GO4Industry

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Guarantees of Origin for Heating and Cooling

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About the project

GO4Industry

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

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AIB	Association of Issuing Bodies
BEG	Federal funding for efficient buildings (*Bundesförderung für effiziente Gebäude*)
BEW	Federal funding for efficient heating grids (*Bundesförderung für effiziente Wärmenetze*)
CEN	European Committee for Standardization
CHP	Combined heat and power generation
EECS	European Energy Certificate System
EED	Energy Efficiency Directive
EEG	Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz*)
EEV	Renewable Energy Sources Ordinance (Erneuerbare-Energien-Verordnung)
EF	emission factor
EnWG	Energy Industry Act (*Energiewirtschaftsgesetz*)
EU	European Union
FaStGO	Facilitating Standards for Guarantees of Origin
FFVAV	District Heating or District Cooling Consumption Metering and Billing Ordinance (*Fernwärme- oder Fernkälte-Verbrauchserfassungs- und -Abrechnungsverordnung*)
GEG	Building Energy Act (*Gebäudeenergiegesetz*)
GO	guarantee of origin
H&C	heating and/or cooling, heat and/or cold
HKNR	German GO registry (*Herkunftsnachweisregister*)

HkRNDV	Implementing Ordinance on Guarantees of Origin and Regional Guarantees for Electricity from Renewable Energy (*Herkunfts- und Regionalnachweis-Durchführungsverordnung*)
kWh	Kilowatt hour(s)
MWh	Megawatt hour(s)
PEF	Primary energy factor
PPA	Power Purchase Agreement
PtH	Power-to-Heat
PtC	Power-to-Cold
RE	renewable energy
RES	renewable energy sources
RED	Renewable Energy Directive
TWh	Terawatt hour(s)

1. Introduction: The role of GOs for heating and cooling in the heat transition

In the supply of heating or cooling via grids, the question arises as to how the attributes of climate-neutral energy generated by specific plants can be assigned to individual consumers. Currently, ecological quality indicators of district heating and cooling (H&C), such as RE and waste heat shares, primary energy factors (PEF) and emission factors (EF) are usually determined for each individual grid. The grid averages, which are reported to all connected customers, take into account the characteristics of all plants that feed into the grid.

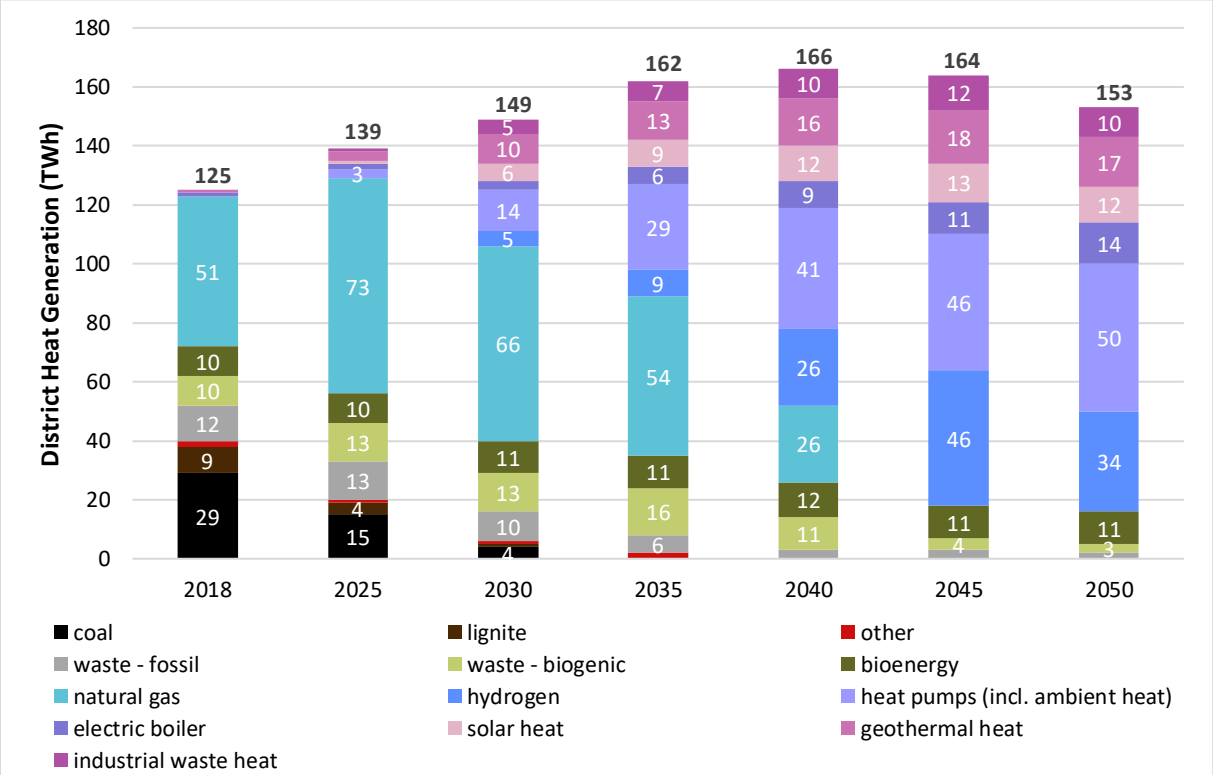
Yet similarly to grid-connected electricity generation, there is interest from customers to purchase **a green heating or cooling product with a 100% share of climate-neutral thermal energy**. This option is relevant when choosing between connecting to a district heating or cooling grid and an alternative, decentralised source of energy. Also, a 100% climate-neutral energy product might fetch a green price premium, which can provide a demand-side impulse to decarbonise the grid – especially if green district H&C marketing focuses on new plants. Besides intrinsically motivated private customers, this is a relevant perspective for commercial customers, many of whom must implement their own climate neutrality strategies. When purchasing energy that is supplied via grids which are not yet fully decarbonised, switching to green energy products can be a necessary component of implementing such strategies. The option to supply their tenants with climate-neutral district heating is also important for commercial or municipal landlords. Finally, developers and building owners faced with regulatory requirements on buildings' emissions or renewable energy use may wish to support the expansion of climate-neutral generation sources in their heating or cooling grids. However, this use case presupposes that legislation provides a role for green district H&C products as an option for complying with regulatory requirements for buildings or being eligible for subsidies.

The prerequisite for all these applications is the existence of a verification procedure that enables a clear allocation of green energy attributes to customers and, in combination with disclosure rules, excludes multiple marketing of such attributes. The **Renewable Energy Directive** (EU) 2018/2001 ("RED II") set the course for the marketing of green district H&C under European law. Art. 19 of the RED II obliges the member states to **extend guarantees of origin (GO) systems**, which have so far been established primarily for electricity, **to H&C** as well as gases and hydrogen from renewable energy sources (RES). When introducing GO systems for thermal energy, however, the specific framework conditions of the H&C sector must be taken into account, which differ in some respects from those of the electricity sector. In this context, it is also important to consider the conditions under which H&C GOs or a marketing of green thermal energy products based on them can contribute to the expansion and decarbonisation of H&C grids.

The expansion of climate-neutral district H&C can make an important contribution to **decarbonising the building sector** as well as supplying industrial and other commercial customers with low-emission thermal energy. In Germany, the total size of all district heating grids far exceeds that of all district cooling grids (21,236 km versus 131.5 km in 2020, see AGFW 2021a). However, with the increasing importance of climate adaptation, district cooling grids could become more relevant. According to the coalition agreement of the German government, **decarbonising and expanding the heating grids** shall play an important role in achieving **the goal of 50% climate-neutral heat generation by 2030** (SPD et al. 2022, p. 58; other measures include comprehensive municipal heating planning, strengthening energy-related renovation and the expansion of decentralised renewable heating systems). Heating grids enable the **transition of entire districts or communities to climate-neutral heat supply**. In addition, there are cost advantages of a large-scale development of heat sources such as deep geothermal energy, solar thermal energy, waste heat, and ambient heat in combination with large-scale heat pumps (e.g. Bacquet et al. 2022; Bürger et al. 2021; Maaß et al. 2021; Engelmann et al. 2021; Thamling et al. 2020). Also, power-to-heat (PtH) plants in combination with heat storage systems can absorb surplus electricity from wind and solar energy and thus strengthen the system integration of fluctuating RE and promote sector coupling.

However, decarbonisation and the expansion of heating grids already require significant investments in the near future. Between 2011 and 2021, the share of RE in the grid-based heat supply rose from around 9% to 17% in Germany (BDEW 2022a; preliminary values for 2021). The share of waste heat has remained relatively stable over the last decade, amounting to 5.5% in 2021. Given the limited growth potential for biomass and municipal waste, the expansion of "new" heat generation options is crucial. These include in particular geothermal energy, solar thermal energy, large heat pumps, electric boilers and utilising unavoidable waste heat, e.g. from industrial processes (Bacquet et al. 2022; Bürger et al. 2021; Maaß et al. 2021; Engelmann et al. 2021; Thamling et al. 2020). In scenario calculations for a climate-neutral Germany by 2045, Prognos et al. (2021) assume that district heat generation from these options must grow from approx. 2 TWh in 2018 to 38 TWh in 2030 (see Figure 1). Accompanying investments in measures such as lower grid temperatures and the integration of heat storage systems are also required.

Figure 1: Contribution of district heat generation to a climate-neutral Germany



Source: Based on Prognos et al. (2021), p. 41.

H&C GOs can support the disclosure of the attributes of H&C supply as a verification instrument and thus form a basis for the transparent marketing of green H&C products. **H&C GOs could thus become a building block in the toolbox of the heat transition**. Synergies can also arise between GOs as a verification system and other instruments such as regulatory requirements of the Building Energy Act (GEG), funding requirements of the Federal Funding for Efficient Buildings (BEG) or the implementation of transformation monitoring as part of the planned Federal Funding for Efficient Heating Grids (BEW).

Against this background, **this report aims to provide an overview of the relevant framework conditions, potential applications and special features of verification with H&C GOs and to discuss resulting implications for H&C GO systems**. **Chapter 2** presents the European and German national framework conditions for verification and disclosure in the H&C sector, supplemented by relevant targets and regulatory and subsidy requirements for the ecological quality of H&C delivery. **Chapter 3** provides an overview of possible applications for verifying the attributes of H&C supply with H&C GOs. **Chapter 4** discusses special features that arise in the marketing of green district H&C compared to the established marketing of green electricity and derives implications for the operational design of GO systems. **Chapter 5** concludes with an outlook on the use of H&C GOs in industry.

2. Legal framework for verification and disclosure in heating and cooling

2.1 European legal framework

At the European level, the **Renewable Energy Directive (RED) and the Energy Efficiency Directive (EED)** define the framework conditions for the disclosure of H&C supply to customers and the verification of RE shares. Both directives also formulate requirements for the member states regarding the share of RE and unavoidable waste heat in heating grids. The following provides an overview of these regulations and their interrelationship.

2.1.1 GOs for heating and cooling in the Renewable Energy Directive

In the electricity sector, the first **Renewable Energy Directive 2009/28/EC (RED I)** established GOs as a central instrument to prove to final customers that a certain share or amount of energy was generated from RES.[1] The core task of GOs is to guarantee the origin of the energy on the basis of objective, transparent and non-discriminatory criteria (Art. 15(1) RED I). The member states had to ensure that **GOs are issued upon request by a producer of renewable electricity** (Art. 15(2) RED I). The **issuance of GOs for H&C from RES, by contrast, remained optional for the member states**.

RED I also formulated **basic requirements for GO systems** that apply equally to electricity and H&C and continue in the successor Directive 2018/2001/EU (RED II).[2] These include the principle that only one GO is issued for each unit of energy and that it must be ensured that each unit of RE is only taken into account once (double marketing ban according to Art. 15(2) RED I / Art. 19(2) RED II). The electronic issuance, transmission and cancellation of GOs must be monitored by the member states or designated competent bodies (Art. 15(4/5) RED I / Art. 19(5/6) RED II). In addition, there are requirements for the minimum information to be provided on the GOs (Art. 15(6) RED I / Art. 19(7) RED II) and regulations on the recognition of GOs from other member states (Art. 15(9) RED I / Art. 19(9) RED II). Another principle is that GOs or GO transfers have no impact on compliance with the EU target for RE or the calculation of gross final RE consumption in the member states (Art. 15(2) RED I / Art. 19(2) RED II). This applies regardless of whether GOs are transferred separately or jointly with the physical energy.

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

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

While the implementation of electricity GO systems was mandatory for the EU member states under RED I, the option to also offer the **issuance of H&C GOs** was rarely used. Before 2019, only the Netherlands introduced a heating GO system (Verwimp et al. 2020, p. 71 f.; CertiQ 2022).[3] The development of standardised rules for GO systems, such as the European Energy Certificate System (EECS) of the Association of Issuing Bodies (AIB) and the CEN standard EN 16325, also initially focused on electricity GOs.[4] In Germany, the German Environment Agency has been responsible for operating the national electricity GO registry (HKNR) since 2013. [5]

A new impetus for the implementation of H&C GO systems has resulted from the **recast Renewable Energy Directive (EU) 2018/2001 (RED II).** Art. 19 RED II expanded the scope of application of GOs to the effect that the member states must provide for the issuance of GOs "at the request of a producer of energy from renewable sources" (2.1). A distinction is made between GOs for i) electricity, ii) gas, including hydrogen, and iii) heating or cooling (7b). **GO systems must therefore also be established for gases and renewable H&C**.

Art. 19(6) RED II contains the new requirement that verification systems must comply with the **European standard CEN – EN 16325**. This standard contains harmonised requirements for the registration of registry users, the issuing and content of the GOs, their transmission and cancellation, error correction and validity period, measurement procedures and audits, as well as other requirements. However, the standard is still being revised in order to expand its scope of application to other energy carriers than electricity. Requirements for gases, heating and cooling were not yet available at the RED II implementation deadline of 30.06.2021.

