GO4Industry

Verification Systems for Renewable Energy

English Translation of Fundamental Report G.1

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This document is an English version of the report Bowe and Girbig (2021) from the GO4Industry project. The original report is written in German. It has been translated by use of an automatic translation tool to allow those speaking English to read it. Both versions are available on the project website www.go4industry.com.

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About the project

Industrial companies both aim for and are required to make their production climate-neutral in the future. This requires an immense increase in the use of renewable energies in all production processes. A reliable verification system for renewable energies functioning across borders is prerequisite for being able to balance the climate protection contribution of renewable energies along a supply chain. With the Renewable Energies Directive, the European Union governs member states to implement the verification systems at national level. In the „GO4Industry“ project funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Hamburg Institute and GreenGasAdvisors are developing the foundations for a comprehensive national verification concept for renewable energies. This includes an analysis of how guarantees of origin and other verification concepts for renewable energy sources for electricity, gases, heating/cooling and liquid fuels could interact in the future.

Current project results are published on the project website: www.go4industry.com

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Table 1: List of Acronyms

Acronym	Explanation /Translation
AiB	Association of Issuing Bodies
BEHG	Brennstoff-Emissionshandels-Gesetz / Fuel Emissions Trading Act
COP	Conference of Parties
RE	Renewable Energies
EECS	European Energy Certificate System
EEG	Erneuerbare Energien Gesetz / Renewable Energy Sources Act (EEG, 2021)
ENWG	Energie-Wirtschaftsgesetz / Energy Industry Act (ENWG, 2005)
ESR	Effort Sharing Regulation
EU	European Union
EU-ETS	EU Emmission Trading System
GEG	Gebäude-Energie-Gesetz / Energy in Buildings Act (GEG, 2020)
GHG	Greenhous gases
GO	Guarantee of Origin
IEM	Internal Electricity Market (EU 2019/944, 2019)
ISO	International Standardisation Organisation
CHP	Combined heat and power
MW	Megawatt
P2G	Power to Gas
P2H	Power to Heat
P2L	Power to Liquid
PEF	Primary Energy factor
PPA	Power Purchase Agreement
PtC	Power to Cold
PtH	Power to Heat
PtL	Power to Liquid
PtX	Power to X
RED	Renewable Energies Directive RED II (2018)
RES-E	Renewabe Energy Sources - Electricity

List of Acronyms continued . . .

Acronym	Explanation /Translation
RES-HC	Renewabe Energy Sources - Heating & Cooling
RES-T	Renewabe Energy Sources - Transport
RFNBO	Renewable fuels of non-biological origin
UNFCCC	United Nations Framework Convention on Climate Change
GHG-Quote	Greenhouse Gas Savings Quota

1 Introduction

In the Paris Agreement (Paris Agreement, 2015), the united nations agreed to **keep global warming below 2°** and **to pursue efforts** to limit the temperature rise **to 1.5°**. This has triggered a profound transformation process that is perceived as a major challenge at all levels: internationally, nationally and in companies and society.

The **European Union (EU)** acts jointly as a confederation of states in the spirit of the Paris Agreement and governs joint implementation in the member states. **Germany** — like the other EU member states — is implementing its own transformation within this framework. **Companies and private individuals** are firmly integrated into this through laws.

A central element of climate policy is the **promotion and use of renewable energies**. Companies and private individuals can contribute to climate protection by meeting their energy needs with renewable energy sources. The origin of the energy provided is not always clear if transported via public grids or separate means of transport, as both renewable energy and energy based on fossil fuels are transmitted together in a mix. This is intentional as it allows for a gradual transition. In order to clearly make "energy from renewable sources" transparently available for final consumers, a **credible and reliable allocation of renewable energy** to a specific point of consumption is required. There are various possibilities for this **verification**, defined in the legal framework or in private sector contracts.

The **possibilities for action** differ significantly depending on the level and the actor. In the best case, the measures of the different levels intertwine. All actors can act both **within the given (legal) path**, as well as from their **own responsibility** additionally support the process. For many industrial companies, a change in energy sourcing is a central option for action in order to contribute to climate protection and decarbonisation. This can be due to legal obligations, economic incentive or on a voluntary basis.

Focus of the GO4Industry Project

Triggered by the amendment of the EU legislation on renewable energies, especially in the Renewable Energy Directive (RED II, 2018), the need for this project arose to explain the classification and effect of the verification systems for renewable energy. As a result of RED II (2018) and in the context of intensifying efforts to curb climate change, many regulations, subsidy and quota systems in the European Union (EU) are currently undergoing some fundamental changes. RED II sets the direction and design for the expansion of renewable energies in all EU member states for the next few years.

The GO4Industry project investigates how industrial companies can make their energy supply renewable under these new conditions. For this purpose, various options are described and examined for their applicability. This is intended to inform and support German industrial companies in particular on their way in this transformation. The project focuses on these energy sources, which receive special attention under the RED II (2018) (figure 1):

