken up in the design of the system rules for the IW³ pilot registry.

With regard to **installation data,** GO issuing bodies must ensure that the quality of specified information on registered installations and associated export and import meters is guaranteed and accurate (FaStGO 2020, p. 41). This includes, among others, information on the fulfilment of qualification criteria (e.g. providing evidence that installations are able to generate energy from the energy sources for which they are registered), the energy source of inputs, the appropriate placement of metering devices to ensure correct determination of the quantity of GOs issued for each energy source, or the accuracy of metering devices. According to the FaStGO draft, issuing bodies must thereby provide for verification mechanisms that provide for confirmation by a party that is independent of parties that benefit from issued GO quantities.

For **measurement data and consumption declarations,** Issuing Bodies must ensure that information on which the GO issuance is based is accurate or correct. Independent audits of relevant documents and, if necessary, of installations or measuring equipment by a production auditor can be provided for, but according to the draft standard this is not mandatory but is left to the discretion of the issuing body (FaStGO 2020, p. 41). For consumption declarations on biogenic feedstocks, the stricter rule applies that registered producers must submit a report from a production auditor to the issuing body at least every two years, confirming the accuracy of the information provided (FaStGO 2020, p. 42). This also applies to plants that use a mixture of biogenic and fossil feedstocks.

3.6.1 Implementation of verification requirements in the electricity GO system

In order to derive verification requirements for the IW³ pilot registry from the framework of the EN 16325 draft, **the implementation in the electricity GO registry of the German Environment Agency was** analysed in more detail. Here, **the important role that independent grid operators play in the German electricity GO registry for the verification of plant and measurement data becomes clear**. According to § 41 HkRNDV, the grid operator to whose grid a plant is connected for which registration in the GO registry has been applied for is obliged to provide the registry administration with information on specified plant data at its request. In the case of certain plants, there is also provision for the reported data to be verified by environmental verifiers acting as independent auditors: for biomass plants with an installed capacity of more than 100 kW, high-efficiency CHP plants with an installed capacity of more than 100 kW, and plants with an installed capacity of more than 100 kW for which no EEG funding was claimed in the last 5 years prior to the application for registration (section 22 HkRNDV). For metering data, grid operators are obliged to report the net quantities of electricity fed into the grid from registered plants (section 41 HkRNDV). For biomass plants registered in the GO registry, there is an obligation to keep input material diaries and to have them checked by the environmental verifier (§ 42 HkRNDV). At least once per calendar year, the amount of electricity produced in the plant and the shares of renewable energies in the energy content of the fuels used must be determined by an environmental verifier and submitted to the registry administration. For waste and substitute fuels, there are simplifying requirements; for example, the GO registry's terms of use specify standard values for percentage biogenic shares here. [36]

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[36] Terms of use for the Guarantees of Origin Registry and the Regional Guarantees of Origin Registry of 20.05.2020, effective from 25.06.2020. General decree on obtaining the authorisation to use, on the use and on the termination of the authorisation to use the Guarantees of Origin Registry and the Regional Guarantees of Origin Registry pursuant to section 52 sentence 1 of the Ordinance on the Implementation of the Guarantees of Origin and the Regional Guarantees of Origin (BAnz AT 24.06.2020 B9).

The Market Master Data Registry (MaStR), which is maintained by the Federal Network Agency (Bundesnetzagentur), is also relevant for the central recording of system data in the German electricity and gas market.[37] All players in the electricity and gas market who assume certain functions must register here (e.g. grid operators, system operators, electricity and gas suppliers who use general supply grids or closed distribution grids, other market players and marketplaces as well as selected authorities; see Bundesnetzagentur 2023). In addition, there is a registration obligation for all active electricity and gas generation plants and electricity and gas storage facilities that are directly or indirectly connected to a grid, as well as for selected consumption units (in the case of electricity consumption units, if there is a connection to a high-voltage or extra-high-voltage grid, and in the case of gas consumption units, if there is a connection to a transmission grid or if they are gas-fired power plants with an electrical output of more than 10 MW. **Grid operators to whose grids a plant is connected** are **requested to verify the plant data in the MaStR** (Bundesnetzagentur 2023).

3.6.2 Design decision in the IW³ pilot registry

When verifying plant and measurement data for heat supply systems, **the challenge is that, in contrast to electricity and gas grids, there are usually no independent grid operators who can confirm the accuracy of data**. In vertically integrated heat supply systems, independent data verification processes would therefore have to rely more heavily on audits than is the case in the electricity system. However, as these are more costly than data verification by grid operators, **a balance is needed between the stringency of the requirements and the costs that this implies for the use of the heat GO system**. The implementation of verification requirements in countries or regions that have already implemented heat GO systems (the Netherlands, Flanders, and Finland) varies accordingly.[38] As a rule, a pre-audit or inspection of the system data and measuring equipment is required during system registration, with periodic repetition. Requirements for the verification of measurement data are inconsistent; in some cases, a general right to inspection is provided for, in others monthly measurement reports are required, at least for certain plants. As far as possible, it also **makes sense to use synergies with existing verification processes** (e.g., in the context of funding programmes or plant approval procedures) **for data verification.**

When designing requirements in the IW³ pilot registry, the research context also had to be taken into account - due to the pilot character of the registry with a limited project duration, it cannot be assumed that participating suppliers or producers will be able to generate increased revenues from the GO application, as the national legal framework and the design of a future national registry are of high importance for the permanent design of green district heating products based on GO. Accordingly, the accuracy of the data must be ensured, but at the same time the verification must be designed to be low effort in order to keep the inhibition threshold for participation in the pilot registry low. Against this background, the following requirements were formulated in the system rules (see Hamburg Institut 2022; verification requirements were not discussed in the stakeholder workshop 2021 but were agreed upon in a workshop with the IW_M project partners HAW and Hamburger Energiewerke).

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[37] See https://www.marktstammdatenregister.de.

[38] See Regeling garanties van oorsprong en certificaten van oorsprong“, https://wetten.overheid.nl/BWBR0035971/2021-01-01; Finnish Act on Guarantees of Origin for Energy (1050/2021), Section 25 and Government Decree on Guarantees of Origin for Energy (1081/2021), Section 6 & 7, https://www.fingrid.fi/en/electricity-market/guarantees-of-origin/legislation/; Besluit van de Vlaamse Regering houdende algemene bepalingen over het energiebeleid [citeeropschrift “het Energiebesluit van 19 november 2010”], chapter II/3, paragraph 1, subparagraph 3, https://codex.vlaanderen.be/Zoeken/Document.aspx?DID=1019755&param=inhoud&AID=1159445; Vereisten waaraan de keuring van productie-installatie van warmte of koude uit hernieuwbare energiebronnen moet voldoen, Belgisch Staatsblad, 25.06.2020, https://emis.vito.be/nl/actuele-wetgeving/10-juni-2020-besluit-van-de-administrateur-generaal-van-het-vlaams.

In the case of plant data, a data comparison with existing, suitable evidence is carried out before confirming the plant registration in the IW³ pilot registry. Pre-audits or an inspection of the plant data and measuring equipment are not carried out, as this would represent a very high barrier to participation in the research context. For CHP plants, data reconciliation is carried out by inspecting publicly available plant data in the market master data registry. For other plants, inspection of the commissioning report of the plant or submission of comparable evidence confirming the plant data is envisaged. The type of proof is open in order to enable learning effects. This can be, for example, a subsidy notification letter or PEF report, provided that the plant data recorded in the registry can be verified on this basis.