In addition, Art. 19 RED II contains **further innovations** that concern all types of energy, such as requirements for taking into account the market value of GOs in the context of financial RE support schemes (2.3/4) and for the recognition of GOs from third countries (11). Art. 19 (8.2) RED II also clarifies the relationship between GOs for renewable electricity and **GOs for electricity from high-efficiency cogeneration** that can be issued under the Energy Efficiency Directive 2012/27/EU (Art. 14(10) EED).[6] If renewable electricity is produced in high-efficiency cogeneration (CHP), only one electricity GO may be issued that specifies both properties (rather than one renewable electricity GO plus one CHP electricity GO). In Germany, the responsibility for issuing combined CHP GOs has been with the German Environment Agency since 1 July 2021; previously, CHP certificates under the EED

[3] See Regeling garanties van oorsprong voor energie uit hernieuwbare energiebronnen en HR-WKK-elektriciteit, https://wetten.overheid.nl/BWBR0035971/2021-01-01.

[4] See EECS Rules, https://www.aib-net.org/eecs/eecsr-rules; DIN EN 16325:2016-01. Guarantees of origin related to energy - Guarantees of origin for electricity, EN 16325:2013+A1:2015.

[5] See https://www.hknr.de.

[6] 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.

were issued by the Federal Office of Economic Affairs and Export Control (BAFA) (under Art. 31 KWKG; see Umweltbundesamt 2020).[7] GOs for renewable electricity from high-efficiency CHP also contain information on heat generation in CHP plants (including thermal output and use of heat, see Art. 9(2) EEV); yet they do not refer to the heat but to the electricity generated in CHP.[8] They are therefore used for electricity disclosure, rather than for heating disclosure.

Following the publication of the RED II, another H&C GO system was implemented in Flanders in addition to the already existing heating GO system in the Netherlands (Verwimp et al. 2020, p. 71 f.; VREG 2022).[9] Subsequently, **H&C GO systems have been introduced or are currently being implemented in several other countries**.[10] Also, the Dutch system was extended to cooling.[11] In Germany, a draft law to establish GO systems for gas, hydrogen, and heating and cooling from RES was published in August 2022.[12]

2.1.2 Disclosure rules in the Renewable Energy Directive and Energy Efficiency Directive

Preventing the multiple marketing of green attributes requires the combination of GO systems with energy disclosure rules (Van Stein Callenfels et al. 2020, p. 22 ff.; Seebach et al. 2015). However, harmonised European regulation that links disclosure rules with the use of GOs has so far only been implemented for electricity disclosure. Building on its predecessor Directive 2009/72/EC, the Internal Electricity Market Directive (EU) 2019/944 stipulates that consumers must be provided with **information on the supplier's overall energy mix** in the previous year and the associated environmental impacts (at least

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[7] Combined Heat and Power Act (*Kraft-Wärme-Kopplungsgesetz*) of 21 December 2015 (BGBl. I p. 2498), last amended by Article 88 of the Act of 10 August 2021 (BGBl. I p. 3436).

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

[9] See Garanties van oorsprong voor groene warmte of koude, https://www.energiesparen.be/garanties-van-oorsprong-voor-groene-warmte-of-koude.

[10] Examples of legal bases for such systems are, for Finland, the "Act on Guarantees of Origin for Energy", https://www.finlex.fi/en/laki/kaannokset/2021/en20211050.pdf; for Denmark, the regulation "Bekendtgørelse om oprindelsesgarantier for elektricitet, gas, fjernvarme og fjernkøling fra vedvarende energikilder", https://www.retsinformation.dk/api/pdf/223821; for Sweden, the law "Lag om ursprungsgarantier för energi", https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/rubriken-upphor-att-galla-uden-dag-som_sfs-2010-601.

[11] See Wet van 1 juni 2022, houdende Regels omtrent garanties van oorsprong voor energie uit hernieuwbare bronnen, https://www.eerstekamer.nl/behandeling/20220609/publicatie_wet/document3/f=/vltmg05deqxb.pdf.

[12] Draft Act on the Implementation of the Requirements in Art. 19 of Directive (EU) 2018/2001 on Guarantees of Origin for Gas, Hydrogen, Heating and Cooling from Renewable Energy Sources, https://www.bmwk.de/Redaktion/DE/Artikel/Service/Gesetzesvorhaben/herkunftsnachweisen-fuer-gas-wasserstoff-waerme-und-kaelte-aus-erneuerbaren-energiequellen.html.

regarding CO_2 emissions and radioactive waste).[13] In addition, the Directive provides for "**product-level disclosure**", where electricity bills must indicate the share of the individual energy sources in the purchased electricity (Annex I No. 5 in conjunction with Art. 18(6) of Directive (EU) 2019/944). The member states' national authorities must ensure that this information is reliable and clearly comparable at the national level.

With reference to Art. 19(8) RED II, the **relationship between GOs and electricity disclosure rules** is also regulated. According to this, electricity suppliers must use GOs to prove RE shares or quantities for electricity disclosure. An exception applies to non-tracked commercial offers, where an amount of electricity cannot be clearly assigned to an energy source on the generation side (e.g. in case of electricity purchased from the electricity exchange). In this case, suppliers may use the residual energy mix, which corresponds to the total annual energy mix of the respective member state, excluding the characteristics of explicitly traced energy quantities (see AIB 2022a; Art. 2(13) RED II). Deviating rules are possible if a member state has decided not to issue GOs to RE producers who receive public financial support. This is the case in Germany for electricity GOs (see Styles et al. 2021a; p. 18ff; Kahl and Kahles 2020).[14]

If member states also issue GOs for other forms of energy, RED II stipulates that for the purpose of disclosure, **utilities must use the GO type that is designated for the supplied type of energy** (Art. 19(8.2) RED II). This means that H&C GOs must be used to label deliveries of thermal energy, gas GOs to label gas supply and electricity GOs to label electricity supply. The Directive does not require the use of GOs for H&C and gases with the same degree of clarity as in the case of electricity, but it is at least implied in principle. The Commission's 2016 proposal for the revision of RED I had contained a clearer provision on this (Art. 19(13)): "Where energy suppliers market energy from renewable sources (...) to customers with a reference to environmental or other benefits of energy from renewable sources (...), Member States shall require those energy suppliers to use guarantees of origin to disclose the amount or share of energy from renewable sources (...)" (COM(2016) 767 final, p. 72).[15]

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

[14] In its draft for a RED III, the EU Commission proposed to delete the possibility of not issuing GOs for financially supported RE producers (see COM(2021) 557 final, p. 34 f.).

[15] COM(2016) 767 final. Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast).

Disclosure rules for district H&C are contained in both RED II and the EED, Directive 2012/27/EU, amended by Directive 2018/2002/EU).[16] According to Art. 24(1) RED II, the member states must ensure that information on the energy efficiency and the RE share of their district H&C systems is given to consumers in an easily accessible form. Art. 24(1) of the RED III draft additionally specifies that information on the RE share shall at least be expressed as a percentage of the gross final consumption of H&C allocated to the customers of each district H&C system.[17] The EED also requires that consumers are provided with information on the input fuel mix and the associated annual emissions (Art. 10a(2c) in connection with Annex VIIa No. 3 EED). The verification of RE shares is not specified in this context. Unlike in electricity disclosure, there is no provision for disclosure at the product level.

For **gases such as methane and hydrogen,** by contrast, the Commission's draft for a new internal gas market directive contains **clear disclosure rules regarding the use of GOs** (COM(2021) 803 final, Annex I No. 5).[18] It stipulates that GOs must be used to label the share of gas from RES that consumers receive. Product-level disclosure is also explicitly provided for. Clarification is still needed on the future relationship between **gas GOs and mass balancing** (see 4.3.1).

2.1.3 Requirements for the share of RE and unavoidable waste heat in H&C grids

Independently of requirements for the declaration of RE shares to consumers, RED II also sets **indicative growth targets for the RE share in H&C supply as well as the share of RE and waste heat in district H&C systems.**

According to Art. 23(1) RED II, member states shall strive to **increase the RE share in the H&C sector** by 1.3 percentage points per year on average (for member states that do not use waste heat and cold as a complementary compliance option, the target increase is only 1.1 percentage points). The EU Commission's RED III draft proposes to replace this target with a binding growth target of raising the RE share in H&C supply by at least 1.1 percentage points per year (or by 1.5 percentage points with waste heat utilisation as a compliance option). Waste heat and cold can only be counted towards the growth target up to 40% of the

[16] 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; Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency.

[17] 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.

[18] 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.

average annual increase (Art. 23(2a)) RED II / Art. 23(1.2) RED III draft). Annex 1a of the RED III draft also formulates additional indicative growth targets for the individual member states (1.5% for Germany). If RE shares of over 60% have already been achieved, these can count towards the average annual growth under both RED II and the RED III draft.

According to Art. 24(4) RED II, the member states shall ensure the **contribution of district H&C systems to the sectoral RE growth target.** For this purpose, they shall aim for an annual average increase of at least one percentage point in the share of RE and waste heat and cold in the district H&C sector. Alternatively (or complementarily), member states may oblige operators of district H&C systems to grant suppliers of RE and waste heat access to the grid under certain conditions. Also, district H&C systems operators may be obliged to offer to purchase RE and waste heat or cold fed into the grid by third parties. The RED III draft proposes that the indicative growth target regarding the share of RE and waste heat in district H&C systems is raised to 2.1 percentage points per year. In addition, there may be an obligation for member states to ensure access for third-party RES and waste heat suppliers or producers for district H&C systems above 25 MW of thermal capacity (Art. 24(4a) of the RED III draft). Here, too, conditions are specified regarding the technical and economic feasibility of such a step.

Calculating the RE share in the H&C sector is done according to the method described in Art. 7 RED II. It refers to gross final energy consumption from RES, expressed as a share of national final energy consumption (Art. 23(1) RED II). Gross final energy consumption from RES in the H&C sector is calculated according to Art. 7(3) RED II as the amount of district H&C produced from RES in a member state, plus other RE consumption for heating, cooling and processing purposes in industry, households, the service sector and agriculture, forestry and fisheries. According to Art. 19(2) RED II, GO transfers have no impact on the calculation of gross final RE consumption in the member states, and thus neither on calculating the contributions to the growth targets. The transfer of GOs between two countries would therefore not affect the achievement of their national targets. Statistical transfers, joint projects or joint support schemes would have to be used for this purpose (Art. 8-13 RED II). In principle, however, the marketing of green district heating products backed by GOs could contribute to increasing the share of RE in district H&C grids in the member states, provided that this would create effective incentives for the expansion of RE generation.

The proposal for a new Art. 15a in the RED III draft is also relevant for the use of renewable H&C in buildings. It stipulates that member states must set an **indicative target for the share of RE in the final energy consumption of their building sector for 2030** that is in line with a corresponding EU target of 49%. The Commission draft proposes 31 December 2024 as the implementation deadline for the RED III.

Qualitative requirements regarding district H&C supply also result from the EED's **definition of efficient district H&C supply**. This is defined in Art. 2(41) EED as "a district heating or cooling system using at least 50% RE, 50% waste heat, 75% cogenerated heat or 50% of a

combination of such energy and heat". For example, in order to promote efficiency in H&C supply, Art. 14 EED requires member states to carry out potential analyses and cost-benefit analyses of using high-efficiency CHP and efficient district H&C supply and, if these measures are viable, to develop and expand the necessary infrastructure and tap suitable energy sources. RED II also refers to the EED definition of efficient district H&C, e.g. in its requirement under Art. 15(4) that member states shall require that a certain amount of RE is used in new or substantially renovated buildings. This minimum level may be met, inter alia, by efficient district H&C, which uses a significant amount of RE or waste heat and cold. Where member states oblige operators of district H&C systems under Art. 24(4b)) to grant suppliers of RE and waste heat access to the grid or to offer the supply and purchase of heat or cold to corresponding third-party producers, operators of efficient district H&C supply systems may be exempted from this requirement (Art. 24(6) RED II).

According to the EU Commission's draft for a revised EED, the **criteria for efficient district H&C systems are to be tightened from 2026** (see Table 1; Art. 2(42) in conjunction with Art. 24 EED draft).[19] From 2035 onwards, the requirements can only be met by using RE and waste heat; CHP heat is then no longer an option. According to the draft EED, the member states shall ensure that newly built or significantly upgraded district H&C systems meet the requirements applicable at the time of commissioning (Art. 24(2) draft EED). The draft EED does not address GOs for H&C from RES, so there is no direct link between GOs and the criteria for efficient district H&C systems.

The Commission's proposal for a revised Directive on the Energy Performance of Buildings also has implications for the ecological quality of district H&C.[20] According to Art. 7 of the Directive, the member states shall ensure that as of 01.01.2027, new public buildings, and as of 01.01.2030, all new buildings, are zero-emission buildings (specified in Annex 3) and until then are at least nearly zero-energy buildings and meet additional minimum requirements stated in Art. 5. For existing buildings, the member states shall ensure the achievement of minimum energy performance classes. When using district H&C to supply buildings, this increases the importance of low PEFs and EFs, as they can be achieved by using RE or unavoidable waste heat.

[19] COM(2021) 558 final. Proposal for a Directive of the European Parliament and of the Council on energy efficiency (recast).

[20] COM(2021) 802 final. Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast).

Table 1: Criteria for efficient district H&C systems according to the draft for a recast EED

Period	Requirement
until 31 December 2025	at least 50% RE, 50% waste heat, 75% CHP heat, or 50% of a combination of these forms of energy or heat
as of 1 January 2026	at least 50% RE, 50% waste heat, 80% heat from highly efficiency cogeneration, or a combination of these forms of energy or heat. The share of RE must be at least 5% and the total share of RE, waste heat or heat from highly efficiency CHP must be at least 50%
from 1 January 2035	at least 50% RE and waste heat; with at least 20% RE
as of 1 January 2045	at least 75% RE and waste heat, with at least 40% RE
from 1 January 2050	only RE and waste heat, with at least 60% RE

Source: Art. 2(42) in conjunction with Art. 24 EED draft (COM(2021) 558 final)

2.2 National framework in Germany

German law contains various framework conditions that are relevant or could provide starting points for the future introduction of H&C GOs and green district heating products based on them. This in particular concerns the national rules for disclosing RE shares in the supply of district H&C. Unlike in the electricity sector, there are also regulatory requirements concerning the ecological quality of district heating supply, and they have implications for the possible future marketing of green district heating products backed by GO cancellation. Key ecological quality requirements in connection with the (expansion) of district heating grids and the supply of district heating to buildings can be found in the Building Energy Act (GEG), in the Federal Funding for Efficient Buildings (BEG) programme and the Federal Funding for Efficient Heating Grids (BEW) programme, which are summarised below. The implications for H&C GOs are discussed in Chapter 3.