- Electricity
- Gases
- Heat/cold and
- Liquid fuels

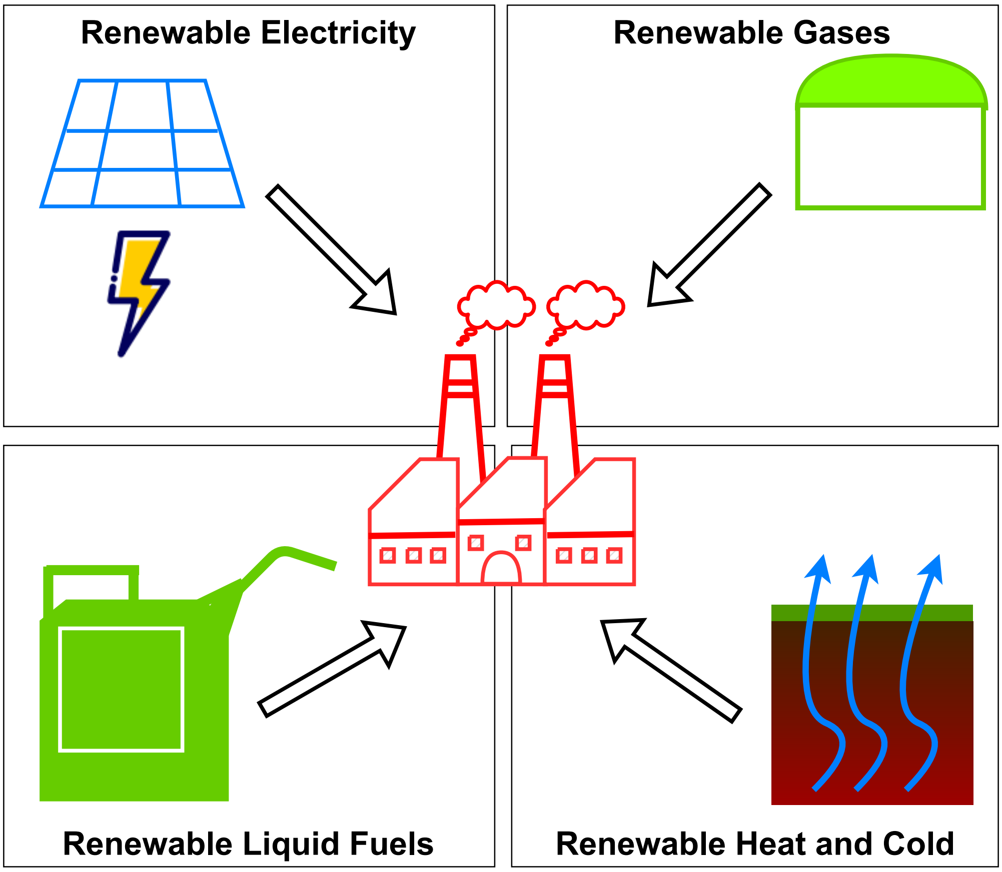


Figure 1: Forms of energy considered in the GO4Industry project

In order to structure the extensive information material, the GO4Industry project examines three content-related work packages, each of which has been divided into different reports:

- **Fundamentals**
  The fundamental work package analyses overarching questions on the instrumental frame-

work of renewable energy verification as well as the system architecture of the legal framework for renewable energy verification at European level and its implementation at national level.

- **Energy forms**
  In the energy forms work package, sector-specific challenges regarding verification of renewable energy for electricity, green gases, heating and cooling, and liquid RE fuels are investigated.
- **Application in the industry**
  The industry work package looks at requirements for the verification of renewable energy properties from the perspective of industry and society. The aim is to provide companies with support on how they can meet the requirements of climate-neutral production or supply chains by means of verification concepts for the various use cases.

Industrial companies are looking for options to find their optimal path on the transformation to an environmentally friendly operation. This report and a number of subsequent reports from the Fundamentals work package address these needs of industry by providing information on framework conditions and thereby offering support for implementation. The **Fundamentals** work package includes the reports:

- G1 Verification systems for renewable energies (Bowe and Girbig, 2021)
- G2 Purpose and instrumental performance of guarantees of origin: Status quo and perspectives for further development (Styles et. al., 2021).
- G3 How guarantees of origin can accelerate the energy transition
- G4 Sectoral, legal and transnational interfaces in renewable energy verification systems (Sakhel and Styles, 2021).

This fundamental report G1, “Verification Systems for Renewable Energy” (Bowe and Girbig, 2021), provides a rough overview of renewable energy verification systems in **the first section** Climate Protection and Renewable Energies and explains how these are linked to the EU’s main climate change instruments. It is shown by way of example how companies are involved in the state-led transformation and what room for manoeuvre exists.

The **second section** of this report, Climate Protection and Renewable Energy, makes the reference to climate protection efforts from the international Paris Agreement (Paris Agreement, 2015) and how these affect German targets for the expansion of renewable energies via EU legislation.

The **third section**, Accounting of Renewable Energy, deals with the framework within which the four renewable energy sources under consideration are treated within the laws and directives, and which methods of verification are provided for in each case. The possibilities of contributing to climate protection within the framework of the law are presented from the perspective of an industrial company.

The **fourth section**, Sourcing Models for Renewable Energy or Renewable Energy Properties, presents the options for an industrial company that either wants to source the renewable energy directly physically or by means of established transport structures such as the public grid. It is shown how, in the case of blending with other energy sources, the proof can be linked to the delivery or how a certificate can be transferred decoupled from the direct physical energy source. The differences or the respective proofs required for renewable energy are explained.

In the **fifth section**, Verification Methods for Renewable Energies, the verification methods are systematically classified, and in the **sixth section**, Comparison of Verification Methods, the applicability of the different verification systems is discussed. The **seventh section**, Climate Protection Contributions: Voluntary, Incentivised and Obligatory, presents how the different verification systems differ in their climate protection effect.

2 Climate Protection and Renewable Energy

Industrial companies are involved in state-controlled climate policy through many laws and instruments. Formative for the implementation of climate protection measures was the

- **International Paris Agreement of the UNFCCC** (Paris Agreement, 2015)
  The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris on 12 December 2015 and entered into force on 4 November 2016.

In order to support the implementation of the Paris Climate Agreement and the United Nations Sustainable Development Goals (SDGs), the EU is focusing not only on reducing greenhouse gas emissions but also on increasing the share of renewable energies and energy efficiency in line with the European Green Deal.

Important **EU directives/regulations** in this context are:

- EU Greenhouse Gas Emission Trading System (EU-ETS, 2003)
- Effort Sharing Regulation (EU-ESR, 2018)
- Renewable Energies Directive (**RED II (2018)**)
- Energy Performance in Buildings Directive (EPBD)

As an industrialised country with a high population density, Germany has supplemented the will to protect the climate with its own legislation and regulations:

- Renewable Energy Sources Law (EEG, 2021), a central steering instrument for the expansion of renewable energies, which first came into force in 2000 and has been continuously developed since then (EEG 2004, EEG 2009, EEG 2012, PV amendment, EEG 2014, EEG 2017, EEG 2021).
- Law on the Saving of Energy and the Use of Renewable Energies for Heating and Cooling in Buildings (GEG, 2020), aims to use energy in buildings as sparingly as possible, including an increasing use of renewable energies for building operation.
- The greenhouse gas reduction quota (formerly: biofuel quota), implemented within the framework of the Federal Immission Control Law and subordinate ordinances, establishes fuels from renewable sources through a quota obligation.
- Law on a national trade in fuel emission allowances (Fuel Emissions Trading Act, BEHG (2019))

The above list of laws and regulations is not complete, but focuses on the topics that may become obsolete when renewable energy is used. In the following, the goals of the EU and national legislation in Germany are discussed.