In the case of measurement data, a plausibility check of the reported meter readings is carried out by HIR as the issuing body in the context of the pilot registry before the GO is issued. This involves checking whether the measurement data reported for a specific period match the installed nominal thermal capacity of the system and, where relevant, typical seasonal availabilities of energy sources (e.g., solar thermal). A monthly transmission of measurement data is recommended so that data on the month of production is visible as information on the GO. In the case of longer periods for data reporting, a correspondingly longer production period is recorded for the issued GO bundle, but daily reporting is also possible. Data transmission can be carried out manually by entering the data in the registry or automatically via an API (Application Programming Interface). The plausibility check is currently carried out manually but could in principle also be automated. In case of discrepancies, producers or suppliers are contacted and requested to check and, if necessary, correct the transmitted data.

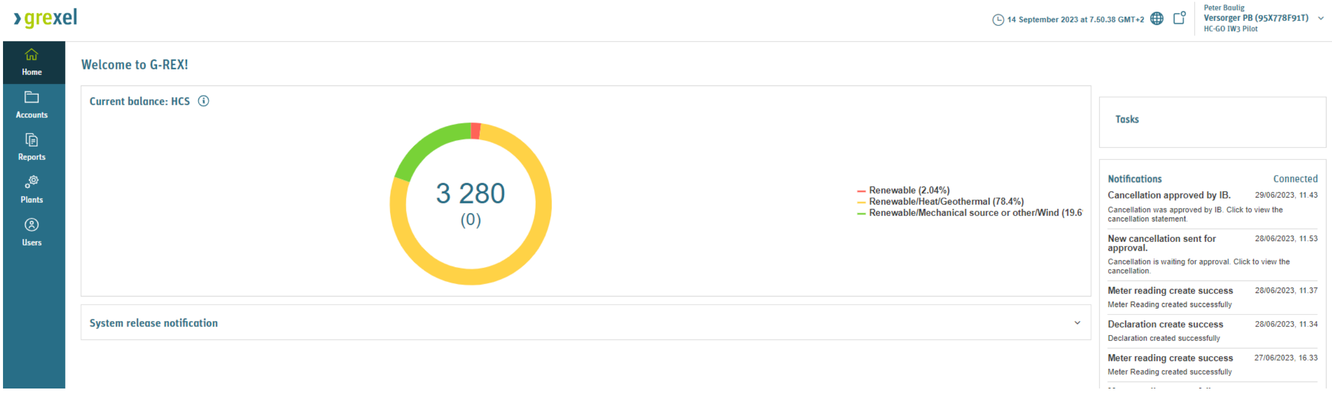
In order to maintain low barriers surrounding the use of the pilot registry, which is primarily aimed at gathering experience for the national implementation of a heating and cooling GO system, a **test use of the registry without independent measurement data verification is possible**. However**, if participating suppliers make statements to customers on the basis of the issued or cancelled GOs, annual verification of the measurement data reported to the IW³ registry by an independent auditor (e.g., a chartered accountant) is foreseen.** This should be done before publication of the heat code. This way, if corrections are required, over-issued GOs can be deleted or under-issued GOs can be made up for before the annual accounting is completed. If too many GOs have already been cancelled, a negative balance is noted in the account of the corresponding supplier or generator; GOs are not issued again until this balance has been cleared. This follows the established practice in the electricity GO registry (see § 15 and § 32 HkRNDV; see also Chapter 3.7.1). In the future, significant simplifications can be expected in the verification of metering data for heat feed-in if certified smart meters are used that could transmit data to the registry via a secure protocol.

When verifying consumption declarations, synergies with existing verification processes can often be used. For example, biomass plants are often designed as CHP plants and participate in the EEG funding or alternatively apply for electricity GOs. In this case, input material logs are already kept and verified by environmental experts. If heat generation plants purchase gas from renewable energy sources (especially biomethane from the natural gas grid) on a balance sheet basis, the submission of mass balance certificates is currently required once a year; if electricity from renewable energy sources is purchased on a balance sheet basis, proof of the cancellation of the corresponding electricity GOs must be submitted (see 3.5). By accepting the terms of use and system rules, participating suppliers and producers agree to submit the corresponding evidence (Hamburg Institut 2022).

3.7 Central processes in the IW³ pilot registry and disclosure of heat origin

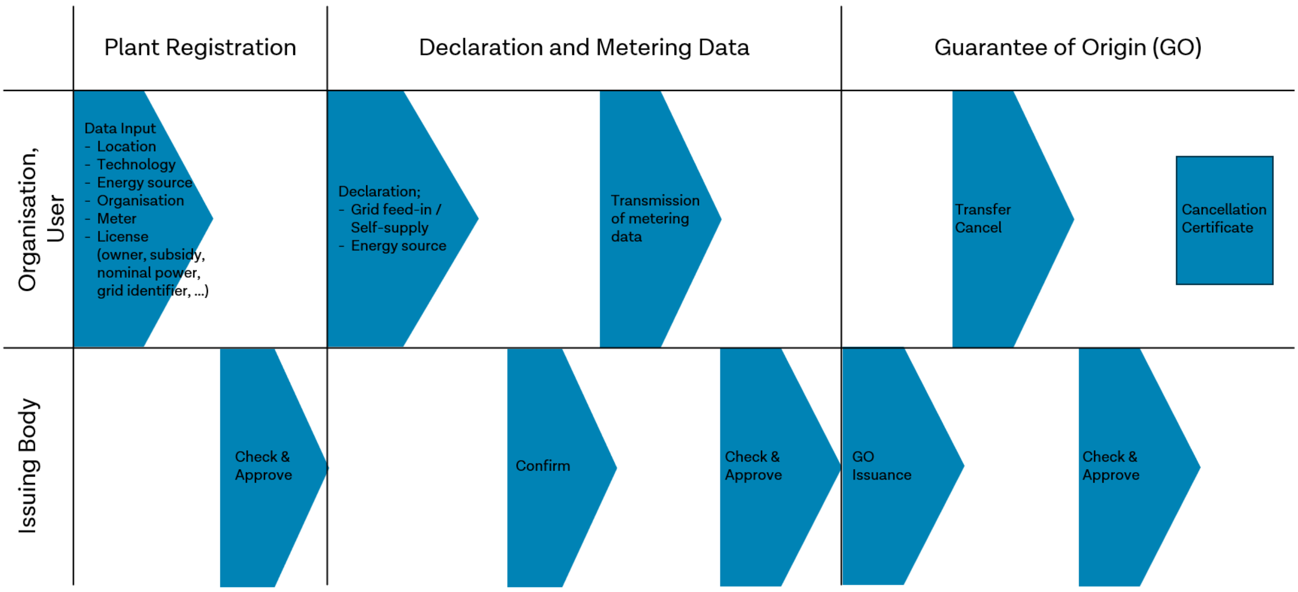
The design decisions described in 3.1-3.6 have been implemented in the design of the registry software and/or the terms of use and system rules of the IW³ pilot registry (Hamburg Institut 2022). Finally, **the processes involved in using the registry are presented** (see Figures 13 and 14). **This is intended to exemplify the functioning of H&C GO registries.** The aim of the pilot registry is to generate experience for the national implementation of H&C GO registries, so that the pilot registry is only operated until the end of the project or the commissioning of a national registry. Subsequently, it will be discussed in which way GO cancellations could be mapped in the heat label.

Figure 13: Start view of the IW³ pilot registry (heat supplier account, demo version)



Source: Grexel

Figure 14: Central processes in the IW³ pilot registry



Source: Own representation, Hamburg Institut

3.7.1 Description of the central processes in the IW³ pilot registry

The processes described are preceded by **the registration of organisations and users in** the IW³ pilot registry. These can be system operators and heat suppliers (for the latter, a dual role as system operator is possible), but also service providers or experts commissioned with system registration or measurement data transmission. The login of registered users in the registry is done via 2-factor authentication.