2.2.1 Disclosure rules for district heating and cooling

The disclosure requirements of RED II and EED for district H&C are implemented in Germany by the **District Heating or District Cooling Consumption Metering and Billing**

Ordinance (FFVAV), which entered into force on 5 October 2021.[21] As an implementation of the EED requirements, Art. 5(1.2a/b) FFVAV stipulates that energy bills must be accompanied by information on the shares of the energy sources and the H&C technologies used in the average total energy mix over the last year. In addition, information on the annual emissions associated with that energy mix must be provided. Art. 5(3) FFVAV implements Art. 24(1) RED II and stipulates that utilities must show on their website and in their invoices information on the PEF as well as the percentage of RE used in their district H&C system. For the definition of RE, reference is made to Art. 3(2) of the GEG.[22]

Unlike electricity disclosure, which is regulated in Art. 42 of the Energy Industry Act (EnWG) (see GO4I report E1, Sakhel et al. 2022a), **the FFVAV does not currently contain any reference to GOs** – how RE shares in H&C are to be verified is not specified either in German or in European regulation. Also in contrast to electricity disclosure, there are **currently no regulations on the marketing of differentiated district heating qualities by means of product mix disclosure**. However, as part of the draft legislation on the establishment of GO systems for gas, hydrogen, and H&C from RES published in August 2022 (see 2.1.1), an **amendment to the FFVAV** is also planned. It stipulates that where a utility commits to its customers to supply H&C from RES, the share or quantity of renewable energy sources and heating or cooling technologies used shall be proven by means of guarantees of origin.[23] Marketing green district heating would thus require proof by means of GOs.

2.2.2 Requirements of the Building Energy Act

The Building Energy Act (GEG) stipulates key requirements for the use of RE for H&C and the primary energy demand of buildings. In contrast to the electricity sector, heat consumers as building owners are subject to regulatory requirements regarding their heat supply, which are also relevant for district H&C.

The legislative purpose of the GEG is **ensuring the greatest possible energy efficiency in buildings, including an increasing use of RE** for the generation of heat, cold and electricity

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[21] District Heating or District Cooling Consumption Metering and Billing Ordinance (*Fernwärme- oder Fernkälte-Verbrauchserfassungs- und -Abrechnungsverordnung*) of 28 September 2021 (BGBl. I p. 4591, 4831). Prior to this, individual disclosure obligations were enacted by state law, e.g. in the Energy Transition and Climate Protection Act of the State of Schleswig-Holstein (EWKG) of 7 March 2017. Pursuant to Art. 8(2) EWKG, H&C suppliers must publish information on the share of the individual energy sources in their overall H&C generation and individual H&C grids on the internet, as well as information on the emissions and PEFs of the grids.

[22] Building Energy Act (*Gebäudeenergiegesetz*) of 8 August 2020 (BGBl. I p. 1728).

[23] Draft Act on the Implementation of the Requirements in Art. 19 of Directive (EU) 2018/2001 on Guarantees of Origin for Gas, Hydrogen, Heating and Cooling from Renewable Energy Sources, https://www.bmwk.de/Redaktion/DE/Artikel/Service/Gesetzesvorhaben/herkunftsnachweisen-fuer-gas-wasserstoff-waerme-und-kaelte-aus-erneuerbaren-energiequellen.html.

(Art. 1(1) GEG). According to Art. 10(1) GEG, new buildings are to be constructed as nearly zero-energy buildings, with a maximum value for their total energy demand (Art. 10(2) GEG). Energy losses must be avoided through structural thermal insulation, and the remaining H&C energy demand must be covered through a proportionate use of RE. RE usage obligations also apply to extensively renovated public buildings (Art. 52 GEG).

The ecological quality of the H&C energy sources used has an impact on the total energy demand of buildings as well as on meeting RE usage obligations. The total energy demand of a building is calculated as the maximum value of its annual primary energy demand for heating, hot water, ventilation and cooling (plus built-in lighting for non-residential buildings, according to Art. 15 and 18 GEG). As the calculation refers to the primary energy demand, not only energy sources used in the building are included, but also energy that was used outside of the building for the generation, conversion and distribution of energy. **A key measure of the primary energy efficiency of the employed energy sources are PEFs**, which take into account the primary energy use along upstream value chains. Annex 4 to the GEG lists PEFs for specific energy sources. The annual primary energy demand is calculated by multiplying the energy demand for each energy source (in the building) by the respective PEF.

If district heating is to be used to supply a new building, the PEF must be determined on a grid-specific basis, based on the heat generation technology mix used in the grid. **Regulations on determining the individual district heating grid PEF** are set out in Art. 22(2-5) GEG. As a rule, the value that a district heating supplier has determined and published for the grid to which a building is connected can be used as the PEF (Art. 22(2.1) GEG). The supplier must determine the fuels and electricity, including auxiliary energy, that were used to generate and distribute the heat in the grid, weigh them with the values in Annex 4 to the GEG and relate them to the quantity of heat supplied, and publish this methodology (Art. 22(2.2) GEG). If heat generated in a CHP plant is used in a heating grid, the electricity credit method shall be applied to determine the PEF of the heat from the CHP plant (with reference to DIN V 18599-1: 2018-09 Annex A; see Art. 22(2.3) GEG).[24] However, the application of the electricity credit method for the assessment of heat from CHP plants can lead to a wide range of PEFs, some of which are below zero. For this reason, Art. 22(3) GEG contains specifications for capping low PEFs at 0.3 (BT-Drucksache 19/16716,

[24] In short, CHP electricity is assumed to displace mainly electricity production from coal power plants. Associated primary energy and emissions savings are credited to the CHP heat generation fed into the district heating grid. For further explanations of the method, see AGFW (2021b), FW 309 Part 1; DIN V 18599-1:2018-09. Prestandard: Energy performance evaluation of buildings - Calculation of the useful, final and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting - Part 1: General balancing methods, terms, zoning and evaluation of energy sources.

p. 123).[25] This value can be reduced by 0.001 percentage points for each percentage share of RE or waste heat utilisation in the district heating grid, down to a value of 0.2 (for a 100% RE and waste heat share).

Requirements for the **proportionate use of RE to cover the H&C energy demand of new buildings** are formulated by Art. 34 ff. GEG. According to Art. 44 GEG, the supply of district heating to the building can replace the proportionate use of RE, provided that the heat distributed in the grid comes to a significant proportion from RE or at least 50% from waste heat, CHP or a combination of these (Art. 44(2) GEG). In this regard, a minimum share of the thermal energy demand of the building must be covered by the use of district heating from RES, from waste heat or from CHP plants (Art. 44(1) GEG). Minimum shares are determined in an energy source-specific manner under Art. 35 to 40 or Art. 42 and 43; in the case of district H&C, they apply to the energy from which the district H&C is wholly or partly derived.

In the BMWK's inaugural climate protection report, a fundamental **revision of the Building Energy Act** was announced in order to align new construction as well as the renovation of existing buildings with the goal of climate neutrality in 2045 as well as a significantly reduced energy demand (BMWK 2022, p. 28). The coalition agreement of the German government also formulated the goal that 50% of the heat consumed in buildings should be generated in a climate-neutral way by 2030 (SPD et al. 2022, p. 58). The reduction of energy consumption and emissions of existing buildings is an important challenge in this context. Along with revised subsidy programmes, the planned GEG amendment aims to, among other things, implement the requirement that from 2025 every newly installed heating system should operate with at least 65% RE (SPD et al. 2022, p. 90; BMWK 2022, p. 27; BMWK/BMWSB 2022, p. 4).

The scientific literature has furthermore been discussing for several years the option of an increased **focus of the GEG on emissions**, with a switch from PEFs to EFs in the assessment of the employed energy sources (Oschatz et al. 2016; Pehnt et al. 2018; Pehnt et al. 2021). According to the immediate action programme pursuant to Art. 8(1) of the Federal Climate Protection Act (Bundes-Klimaschutzgesetz, KSG) for the buildings sector, the set of requirements is to be geared towards emissions savings as part of a comprehensive amendment to the GEG in 2023 (BMWK/BMWSB 2022, p. 5). Also relevant is the EU Commission's proposal for a revised EED, which envisages that from 2035 onwards, CHP shall no longer count as a compliance option for fulfilling the **definition of an efficient district H&C system** (Art. 24 EED draft version; see 2.1.3). Thus, regulation is set to attribute more weight to RE and waste heat shares in district heating in the future. Of particular interest in this context is what role district heating will play as a compliance option

[25] BT-Drucksache 19/16716 dated 22.01.2020. Gesetzentwurf der Bundesregierung. Entwurf eines Gesetzes zur Vereinheitlichung des Energieeinsparrechts für Gebäude.

in the German government's plan that every newly installed heating system should be operated on the basis of 65% RE from 2025.

Individual federal states (*Bundesländer*) have already legally implemented **requirements for the replacement of heating systems in existing buildings**. These can provide initial orientation. Such requirements are authorised at the federal level by Art. 56(2) GEG, according to which the states may provide for an obligation to use RE for existing buildings. For example, the law on the use of renewable heat energy in Baden-Württemberg obliges building owners to cover at least 15% of their annual heat energy demand with RE when replacing or retrofitting a heating system or to reduce the heat energy demand by at least 15% (Art. 4 EWärmeG). Among other things, connecting to a heating or building grid can serve as a substitute measure, provided that at least 50% of the distributed heat comes from high-efficiency CHP plants, at least 50% from waste heat, at least 15% from RE, or a combination of these options (Art. 10 EWärmeG). The Hamburg Climate Protection Act stipulates that when replacing or retrofitting a heating system after 30 June 2021, building owners must cover at least 15% of the annual heating energy demand with RE (only applies to buildings constructed before 1 January 2009; Art. 17(1) HmbKliSchG). Here, too, connection to a heating grid can be used as a substitute measure, provided the grid meets the aforementioned requirement for the RE share or has a verified decarbonisation roadmap (Art. 18 HmbKliSchG). Another example of a similar requirement, valid from 2022, can be found in the Energy Transition and Climate Protection Act of the state of Schleswig-Holstein (Art. 9 EWKG).

The regulatory requirements do not yet provide for a product-specific calculation of RE or waste heat shares and PEFs of the district H&C supply: The PEF is calculated for the heating grid to which a building is connected, and requirements for RE, waste heat, or CHP shares refer to the total heat or cold distributed in the H&C grid. Possible further development perspectives that could result from product-level balancing are discussed in 3.3.

2.2.3 Requirements of the Federal Funding for Efficient Buildings (BEG)

Combining several individual programmes to promote efficiency and RE use in buildings, the BEG has been the **federal government's central funding programme for energy-related construction measures since 2021**. It comprises three sub-programmes.[26] The funding guidelines for residential buildings (WG) and non-residential buildings (NWG), which came into force on 1 July 2021, promote the new construction and initial purchase of newly constructed energy-efficient buildings as well as the energy-efficient refurbishment and initial purchase of refurbished existing buildings. The funding guideline for individual measures

[26] Guidelines for Federal Funding for Efficient Buildings (*Bundesförderung für effiziente Gebäude*): Residential Buildings (BEG WG) of 7 December 2021; Non-residential Buildings (BEG NWG) of 7 December 2021; Individual Measures (BEG EM) of 16 September 2021.

(EM) has been in force since 1 January 2021 and promotes selected individual measures for the energy-efficient refurbishment of existing residential and non-residential buildings.

In summer 2022, a number of changes were made to the BEG EM, WG and NWG funding guidelines (see KfW 2022 for an overview).[27] Among other things, funding for new construction is now only available for new residential buildings and non-residential buildings that achieve the “Efficiency Building Level 40” and are certified as meeting sustainability class requirements. In the course of the immediate action programme pursuant to Art. 8(1) of the Federal Climate Protection Act (KSG) for the buildings sector, a more far-reaching realignment of the BEG is planned, with a stronger focus on refurbishments and the launch of a new construction subsidy program for "climate-friendly construction" from 2023 (BMWK and BMWSB 2022). 2022 reforms of the BEG subsidy for new construction already aimed to achieve a stronger alignment with GHG emissions and life cycle considerations, as reflected in the "Quality Label for Sustainable Buildings" (*Qualitätssiegel Nachhaltige Gebäude*, QNG) which is required to achieve sustainability class status.

The characteristics of purchased district heating can be relevant for achieving the **sustainability classes for efficiency buildings**. The "Sustainable Building Plus" or "Sustainable Building Premium" quality labels include requirements for GHG emissions and primary energy demand (BMI 2021, p. 16 f.). However, the catalogue of criteria is broad overall, so that ecological quality indicators for district heating supply are included as one factor among many in an overall assessment.

More direct requirements on the ecological quality of **district heating are set primarily as part of the funding requirements for the "Renewable Energy Efficiency Building" class**. As of August 2022, this funding class is still available for refurbishments under the BEG WG and NWG funding guidelines (KfW 2022); under the December 2021 versions of the guidelines, the renewable energy class initially also applied to new construction. Achieving this class entails higher subsidies for grant repayments (or higher funding in case of municipalities). For residential buildings, the maximum grant size is also increased (or max. costs eligible for funding in case of municipalities). Funding according to the "RE Efficiency Building" class requires that RE and/or unavoidable waste heat provide at least 55% of the H&C energy demand of the building. **Connecting newly constructed or refurbished buildings to heating or building grids counts as a compliance option**. Only certain energy sources and technologies count towards the compliance rate, including unavoidable waste heat but excluding, for example, heat from waste incineration (see BEG WG and BEG NWG, p. 16; KfW and BAFA 2022, p. 72 f.). Alternatively, a 55% share of RE can be assumed by default if the heating grid has a PEF of no more than 0.25 or there is a

[27] Announcement: Amendments to Guidelines of 21 July 2022, BAnz AT 27.07.2022 B1.

transformation plan promoted under the BEW (thermal waste recovery can be included in the PEF calculation; KfW and BAFA 2022, p. 74).

The individual measure funding of the BEG EM also covers the construction, **conversion or expansion of building grids** (defined as grids that supply up to 16 buildings and up to 100 residential units with heat). With the amendment to the BEG EM of 21 July 2022, the funding rate for this is 25%. The construction, conversion and expansion of heating grids to supply the general public fall within the scope of the BEW. However, the BEG EM also promotes the **connection to a building grid or heating grid,** also with a funding rate of 25%.