2.1 Objectives and Instruments of the European Union

The EU implements the Paris Agreement jointly in the sense of the European idea as a confederation of states ("regional economic integration"). Therefore, certain governing laws in the EU prescribe to the member states what this common path should look like.

The **European Union** has set its own target to become **greenhouse gas neutral by 2050** -- implemented as net zero, in terms of carbon dioxide emissions. The EU Commission, the European Council and the European Parliament are working to enshrine the goal of a climate-neutral EU in law with the European Climate Law. To achieve this goal, there are two main instruments

- The **EU's Emission Trading System** ((EU-ETS, 2003)) is a cornerstone of the EU's climate change policy and a key instrument for reducing greenhouse gas emissions in a cost-effective way. It is the world's first significant CO_2 market and the largest to date.
- **Effort Sharing Regulation** (EU-ESR, 2018). Mitigation of GHG emissions from sectors not covered by the ETS.

In the EU ETS, emissions are traded with fixed caps (cap and trade). The total volume of emissions of certain greenhouse gases (GHG) that installations covered by the EU ETS may emit is limited by a cap. Over time, the caps are reduced. If the available certificates are not sufficient for a company at the end of the year, they must be purchased otherwise there is a risk of heavy penalties. On the other hand, certificates in excess can be sold to those who need them ("trade"). The ETS therefore offers the option of reducing emissions where the costs are lowest. The influence of the ETS is reflected, for example, in an increased price of energy from fossil sources.

In addition to the goal of greenhouse gas neutrality, the EU is pursuing the goal of massively promoting **renewable energies**, as these are to replace fossil energy sources and secure the energy supply for economic prosperity in the future. Here, the **European Union's Renewable Energy Directive** sets the framework for the expansion of renewable energies in the EU member states. This directive was comprehensively amended in 2018, so that in this context we are talking about RED I (2009) and the amended RED II (2018) (From 2018, in implementation until mid-2021). RED I (2009) set a target of 20% renewable energy (depending on total consumption) by 2020. RED II (2018) sets the target at 30% by 2030. The current amendment under the European Green Deal on the way to a RED III raises the target for 2030 again significantly to 55%.

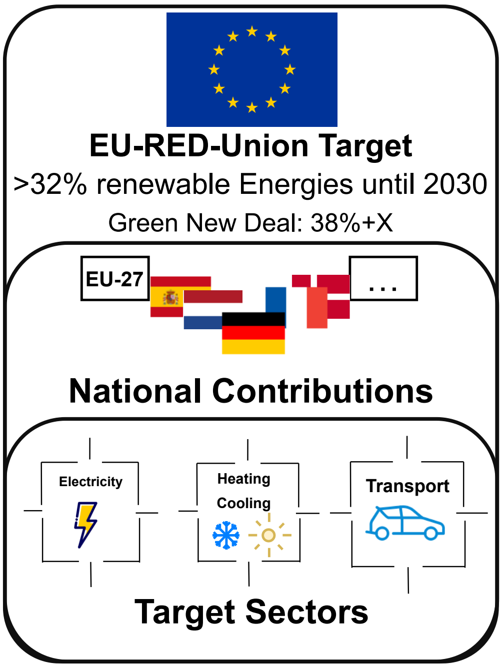


Figure 2: Overall target, national contributions and consumption sectors in EU RED II

Within the RED, the EU has set itself corresponding framework conditions for the **promotion of renewable energy**, see figure 2. The overall target for the expansion of renewable energies is pursued through the sum of the **national contributions of the Member States**. The respective contributions are recorded in detail and published regularly by the EU Commission, e.g. here: European Commission (2020a). The national contributions are further **broken down into sectors**. The **electricity sector** (Electricity, RES-E), the **heating & cooling sector** (Heating & Cooling, RES-HC) and the **transport sector** (Transport, RES-T) are each considered separately. Separate measures were formulated for the transport sector and underpinned with a corresponding set of instruments and sub-targets. In the heating & cooling sector, the member states have set themselves the target of an annual percentage increase in the share of renewable energies in relation to total consumption. The target path is non-binding here, but serves as an orientation and may become binding in the future.

Explanation of special EU definitions

In order to make the targets measurable and enforceable within the EU, the legal framework contains **definitions that are valid throughout the EU**. In the following, some important EU definitions are explained that will later be significant in the context of application of renewable energies:

Renewable energy sources

RED II (2018) defines which energy sources are considered renewable. These are:

- Wind
- Sun (solar thermal and photovoltaic)
- geothermal energy
- Ambient energy
- Tidal, wave and other ocean energy,
- Hydropower
- Energy from biomass, landfill gas, sewage gas, biogas

This list from Art. 2 of RED II (2018) is exhaustive, i.e. no further energy sources are considered renewable. In addition to the renewable energies mentioned, RED II also takes waste heat and cooling into account in a separate category.

Biomass in RED and in the ETS

If **biomass** is used instead of fossil fuels, e.g. in the form of wood or biomethane, CO_2 is also released. However, this greenhouse gas was taken out of the atmosphere during biomass growth. Therefore, GHG emissions from biomass combustion are considered climate neutral, the so-called "**zero-rating**" (Europäische Kommission, 2017). This makes an application of renewable energies from biomass in the ETS possible (see section 3). The specifications for this are being revised at the time of writing.