System operators or heat suppliers can then **registry heat generation systems**. For this purpose, various system data are recorded, such as system technology and location, commissioning date, energy sources used, identifier and name of the grid into which the system is fed, identifier of the meter (as well as correction factors, if applicable, if the meter does not measure the net heat production of the system fed into the grid but also records auxiliary energy consumed by the system itself). In particular, data that can potentially change over time (e.g., nominal thermal capacity, production status) are recorded as a licence with a starting point and possible end time of validity. Plant data is checked and approved by HIR as the registry administrator of the IW³ pilot registry on the basis of suitable documentation (see 3.6). Subsequent changes to plant data also require approval before they become effective and are documented by the registry software. The information required for registration is documented in the terms of use (Hamburg Institut 2022) and in the appendix (section 6.1).

For plants registered for more than one energy source, **a declaration of the percentage share of different energy sources in the energy input is required** (EN 16325-compliant calculation principles of the input ratio are included in the conditions of use and system rules, see Hamburg Institut 2022). The input material ratio is explained in more detail via consumption declarations, whereby in the case of electricity- or gas-based heat generation, GO cancellation statements or mass balance certificates can be used as proof. For all plants, a declaration must also be submitted stating the proportion of generated energy that was fed into the heating grid or consumed by the plant operator for self-supply in a given period (in each case with values from 0 to 100 %). If it is not exclusively a system with grid feed-in or self-supply, GOs are issued proportional to the specified ratio. Declarations must also be approved by the registry administration before a GO can be issued to plants.

The next step is the **reporting of metering data** by system operators or applicants or by the actors commissioned as metering points. Metering data can be transmitted manually in kWh or MWh for a specific period. Monthly data reporting is recommended, but shorter or longer reporting periods are also possible (up to annually for small plants). Alternatively, measurement data reporting can be automated using API. In this way, interfaces to digital measurement data acquisition systems of plant operators or heat suppliers can be established. Measurement data is subjected to a plausibility check by the registry administration by comparing reported data with the nominal thermal capacity as well as technology-specific and, if applicable, year-specific average values for full utilisation hours. The registry administration can then issue **GOs** for approved measurement data reports. GOs are issued as a bundle, whereby the heat generation period covered by a measurement data report is visible as information. Further information is derived from the system data and information provided in the declarations (see Hamburg Institut 2022 and section 6.2 in the appendix). The GO is only issued for whole, reported MWh. The registry stores data on smaller energy quantities and takes these into account in the next issuance for the plant.

GOs are issued to the account of the system operator (or the heat supplier if the latter is also the system operator). For installations with several owners, a proportional GO can also be issued to the accounts of different owner organisations or the account of an aggregator organisation. This can be set up during plant registration. Account holders can **transfer GOs between accounts** without the need for approval by the registry administration. A transfer would be required, for example, if the system operator is a different organisation than the heat supplier requesting **cancellation of GOs.** The cancellation of GOs assigns the attributes of the underlying MWh to a specific customer or a specific heat product supplied by a heat supplier. To perform a cancellation, various information has to be provided, such as information on the beneficiary of the GO cancellation (either the name of a specific customer, subject to their consent, or a heat supplier product), information on the grid where the heat supply takes place and the period of heat consumption (see Hamburg Institut 2022 and section 6.3 in the Annex). The registry administration checks whether the grid of the heat supply corresponds to the grid of the plants for which GOs were issued and whether the year of heat production corresponds to the year of heat consumption. If this is the case, the cancellation is approved. The registry automatically generates cancellation statements that contain all relevant GO information (see Figure 15, Section 6.4 in the Appendix). The cancellation statements can be downloaded as a PDF file and shared with customers or published on the heat supplier's website as proof of product identification.

If the **need for correction** is identified during the examination of plant, declaration and measurement data, corresponding changes can be made by the applicants themselves or - in consultation with the applicants - by the registry administration. Due to the principle of unchangeability of GOs, incorrect GOs cannot be changed after they have been issued. If corresponding GOs have not yet been transferred to the account of another organisation or cancelled, they can be cancelled. In this case, the registry administration has the possibility to manually issue new and corrected GOs. If a GO cancellation or transfer has already taken place and serious and obvious errors are subsequently revealed, the registry administration may make a negative carry forward on the operator's GO account. If this is the case, new GOs for measurement data reports are only issued again when the heat quantity for which GOs were erroneously issued has been compensated for by heat generation in the corresponding plant (cf. on this § 15 and § 32 HkRNDV, on which the described procedure for cancellation and subsequent error correction was based).

Figure 15: Cancellation statement for a test installation created in the demo version of the IW^3 pilot registry

Cancellation Statement

This document certifies that the specified Guarantees of Origin for Heating or Cooling have been cancelled for the benefit of the specified receiver and for the period and purpose specified herein. Each GO has a value of 1 MWh. The environmental qualities of the associated energy have been consumed and this Cancellation Statement and these certificates may not be transferred to any party other than the energy supplier or end-consumer specified below. Onward sale of this Cancellation Statement is prohibited. Cancelled Guarantees of Origin cannot be transferred to other account holders.

Issuance, transfer and cancellation of the Guarantees of Origin is supervised by the IW3 Pilot Heating and Cooling GO registry, which was developed as part of the energy transition laboratory IW3 "Integrierte Wärmewende Wilhelmsburg", funded by the German Federal Ministry for Economic Affairs and Energy (BMWi).

Transaction details

Transaction type: **Cancellation**
Status: **Completed**
Transaction number: **20230118000000017**
Volume: **594 MWh**
Transaction started: **1/18/23, 12:08 PM**
Transaction completed: **1/18/23, 12:09 PM**
Public Statement: **No**
Standard: **HCS**

From account

Organization name: **Testorganisation**
Organization ID: **95X0F5804M**
Domain: **HC-GO IW3 Pilot**
Domain code: **HC**
Account number: **643002406400001703**
Street:
ZIP code: **22765**
City: **Hamburg**
Country: **Germany**

Beneficiary

Name of Beneficiary: **Haushaltskunden**
Country of consumption: **Germany**
Organization ID: **95X0F5804M**
Location of beneficiary: **Berlin**
Consumption period: **12/1/22 - 12/20/22**
Usage type: **Disclosure**
Cancellation purpose: **Heizung und Warmwasser**
Type of beneficiary: **End consumer**

Certificate Number (From-To)	Volume	Unit	Production period	Issuing date	Issuing country	Issuing body	Trading schemes	Earmark	Plant name and GSRN	Operational date	Energy source code and name	Technology code and name
643002406401009510000000012372 - 643002406401009510000000012965	594	MWh	7/1/22 - 7/31/22	1/18/23	DE	HIR Hamburg Institute Research gGmbH	HC Go	Investment support	Geothermie-Testanlage - 643002406401000088	7/1/22	F01040200 - Renewable/Heat/ Geothermal	Q040200 - Geotherm pumping installation Non-CHP/Unspecifie

CERTIFICATE INFORMATION

Support schemes: **Investment support**
Standard: **HCS**
Production support description:
Investment support description: **The Originating Plant has received Public Support relating to investment in it**

ISSUER

Issuing body: **HIR Hamburg Institute Research gGmbH**
Issuing body code: **95**
Issuing country code: **DE**
Competent authority code: **HC01**

PLANT

Plant name: **Geothermie-Testanlage**
GSRN: **643002406401000088**
Operational date: **2022-07-01**
ZIP code: **00000**
City: **Stadt**
Country: **Germany**
Country code: **DE**
Latitude N:
Longitude E:
Coordinate code:

ENERGY SOURCE AND TECHNOLOGY

Energy source: **Renewable/Heat/Geothermal**
Technology: **Geothermal pumping installation/Non-CHP/ Unspecified**