Similarly to the GEG requirements for heating grids, the BEG minimum shares for RE and/or unavoidable waste heat refer to heating grids as a whole. Potential links for green district heating products verified by heat GOs are discussed in 3.4.

2.2.4 Requirements of the Federal Funding for Efficient Heating Grids (BEW)

The aim of the BEW funding guideline, which came into force on 15 September 2022, is to **promote the expansion of RE and waste heat in H&C grids**.[28] It provides incentives for the conversion of existing, predominantly fossil H&C grids to RE and waste heat, and to promote the construction of new H&C grids that rely predominantly (at least 75%) on RE and waste heat. The BEW replaces the previous, more narrowly defined "Heating Grid Systems 4.0" funding programme. Funding in the form of non-repayable grants is provided in four modules (see BAFA 2022):

1) **transformation plans and feasibility studies** (the basis for funding of implementation measures in module 2)
2) **construction of new heating grids or the transformation of existing grids** (prerequisite: the supported grids must achieve emissions neutrality by 2045).
3) **individual measures**
4) **operating cost subsidies** for solar thermal systems and electrical heat pumps that feed into heating grids.

The funding requirements for the BEW focus on the **target of emission-neutral heating grids by 2045**. This target is operationalised by transformation plans and feasibility studies, with the progress being verifiable throughout. Additional funding criteria concern, for example, the sustainable availability of biomass in case of bioenergy use and the maximum flow temperature and the exclusion of heat from coal-fired plants in new H&C grids. Fossil heat

[28] Guideline for the Federal Funding of Efficient Heating Grids (*Bundesförderung für effiziente Wärmenetze*) – "BEW" of 01.08.2022, BAnz AT 18.08.2022 B1.

plants are not eligible. Modules 2 and 3 include investment cost support of up to 40% of the eligible expenditure for investments in generation plants and infrastructure. Maximum funding limits apply; in addition, the project-specific funding depends on the respective economic viability gap. The operating cost subsidy for the generation of heat from solar thermal systems and electrical heat pumps is granted for ten years. The amount of heat fed into the grid must be verified annually.

Links between the BEW and green district heating products or verification with heating GOs are discussed in 3.4.

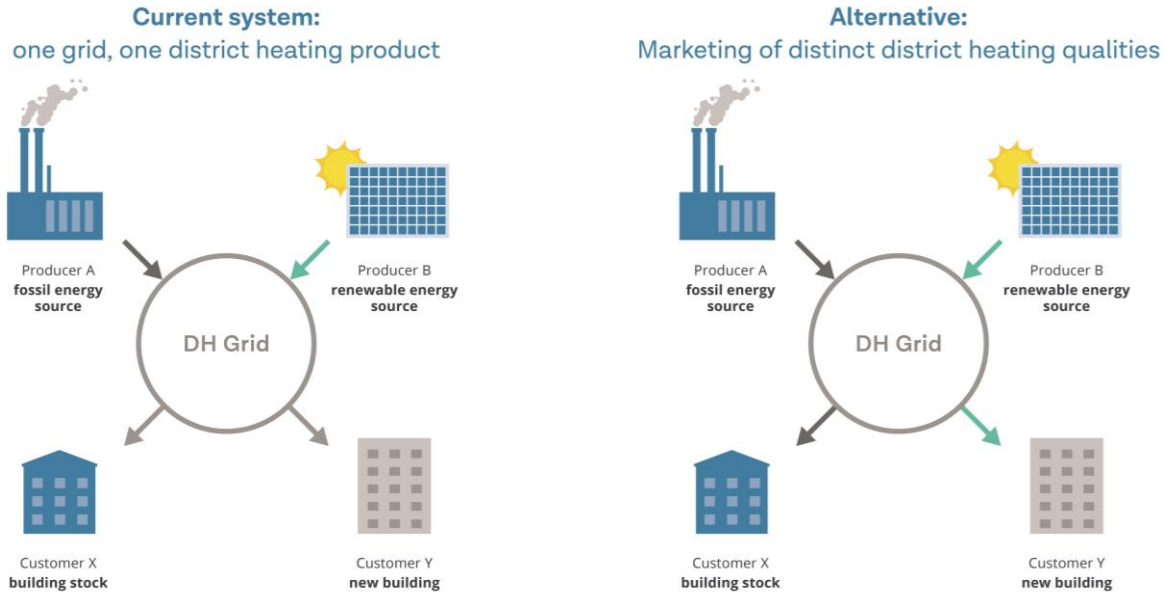
3. Use cases for verification with heating and cooling GOs

In the current legal situation, both disclosure requirements for the supply of H&C and regulatory requirements and funding prerequisites in relation to H&C grids refer to the **total thermal energy distributed in a grid**. For each building that is (newly) connected to the grid, the same PEFs, EFs and RE shares apply, whose values depend on all heat generation plants and consumption points in the grid (see the left-hand side of Figure 2). This means that the environmental benefits of climate-neutral heat from new plants cannot be allocated to specific customers, and this is a major disadvantage: Since, especially in large existing grids, renewable heat from new plants is absorbed into the existing energy mix, it cannot be marketed separately as such. As almost all larger German heating grids are currently still dominated by high-capacity fossil fuel-based plants, adding new and smaller, climate-neutral heat sources to the grids only leads to gradual changes in the quality indicators in the short term; **the key figures such as PEF, EF and RE or waste heat shares will adjust only incrementally**. And since this gradual improvement equally benefits all customers connected to the grid, there is **little incentive to contribute to the transformation of the heating grid by paying a voluntary price surcharge**. For district heating suppliers, uniform ecological indicators mean that they cannot sell the heat from climate-neutral sources, which is often more expensive than conventional heat generation, at a premium. While current high gas price levels and efforts to achieve greater independence from Russian natural gas also improve the competitive situation for RE and waste heat sources, uncertainty regarding future price relations can still inhibit investment.

Only when it is ensured that the ecological benefit and value of the climate-neutral heat from a new plant can be assigned to a customer can that heat be specifically marketed. Such an allocation could be established by cancelling H&C GOs for specific H&C consumption. This would enable a product-level disclosure that offers customers heating products with specific quality characteristics (see the right-hand side of Figure 2). Being able to sell a pure green heat product could make investments in new RE plants and the integration of waste heat sources more profitable for suppliers. On the demand side, there would be a **market contribution to accelerating the decarbonisation of heating grids.**

But even independently of any green price premiums, offering a green heat product can allow suppliers to maintain a competitive edge over decentralised RE generation options. For example, if a (e.g. commercial) building owner wants to cover their entire consumption from climate-neutral sources in the short term, the only option to do so in a grid that is still undergoing transformation would be to switch to decentralised heat generation in the absence of product-level disclosure. For decentralised heat generation, RE shares are calculated individually for each building, whereas for a heating grid, RE shares refer to the supply of all connected buildings. As a result, if RE shares and EF and PEF are calculated for the entire grid, a 100 % RE share with associated low EF and PEF could only be realised once the entire grid has been shifted to 100 % RE supply. If individual customers choose to disconnect in the meantime, this could jeopardise the economic viability of heating grids, which can in the long term be used to supply not only individual buildings but also entire districts or communities in a climate-neutral manner.

Figure 2: Disclosure and marketing options for district heating



Source: Hamburg Institut

The **demand for green district heating with product-specific quality indicators** essentially concerns five potential target groups or application areas:

- households
- companies, especially those that seek to implement climate strategies
- regulatory requirements
- support programmes
- hedging against rising CO_2 prices

The introduction of H&C GOs, as required by RED II, **can provide the basis for legally secure product-level disclosure for all these areas of application**. In each case, H&C attributes would be clearly allocated to individual buildings or customers, and multiple marketing would be prevented. Depending on the design, such product-level disclosure could become a market driver for the decarbonisation of heating grids in addition to subsidies and regulatory law. In the following, the **use cases for verification with H&C GOs and the marketing of green district heating products enabled by such verification** are examined in more detail. Since the use of GOs from non-interconnected grids for disclosure purposes in the H&C context is a controversial topic (see 4.1), the use cases presented here for now refer to the **use of GOs from the grid to which both producers and consumers are connected**.

In principle, green district heating marketing should not merely lead to a redistribution of existing green energy attributes in any given district heating system. Rather, the aim is to provide **impetus for an accelerated expansion of climate-neutral district heating sources** (see 4.5.4). At the same time, grids in which suppliers already invested a lot in RE and the utilisation of waste heat sources should not be disadvantaged in their marketing options.

3.1 Verifying the supply of green district H&C to households

No empirical findings are available yet regarding the possible demands that private customers make on the supply of green district heating. In the German electricity sector, a shift towards green electricity supply has been taking place for many years, especially in the demand by households. According to supplier surveys by the Federal Network Agency (Bundesnetzagentur/Bundeskartellamt 2022, p. 308 f.), the **share of green electricity products in the supply of power to households has tripled over the last ten years**, from approx. 11% in 2011 to 31% in 2020. That share has also increased for **industrial, commercial and other non-household customers**, albeit not quite as rapidly (from 6% in 2011 to almost 14% in 2020, with total electricity sales to non-household customers being more than twice as high as sales to households). Companies are increasingly becoming the driver of demand growth in the European green power market (AIB 2021, p. 15).

However, GO revenues usually account for only a few percentage points of the total revenues of power plants, and this small contribution is furthermore difficult to plan due to price fluctuations on GO markets (Güldenberg et al. 2019, p. 217; Hulshof et al. 2019). **In the electricity sector, GO revenues have therefore not been considered a measurable driver for investment decisions so far**. However, compared to 2021, electricity GO prices in 2022 are significantly higher (Greenfact 2022; Commerg 2022). If prices for electricity GOs form a more stable, relevant revenue component in the future, a stronger, market-driven incentive effect could result. The conclusion of long-term PPAs by industrial customers could also contribute to this (see 3.2 and 3.5).

Greater quality differentiation of green power products could strengthen the financing effect of GOs in the electricity sector in the future (see GO4I report E1, Sakhel et al. 2022a). With regard to marketing, the following aspects appear particularly relevant:

- Households show an increased willingness to pay for green electricity, and they differentiate between green electricity products with different quality characteristics (Schudak and Wallbott 2019, p. 251 f.).
- In the market for electricity GOs, the country of origin, the technology or energy source, the age of the plant and the subsidy status in particular have a price-differentiating effect (Güldenberg et al. 2019, p. 209 ff.).
- Private consumers also consider the regional origin of electricity products to be important (Schudak and Wallbott 2019, p. 251 f.). According to a survey conducted by imug, 28% of consumers are willing to pay more for electricity that demonstrably comes from their own region (Mundt et al. 2021, p. 37).

While the market for green district heating products differs from the electricity market, some of these findings may be transferable. However, lacking practical experience, it is currently not possible to say which characteristics of green district heating products drive consumers' willingness to pay and how large any additional willingness to pay could be.

3.2 Verifying the supply of green district H&C to companies

Companies can be an important target group for climate-neutral district heating products. Customers from the industrial, commercial, trade and service sectors but also public sector actors increasingly face the challenge of achieving climate targets by implementing concrete measures. **Procuring climate-neutral energy is an important lever here**. This could include the purchase of CO_2-neutral district heating products with a balance of 100% RE and/or waste heat. After all, these costumers account for more than half of all district heating sales: In 2021, industry had a share of approximately 34% of district heating use, while other non-household sectors (such as the tertiary sector, excluding housing associations) accounted for approximately 22% (see BDEW 2022b; values are provisional and include district cooling).

Especially for industrial customers, the carbon footprint of their products will become an important competitive factor in the future. The carbon footprint constitutes important information not only for consumers but also for investors and suppliers. Especially when process heat or cold is delivered via grids, the emission factors of that energy can be highly relevant for industrial customers.

Parallel to climate accounting rules for electricity set by the Greenhouse Gas Protocol guidelines, buying a green district heating product could make it possible to apply the **market-based approach** for "Scope 2" emissions from procured energy. The established

prerequisite for electricity procurement is that the EF must be clearly and reliably attributed to specific consumers (WRI/WBCSD 2015, p. 62 ff.). In the heating context, this could be ensured via GO cancellation for specific heat consumers. In "Scope 3" accounting, emissions from the upstream chain would also need to be included.

If no product-level disclosure for the supply of district heating is available, climate accounting for procured thermal energy can only be done using the **location-based approach**, which uses the average emission intensity of the energy in the public grid to which the consumer is connected. Then the purchase of district heating from RE or waste heat can only be taken into account up to the average share of RE or waste heat in the grid. Corporate customers aiming for climate neutrality are at a clear disadvantage here: proof of climate-neutral energy procurement could only be provided once the entire grid has been converted to climate-neutral heat sources – which may be too late to achieve the company's climate goals.

Another particularly relevant target group for the marketing of green district heating is the **housing industry**. Apart from a multitude of legal requirements that need to be met, the sector is increasingly pursuing self-imposed climate goals and strategies. Moreover, a climate-neutral heat supply can increase the attractiveness of housing and thus be a competitive advantage.

3.3 Verification for regulatory requirements

The regulatory requirements of the GEG offer two aspects that a product-specific disclosure of district H&C attributes could build on:

- requirements regarding the **primary energy demand** of new buildings and fundamentally renovated public buildings (with PEF as the central criterion for assessing energy supply)
- **minimum RE shares in the heat supply.**

The generally recognised technical rules (e.g. worksheet FW 309 Part 1 of the AGFW (2021b) or the preliminary standard DIN V 18599-1: 2018-09 Annex A) provide for the determination of **a uniform grid PEF that takes into account all different heat generation sources.** RE, waste heat and CHP shares are also determined on a grid-specific basis.

Buying green district heating with a low PEF could be an interesting option for building owners from a cost perspective. Compared to installing decentralised RE systems or very high levels of insulation, procuring district heating from climate-neutral sources can be a more cost-efficient option. Customers (as building owners) might show an additional **willingness to pay for a green district heating product** if the allocation of attributes from RE plants or waste heat sources from the same grid to their building could be used to fulfil either the GEG or the BEG subsidy requirements (see 3.4).