RED II (2018) introduces a completely new terminology for **energy sources from biomass**. In principle, these are referred to as "**bio(mass) fuels**". Due to its own regulations and sub-targets in the transport sector, there is the additional term "**biofuels**". Table 2 gives an overview of the terminology.

Table 2: Definitions for energy carriers from Biomass in RED II

	Sector Accounting:		
	Electricity	Heating / Cooling	Transport
Liquid	liquid biofuels		biofuels
Gaseous	biomass fuels		
Solid	biomass fuels		

Renewable fuels of non-biological origin

The term "**renewable fuels of non-biological origin**" (RFNBO) was newly introduced in **RED II (2018)** for electricity-based fuels. Using this terminology, these fuels can be specifically assigned to government support.

Sustainability

The large-scale cultivation of biomass can – in addition to the desired positive effects – also have negative impacts, e.g. in the case of land use changes due to the destruction of species-rich rainforests or peatlands. Therefore, the EU has defined "**sustainability criteria**" for the production of energy from biomass. These must be complied with in particular for biofuels, for biomass fuel or in the ETS. In detail, these stipulate, for example, that the biomass may not be cultivated on nature conservation areas, moors or similar.

Greenhouse gas emissions savings

For biofuels and renewable fuels, RED II (2018) sets thresholds for "**greenhouse gas emissions savings**". These fuels must save a certain amount of GHG emissions compared to comparable fossil fuels, which is determined by a life cycle assessment. The aim of these additional criteria is to avoid climate damage caused by unfavourable cultivation and delivery conditions.

2.2 Accompanying Climate Protection Measures in Germany

Beyond the activities and goals within the framework of the EU, **Germany has implemented its own goals and measures**. Due to their significant effectiveness, the following are explicitly highlighted here: the Renewable Energy Sources Act (EEG, 2021), the Fuel Emissions Trading Act (BEHG, 2019) and the Building Energy Act (GEG, 2020).

The promotion of renewable energies was driven forward in particular by the Renewable Energy Sources Act (EEG, 2021), which aims to bring renewable electricity production plants onto the market. Here, the current target is to cover 65 % of electricity consumption (gross electricity consumption) with wind and solar energy, for example, by 2030. The Renewable Energy Sources Act (EEG, 2021) stipulates for defined renewable technologies that financial support is to be used to bring them into a competitive situation compared to the use of fossil fuels. The amount of financial support was determined, for example, through feed-in tariffs, market premiums or tenders. The Energy Industry Act (ENWG, 2005) regulates the energy market in general and also includes special regulations for renewable energies, which are closely linked to the Renewable Energy Sources Act.

The **Fuel Emissions Trading Law** (BEHG, 2019) implements the Effort Sharing Regulation. The national emissions trading system (nEHS) laws where the EU-ETS (2003) does not. It makes fuels more expensive due to their greenhouse gas emissions. This will initially take place via a fixed and rising price, which is to be formed on the market from 2026 via an artificially scarce total quantity of emissions. The system works similarly to the EU ETS via a certificate system. Unlike the ETS, where emitters offset their emissions with EUAs, the sellers (distributors) of fuels are obliged to buy certificates from the national emissions trading system (nETS).

The (BEHG, 2019) – like the EU-ETS (2003) – defines emissions as a negative object to be taxed or reduced. If fuels from renewable energies are distributed, no nEHS certificates are required for these, as they do not cause fossil greenhouse gas emissions (Deutsche Emissionshandelsstelle (DEHSt) im Umweltbundesamt, 2021).

Due to the **greenhouse gas reduction quota, which is anchored in the Federal Immission Control Act (BImschG)**, all mineral oil sellers in Germany are obliged to achieve a certain greenhouse gas reduction compared to fossil reference fuels by blending renewable components into their fuels. The quota has meant that these blends can now be bought nationwide, for example as E10.The **Building Energy Law** GEG (2020) sets minimum standards for buildings that are heated or cooled. It also contains regulations for the use of renewable energies, e.g. as a solar thermal system on the roof. These are particularly envisaged as part of the building, but there is also the possibility of using renewable energy from outside the building, e.g. in the form of renewable gas. It is required that the energy quality of buildings must be documented in an energy certificate when they are sold or rented. In November 2020, the new Building Energy Law came into force. It replaces the Energy Conservation Law (EnEG), the Energy Conservation Ordinance (EnEV) and the Renewable Energies Heat Law (EEWärmeG). With the new law, renewable energy and energy efficiency become important aspects of the new regulations, which are combined with other regulations. In the past, owners and sellers were already obliged to submit an energy certificate. According to the new GEG, estate agents are also obliged to provide an energy certificate.

2.3 Voluntary Certification for Companies

Companies and private individuals often act out of their own responsibility and beyond government requirements and incentives. The respective goals are individually motivated and can differ greatly. Certification systems ensure comparability here.

Certification systems are designed to create transparency so that characteristics of energy sources in terms of their provision, such as origin, composition, associated processes, comply with predefined criteria. The requirements of the certification systems are characterised by initiatives that sustainably protect the environment and resources. This affects all sectors of the industry and **influences** their **decisions**, whether they are small or large organisations. The implementation of the requirements set within the scope of a certification is usually documented through an audit. This ensures that compliance with the required criteria can be independently verified and made clear to third parties in a transparent manner.

After successful certification by an accredited certification body, the respective company is interested in announcing its successful certification. This applies externally, e.g. to customers and investors, but also internally, e.g. to employees. Examples are announcement of successful certification according to the ISO management system standards

- DIN EN ISO 9001 Quality Management System
- DIN EN ISO 14001: Environmental management system
- DIN EN ISO 50001: Energy management system

Of course, companies also voluntarily define their own standards and it is quite legitimate to propagate these as a unique selling point. However, certifying organisations orient themselves towards established management standards due to comparability.