ATTRIBUTES

Aggregation stage: **Liquid**
Dissemination level: **Transferred over a Heating or Cooling Grid**
Energy carrier: **Heating and Cooling**
Medium: **Water**
Network identity: **B001**
Network name: **Beispielnetz**
Nominal capacity: **1400**
Purpose: **Disclosure**
Thermal energy type: **Heating**

Source: Grexel and Hamburg Institut

3.7.2 Use of GOs in the context of heat disclosure

Guarantee of origin systems must be accompanied by disclosure rules to ensure the legally secure, unambiguous assignment of green attributes to consumers (see Verwimp et al. 2020a). Rules that ensure comparability of labels from different suppliers are also important for the transparency and comprehensibility of the information presented (see Schudak and Wallbott 2019). **For electricity disclosure, RED II (or RED III) and the Electricity Directive (2009/72/EC; from 01.01.2021 RL (EU) 2019/944) contain clear and binding requirements that GOs must be used for the disclosure of electricity from renewable sources** (Art. 19 para. 8 RED II; Annex I No. 5 a RL (EU) 2019/944). Exceptions apply only to non-traced commercial offers, for which suppliers can use the residual energy mix for disclosure, and in the event that Member States decide not to issue GOs for subsidised electricity, as in the case of Germany with the disclosure of the share of EEG-subsidised electricity disclosure. **The RED III introduces equivalent regulations for gas disclosure in connection with the draft of the Internal Gas Market Directive** (Art. 19 para. 8 RED III; Annex I, section 5 COM(2021)0803).[39] **For heat, disclosure provisions are contained in Article 24 (1) RED II,** according to which end-users must be provided with information on the energy performance and the share of renewable energy of their DHC systems. **RED III also does not explicitly specify the role of GOs.** According to the Energy Efficiency Directive, end-users must also be provided with information on the fuel mix used and the associated quantities of greenhouse gas emissions (Art. 10a para. 2 lit. c Energy Efficiency Directive 2012/27/EU) - here, too, there is no reference to the GO system for heating and cooling to be set up according to Art. 19 RED II. However, the requirement of RED II or RED III remains relevant that utilities must use the guarantee of origin provided for the type of energy supplied for disclosure purposes if Member States have also provided for guarantees of origin for other types of energy [than electricity and gas] (Art. 19 para. 8 RED II or Art. 19 para. 8 RED III).

Accordingly, Member States have leeway in the design of the relationship between heat disclosure and GOs. As discussed in chapter 3.1, this lack of harmonisation is particularly problematic if GOs can be used for disclosure without taking grid boundaries into account. In the case of different regulations in different Member States, this could lead to multiple marketing and/or claiming of green attributes. On the other hand, if the GO cancellation for disclosure purposes is limited to connected heat supply systems, Member States can clarify the role of GOs in heat disclosure, which ensures a clear attribute allocation at least for heat grids in their territory (in the case of cross-border grids, coordination with disclosure rules of the neighbouring state would be necessary).

In Germany, a corresponding clarification has been made by § 5 para. 1 no. 7 FFVAV, according to which in cases where a utility undertakes to supply customers with heat or cooling from renewable energy or unavoidable waste heat, the share or quantity of the renewable energy sources and the heating or cooling technologies used must be proven by means of guarantees of origin issued by the competent authority pursuant to § 5 HkNRG. **Accordingly, in the FFVAV, the obligation to use GOs as a verification instrument for the supply of renewable heat to end customers only exists if specific renewable heat products are sold** (see 2.3.6). However, as soon as several products are offered in the heating grid (e.g. a green product with 100 % renewable energy and unavoidable waste heat and a basic product with a share of fossil-generated heat), GOs would have to be used for the disclosure of the renewable energy and waste heat shares in all products in order to exclude multiple marketing and claiming of green attributes. If the GO cancellation for disclosure purposes is

[39] COM(2021) 803 final. Proposal for a Directive of the European Parliament and of the Council concerning common rules for the internal markets in renewable gases and natural gas and hydrogen.

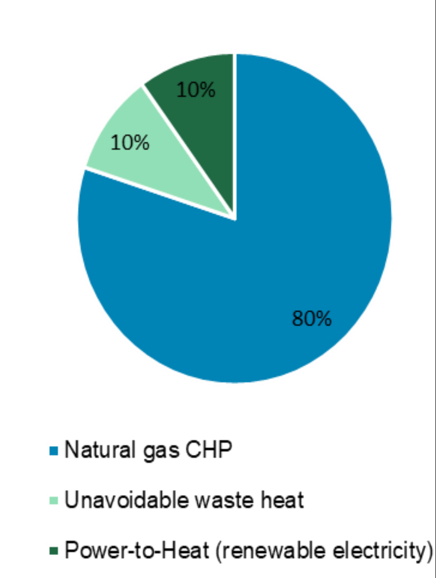
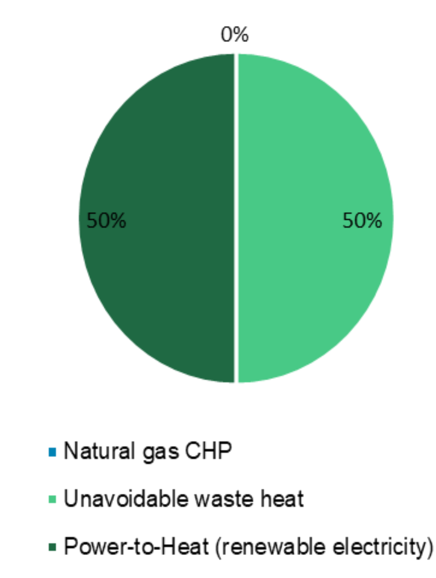
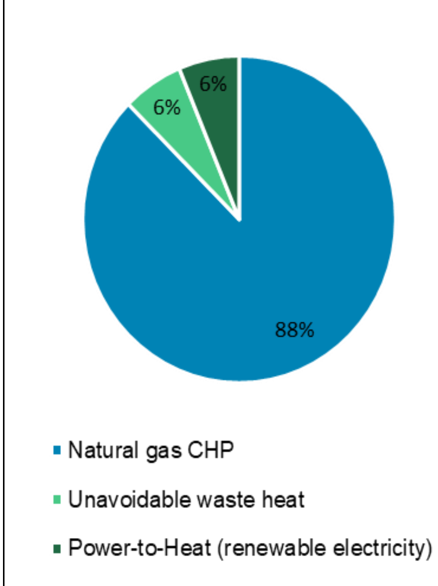
limited to technically interconnected grids, the proof of grid-uniform renewable energy and waste heat shares could continue to be provided without the use of GOs in grids without product differentiation (e.g., through periodic expert confirmation). If GOs are used across grids for disclosure purposes, however, it would have to be ensured that GOs are also used when reporting grid-uniform key figures in order to make visible when attributes are exported from a grid. Otherwise, if there is no product differentiation in one's own grid and at the same time attributes are exported via GO sales, double marketing can occur if attributes are shown both for one's own grid and a green district heating product in another grid.

Compared to the regulations implemented in the FFVAV, Art. 24 para. 1 RED III contains the new addition that **information on the renewable energy share must be expressed at least as a percentage of the gross final energy consumption of heating and cooling allocated to the customers of a given DHC system**, including information on how much energy was consumed to deliver a unit of heat to the customer or end-user (Art. 24 para. 1 RED III; see Chapter 3.2). **This includes the consideration of losses in the disclosure**.