Currently, however, the attributes of district heating supply cannot be allocated to specific buildings. If a building is supplied by district heating, **requirements on RE share and PEF must be met with reference to all consumers within the grid**. In contrast to other heat supply options, where RE shares only refer to the supply of the individual building, this implies an obligation to exceed the requirements for new buildings. For decentralised gas heating systems procuring biomethane from the natural gas grid, on the other hand, the GEG already explicitly allows for compliance by an attribute allocation process: In this case, a reduced PEF may be used (Art 22(1)(2) EEG), and purchasing the biomethane may count towards the minimum RE requirements (Art. 40(3) EEG). In each case, mass-balancing is required for verification.

This means that even if district heating helped to meet the requirements regarding RE shares or primary energy demand more cost-efficiently, it would be at a competitive disadvantage compared to decentralised heating options. Since the decision between decentralised options and district heating is a long-term one, this can delay the expansion of district heating and thus the implementation of a climate-neutral heat supply for new and existing buildings alike, especially in urban areas. **Here, product-level accounting and disclosure for green district heating could make a relevant contribution to creating a level playing field**.

3.4 Verification for funding programmes

The climate neutrality target in the building sector requires a conversion to climate-neutral heat sources for all buildings and heating grids, as completely as possible and as fast as possible. Support programmes play an important role here. In the context of product-specific disclosure, coordination with the **"Federal Funding for Efficient Buildings" (BEG)** and the **"Federal Funding for Efficient Heating Grids" (BEW)** is particularly relevant.

The **BEG** refers to the **ecological quality requirements for district heating** stipulated by the funding requirements for the "RE Efficiency Building" class for renovations (see 2.2.3). Being allowed to meet the minimum share of RE and/or unavoidable waste heat through a green district heating product would be a sensible further development option here.

The BEG funding conditions of 7 December 2021 stipulate that a flat-rate RE share of 55% can be applied to heating grids if a BEW-funded transformation plan is in place or the PEF of the heating grid does not exceed 0.25. **Transformation plans are an important instrument for setting a binding path for the complete decarbonisation of heating grids by 2045**. Proving minimum shares for RE and waste heat by means of a green district heating product could replace the PEF requirement as an alternative compliance option. Achieving a PEF of 0.25 requires a RE and waste heat share of at least 50% in the heating grid.[29] For grids

[29] This is due to the PEF being capped at 0.3 (Art. 22(3) GEG), minus 0.001 for every percentage point of RE or waste heat share (KfW and BAFA 2022, p. 57).

undergoing transformation, this can be just as difficult to achieve as a RE/waste heat share of 55%. By contrast, meeting minimum shares through a green district heating product backed by GOs from new RE or waste heat plants could provide incentives for the expansion of climate-neutral heat generation capacities.

This would for example open up the option of **combining the construction of new buildings with the installation of new RE-based heat generation plants in the heating grid.** Heating suppliers could conclude a contract with the building owners for the allocation of RE attributes from these plants.

The marketing of green district heating products (backed by GOs from the respective heating grid) could support the **BEW funding** in two respects:

- The **combination of BEW support and green district heating marketing** could accelerate the expansion of RE and waste heat utilisation and the achievement of net zero emissions. Using a BEW subsidy requires the district heating supplier to finance at least 60% of investment costs through their own capital. If green district heating marketing contributes to a faster refinancing of such investments, this could create incentives to decarbonise grids even more quickly than specified by the BEW.

- As an alternative to claiming a BEW subsidy, the **marketing of green district heating from unsubsidised plants** could provide additional impetus for the expansion of climate-neutral heat generation. This would reduce the need for funding to decarbonise individual heating grids and increase the number of transformation plans that could be funded from the available BEW budget.

In addition, if BEW support is claimed, **new verification obligations arise for plant operators and subsidy recipients**, e.g. with regard to the share of RE and waste heat in the district heating supply. Here, using GOs could ensure **more uniform verification processes** and optimise the interaction between heating disclosure, green district heating marketing and monitoring the implementation of transformation plans. The verification regarding operating cost support for selected heat sources envisaged in the BEW (see 2.2.4) offers further potential for **synergies in the area of data interfaces between the competent authority and the GO registry**.

3.5 Buying green district H&C to hedge against rising CO_2 prices

CO_2 prices in the European and German emissions trading system (European Emissions Trading EU-ETS, since 2021 supplemented by national emissions trading based on the *Brennstoffemissionshandelsgesetz* BEHG) are a **relevant influence on generation costs and thus on the pricing of district heating from fossil sources**. In the BEHG, which is particularly relevant for the heating sector, CO_2 prices follow a continuous upward trend:

- For the sake of planning security, emission certificates will be issued at a predetermined, annually rising price until 2025 (from €25 in 2021 to €55 in 2025).
- From 2026, prices will be determined, within the €55 to €65 range, by auctioning off additional certificates (Art. 10 BEHG; DEHSt 2022).[30]
- An evaluation process is currently underway for pricing after 2026.

These rising emission prices entail competitive advantages for district heating based on RES and unavoidable waste heat. **Long-term supply contracts for district heating from RES or waste heat could insure customers against future increases in CO_2 prices**.

Paying a surcharge for a green district heating product can promote the expansion of RE and waste heat projects in the consumers' grid today as it helps to make these sources of heat more competitive. If investments in RE and waste heat can be realised earlier than would be the case without green district heating marketing, additional emission savings could be realised over time. However, this presupposes that, on the one hand, the emissions costs as part of the variable components of the heat price and, on the other hand, the attributes of heat generation are jointly allocated to individual customers or district heating products. However, the mere introduction of product differentiation and a change in the accounting method should not lead to an increase in the CO_2 cost burden for existing contracts. **Exempting green district heating products from the CO_2-related price components could be justified if buying the product supports the expansion of climate-neutral heat sources in the grid** (while the attribute mix remains unchanged for customers of the basic product).

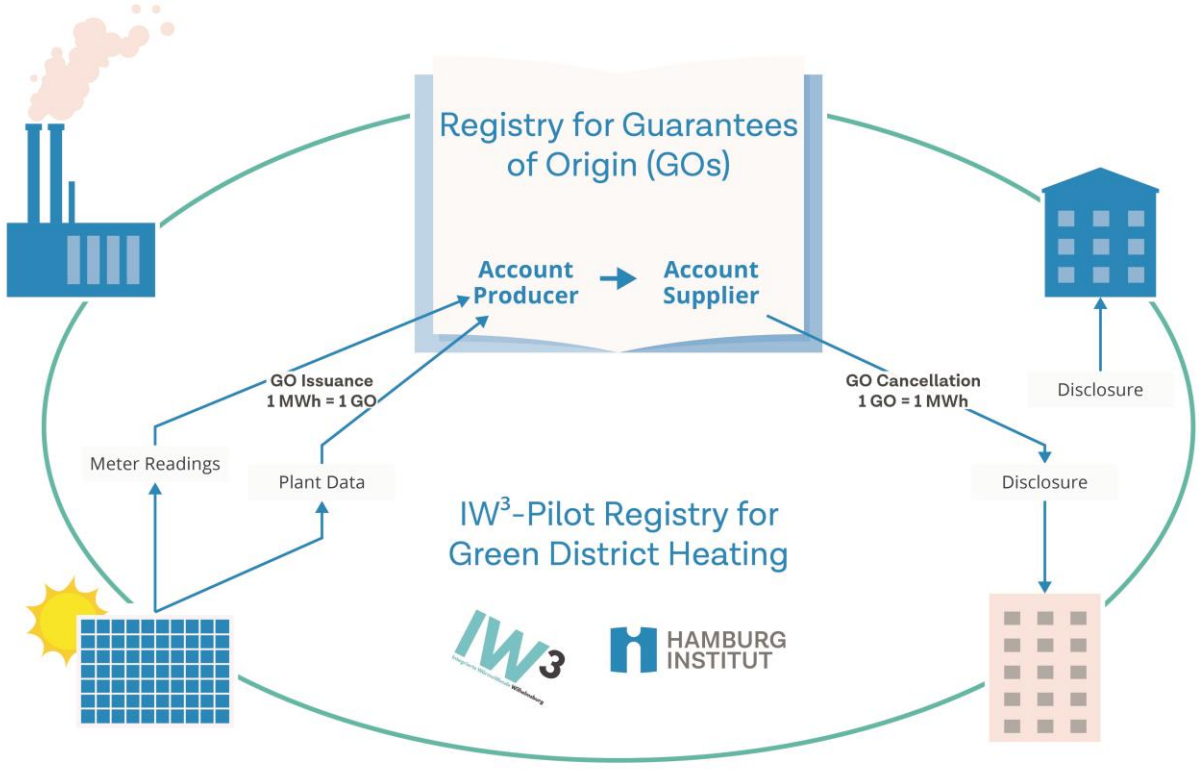
Connecting to a district heating grid is a long-term choice, and the duration of heat supply contracts is set accordingly. Yet product differentiation creates the scope for more flexibility regarding heat quality, insofar as it may differ across products. Following the example of PPAs in the electricity market, **green district heating could be sold under "Green Heat Purchase Agreements"**. This could be done by an allocation of RE and waste heat attributes to consumers by means of GO cancellation. Heat purchase agreements for corporate and collective small consumers are explicitly listed in the EU Commission's RED III draft as a measure by which member states could increase the RE share in the H&C sector (as Art. 23(4) RED III draft version, see COM (2021) 557 final, p. 38).

[30] Fuel Emissions Trading Act (*Brennstoffemissionshandelsgesetz*) of 12 December 2019 (BGBl. I p. 2728), as amended by Article 1 of the Act of 3 November 2020 (BGBl. I p. 2291).

4. Marketing green district H&C: Implications for the operational design of GO systems

The basic principle of H&C GOs is the same as for electricity: For each MWh of energy produced, as evidenced by plant or measurement data, a GO is issued to the electronic registry account of the producer of heat or cold (see Figure 3). The producer can transfer the GOs to the accounts of suppliers (or an intermediary, if applicable). Finally, a GO is cancelled for each MWh of heat or cold consumed. That way, the characteristics of the produced thermal energy are assigned to the consumer. This enables an allocation of green attributes from production to consumption. If the disclosure rules ensure that RE shares are only accounted for by cancelling GOs, this satisfies the RED II requirement that one unit of RE is only accounted for once (see 2.1.1). According to Art. 19 (6) RED II, the monitoring of the issuance, transfer and cancellation of the GOs must be carried out electronically, accurately, reliably and in a fraud-resistant manner.

Figure 3: Basic principle of a GO registry for district heating and cooling



Source: Hamburg Institut

A detailed scientific investigation of design options for heating and cooling GO registries is currently being conducted in the **BMWK-funded energy transition laboratory "IW³ - Integrierte WärmeWende Wilhelmsburg"** which is led by Hamburger Energiewerke. As part of that project, the Hamburg Institut has realised a pilot GO registry for green district heating.

The registry is currently undergoing tests in cooperation with Hamburger Energiewerke. Its aim is to generate experiences and recommendations for a national implementation of H&C GOs. Further information is available on the project and registry websites.[31]

The following section provides an overview of the **key differences between the marketing of green district H&C and the established green electricity market. Implications for the operational design of H&C GO systems** are derived from this.

4.1 Cancelling GOs from non-interconnected grids

Electricity grids are interconnected across Europe.[32] In the established electricity GO market, GOs are traded and transmitted independently of the physical energy and grid connections in the European internal market. While this practice abstracts from individual grid connections and interconnector capacities, it follows the logic of a joint European system of electricity grids and markets. **By contrast, H&C grids are local (or, in some cases, regional) closed systems**.[33] Accordingly, the question arises for H&C GO systems whether cancelling GOs for disclosure purposes should be allowed across grids or limited to technically interconnected grids (which may include cross-border transfer).

In principle, there are arguments for both approaches, and their weighting depends on specific national framework conditions for district H&C (see also Styles 2021). **H&C GO systems that already exist or are under preparation have accordingly chosen different solutions.** In the Dutch GO system for thermal energy, cross-grid cancellation is not allowed (Verwimp et al. 2020, p. 71 f.). GOs for heat from RES can only be used as proof of supply to consumers located within the same heating grid into which the heat was fed.[34] In Finland, where district heating systems already had a comparatively high RE share of 44% in 2020 (Statistics Finland 2021), cross-grid cancellation is possible.[35] In the Flemish system, cancellation across grid boundaries is also possible, but a differentiation is made between grids based on temperature levels (Verwimp et al. 2020, p. 71 f.).

The argument in favour of **cancelling H&C GOs independently of grid boundaries** is that, similarly to the logic of quota systems, the incentives for RE expansion first are highest where

[31] See https://www.iw3-hamburg.de; https://waermeregister.de.

[32] This also applies to gas grids, where, however, deliveries by truck or closed grids for specific gases also play an important role.

[33] Examples of regional interconnected systems in Germany include those in the Ruhr and Saar regions (Engelmann et al. 2021, p. 342 and 252).

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

[35] Cf. Act on Guarantees of Origin for Energy, https://www.finlex.fi/en/laki/kaannokset/2021/en20211050.pdf.

the generation and system integration costs are lowest (cf. Pototschnig and Conti 2021). In addition, incentives for RE expansion that may result from revenues from GO sales can arise independently of whether there is demand for green district H&C in the producer's grid. On the other hand, if a grid exhibits high demand for green district heating but that demand may only be met with GOs from that same grid, liquidity in the market may be low and unplanned outages of RE plants can lead to challenges. By contrast, if consumers could buy GOs from other grids, they would not have to rely on suitable offers from their own grid.

A key argument against cross-grid cancellation of GOs, on the other hand, is concerns about credibility for H&C customers (see, for example, Verwimp et al. 2020, p. 71 f.; van Stein Callenfels 2020, p. 25). Neglecting the physical connection between generation and consumption has already led to accusations of greenwashing in the electricity sector, despite the extensive integration of electricity trading and grids. This discussion is particularly intense regarding GOs from countries that are not connected to the European electricity grid (see GO4I report E1, Sakhel et al. 2022a). Relevant issues in this context are the consumers' willingness to pay for GOs from non-interconnected grids and the implications for the incentives for grid transformation. It would prove problematic if disclosing RE shares with GOs from non-interconnected grids were to weaken the incentives to transform a supplier's own grid.

For reasons of transparency, **H&C GOs should therefore specify the grid into which the heat or cold was fed** (FaStGO 2020, p. 54). The **legal requirements for heating disclosure** must also be observed (see 2.1.2). According to Art. 24(1) RED II, consumers must be given information on the overall energy efficiency and the share of RE in *their* district H&C systems. In German national law, this is implemented by the FFVAV requirement that utilities must provide information on the PEF and the percentage of RE used in **their technically connected district H&C system**. This implies that even if the use of GOs from non-interconnected grids were allowed for disclosure purposes in GO system rules, the PEF and RE shares of technically connected grids would still have to be shown additionally. This would increase the complexity of disclosure and reduce the credibility for customers, compared to a focus on H&C GOs as a verification tool for green attributes within interconnected grids.