Participation in a certification process is based in the first step on **companies voluntarily** agreeing to fulfil the requirements set. The first step of a voluntary certification is the "self-declaration", with which companies commit themselves to comply with the requirements. Depending on the certification requirements, a baseline and boundary must be defined. In order to fulfil the requirements of a management system, a continuous improvement process PDCA (Plan-Do-Control-Act) must be established as required by the ISO management systems. **Binding approval from top management** must be obtained. Certification is to be used whenever complex obligations are to be met that are based on detailed specifications and require continuous review. Certifying organisations are listed according to their qualification and accreditation at the national accreditation body of the Federal Republic of Germany (DAkkS). **Accreditation with the DAkkS** ensures that the certifying body also has the authority to carry out qualified auditing and issue a certificate. A self-declaration is only suitable if relatively simple requirements are set.

The main drivers for the use of certification systems are factors such as social and political will leading to compliance with standards, guidelines or regulations. The economic pressure on industrial companies to succeed means that companies weigh up whether participation in a certification system is worthwhile. The voluntary participation in a certification system is based on the prospect of increasing the e**conomic success of the company**. Possible decisions criteria:

- Expansion of own production to new product fields
- Cost savings through the use of more efficient technologies
- Lower costs for waste management and emissions
- Obtaining substantial subsidies
- and finally, as an important argument, the image on the market.

The industrial and manufacturing sector expects that participation in the voluntary instruments will be beneficial. Their interests are partly oriented towards the legal framework as well as support offers in order to achieve a smooth operational implementation. The respective definition of "green" is unclear, so criteria are needed that define a framework for the respective systems and are usually made publicly transparent.

3 Accounting of Renewable Energy

In the previous section 2, it was shown that renewable energies play an important role in climate protection at all levels. They also help to achieve climate protection goals beyond energy supply, such as GHG reductions or increasingly climate-neutral operation of buildings (accompanying efficiency measures). Building on this, the following section examines the conditions **under which renewable energies can be accounted**. The four energy sources electricity, gases, heating/cooling and liquid fuels are considered in terms of their potential contribution to achieving the target, e.g. in RED II (2018) and how these can be accounted. In addition, it is derived which framework for action exists for industrial companies that would like to convert their processes to renewable energy within the framework of government instruments.

3.1 Accounting of Renewable Electricity

The establishment of renewable sources of electricity, such as photovoltaics, wind power, electricity from biogas, and many more, took place in Germany mainly through the Renewable Energy Sources Act (EEG, 2021). This support has essentially led to almost half of the electricity consumed in Germany now being renewable. The statistical accounting for the **RED electricity sector (RES-E)** in Germany is based on the amount of renewable electricity fed into the grid domestically. To calculate the share of renewable energies, this production is compared to the total final energy consumption of industry, commerce, trade, services, household and transport as well as line losses and own consumption of power plants (AG Energiebilanzen e.V., 2019). A subsequent allocation of renewable electricity production in the transmission grid up to consumption is not necessary. So far, an industrial company **cannot contribute to the German electricity sector target (RES-E) through consumption-side measures**. The EEG does not provide for individual electricity consumption to be counted towards the overall targets. It could only do so as a plant operator through the production and grid feed-in of renewable electricity.

In Germany, renewable electricity consumed by an industrial company's **vehicle fleet** can currently only be accounted for in the **transport sector (greenhouse gas reduction quota, RES-T)**, if the electricity is used directly outside the public grid or **converted directly** and accounted as gas or liquid fuel (see sections 3.2 and 3.4). However, the regulations in Art. 27 (3) of RED II (2018) create a framework so that, in the future, electricity can also be claimed from the grid as fully renewable energy (see section 5.3). Due to the overarching framework of the RED, it is also conceivable that, in the future, electricity-based fuel produced in Germany, e.g. hydrogen, will be accounted in the transport sector after use in the vehicle fleet in another member state. To make a distinction, the multiple accounting of e.g. electricity quantities in RED II (2018) or the greenhouse gas reduction quota is briefly discussed here. Multiple accounting is possible here, but this is limited exclusively **to the sub-targets in the transport sector**, which are calculated independently of the national contribution. For the national sector contribution (RES-T or RES-E), there is only single accounting (Hoffmann, 2020). For the national contribution, RED II (2018) gives the member states both the option of calculating the contribution on the basis of average values (2 years in the past) or of counting electricity sourced from the electricity grid for this purpose. Under the current model, every feed-in to the grid is accounted in the power sector (see above). The procedures to enable electricity to be drawn from the grid and at the same time exclude double counting are being worked out at the time of writing.

Electricity consumed by a business in heat applications can be taken into account advantageously in the Building Energy Law (heat sector RES-HC or EPBD) if it is **supplied directly** to the building in question. In addition, heat pumps operated with mains electricity are an integral part of the system. However, for these, the contribution of the **ambient heat** used is considered renewable, so the local (grey) electricity mix is used as long as the energy efficiency of the heat pump (annual performance factor) meets the requirements. The RED II (2018) **does not provide** for the accounting of renewable electricity sourced via the electricity grid, as this is already accounted for in the electricity sector (see above).

If the heat from an EEG combined heat and power unit (CHP) is used, this is also implicitly counted towards the heating sector. The accounting of renewable heat contributions is calculated with reference efficiencies (AG Energiebilanzen e.V., 2019).

If an industrial company wants to **voluntarily** apply renewable electricity, **green electricity products** are an important option with **electricity dislosure**. The RED II (2018) as well as the previous RED I (2009) included the system of **guarantees of origin for this purpose**. In this way, the consumer financially supports production facilities for renewable energies via the guarantee of origin, but target accounting is excluded (Art 2 in RED II (2018)). Further information may be found in section 5 on verification methods and in subsequent reports.

3.2 Accounting of Renewable Gases

Renewable gases (especially biomethane and renewable hydrogen) **do not have** their own **RED target sector**. Accordingly, accounting in one of the other sectors is only possible after **conversion**.

The most important demand for **biogas and biomethane** in Germany aims at producing electricity in **combined heat and power plants under the Renewable Energy Sources Act** (EEG, 2021), with a use of the resulting (combined) waste heat. In principle, electricity-based hydrogen gas can also be counted as "storage gas" when converted back into electricity, but so far it has hardly played a role in terms of volume. The renewable gas converted in this way is counted in the **electricity sector** (RES-E) after being fed into the electricity grid (see above). In this way, an industrial enterprise can contribute to the electricity sector by operating a CHP with gas from renewable sources.