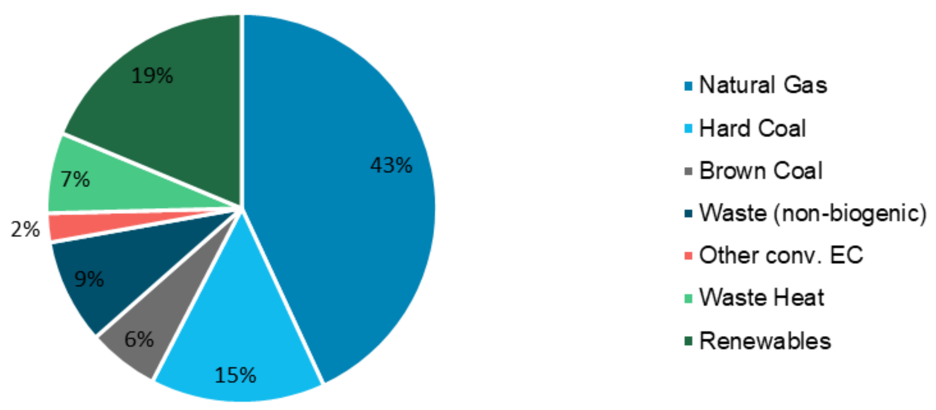
3.7.2.1 Options for displaying the thermal disclosure and included information

No uniform guidelines are yet available for the presentation of heat disclosure according to FFVAV. Similar to the guidelines for electricity disclosure of the BDEW (BDEW 2022), **such guidelines do not necessarily have to be set by the state**, **but could also be developed by industry associations, for example.** Empirical research on the requirements that heat customers place on the disclosure of supplied heat is also not yet available. **However, one approach could be to build on the design of electricity disclosure**, **as customers are already familiar with the way information is presented.** Furthermore, research results on customer requirements are available (Schudak and Wallbott 2019; Mundt et al. 2021). The total energy carrier mix of the company pursuant to Article 42 (1) EnWG in the context of electricity supply could be interpreted as the grid mix in the case of heat supply (provided that only one utility is active in heat supply the respective grid - otherwise the total energy mix would have to be calculated on a company-specific basis). Based on the layout proposal for electricity disclosure contained in the BDEW guideline on electricity disclosure, a possible form of presentation for heat disclosure is presented in Figure 16 for the example grid shown in Table 2 in Chapter 3.2.

Figure 16: Possible representation of energy carrier shares in the context of heat disclosure

Total energy source mix 'Example supplier, model grid	Green district heating' product mix	Remaining energy source mix
		
Amount of heat generated: 400,000 MWh	Amount of heat generated: 34,091 MWh	Amount of heat generated: 365,909 MWh
Amount of heat supplied: 352,000 MWh	Amount of heat supplied: 30,000 MWh	Amount of heat supplied: 322,000 MWh
Renewable energy and waste heat shares of the generated heat quantity (incl. grid losses): 20,0 %	Renewable energy and waste heat shares of the generated heat quantity (incl. grid losses): 100 %.	Renewable energy and waste heat shares of the generated heat quantity (incl. grid losses): 12,5 %

For comparison: District heating generation in Germany 2022



Assumption: The GO cancellation for disclosure purposes is limited to interconnected heat supply systems; in the case of trading across grid boundaries, it would be highly recommended for transparency reasons to include the grid origin of the GO in the disclosure.

Source: Own representation, based on model grid data in Styles et al. 2022 (see Table 2); design based on BDEW 2022, p. 97; data on district heating generation in Germany 2022 from BDEW 2023a.

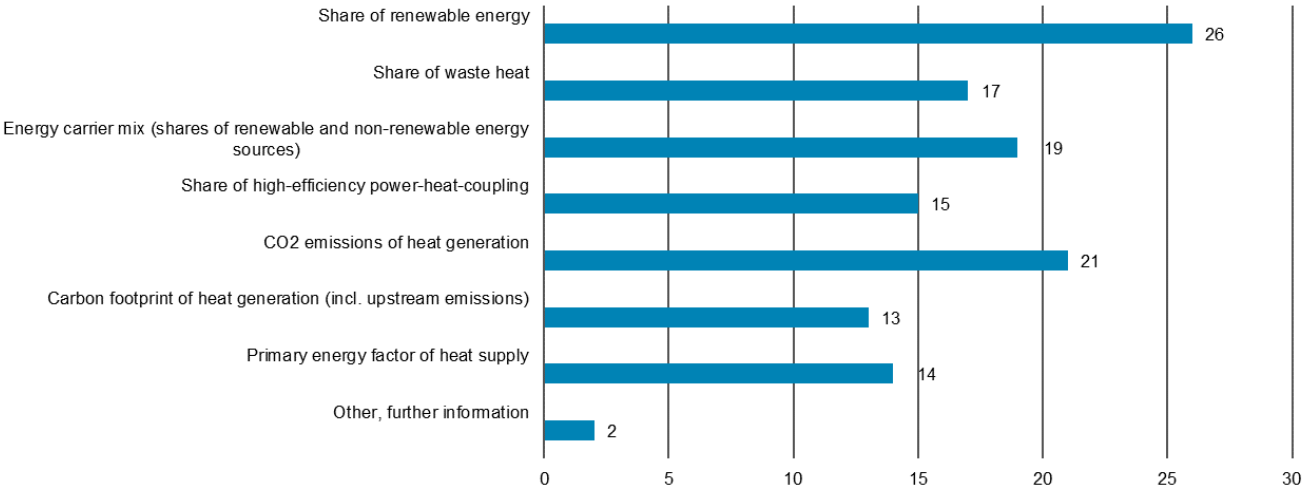
In the chosen form of presentation, the **shares of individual energy sources are shown for the total energy carrier mix, the product mix, and the remaining energy carrier mix in relation to the amount of heat generated** (analogous to the calculation of GEG coverage shares according to AGFW Code of Practice FW 309 Part 5). Alternatively, a reference to the heat quantity supplied would also be conceivable - in this case, however, there would be no consistency with GEG coverage shares. For reasons of transparency, it would also be desirable to separately identify the attributes assigned to grid losses (and losses from storage facilities located in the grid). For the RED III requirement that suppliers must provide information on how much energy was consumed for the delivery of a heat unit to the customer or end consumer, the auxiliary energy input would also have to be taken into account if necessary (at least the auxiliary power input for grid operation).

In addition, the annual greenhouse gas emissions associated with the energy mix must be reported pursuant to Article 5 (1) No. 2 FFVAV, as well as the primary energy factor of the technically connected DHC system pursuant to Article 5 (3) FFVAV. For the climate accounting of customers, **it would at least make sense to report product-specific greenhouse gas emissions** (see Chapter 2.3.2). A distinction can be made between **direct GHG emissions from heat generation** and **GHG emissions including upstream emissions.** In the context of electricity disclosure, the direct emissions of CO_2 are currently reported for net electricity generation (without upstream emissions, see BDEW 2022, p. 94 ff.). Renewable energies are assigned an emission factor of 0 g/kWh CO_2 emissions. This information is relevant for corporate customers within the scope of Scope 2 climate balancing for purchased energy. GHG emissions including upstream chain emissions, on the other hand, would be relevant for Scope 3 accounting. If the attribution of costs under the GEG is given, the reporting of product-specific PEFs would also be relevant (see Chapter 2.3.3). **Depending on the application, however, it may differ which upstream chains are included in the balancing**. According to DIN V 18599-1 Annex A Section A.1, standard factors for primary energy and emission factors include upstream primary energy requirements or emissions from extraction, processing, conversion, transport, and distribution of the considered energy sources, including auxiliary energy. Standard factors in the GEG also show primary energy and emission factors of zero for geothermal energy, solar thermal energy, ambient heat, electricity generated close to buildings from photovoltaics or wind power, geothermal cooling, and ambient cooling (incl. upstream chains, see Annexes 4 and 9 GEG). For corporate Scope 3 accounting, on the other hand, upstream emissions from plant production are usually also relevant, so that carbon footprints greater than zero also occur here for renewable energy (in Germany, for example, the emissions balance of renewable energy sources provided by the Federal Environment Agency can be used here, see Lauf et al. 2022).