The 2020 draft of the GO standard EN 16325, which is still under revision, plans to leave the decision on cancellation rules with regard to grid boundaries to national or regional GO systems (FaStGO 2020, p. 56). In the German context, **if the primary aim of green district H&C is to contribute to the transformation of local supply systems, it seems advisable to focus on the supply of green products within interconnected grids**. This would also be a prerequisite for such products to count towards regulatory or subsidy requirements, if such a use case was intended by the legislator. At least in the case of vertically integrated supply systems, where the suppliers own some of the generation capacity or conclude long-term supply contracts with third-party-owned generation plants, it can be assumed that no market price would form for the H&C GOs themselves. However, price differentiation would

likely materialise regarding different green district H&C products that are backed by GOs for verification.

4.2 Handling grid and storage losses

In the electricity sector, most GO systems neglect energy losses that occur during transmission and storage (Cornélis and Lenzen 2020, p. 6). Implicitly, such energy is assigned the characteristics of the residual energy mix, similarly to the electricity disclosure of non-tracked commercial offers (e.g. of "featureless" electricity procured via the electricity exchange). In the case of electricity grids, independent grid operators must compensate for the energy losses.[36] Electricity producers can market all of the electricity they feed into the grid, as well as the GOs issued for this purpose.

In contrast to the liberalised electricity market, H&C supply systems in Germany tend to be vertically integrated. This means that the grids are usually operated by H&C suppliers who also operate at least part of the generation capacity (see Engelmann et al. 2021, p. 342). Thus, in this case there is no independent grid operator responsible for compensating for losses. **Instead, the losses are taken into account by planning for additional generation**. Furthermore, the relative losses in thermal energy are larger than in electricity grids. In 2020, losses in German heating grids averaged 13% (AGFW 2021a, p. 13), compared to losses of only 5.5% of the net electricity production that was fed into public grids (Bundesnetzagentur/Bundeskartellamt 2022, p. 35). Thus, a credibility problem may arise if losses are neglected in the marketing of green district H&C products (see also Klimscheffskij et a. 2020, p. 45).

The storage of thermal energy, especially over longer periods of time, can also be subject to significant losses (depending on the storage technology, see Engelmann et al. 2021, p. 120; IRENA 2020a). For **storage plants that are located upstream of the grid** and are directly connected to a generation plant, the FaStGO draft EN 16325 proposes that GOs can be issued for energy fed into the grid (provided that no GOs were already issued for the plant itself; see FaStGO 2020, p. 31). Since the GO issuance refers to the energy fed into the grid, storage losses are thus taken into account. By contrast, **losses in storage plants that draw heat or cold from the grid and feed back into it** can be treated in the same way as grid losses. Alternatively, it would be possible to cancel GOs for the stored energy and reissue (a smaller amount of) GOs for the energy fed back into the grid.

When dealing with losses, **the specifications on H&C disclosure in RED III** could also prove relevant (see 2.1.2). Art. 24(1) of the RED III draft specifies that **information on the**

[36] In some countries, e.g. the Netherlands, it is possible to procure grid losses as green electricity with GO cancellation. That way, grid losses are integrated into electricity GO systems. In Germany, GOs currently cannot be cancelled for grid losses (see Styles et al. 2021b).

RE share must include at least the percentage of the gross final consumption of H&C for the customers of a given district H&C system, "including information on how much energy was used to deliver one unit of heating to the customer or end-user" (COM(2021) 557 final, p. 46). According to Art. 7(3) RED II, moreover, "gross final consumption of energy from renewable sources in the heating and cooling sector shall be calculated as the quantity of district heating and cooling produced in a Member State from renewable sources, plus the consumption of other energy from renewable sources in industry, households, services, agriculture, forestry and fisheries, for heating, cooling and process purposes" (unchanged in the RED III draft). The amount of district H&C produced from RES includes thermal energy that is lost during delivery to customers due to grid transport and intermediate storage.

If product-level disclosure is to be consistent with regulatory requirements, Art. 22(2) of the GEG, too, requires that losses be taken into account: Using a PEF determined and published by a district heating supplier to calculate the total energy demand of buildings requires that the fuels and electricity used to generate and distribute the heat in the grid, including auxiliary energy, are determined and weighted with the values from Annex 4 to the GEG and related to the quantity of heat delivered (see 2.2.2). **Thus, grid and storage losses must be taken into account in calculating the PEF in accordance with the GEG**. When it comes to verifying the shares of RE or waste heat or CHP heat in the supply of district heating, that energy is also set in relation to the total heat quantity fed into the grid (see AGFW 2021b, FW 309 Part 5). In this way, losses are taken into account as well.

In summary, both for reasons of credibility and to maintain consistency with established calculation rules for ecological quality indicators of district heating, **grid and storage losses should be taken into account in H&C disclosure.** If GOs are used for verification, this could be reflected in the fact that suppliers cancel GOs proportionately for losses when delivering H&C to consumers (see also Hamburg Institut 2022). For example, with an annual net heat production from RE of 1,000 MWh fed into the grid, 1,000 GOs would be issued. With grid losses of 10%, 900 GOs could be cancelled for the consumption of renewable heat by customers and 100 GOs for losses. The attributes assigned to transmission losses could be listed separately in disclosure statements.

4.3 Verification at sector interfaces

An essential question of verification at the interface of the electricity and H&C sectors is **when electricity and gases taken from public grids and used for the production of H&C can be considered fully renewable** (see GO4I report G4, Sakhel and Styles 2021). Besides its important regulatory and subsidy law implications, this question is also highly relevant for GO issuance and H&C disclosure. For example, it must be clarified under which conditions plants that obtain gases from the natural gas grid or heat pumps and PtH plants that obtain electricity from the grid will be issued RE-GOs for their output of thermal energy. Linked to this is the question of whether and when H&C generation options are considered renewable in terms of disclosure rules.

4.3.1 Taking gas from the grid to generate heat and cold

Mass balancing is established as a verification system for proving that gas (currently in particular biomethane) obtained from the natural gas grid comes from renewable sources. The documentation includes at least information about the production and feed-in of the gas, each transfer of the right to withdraw a quantity of gas corresponding to the quantity of biomethane transported in the natural gas grid, and the ultimate withdrawal from the natural gas grid (BMU 2012, p. 7 ff.). According to Art. 30 RED II, mass balancing for gaseous and liquid fuels is required to meet the sustainability and emissions reduction criteria. Mass balancing must also be used to prove that each delivery is only considered once when calculating the RE share of gross final energy consumption in the member states in accordance with Art. 7(1) RED II. In German regulatory law, the GEG allows mass-balanced purchases of biomethane from the natural gas grid to be counted towards RE utilisation requirements (Art. 40(3) GEG). Also, a reduced PEF may be used compared to natural gas (Art. 22(1.2) GEG). The EEG also requires mass balancing in order for gas taken from the grid to be recognised for electricity generation as landfill gas, sewage gas, mine gas, biomethane or storage gas (Art. 44b(5) EEG 2021; for eligibility under the EEG, the gas must furthermore be fed into the German natural gas grid, including the German exclusive economic zone, BMU 2012, p. 5).

Initially, it therefore seems **reasonable to recognise mass balancing also in the context of issuing H&C GOs as proof of the green attribute of the gas that is used to produce H&C**. However, as Art. 19 of RED II also prescribes the introduction of gas GOs, the **future relationship between GOs and mass balancing for gases needs to be clarified** (cf. BDEW 2020; Bowe and Girbig 2022). According to the Commission's draft for a new Directive on the internal natural gas market, RE shares in gas deliveries shall in the future be documented through GO cancellation (Annex I No. 5 COM(2021) 803 final; see 2.1.2). Besides private and commercial consumers, the supply of green gas products would also be important for gas-fired H&C plants. Passing on the attributes of cancelled gas GOs to H&C GOs would be consistent with the system.

However, a definition would be needed of the conditions under which a green district H&C product backed by corresponding GOs could be recognised for regulatory and subsidy purposes, if the legislator were to allow this. **For example, the requirement could be that feed-in into the European gas grid must be proven by means of gas GOs.** It would also be possible to integrate mass balancing information into the GO system. In principle, there could also be different forms of verification depending on the purpose of the green district H&C product. However, this would increase the complexity of the verification system and imply additional consumer efforts to check the suppliers' statements regarding attributes of green district H&C.

4.3.2 Taking power from the grid to generate heat and cold

In the German regulatory and funding legislation for the H&C supply of buildings, so far **only electricity from RE that was sourced via direct lines or generated in the immediate vicinity of the buildings is eligible** (see Art. 23(1) and Art. 36 GEG; BEG WG and BEG NWG, p. 16). **However, the integration of large-scale electricity-based solutions into heating grids is an important option for decarbonising the district heating supply**, especially as an alternative to biomass for covering peak loads and ensuring security of supply (e.g. Engelmann et al. 2021, p. 286 ff.; Bürger et al. 2021, p. 89 ff.; Bacquet et al. 2022, p. 205 ff.). These include PtH plants such as electric boilers and heating rods, which in combination with heat storage systems contribute to integrating fluctuating RE into the system by absorbing surplus electricity from the grid. Also relevant are large-scale heat pumps that use electricity in combination with ambient heat, geothermal energy, solar thermal energy and unavoidable waste heat. When supplying PtH systems and large-scale heat pumps with renewable power, electricity procurement via direct lines is not always possible, especially in urban areas with low renewable power generation. Obtaining the electricity from the grid allows much greater flexibility in terms of where the renewable power is generated. Also, economies of scale can be used when realising larger plants that supply electricity for various applications. Sourcing renewable power via grids can therefore be a more cost-efficient decarbonisation option for electricity-based H&C than investment in local renewable power generation capacities (if that is even feasible on site).

It would therefore be advisable to specify conditions **under which the use of electricity from the grid to produce district H&C can be considered fully renewable**. A minimum requirement to prevent the multiple marketing and multiple use of green attributes would be GO cancellation. Recommendations for GO use in energy conversion processes were developed in the AIB-led FaStGO project, which advised on the 2020 revision of EN 16325 (Verwimp et al. p. 35 ff.; FaStGO 2020, p. 30 f.). According to the recommendations, for example, electricity GOs would be cancelled for the electricity that is used to generate heat, and heat GOs would be issued for the produced heat that is fed into the heating grid (see also GO4I report G4, Sakhel and Styles 2021). Selected attributes (especially the energy source) would be passed on from electricity GOs to H&C GOs. This procedure takes account of conversion losses, as GOs are only issued for net energy production.

Further conditions could be placed on the quality of the GOs in order to meet regulatory or subsidy requirements. In the political discussion as to when electricity from the grid can be considered fully renewable, the **focus has so far been on defining requirements for the production of green hydrogen and other electricity-based fuels** (Renewable Fuels of Non-Biological Origin, RFNBOs). In the context of **counting electricity-based renewable fuels towards transport sector targets,** Art. 27(3) and Recital 90 RED II state that electricity used for fuel production can be fully recognised as renewable in two cases: (1) if it comes from a direct line to a renewable electricity producing facility or (2) if, when the power is taken from the grid, it can be proven that it was produced exclusively by means of RES and

there is a geographical and temporal correlation between renewable electricity and fuel production. Furthermore, the production of electricity-based fuels should be associated with the use or financing of additional renewable generation. A draft for a **methodology to be defined by delegated act regarding the application of the criteria** was published by the EU Commission on 20 May 2022.[37] The proposed requirements are summarised in GO4I Report E1 (Sakhel et al. 2022a). The grid-bound supply of electricity may be assumed to be fully renewable if the RFNBO producers have concluded one or more PPAs for equivalent quantities of renewable power. Additional criteria concern the commissioning date and support status of the electricity generation plants and the temporal and spatial connection between power generation and RFNBO production.

The role of GOs in verification is not specified in the current draft legislation, beyond the indication that Art. 19 RED should ensure that GOs issued to a renewable power plant are cancelled in order to avoid double counting in case of GO issuance for RFNBOs. However, checking whether GOs have been issued to a PPA electricity generation facility could be more burdensome than providing for GO cancellation for electricity consumption by electrolysers as part of the verification process. Alternative criteria for when electricity consumption can be assumed to be fully renewable apply in the case of a high average renewable power share in combination with a limit on the number of hours of creditable RFNBO production, as well as in the presence of redispatch measures. In this case, however, **the multiple use of green attributes cannot be ruled out,** as the attributes are not explicitly tracked from electricity production to consumption (see also AIB 2022b). In the current national legal framework, requirements for green hydrogen to be exempt from the EEG levy logically provide for GO cancellation as part of the verification (Art. 12i EEV). The draft of the Energy Surcharge Act (*Energie-Umlage-Gesetz*, EnUG) provides for spatial, temporal, and other requirements to be regulated by ordinance (including the requirement that only unsubsidised electricity may be consumed for the production of hydrogen) (BT-Drucksache 20/1630 of 02.05.2022, p. 74).

At least after the expiry of transition periods, the draft delegated act sets demanding requirements for the verification of grid-bound electricity. However, in the context of RFNBO production, the importance of conversion losses must be taken into account (e.g. IRENA 2020b): Where feasible, a direct use of electricity is more energy-efficient than its conversion to RFNBOs. It is therefore important to ensure that an increase in electricity consumption for RFNBO production is accompanied by an expansion of RE generation capacity, rather than an increase in fossil-based electricity generation. Since the direct use of electricity in heat pumps or PtH/PtC plants for the decarbonisation of H&C grids would generally be a more efficient option than using RFNBOs to generate heat or cold, it seems sensible **to formulate**

[37] Draft Commission Delegated Regulation (EU) 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, Ref. Ares(2022)3836651 - 20/05/2022.

a more lenient and administratively leaner set of criteria compared to RFNBO production. For example, to count as heat from RE for regulatory or subsidy purposes, **cancelling electricity GOs with certain quality characteristics** could be required for PtH or PtC plants (likewise for the electricity-derived output of heat pumps). Conceivable options would be to require that:

- a minimum share of electricity GOs come from the fluctuating RE sources photovoltaics and wind power (to strengthen the role that sector coupling plays in integrating fluctuating RE);
- a certain share of the electricity GOs comes from plants located in the German price zone or electrically connected price zones (based on Art. 12i EEV);
- electricity GOs come from unsubsidised plants (to avoid any double support for electricity and heat generation).
- In the case of PtH plants such as electric boilers or heating rods, potentially there could also be a requirement for a temporal correlation between renewable power generation and consumption (to be verified, for example, by means of GOs with hourly time stamps, see EnergyTag 2022) or some other benefit for system stability.