In the case of conversion to **heat**, renewable gases can also be accounted: Biomethane can be applied to the obligations of the GEG (2020) under certain conditions (mass balance, high-efficiency CHP). For newly installed combined heat and power plants, a minimum share of 30% biomethane (and at least 50% for condensing boilers) is required. The recognition of biomethane from the gas grid is permitted if mass **balance systems** are used. A primary energy factor (PEF) that is advantageous compared to natural gas is then specified for biomethane verified in this way.

In **heating and cooling distribution** grids, the renewable gases converted into heat can also be used to provide the thermal energy. Here, the contribution of renewable energy fed into the grid is not directly assigned to an individual consumption point. Nevertheless, this contribution improves the PEF for all buildings connected to the grid. For the accounting options for district heating and cooling, see also section 3.3.

Accounting in the **transport sector** (RES-T) for the consumption of renewable gases is an important use case for renewable gases and can easily be implemented in an industrial company with a corresponding **vehicle fleet** (e.g. operated with CNG, or H2): In Germany, the use of renewable fuels such as bio-CNG is specifically enforced via a mandatory greenhouse gas reduction quota (GHG quota in the BimSchG). Both biofuels and fuels of non-biological origin are included in this obligation. The GHG reduction contribution is determined with a GHG balance, for which a **mass balance** is mandatory.

The industrial company may receive the renewable fuels at a favourable price due to the GHG quota. The reason for this is that the distributors of fuels (e.g. mineral oil companies) that apply **renewable gases** (possibly mixed proportionally) can **count** the fossil greenhouse gas emissions saved in this way **towards the quota**. If they exceed this quota, they can sell on the surplus quota shares. In the event that the quota has not been met, they can then purchase the missing quota shares from others to avoid the otherwise due levy of 470 €/t CO_2. Thus, fuelling one's own vehicle fleet can both contribute to the **transport sector** (RES-T) and be economically beneficial.

An industrial company in **ETS monitoring** as well as a fuel applied under the BEHG can positively account **biomass-based renewable gases** such as biomethane in the course of the **zero-rating** of biomass. Here, accounting in the RED and simultaneous accounting in the ETS may be possible if the same amount of gas contributes to the promotion targets for renewable energies on the one hand and avoids fossil CO_2 emissions on the other (more precisely: replaces CO_2 emissions from fossil sources with those from renewable sources). For the recognition of biomethane (a form of biomass), **mass balance** must be carried out in Germany (Deutsche Emissionshandelsstelle (DEHSt) im Umweltbundesamt, 2021). A parallel or alternative applicability of guarantees of origin for the proof of feed-in is being discussed at EU level at the time of reporting.
Hydrogen (both renewable and fossil), unlike methane, does not contain carbon, therefore no CO_2 is emitted locally during combustion. This has an effect in the EU ETS monitoring and equally in the BEHG, so that a replacement of fossil fuels with hydrogen gas is **not measured as a GHG emission**. Proof of H_2 supply is sufficient in this case; a possible (and desirable) renewable origin is not relevant here (Deutsche Emissionshandelsstelle (DEHSt) im Umweltbundesamt, 2021).

The following therefore applies to all companies in ETS monitoring or all fuel supplies in BEHG: if renewable gases such as biomethane or hydrogen are used, the additional costs that would otherwise be incurred for gases from fossil sources can be waived.

Excursus on imported hydrogen: GHG emissions can occur during the **production** of fossil-based hydrogen. If this is done within the EU, any GHG emissions are already recorded in the

ETS monitoring during production and thus make this hydrogen more expensive than hydrogen produced from renewable sources. Since this mechanism does not apply to **imported H_2**, a **cross border adjustment** mechanism (CBAM) is being developed at the time of writing to take this type of GHG emissions into account.

If an industrial company wants to apply renewable gases voluntarily, RED II (2018) enables green gas products by introducing **guarantees of origin for (renewable) gases**. RED II thus harmonises the various national gas GO systems already existing in some member states in the EU, which have arisen so far in the absence of a central regulation.

In Germany, there is already a **market for green gas products**, which, however, has not yet been legally regulated in the absence of the Gas-GO. Suppliers prove the energy mix to their customers using various systems, the best known of which is probably the "certificate model" of the Biogas Register Germany. This voluntary model is similar to the electricity origin labelling model with guarantees of origin and does not claim to fulfil the requirements of a mass balance (Altrock et. al., 2021). With the introduction of regulated gas origin labelling, a central and state-regulated verification system can contribute to the credibility of these products in the future. Companies can support the production of renewable gases and have the origin attributed to them by purchasing green gas products, both now and in the future. Here, however, the background processing in Germany will change in the foreseeable future.

3.3 Accounting of Renewable Heat and Cold

In addition to accounting in the RED, accounting is also possible under the GEG/EPBD. In Germany, the Building Energy Act (GEG) regulates efficiency requirements and the use of renewable energies in buildings. An industrial enterprise that wants to switch its demand for heating or cooling to contribute to the **heating and cooling sector of** RED II (2018) (RES-HC) in an accountable manner has two options for doing so. Both,

- **the use of renewable energy** as well as
- the use of **waste heat or cold** can be accounted.

The accounting of waste heat use is limited to 40 % of the annual increase for the member states in the RED, which places a priority on the expansion of **renewable energies** (Art 23 (2) of RED II (2018)). Renewable heat is taken into account, among other things, if it is supplied directly to the building in question or is generated there, e.g. in a solar thermal system.