In the absence of a uniform methodology for the calculation of carbon footprints including upstream emissions, the reporting of direct GHG emissions from heat generation initially appears to be a priority for heat disclosure, analogous to electricity disclosure. This is also in line with feedback from a survey conducted at the IW³ stakeholder workshop in April 2021 - before publication of the FFVAV - where significantly more participants considered this information to be relevant than the carbon footprint including upstream emissions (see Figure 17). **In the context of corporate carbon accounting, Scope 3 emissions can be determined on the basis of the reported energy source mix using standard factors**. If the purpose of GO and product accounting should be expanded in the future to include the attribution of costs, e.g., within the framework of the GEG, corresponding factors that are consistent with specified calculation methods could be additionally specified with reference to the respective purpose. In the interest of transparency and comprehensibility for customers and minimisation of effort for heat suppliers, it would be desirable to harmonise the methods and standard factors used across different laws and ordinances.

Figure 17: Survey results regarding the contents of heat disclosure

What information should ideally be included in heat disclosure? (Multiple answers possible, n = 27)



Note: 8 out of 35 participants did not give an answer.

Source: Own representation, based on online survey at IW³ stakeholder workshop on 13.04.2021

3.7.2.2 Full disclosure of heat generation and consumption as an option

Finally, in the case of a GO issuance only for renewable energy and unavoidable waste heat, it is important to note that **information on the total amount of heat input including heat generation from other energy sources and technologies is** also necessary for the verification of corresponding shares. While the clear allocation of green attributes is ensured via such partial disclosure by means of GO, **two 'qualities' of verification** are nevertheless introduced: Increased verification requirements for heat generation based on renewable energy and unavoidable waste heat with registration of plants in the H&C GO registry, while for shares of other – and especially fossil – energy sources, a simple self-disclosure by heat suppliers is sufficient in the context of disclosure. This also applies to electricity disclosure, especially since electricity suppliers can use the residual energy mix as a pool of non-explicitly tracked attributes for non-traced trade offers (according to § 42 para. 4 EnWG, the ENTSO-E energy carrier mix for Germany adjusted for GO cancellations and shares of EEG-subsidised electricity to be used for this). **The electricity disclosure in the Netherlands, Austria, and Switzerland, on the other hand, provide for mandatory full disclosure,** in which each electricity consumption is explicitly assigned renewable or non-renewable attributes by means of GO cancellation. **In Sweden, a voluntary full disclosure option exists**, with 95% of all electricity generating capacity registered for GO issuance as of 2020 (RECS 2020). Increased transparency and a greater focus on active procurement decisions in suppliers' portfolios could thereby further increase demand for carbon neutral energy. In the Netherlands, mandatory full disclosure was introduced in 2020 and led to increased activity in the issuance and cancellation of renewable electricity GOs (RECS 2022; the volume of GO imports did not increase in the first two years after the introduction of full disclosure, but additional demand was primarily met by an increase in domestic renewable electricity GO issuance). The introduction of the full disclosure obligation was also welcomed by environmental and consumer associations in the Netherlands, which were often critical of the GO system in the past due to cross-border trade in green attributes (RECS 2022; although such trade is also possible in the electricity GO system within the European internal market in the full disclosure system).

In the context of heat, a full disclosure of all energy sources and heat generation technologies used by means of GOs would create the basis for an annual determination of the renewable energy and waste heat shares on the basis of verified data sources. This would not only strengthen the transparency and reliability of the information for customers, but also allow the use of the H&C GO registry for the digital fulfilment of reporting requirements within the framework of the transformation monitoring of heating grids or other information obligations directed at heat suppliers (see chapter 2.3.4). If appropriately designed, a H&C GO registry could standardise the fulfilment of corresponding reporting requirements for heat suppliers, but also considerably simplify them through a higher degree of digitalisation (e.g. by means of an automated calculation of renewable energy and waste heat shares based on the plant and measurement data available in the registry, or through the possibility of granting various state and federal authorities access to corresponding data via monitoring accounts). In the case of full disclosure, **grid losses could also simply be determined as the difference between the GO issuance for annual heat generation and GO cancellation for heat quantities delivered to customers** and taken into account in the disclosure.

Due to the **vertically integrated character of heating grids,** it is to be expected that the **additional effort of full disclosure** remains **manageable compared to partial disclosure of renewable energy and unavoidable waste heat,** as heat suppliers usually operate the majority of renewable and non-renewable plants connected to a grid themselves (unavoidable waste heat, on the other hand, is usually purchased by suppliers from industrial, commercial or service companies). Since the corresponding heat suppliers are already familiar with the functioning of the registry in this case, the additional input of plants hardly increases the effort, especially since the verification of several plants can be combined in the case of possibly required expert confirmations (cf. chapter 3.6). Provided that the GO cancellation for disclosure purposes remains limited to connected heat supply systems, **heat suppliers could be offered the option of full disclosure on a voluntary basis, which would allow for grid-wide testing and evaluation of experiences**.

4 CONCLUSION: DESIGN DECISIONS IN THE CONTEXT OF A NATIONAL IMPLEMENTATION OF HEATING AND COOLING GO SYSTEMS

The national (or, in individual cases, regional) implementation of heating and cooling systems in the EU opens up **new perspectives for the legally secure marketing of green DHC products**. The extent to which GOs can accelerate the decarbonisation of heating and cooling grids as a verification instrument depends on the design of corresponding systems, but also on their use by market actors and their acceptance by important stakeholders such as consumer associations. This report has shown that there are a number of design options that can significantly influence the functioning and role of GOs in the heat transition. In order **to make design decisions that fit the respective national market and regulatory framework conditions, a process that involves relevant stakeholder groups at an early stage is recommended.**

An important decision that influences the orientation of the heating and cooling GO system is the **definition of the purpose that GOs should fulfil as a verification tool**: Supporting the consumer market for green district heating is the core function of GOs according to the Renewable Energy Directive, but they can also be used for verification in the context of regulatory requirements. In addition, enforcement can be facilitated with regard to various reporting requirements addressed to building owners, but especially to heating and cooling suppliers. Heating and cooling GOs have the potential to standardise and digitalise the provision of information on shares of renewable energy and unavoidable waste heat, primary energy factors and emission factors of heating and cooling grids across various legal requirements. The greatest synergies and digitalisation potentials could be realised within the framework of a grid-related full disclosure of the generated and consumed thermal energy quantities by means of GO, since the calculation of renewable energy and waste heat shares - and in the future also primary energy and emission factors - could be integrated into the registry software of the GO system. Nevertheless, the realisation of corresponding synergy potentials can be challenging. The example of Germany shows that, for example, an alignment of the definitions of renewable energy and unavoidable waste heat across different laws, ordinances and funding guidelines would be necessary; the same applies to the concretisation of verification procedures. For a pragmatic approach, it is therefore recommended to first **establish a robust GO system with registries and disclosure rules that is adaptable both technically and with regard to the legal basis and is designed flexibly enough to be usable for different possible roles and tasks**.

In the context of the IW³ pilot registry, the focus of the technical implementation was on the consumer information function and the support of local heat grid transformations. However, the connectivity to the verification of regulatory requirements and possible applications for facilitating enforcement were also examined and, where feasible with a reasonable amount of effort in the research context, included in the design decisions. In addition to the purpose of GOs, the following **central design parameters for national GO systems for heating and cooling emerged** on the basis of the research on the IW³ pilot registry.