In calculating the RE share in gross final energy consumption under Art. 7, it is currently **only with regard to RFNBOs that the RED III draft provides for the option that generated energy is counted in the sector in which it is consumed** (i.e. electricity supply, H&C supply or transport; see Art. 7(1.2) RED III draft). For the calculation of RE shares in the electricity, H&C and transport sectors, renewable electricity production is in principle accounted for in the electricity sector, "excluding the production of electricity in pumped storage units from water that has previously been pumped uphill as well as the electricity used to produce renewable fuels of non-biological origin" (Art. 7(2.1) RED III draft). For the calculation of gross final energy consumption from renewable sources in the H&C and transport sector according to Art. 7(3/4) RED II or RED III, direct electricity use is not included in this respect.[38] **However, the method for calculating the minimum RE shares in the transport sector to meet the transport sector target according to Art. 25(1) RED II is independent of this** (see also Hoffmann 2020). According to Art. 27(1a) RED II, electricity provided for the road and rail transport sector is thus taken into account for the calculation of RE minimum shares. **A corresponding clarification would also be useful for the sectoral growth targets for RE shares in H&C supply according to Art. 23 and 24 RED II** in order to remove barriers to the development of these important decarbonisation options for H&C grids (see 2.1.3). For example, the ITRE report on Compromise Amendments to the RED III

[38] For heat pumps, Annex VII RED II provides a methodology for calculating the RE share of the total useful heat produced, taking into account seasonal performance factors for heat pumps (see also Commission Delegated Regulation (EU) 2022/759 of 14 December 2021 amending Annex VII to Directive (EU) 2018/2001 as regards a methodology for calculating the amount of renewable energy used for cooling and district cooling).

draft proposes to enable member states to count renewable power towards the Art. 24 target (Secretariat of the Committee on Industry, Research and Energy 2022). In principle, H&C GOs in combination with the cancellation of electricity GOs could support appropriate verification processes and prevent the multiple use of green attributes.

4.4 Independent data verification

GOs contain different types of **data whose accuracy and reliability must be ensured** in order to guarantee the credibility and reliability of this information tool:

- **Plant data** (e.g. on technology and energy sources used, installed capacity, commissioning date, funding status)
- **Measurement data** (regarding the net heat generation fed into the heating grid or used for self-supply, if GOs are also issued for self-supply)
- **Consumption declarations** (on fuels used, if plants use more than one energy input; also relevant for energy conversion plants, where the renewable attribute of the energy purchased must be proven, e.g. for biomethane CHP plants or PtH plants).

Harmonised requirements for data verification are formulated both by the current version of EN 16325 for electricity GOs and by the EECS system (originally for electricity GOs; rules for EECS gas GOs were first added in 2020, see AIB 2022c). As part of the ongoing revision of EN 16325, uniform requirements for electricity, H&C and gas GOs are formulated, which can be supplemented by specific requirements for the different forms of energy. With regard to the **registration of plant data,** the publicly available FaStGO draft standard proposes that issuing bodies should provide verification mechanisms by which the data is validated by an independent body (i.e. independent of any actors who benefit from the GO issuance, see FaStGO 2020, p. 41). Regarding **metering data and consumption declarations**, the draft requires issuing bodies to ensure that the information underlying the GO issuance is accurate. For this purpose, issuing bodies are allowed to provide for independent verification by auditors to confirm the correctness of production and (where necessary) consumption declarations (FaStGO 2020, p. 41). For consumption declarations on biogenic fuels or mixtures of fossil and biogenic fuels, those who register the plants are additionally required to submit an auditor's report to the issuing body at least every two years (FaStGO 2020, p. 42).

Differences in data verification between electricity and H&C GOs arise in particular with regard to the actors who can carry out independent confirmation of plant and measurement data. **In the electricity GO system, independent grid operators play an important role in this respect**. In Germany, grid operators are obliged to provide the HKNR with certain data

pertaining to the plants connected to their grids on request (Art. 41 HkRNDV).[39] They must also report the net amount of electricity fed into the grid by registered plants (Art. 41 HkRNDV). Data verification via grid operators also takes place in the market master data registry for electricity and gas generation plants (MaStR 2022).[40] Environmental experts are used in accordance with Art. 22 HkRNDV to confirm the accuracy of plant data in the case of biomass plants or plants that have received EEG support for a maximum of six months in the five years prior to the registration application (in both cases, the requirement only applies to plants with an installed capacity of more than 100 kilowatts). For high-efficiency CHP plants above this size, confirmation of the submitted data by environmental experts is also a prerequisite for plant registration.

Unlike in the liberalised electricity market, **most H&C supply systems in Germany are vertically integrated**. This means that the same company that is responsible for supply and grid operation also operates at least part of the generation capacity (Engelmann et al. 2021; p. 342 ff.). Unlike in the electricity GO system, data verification can therefore not rely on independent grid operators, with the exception of CHP plants, where data on installed thermal capacity, for example, is also recorded in the market master data registry. Similarly to high-efficiency CHP plants in the HKNR, **plant data** from plants above a certain capacity could be confirmed by environmental experts, for example. It would also be possible to build on the established PEF certification of heating grids by independent experts. Planning data may be used to determine the PEF if the grid is new or still under reconstruction and actual data are therefore not yet available (see AGFW 2021b, FW 309 Part 7; certificates issued on the basis of planning data are valid for a maximum of seven years). For registration in a H&C GO registry, by contrast, the plants would already have to be operational and the relevant technical parameters would have to be established and verifiable. If plant data need only be independently verified when the plant is registered, when significant changes occur or after a longer period of time has elapsed, the verification effort should remain at the same level as for PEF certification. Nevertheless, it would make sense to examine where synergies with verification processes for support programmes (e.g. BEW) or plant approval processes can serve to curb the verification effort for plant operators.

The verification of measurement data as the basis for GO issuance also faces the challenge that, unlike in electricity and gas grids, that information usually cannot be confirmed by independent grid operators. As a basic requirement, it seems advisable to check during

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[39] Implementing Ordinance on Guarantees of Origin and Regional Guarantees for Electricity from Renewable Energy (*Herkunfts- und Regionalnachweis-Durchführungsverordnung*) of 8 November 2018 (BGBl. I p. 1853), last amended by Article 15 of the Act of 20 July 2022 (BGBl. I p. 1237).

[40] By contrast, biomass plants registered in the HKNR are examined at least annually by environmental experts who determine the amount of electricity produced in the plant and the renewable share in the energy content of its fuels and transmit this information to the registry (Art. 42 HkRNDV, simplifications apply for waste and substitute fuels). Verification processes for heat from biomass plants could be designed analogously.

plant registration that the metering devices comply with the Measurement and Calibration Act and are regularly tested and serviced (cf. Hamburg Institut 2022). It would also be possible for the GO system rules to demand confirmation of the measurement data by an independent auditor, e.g. annually before publication of heating disclosure statements. The auditors could be environmental or PEF experts or auditors (in the context of PEF assessments, synergies could also arise with the annual calculation of product-specific PEFs). **Verification processes are an important ingredient to offering credible green energy products – however, it is also important to avoid high additional administrative burdens for plants that use RE and unavoidable waste heat**. The verification should in no way become an obstacle to the expansion of climate-neutral generation capacity in H&C grids. It therefore also makes sense to use **synergies with other verification processes** (e.g. for the BEW operating cost subsidy) as far as possible. Synergies could also arise if **GOs or cancellation statements** issued on the basis of verified data **could be used as a uniform verification instrument for RE and waste heat shares in heating grids** (e.g. within the framework of BEW transformation monitoring or by creating digital interfaces with a future building registry, cf. Becker et al. 2022).

4.5 Disclosure of green district heating and cooling

According to Art. 19(2) RED II, member states must ensure that **GOs are issued upon request by a RE producer**. Beyond that, **member states are free to offer the issuance of GOs for other energy sources as well.** For example, the Netherlands, Austria and Switzerland (as a non-EU country) have mandatory full disclosure for electricity: Electricity suppliers must disclose to their customers the shares of all the energy sources they used by means of GO cancellation (Güldenberg et al. 2019, p. 204 ff.; RECS 2020). In Sweden, GOs may be used for non-renewable energy, and indeed 95% of the Swedish electricity generation capacity is registered for GO issuance (RECS 2020).

4.5.1 GOs for unavoidable waste heat and cold

For the decarbonisation of H&C grids, unavoidable waste heat and cold is an important option alongside renewables (e.g. Engelmann et al. 2021; Bacquet et al. 2022; Bürger et al. 2021; see also section 2.1.3). As a further climate-neutral source of thermal energy, it would therefore **make sense in the H&C context to also offer GO issuance for unavoidable waste heat and cold and to show their shares alongside RE shares in H&C disclosure**. The Finnish H&C GO system rules, for example, provide for the issuance of GOs for waste heat and cold.[41]

[41] See Act on Guarantees of Origin for Energy, https://www.finlex.fi/en/laki/kaannokset/2021/en20211050.pdf.

According to Art. 2(9) RED II, “waste heat and cold” is defined as “unavoidable heat or cold generated as a by-product in industrial or power generation installations, or in the tertiary sector, which would be dissipated unused in air or water without access to a district heating or cooling system, where a cogeneration process has been used or will be used or where cogeneration is not feasible”. A more detailed **examination of what waste heat and cold means in the context of the EED and RED requirements** was undertaken by the Joint Research Centre of the EU Commission (Lyons et al. 2021). It emphasises the **"waste" nature of thermal energy generated and made available off-site**: it must be a by-product of industrial or service activities or electricity generation whose avoidance or on-site use would not have been reasonably possible. It is clarified that heat that is intentionally generated by CHP plants is not considered waste heat – therefore, for electricity generation plants, only heat retrieved from condensers after all reasonable efficiency measures have been exhausted qualifies as waste heat (Lyons et al. 2021, p. 17 ff.). Also, all recognised waste heat and cold must be fed into a district H&C grid. District H&C is defined in Art. 2(19) RED II as “the distribution of thermal energy in the form of steam, hot water or chilled liquids, from central or decentralised sources of production through a grid to multiple buildings or sites, for the use of space or process heating or cooling".

If waste heat or cold is an **unavoidable by-product** in this sense, it can be considered climate-neutral thermal energy when fed into a H&C grid, regardless of whether it derives from a process fired with RE or fossil fuels (origins that classify as neither renewable nor fossil, e.g. from exothermic chemical processes, are also possible). The emissions are then attributed to the industrial, service or electricity generation process and the resulting products. **On the way to climate neutrality, those emissions must also be reduced, and the processes must be converted to RE** (with incentives set e.g. through regulatory requirements, emission prices, subsidies or market incentives). **However, since without being fed into H&C grids, the waste heat and cold would be released unused into the environment, its utilisation can already reduce emissions from H&C generation today** by reducing the need for fossil-fuelled generation plants. According to generally recognised rules of technology, the process-related share of waste heat can be assigned a PEF and EF of zero (see AGFW 2021b, FW 309 Part 1). However, district heating-related shares of fuel input (e.g. to raise the temperature level of waste heat) receive a positive PEF and EF.

For industrial companies, but also data centres for examples, **considering waste heat and cold in disclosure rules and GO issuance** could offer new incentives to make this energy usable and to market it as green district heating. **Incentives could also increase for utilities to integrate waste heat and cold into their grids**. The prerequisite is assurance, for example by means of periodic plant audits, that the heat or cold actually qualifies as unavoidable waste energy. Lyons et al. (2021, p. 22) suggest that for the purpose of counting towards RED II targets regarding RE and waste heat shares in the H&C supply (according to Art. 23 and 24 RED II), national registries for waste heat and cold should be established, where industrial companies in particular should report their specific generation quantities and calculation approaches. Integrating waste heat and cold into H&C GO systems could avoid a

duplication of verification efforts and create a uniform information basis for different purposes (disclosure and calculating sector-specific target achievement).

4.5.2 GOs for waste heat from thermal waste treatment

Waste heat from thermal waste treatment plants is a special case, as it does not fall under the definition of unavoidable waste heat and cold according to Art. 2(9) RED II. Nevertheless, **using it makes ecological sense** and can contribute to the decarbonisation of heating grids by covering the base load (see also Ochse and Hansmann 2022, p. 32). The **prerequisite here is compliance with the waste hierarchy,** as implemented in Germany by the Circular Economy Act (*Kreislaufwirtschaftsgesetz*, KrWG): The priority is waste avoidance over preparation for reuse, recycling, and energy recovery or other uses (e.g. backfilling) (see Art. 6(1) KrWG; Pehnt et al. 2018, p. 25).[42] Other uses are in turn preferable to waste disposal. According to Art. 6(2) KrWG, based on this order of priority, measures that best ensure the protection of humans and the environment, taking into account the precautionary and sustainability principles, have priority. In addition, technical possibilities, economic reasonableness and the social consequences of the measures must be considered. Even though waste is not an unavoidable input material, it would make sense to equate waste heat from thermal waste treatment to unavoidable waste heat if the waste hierarchy and the above-mentioned criteria are observed. However, it would have to be demonstrated that compliance with the waste hierarchy is indeed guaranteed by waste and circular economy policy instruments. Considering heat from waste incineration as unavoidable waste heat must not create incentives to break the waste hierarchy and prefer waste incineration to higher-order uses (cf. Pehnt et al. 2018, p. 25).

For transparency reasons, it therefore seems **sensible to include waste heat from thermal waste treatment in the understanding of "green district heating", while showing it separately from unavoidable waste heat in the disclosure**. In their proposal for binding heating grid decarbonisation roadmaps, Möhring and Pehnt (2022, p. 43) similarly treat heat from RE, unavoidable waste heat and heat from thermal waste treatment plants as equally permissible but distinguishable fulfilment options (in addition to other options such as electric boilers and green gases).