If a business obtains **district heating or district cooling via a grid** or similar supply, RED II (2018) obliges grid operating companies to provide information on the average share of renewable energies or waste heat in the total mix of the grid in the future. This obligation was transposed into

German law in September 2021, in the Ordinance on the Implementation of the Requirements for District Heating & Cooling, (Verordnung zur Umsetzung der Vorgaben zu Fernwärme & Fernkälte, FFVAV). Thus, all consumption plants withdraw the same heat/cooling mix from the respective grid and know the respective renewable share of their grid. A possibility for coupling heat supply and verification (reference model B in section 4) of heat through district heating networks (analogously this also applies to cooling) is not provided for in principle in the ENWG (2005), as the conditions here are fundamentally more difficult than in the electricity or gas grid (Schweikardt et. al., 2012). However, a grid connection obligation and feed-in priority for renewable energies or waste heat or cooling is provided for as an option for the member states in RED II (2018), which can still be implemented in the national framework, or in some cases already has been. This means, for example, that an industrial company can feed its waste heat into the district heating network. There, the grid operator has to accept it and thus increase the share of renewable heat/cold or waste heat or cold in the overall mix. The (proportional) feed-in of renewable heat or cooling therefore leads to an improved primary energy factor (PEF). However, this proportionally weighted contribution is not allocated to individual consumers (see above).

RED II (2018) makes it possible to introduce voluntary heat products within the framework of energy disclosure labelling by means of easily transferable guarantees of origin. The further design of the legal framework for green heat products depends on how independent the guarantees of origin can be transferred from the local heating or cooling network. This determines the extent to which final customers can support renewable heat projects outside the boundaries of the respective grid. On the other hand, it also depends on to whom, for example, an industrial company can market guarantees of origin from the feed-in to the heating network and which final customers can thus contribute to the economic operation of this renewable heat production. The market and regulations for heat origin labelling in this country, as in other EU countries, are hardly developed at the time of writing.

3.4 Accounting of Renewable Liquid Fuels

An industrial operation can also contribute to the RED II (2018) expansion targets when using renewable liquid fuels. However, RED II does not have a separate sector for liquid fuels, so contributions from liquid fuel consumption – as with renewable gases, see section 3.2 – can only be counted towards one of the RED sectors after conversion.

The accounting in the **electricity sector** (RES-E) is financially supported via the German (EEG, 2021) as "electricity from biomass", e.g. in the past as vegetable oil combined heat and power units. The conditions for accounting in the context of the EEG are similar to those for renewable gases (section 3.2). For CHP, heat extraction or high-efficiency CHP is mandatory. For the **provision of heat** from liquid fuels, the GEG (§39) stipulates a share of at least 50% for new plants.

In the **RED transport sector** (RES-T), both liquid biofuels and renewable fuels of non-biological origin (RFNBO) can be used. In Germany, the Federal Immission Control Act (BImSchG) regulates the implementation of the sub-targets, with individual ordinances on biofuels (36th BImSchV), on electricity-based fuels (37th BImSchV) and GHG reduction regulations (38th BimSchV). An industrial company can benefit from the GHG reduction quota, e.g. by using this **renewable fuel in its vehicle fleet**. The renewable fuels used in this way allow the quota shares to be accounted or marketed, which makes them competitive with fossil fuels.

In the monitoring of the **EU-ETS (2003) and in the BEHG (2019)**, the use of liquid biofuels can be recognised as climate neutral (**zero-rating**). For a transition period, even fuels with <70% fossil content by weight are excluded from the national emissions trading system until 2022 (Deutsche Emissionshandelsstelle (DEHSt) im Umweltbundesamt, 2021).

In contrast to the previously designated energy sources, there is **no guarantee of origin and no energy origin labelling for liquid fuels**.

3.5 Summary of the Accounting Options

The previous subsections show that there are very different ways in which industrial companies can change their energy consumption so that this has an impact on achieving the RED targets. The options vary greatly depending on the energy source under consideration. Table 3 summarises the energy sources for which the production or consumption of renewable energies can be counted.

Table 3: Accounting options for renewable energies in RED II

	Electricity Sector	Heating/Cooling Sector	Transport Sector
Electricity	Counting of production (e.g. EEG)		Accounting of consumption against minimum share
Gases	Counting of consumption for EEG electricity	Counting of consumption in the GEG	Counting of consumption to GHG quota
Heat/Cold		Counting of production in the GEG	
Liquid Fuel	Counting of consumption for EEG electricity	Counting of consumption in the GEG	Counting of consumption to GHG quota

4 Sourcing Models for Renewable Energy or Renewable Energy Properties

The previous section presented alternatives for companies that want to participate in the transition from fossil energy use to renewable energy use. The following section describes which options – or sourcing models – are available to industry to contribute to the use of **renewable energies**.

First, the two fundamentally different **physical energy sourcing options** are presented. Subsequently, the option to obtain certificates as proof of the renewable energy property is discussed – this option is decoupled from direct physical energy sourcing. It should be emphasised that a distinction must be made between the physical energy source and the verification of the renewable property. The transfer of the renewable property can take place immediately or at the same time as the energy transfer, or it can be linked to the soucring of the energy via a balancing system, or it can also be decoupled from an immediate energy sourcing.

The physical sourcing of energy - regardless of origin - can either be **direct and unmixed** or via a **common grid and transport infrastructure with mixing** of renewable energy and energy from other (possibly fossil) sources. Figure 3 gives examples of the two options.

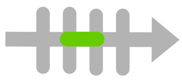
	Direct delivery Unmixed transport possible	**Transport via common grid infrastructure** Mixing with other energy sources
		
Electricity	• Connecting cable • Battery	• Electricity grid
Gas	• Biogas pipeline • Truck with gas pressure tank	• Gas grid
Heat/Cold	• Heat or cold pipeline • Insulating container	• Heating or cooling grid
Liquid Fuels	• Direct pipeline • Trucks, tankers	• Pipeline grid

Figure 3: Examples of physical renewable energy sourcing by energy form

In order to avoid confusion between the physical sourcing of energy and the verification of the renewable energy property, the following section clarifies the basic terminology. The distinction between physically occurring energy sources and the verification of the renewable property may seem trivial, but in detail this becomes a complex concern, e.g. in the case of gases.