The **cross-grid cancellability of GOs for disclosure purposes is** a fundamental decision in the context of heating and cooling. In the context of the national implementation of systems, it must be clarified whether the closed character of heating and cooling grids is taken into account in the verification and disclosure system or whether grid boundaries are abstracted from. A consideration of grid boundaries in the context of cancellation rules can be expected to result in higher credibility for consumers, a more effective exclusion of multiple marketing and multiple use of green attributes and more effective incentives for local grid transformations. On the other hand, a cross-grid GO cancellation may prove useful, e.g., in the context of quota systems, where the cost-efficiency idea, according to which investments in renewable energy and waste heat should first be stimulated where they can be realised most cost-effectively, is paramount. In the case of heat disclosure, the presentation of the grid origin of GO is strongly recommended from the point of view of transparency and consumer protection. In the IW³ pilot registry, the decision was made to focus on the balanced supply of green heat within technically connected grids. This means that a grid connection between the generation plant and the point of consumption is required in order to cancel GO for disclosure purposes.

Dealing with grid losses and losses of storage facilities located in the grid also proves to be important for the credibility of the system in the heating and cooling context. This results on the one hand from the quantitative relevance of corresponding losses, but on the other hand also from the fact that losses, at least in vertically integrated grids, are directly taken into account in the production planning of supply companies. This is different from the electricity sector, where independent grid operators are responsible for compensating for losses. Especially with a desired connectivity to regulatory requirements (in Germany, for example, for the calculation of primary energy factors according to the Building Energy Act), but also to the revised disclosure rules of Art. 24 para. 1 of the Third Renewable Energy Directive (RED III), a consideration of corresponding losses proves to be important for a consistent calculation of renewable energy and waste heat shares based on GO. In order to ensure correct accounting of losses, it is recommended that they are taken into account in the GO cancellation. In this respect, the system rules for the IW³ pilot registry include the recommendation that suppliers who supply green district heating products cancel additional GOs with green attributes on a pro rata basis in order to take grid and any storage losses into account. As a first step, it would be advisable for GO systems to explicitly allow GO cancellation for grid and storage losses and to make it comprehensible in cancellation processes.

With regard to the **integration of heat customers into the GO registry,** it can be stated that the transparency of GO information, the customisability of green district heating products and the planning security with regard to GO availability and prices depend strongly on the concrete contract design and the disclosure rules in the heat GO system, both when enabling GO cancellation by heat customers and when limiting GO cancellation to heat suppliers. However, if grid and storage losses are to be taken into account in the design of green district heating products, this argues in favour of a GO cancellation by suppliers, as the availability of information on expected loss levels is highest with them. The use of GOs for transformation monitoring of heating and cooling grids also appears to be more compatible if cancellations are only carried out by suppliers, to whom reporting requirements are usually directed. Transparency for customers and digital proof of the attributes of the heat supply for building owners can nevertheless be created by the GO registry supporting the issuing of detailed cancellation statements, which can be passed on or published by heat suppliers to customers. Transparency accounts without cancellation rights could be set up for customers to make the corresponding certificates available digitally.

A **GO issuance for self-supply** seems to make sense for prosumer plants that both feed into the grid and are used for self-supply. Here, the GO cancellation can ensure a clear allocation of green attributes to self-supply or the supply of customers. In order to avoid mixing climate accounting scopes 1 (direct emissions from the company's own sources) and 2 (purchased energy), it makes sense to combine a GO issuance for self-supply with a disclosure rule according to which corresponding GOs may only be used to disclose the self-consumed energy from the corresponding plants.

With regard to **verification of energy carrier conversions,** the introduction of GO registries for gases and heating and cooling represents an opportunity to create a consistent system for tracking green attributes across sectors. For energy carriers that are purchased through grids and converted into other energy carriers (e.g. in the context of power-to-heat or power-to-gas plants, but also in the case of gas used for heat generation), the cancellation of GOs for energy inputs is an important minimum requirement in order to exclude multiple consideration of green attributes in the GO issuance for the energy output (in the case of gases, a mass balance certificate would also be an option, provided a coupling or reconciliation with the gas GO registry is implemented). In Germany, the non-issuance of GOs for EEG-subsidised electricity generation plants poses a challenge, as this makes the verification at sector coupling interfaces much more complicated or excludes the cross-sectoral allocation of the attributes of EEG-subsidised plants, which are shown as a share of EEG-subsidised vis-à-vis all final electricity consumers in the same amount. Another challenge arises in dealing with self-supply cases where a supplier operates both electricity generation plants and Power to X plants and uses the electricity grid to transport electricity. The issuing of self-supply GOs also for electricity generation plants that feed into grids at least temporarily would facilitate verification here (also accompanied by corresponding disclosure rules for self-supply). The basic requirement of a GO cancellation for energy sources used can also be supplemented by qualitative requirements for the attributes of GOs used for this purpose, which can result from specific demands of customers, but can also be formulated as a prerequisite for usability as it represents proof of regulatory requirements. Examples of qualitative criteria are, for example, requirements with regard to the renewable energy sources or technologies used, the subsidy status of plants, or the spatial and temporal correlation, especially of electricity generation and consumption in the case of Power to X plants.

The **verification of measurement and system data** is a particular challenge for vertically integrated heating and cooling grids, as the corresponding data cannot be confirmed by an independent grid operator. For system data, expert confirmation before the first GO is issued seems advisable, unless documents can be presented that show the accuracy of the information provided (e.g., subsidy notices, commissioning protocols or similar). Measurement data could, for example, be confirmed by auditors as part of annual audits. However, proportionality must be maintained with regard to the effort and costs of participation in the GO system, as otherwise barriers to participation may arise, especially for smaller suppliers. The performance of independent measurement data checks could also be left to suppliers on a voluntary basis or formulated as a requirement within the framework of quality labels for green district heating marketing. In any case, it would be important for the GO issuing body to check the plausibility of reported data, combined with the possibility to demand corrections or independent checks.

In order to effectively exclude multiple consideration of green attributes, heating and cooling GO systems must be accompanied by **disclosure rules** that clarify in which cases GOs are mandatory for verification. For electricity and - with RED III - also gases, corresponding specifications have been made at European level, although for heating and cooling, the relationship between disclosure requirements and GO systems remains less clear. Accordingly, national regulations are necessary at this point in order to create clarity for market actors and to lay the legal foundation for a clear, legally secure allocation of green attributes. More detailed regulations aimed at a transparent and comprehensible presentation of information in heating and cooling disclosure could be developed, as in the case of electricity disclosure in Germany, e.g., by associations of relevant stakeholders (e.g., supplier or consumer associations). In this context, it may be useful to build on the presentation of electricity disclosure, which is already familiar to customers.

Finally, in order to create a comparable verification basis for renewable and non-renewable energy sources and to enable a consistent determination of renewable energy and waste heat shares, the **design of the GO and disclosure system as a full disclosure system** offers advantages. Especially in vertically integrated grids where suppliers operate several renewable energy as well as fossil energy plants, the additional effort of such a system is likely to be manageable compared to a GO issuance only for renewable energy and waste heat. If the GO cancellation is limited to technically linked heating and cooling supply systems, full disclosure can be offered to suppliers as a voluntarily selectable option in order to gain experience with the system. This could also include a voluntary use of the H&C registry for enforcement facilitation purposes, as an option for suppliers to provide federal and state authorities with information on renewable energy and waste heat shares digitally and bundled in a central location. In any case, it is advisable to keep synergies between various current and future verification requirements in the context of the heat transition in mind when designing heating and cooling GO and disclosure systems, in order to implement administrative simplifications for suppliers and enforcement authorities by means of a digitalisation of corresponding processes.