4.5.3 Full disclosure of heat and cold generation and consumption

Besides using GOs for the verification of RE and waste heat, it could also make sense to offer **full disclosure of all heat and cold generation sources by means of GO issuance and cancellation, at least as an option.** That way, suppliers could test full disclosure on a grid-by-grid and voluntary commitment basis. Art. 5 of the FFVAV stipulates that suppliers

[42] Circular Economy Act (*Kreislaufwirtschaftsgesetz*) of 24 February 2012 (BGBl. I p. 212), last amended by Article 20 of the Act of 10 August 2021 (BGBl. I p. 3436).

must provide their customers with information not just on the RE share and the PEF but also on the energy sources and heat or cold generation technologies used in the overall energy mix (on average over the previous year, see 2.2.1). Since GOs contain information on both the technologies and the energy sources used, they could supply the necessary assurance. GO issuance for all energy fed into a H&C grid and GO cancellation for all energy delivered to customers would also **facilitate the consideration and verification of losses** (see 4.2): On an annual balance, grid and storage losses are calculated as the difference between the energy fed into the grid and the energy withdrawn from the grid. If both production and consumption are covered by GO issuance/cancellation, there is no need to separately verify the size of energy losses. In the case of full disclosure, losses would also be assigned attributes by means of GO cancellation (see 4.2).

Furthermore, an important difference between electricity disclosure and H&C disclosure is the **role of the residual energy mix**, which is defined as the total annual energy mix of a member state, excluding the characteristics of explicitly tracked energy quantities (Art. 2(13) RED II). In the electricity sector, the total annual energy mix of a member state is determined on the basis of European statistics; the residual energy mix calculation takes into account imports and exports of electricity attributes (AIB 2022a). In Germany, in addition to renewable power quantities that are tracked by cancelling GOs, EEG electricity that is allocated to the EEG levy payers or, in the future, to all electricity consumers, is deducted from the attribute pool of the residual energy mix (Art. 42(4) EnWG). According to Art. 19(8a) RED II, energy suppliers may use the residual energy mix (which may also contain RE quantities) to identify non-tracked commercial offers, such as "grey electricity" bought on the electricity exchange (see 2.1.2).

In closed H&C grids, where suppliers know the set of thermal energy generation plants, there can practically be no untracked commercial offers. The **question therefore arises as to what role the concept of the residual energy mix plays in H&C disclosure**. If the electricity disclosure rules from Art. 19(8) RED II were to be transferred directly to the H&C case, in the absence of non-tracked commercial offers, RE shares would have to be declared exclusively through GO cancellation (the role of GOs for subsidised plants remains to be clarified for H&C, see GO4I report E1, Sakhel et al. 2022a). At least insofar as H&C disclosure occurs on a grid-specific basis, the shares of non-renewable energy sources in the supply of H&C would have to be calculated individually for each grid and could not – as with electricity – be based on public statistics on the overall national energy mix. It therefore makes sense to specify how the **verification of non-renewable energy sources** is to be carried out. The preparation of PEF certificates for heating grids is well established, but these are carried out at longer intervals (according to AGFW 2021b, FW 309 Part 7, the certificates are valid for a maximum of ten years, provided they were issued on the basis of data covering a period of three years). **GO-based full disclosure could enable annual verification here**. If suppliers operate both renewable and non-renewable energy plants, the additional effort of registering and verifying both types of plants should be manageable. To

gain some practical experience with this, suppliers could initially be allowed to engage in full disclosure on a voluntary basis.

For **grid operators who do not want to introduce product-level disclosure** but rather prefer to show the same H&C mix to all customers, it could be examined whether, with a view to minimising costs, **regular audits of the generation mix are sufficient**. This applies in particular to **small grids with few connected plants and customers**. On the other hand, uniform verification via a H&C GO registry could facilitate verification processes within the framework of the GEG, BEG, BEW or state law requirements or funding measures for H&C from climate-neutral sources. The costs and benefits of various design options in introducing H&C GOs remain to be evaluated in more detail. This also applies to the possible issuing of **H&C GOs for self-supply plants**. This could be of interest e.g. for industrial customers and the housing sector, which could use the corresponding GOs as evidence for climate accounting and reporting to stakeholders and tenants. Self-supply GOs could be marked as such (by an information field for the energy dissemination level, see Van Stein Callenfels et al. 2020, p. 10 et seq.).

4.5.4 Considerations regarding green district heating from existing plants

Like electricity GOs, H&C GOs are initially a **neutral information tool** that provides information on generation facilities and energy attributes for all energy sources covered by the GO system (RE, but potentially also waste heat and non-renewable energy sources). **When product-level disclosure is introduced in the H&C context, GOs ensure the prevention of multiple marketing and multiple claims of green attributes**. However, in the H&C context, when introducing product-level disclosure, it is important to note that – unlike in the electricity sector – there are **regulatory requirements for the ecological quality of thermal energy used to supply buildings** (see 3.3-3.5). This has important **implications for dealing with green thermal energy from existing plants**.

In particular, the PEF of the thermal energy used influences **the total energy demand of buildings**, which has been regulated since 2002 under the EnEV and since 2020 under the GEG. In the case of supply via district heating grids, the PEFs to be used are those that suppliers have determined for their supply systems in accordance with the regulations specified in Art. 22 (2)-(5) GEG (see 2.2.2). There are **no general requirements for compliance with a minimum PEF, as requirements for buildings refer to the permissible total energy demand**: If the procured heat has a low, advantageous PEF, it will suffice to implement the minimum legal requirements regarding insulation at low cost. If the energy supply has a higher PEF, more elaborate insulation measures would be required.

PEFs for heat supply systems are recalculated periodically, and also in the event of changes in the grid, such as the addition of new generation plants.[43]

At least if a green district H&C product is to be eligible for subsidies or to comply with regulatory demands, it must be ensured that a reallocation of the green energy does not worsen the attribute mix in the regular standard product to such an extent that its customers subsequently fail to meet EnEV or GEG requirements. But also for older buildings, for which there are no regulatory requirements yet for energy demand or RE shares in the H&C supply, it would be problematic if the **redistribution led to a concentration of non-renewable attributes with less favourable PEF or EF in the standard product mix**: For example, when applying for subsidies, this could make it more difficult or costly to achieve the required level of efficiency in a building. Similarly, a reallocation of the CO_2 costs of the heat supply that is due solely to a redistribution of green attributes from existing plants would be extremely critical from a legal and acceptance perspective. Any **price differentiation would require an objective justification** (cf. Fricke 2018, p. 148 f.), **such as the costly expansion of renewable heat plants and the connection of additional waste heat sources**.

If disclosure at product level is to play a **role in fulfilling regulatory and subsidy requirements or in determining CO_2 price components**, care should therefore be taken to ensure that the introduction of product-level disclosure does not worsen the attribute mix of the heat or cold purchased by customers in the standard product**. For the marketing of specific green district heating products, it would therefore be advisable to focus primarily on H&C from new plants** that has not yet been included in the calculation of the grid PEF. Such products could provide **additional impetus for the decarbonisation of H&C grids.** Exemptions could be created for grids where suppliers have already invested heavily in expanding RE and waste heat utilisation in the past and accordingly already have a high share of climate-neutral H&C generation. For example, a RE or waste heat share or maximum PEF could be determined that must be guaranteed for all users in the grid in order to also enable green district heating marketing from existing plants. For **grids with already high RE shares**, the possibility to offer products with a share of 100% green district heating could still be relevant, in order to be able to compete with decentralised options when new customers are connected.

Alternatively, regulatory and subsidy requirements and the determination of CO_2 price components could continue to be based on ecological quality indicators calculated uniformly for the whole grid. Then disclosure at the product level would have a purely informational function for intrinsically motivated customers, or possibly a function for climate

[43] According to AGFW (2021b), FW 309 Part 7, the PEFs and EFs of heating grids must be re-determined and re-certified if changes in the system configuration or energy carrier mix occur that result in a significant deterioration of ecological quality indicators. In the case of improvements, updates can be made voluntarily.

accounting. In this case, however, **different customers may claim the same attributes for different purposes (regulatory and subsidy law or disclosure)**. With a strict legal separation of use cases and accounting approaches, this would not necessarily entail multiple claims. However, it could affect the credibility of the marketing of green district heating products and, in combination with the restriction of use cases, reduce the willingness to pay for such products. This could **weaken the potential contribution that green district heating marketing could make to financing the expansion of climate-neutral H&C options**.

5. Conclusion: Prospects for the use of H&C GOs in industry

Introducing H&C GOs would make it possible to clearly allocate the green characteristics of thermal energy supplied via grids to consumers and prevent their multiple marketing. In combination with product-level disclosure rules, this would create a **legally secure basis for marketing and purchasing green district H&C products,** as already established in the electricity sector. However, when **designing H&C GO systems and disclosure rules, specific aspects that relate to the district H&C industry and its technical and legal framework conditions must be taken into account**. These include:

- The question of **whether or under what conditions GOs from non-interconnected grids** can be cancelled for disclosure purposes, as unlike electricity grids, H&C grids are local (or regional) closed systems.
- The handling of **grid and storage losses** in GO cancellation and disclosure rules, as these are significant for thermal energy and are taken into account directly in production planning in vertically integrated supply systems.
- **Verification at sector interfaces, especially for PtH and PtC applications**, for which it would be advisable to specify under what conditions electricity taken from the grid can be considered fully renewable.
- **The formulation of requirements for the verification of plant and measurement data**, taking into account the vertically integrated nature of H&C supply systems.
- **The question for which energy sources GO issuance is offered**: for RE, unavoidable waste heat, waste heat from thermal waste treatment plants or for all H&C sources and generation technologies.

Another relevant difference to the electricity sector is the fact that, at least for some of the buildings supplied, requirements on the ecological quality of the district H&C already arise from regulatory and subsidy law, which have so far referred to PEFs or RE and waste heat shares calculated for each grid. **An important issue for the future marketing of green district H&C is how such products, backed by GOs, will be treated in the future under**

regulatory and subsidy law. Based on existing regulations, a precondition would be the **use of GOs from interconnected grids** for such products.

On the one hand, there is the **option of a strict separation between product-level disclosure and regulatory and subsidy requirements**, where the latter could continue to be based on per-grid indicators. However, this could result in a de facto multiple use of green attributes by district heating customers, albeit for different purposes: once through the average share of RE and waste heat in the grid mix for regulatory and subsidy requirements, and once through the GO-backed information of RE and waste heat shares in product-level disclosure, which is used for customer information or for climate accounting. The different contexts in which the ecological quality indicators are used would have to be communicated very clearly here, as otherwise the credibility of green district H&C marketing could suffer. Claiming the green attributes more than once would likely reduce the willingness to pay green price premiums for such products. This could in turn limit the contribution that demand-side stimuli could make to the decarbonisation of H&C grids.

On the other hand, **recognising green district H&C products under regulatory and subsidy law** could be an effective incentive for customers to contribute to the expansion of RE and waste heat utilisation in their supply system by choosing a suitable product with a price premium. The same applies if the allocation of green attributes backed by H&C GOs has an effect on the CO_2 price components of the tariffs. If this path is chosen, it must be ensured that the introduction of product-level disclosure does not make buyers of the standard product worse off regarding the ecological quality of the heat, or they should be guaranteed a certain minimum standard. For the marketing of H&C in specific green products, this implies a **focus on new RE and waste heat plants that have not yet been included in the calculation of per-grid PEFs, EFs, and RE and waste heat shares that are already used as a fulfilment option for regulatory or subsidy requirements**. Special arrangements could be made for grids that have already achieved high RE and waste heat shares by the time product-level disclosure is introduced.

The role that H&C GOs could play for industrial customers significantly depends on this decision regarding the design of the verification system. Customers from the commercial, trade, services and industrial sectors increasingly face demands to report the environmental impacts of their activities and to obtain energy from climate-neutral sources (see GO4I Report I1, Sakhel et al. 2022b). When connecting to H&C grids, buying an energy product that is 100% from RE and unavoidable waste heat can therefore be an attractive choice, be it for the purpose of improving corporate carbon footprints (CCF) or product carbon footprints (PCF). However, if other customers in the same grid are claiming green characteristics by using grid-wide ecological indicators in the context of regulatory and subsidy law, this can pose a credibility problem for corporate climate accounting – even if these companies pay a premium for their green district H&C product. In the electricity sector, this challenge already arises when, for example, German companies use the market-based climate accounting approach for their GO-backed green electricity, with GOs originating e.g.

from Norwegian plants, while Norwegian companies may base their climate accounting on the location-based approach without GO cancellation (see 3.2). In the H&C context, a **strict separation of the calculation rules for ecological indicators according to regulatory and subsidy law on the one hand and climate accounting on the other hand** could avoid a double claim of the attributes for climate accounting. **However, a perception of double counting could still persist in the minds of H&C customers**.

If, **on the other hand, the allocation of green attributes by means of GO cancellation is applied uniformly to disclosure and climate accounting rules as well as in regulatory and subsidy law**, industrial consumers may want to procure green thermal energy for various applications:

- For credible climate accounting, since the exclusive allocation of RE and waste heat through GO cancellation can prove that the green attributes are not claimed by other customers.
- Making the contribution to grid decarbonisation visible for climate and sustainability reporting, provided that the green thermal energy comes from new RE and waste heat plants whose attributes have not yet been included in the calculation of grid-wide PEFs, EFs, and RE or waste heat shares for other purposes.
- As a fulfilment option for GEG requirements or BEG funding criteria in the construction or refurbishment of non-residential buildings or, in the future, to replace heating systems in non-residential buildings.
- Long-term hedging against CO_2 price increases by means of "Green Heat Purchase Agreements"

Furthermore, H&C GOs can be relevant for companies that **produce unavoidable waste heat or cold**. Taking such energy into account in GO systems and GO-based disclosure rules could help to integrate more of it into the supply systems.

Finally, using H&C GOs for RE, waste heat and potentially other energy sources could help to **standardise verification for stakeholders and public authorities**. This applies to utilities as well as industrial customers, the housing sector and building owners in general. Synergies could arise if H&C GOs issued for verified plant and measurement data could also be used as a verification tool for various reporting obligations as well as funding and regulatory verification requirements, especially if digital interfaces are established between different registries or databases. Information on the issuance of H&C GOs based on verified data could also support national monitoring processes on RED II or RED III targets for RE and waste heat shares in district H&C systems.

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