5 APPENDIX

5.1 Information for system registration in the IW³ pilot registry

- Plant number (GSRN, can be generated automatically) and plant name
- Address or geographical coordinates
- Technology
- Energy source(s)
- Notifying and operating organisations (may be identical)
- Information on the meter: unique grid reference, meter formula operator (+/-) and meter coefficient (multiplication factor, usually 1; meter formula operator and meter coefficients can be used e.g. for separate auxiliary energy meters).
- Trading system (H&C GO (Heating-Cooling-GO) as placeholder in the context of the IW³ pilot registry)
  - Indication of whether the system or the amount of heat produced has received financial support from a funding programme and the type of funding: production funding, investment funding, production funding and investment funding, no funding.
  - If it is a CHP plant whose electricity production was subsidised under the EEG or KWKG, the coupled heat produced is also considered to be financially subsidised (by means of production subsidies) in the context of the IW³ pilot registry.
- Indication to which account in the IW³ pilot registry the GOs are issued (account of the owner organisation or aggregator organisation)
- Attributes of the energy generated:
  - Energy sources (heating and cooling for IW³ pilot registry)
  - Type of thermal energy (heat or cold)
  - Medium (water, thermal oil, salt, refrigerant, air/residual gas, unspecified)
  - State of aggregation (liquid, solid, gaseous)
  - Grid identification (code for the technically related heating or cooling system)
  - Grid name
  - Nominal power (of the system), if applicable of the element (kW)
  - Commissioning date of the plant and, if applicable, of the element
  - Degree of distribution (what proportion of the generation was consumed by the operator of the plant for self-supply or fed into the grid).

5.2 Contents of guarantees of origin in the IW³ pilot registry

- **General GO information:**
  - Unique GO number (assigned by the registry)
  - Date of the GO issuance
  - Identity of the GO issuing office
  - Start date and end date of the heat production period to which a GO bundle relates
  - Trading systems: Placeholder HC-GO (Heating Cooling-Guarantee of Origin) for IW³ pilot registry
  - Standard: Placeholder HCS (Heating Cooling System) for IW³ pilot GO registry
  - Indication of whether the plant or the quantity of heat produced has received financial support from a funding programme and the type of funding (production funding, investment funding, production funding and investment funding, no funding).
- **General facility information:**

- Plant name and plant number (GSRN, can be generated automatically by the registry)
  - Postcode and town or geographical coordinates of the facility
  - Country of the plant location
  - Plant technology
  - Energy source(s) used
- **GO issuer information:**
  - Name of the issuing body (HIR Hamburg Institut Research gGmbH)
  - Code of the issuing authority (95) and code of the competent authority (placeholder HC01)
  - Country code of the issuance (DE)
- **Information on the owner of GO:**
  - Name of the organisation
  - Organisation ID (optional)
  - Domain: HC-GO IW^3 pilot registry, domain code: HC
  - Registry account number and, if applicable, account name (e.g., sub-accounts for different heat products possible).
- **Information on the GO attributes:**
  - Energy source: heat and cold
  - Type of thermal energy generated (heat or cold)
  - Degree of distribution of the generated energy (fed into a heating or cooling grid or self-supply)
  - Medium (water, thermal oil, salt, refrigerant, air/residual gas, unspecified)
  - Aggregate state of the heat medium (liquid, solid, gaseous)
  - Nominal heat output of the system in kW
  - Commissioning date of the system
  - Optional: Nominal power and commissioning date of plant elements
  - Intended use of the GO (selection option in the research context: disclosure)
  - Grid identifier and grid name
  - Optional: Further information (free text field e.g., for specifying funding programmes)

5.3 Information for cancellation requests in the IW^3 pilot registry

- Volume of GOs to be cancelled
- Beneficiary of the cancellation (product name or customer name)
- Identifier of the grid in which the supply of a heat product took place or to which a consumption point is connected (as the location of the beneficiary).
- Type of beneficiary (energy supplier or end consumer)
- Country of consumption (Germany)
- Cancellation purpose (e.g., heat identification for a specific calendar year)
- Category of use (marking or other, if GO issuance and scoring was for test purposes)
- Start and end of the consumption period

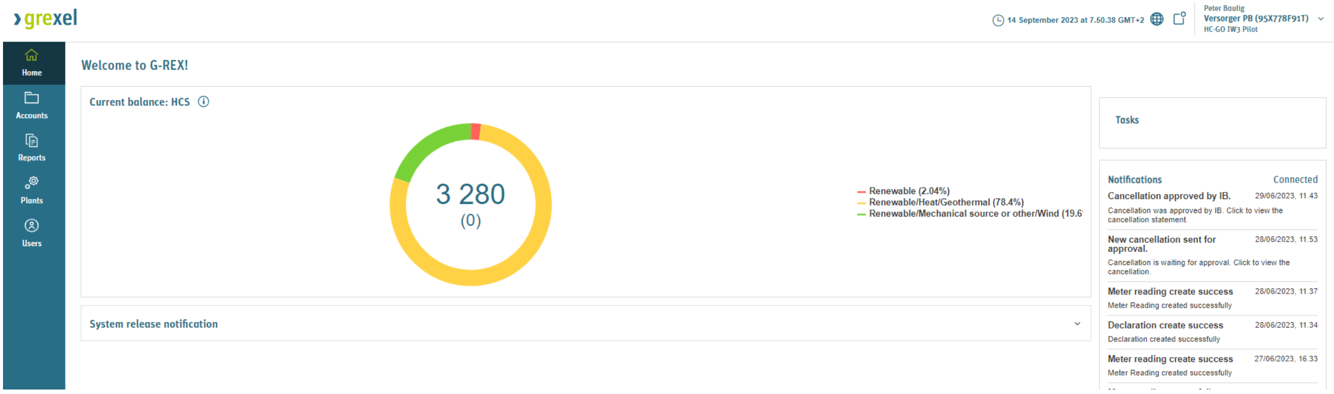
5.4 Information on cancellation statements in the IW³ pilot registry

Information on the cancellation statement	
Transaction details	• Transaction type: Cancellation • Status: Completed • Transaction number • Volume of cancelled GOs • Transaction started: Date, time • Transaction completed: Date, time • Standard: HCS (Heating Cooling System, for IW³ pilot registry)
Cancellation carried out from account	• Name of the organisation • Organisation ID (optional) • Domain: HC-GO for IW³ pilot registry, Domain code: HC • Registry account number and, if applicable, account name (e.g., sub-accounts for different heat products possible). • Street (optional) • Location • Postcode • Country: Germany
Beneficiary	• Beneficiary name: Product or customer (if agreed) • Country of consumption: Germany • Organisation ID (optional) • Location of the beneficiary (grid identifier) • Consumption period (e.g., beginning of year - end of year) • Type of use: Disclosure • Cancellation purpose: e.g., heat marking 2022 • Type of beneficiary: energy supplier or end consumer
Information on the cancelled GO bundle	• Volume • GO number start - GO number end • Place of issuance • Energy source code • Technology code • Start date of generation, end date of generation • Date of issuance • Trading systems (HC-GO for IW³ pilot registry)
Further GO information	• Funding programmes: Production funding, investment funding, production funding and investment funding, no funding • Standard: HCS (for IW³ pilot registry) • Description of production funding (if applicable, will be generated automatically) • Description of the investment funding (if applicable, will be generated automatically)

Energy source and technology	• Energy source: code and name (according to European Energy Certificate System classification) • Technology: Code and name (according to European Energy Certificate System classification)
Issuer	• Issuance agency: HIR Hamburg Institut Research gGmbH • Code of the issuing office: 95 • Country code of the issuance: DE • Code of the competent authority (wildcard): HC01
Attachment	• Plant name • GSRN • Commissioning date • Postcode, city and/or • Longitude N Latitude E: Coordinate code • Country: Germany, country code: DE
Attributes	• State of aggregation • Degree of distribution (fed into a heating or cooling grid or self-supply) • Energy source: heat and cold • Medium • Grid identifier • Grid name • Rated power (kW) • Cancellation purpose • Type of thermal energy (heat or cold)

Source: Hamburg Institut 2022

LIST OF FIGURES



LIST OF TABLES

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