A) Direct Sourcing of Renewable Energy

In the case of direct energy sourcing (Figure 4), there is a direct connection between the energy source and the renewable energy property. The transmission of renewable energy between the production facility and the consumption facility is clearly defined **by the interconnector or direct transport by vehicles without mixing with other energy sources**. As a result, quantitative verification of the transferred renewable energy is not required in all cases. Nonetheless, this can be the basis of a contractual agreement, e.g. for the contributions to infrastructure use. This model comes into practice when two companies share a production facility and transfer the renewable energy e.g. via a heat line, power cable or gas pipeline or energy carriers by means of vehicles.

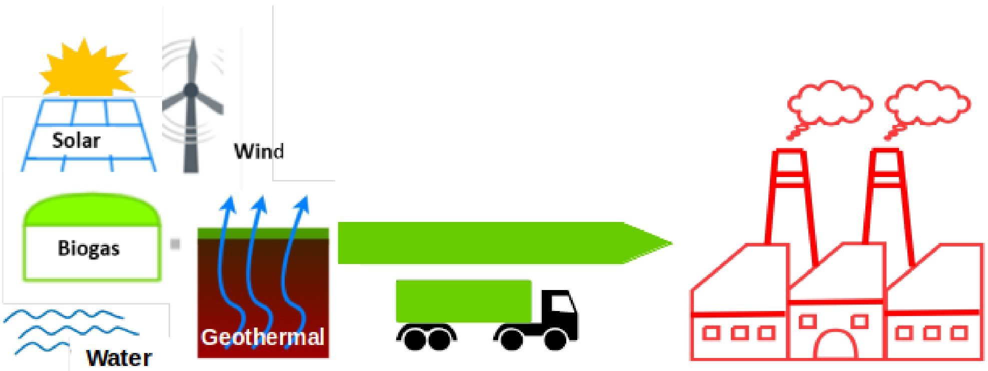


Figure 4: Energy sourcing model A) Direct source of renewable energy

B) Coupling of Energy Delivery and Renewable Property

When energy is sourced from publicly available grids or by means of transport vehicles, there is no longer a direct connection between energy source and the renewable energy property, as a **mixture of energies from different sources** can take place (Figure 5). In this case, only a **fictitious or on-balance-sheet delivery is feasible**. By balancing the energy shares (renewable/non-renewable), a **coupling of the renewable properties to the supplied energy carrier** takes place. The RED II (2018) therefore limits the fiction of such a supply to a shared infrastructure with the introduction of mass balance systems and/or the definition of an electricity supply according to RED II (2018) Art 27 (3) (Section 5).

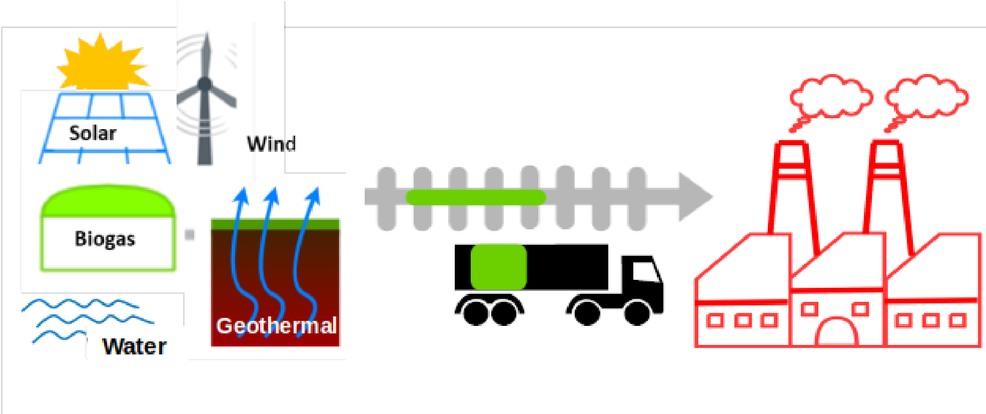


Figure 5: Energy sourcing model B) Coupling of energy delivery and RE properties

C) Decoupling of Energy Delivery and Renewable Property

However, there is also the alternative for companies to acquire **certificates** as proof of renewable energy property and thus support the use of renewable energy **independently of a direct physical energy purchase** (figure 6). The decisive factor here, however, is that the energy demand must generally be present in the company and that certificates are acquired precisely for this demand. For this purpose, a certificate is issued at the production plant and assigned to the consuming company. Here, the actual energy transport is abstracted and the renewable property is transferred independently of a direct energy flow between the production plant and the consuming company with the use of a book & claim system. The most important practical example of this model is the liberalised electricity supply within the European internal market, within which green electricity products are offered with guarantees of origin.

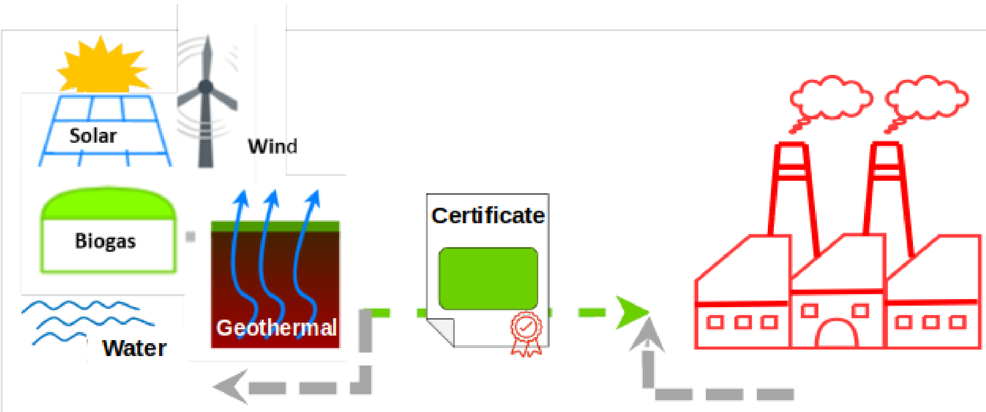


Figure 6: Energy sourcing model C) Decoupling of energy delivery and renewable property

The models described above represent different variants with regard to the connection between the renewable energy property and the coupling to or decoupling from the physical energy reference and thus also require different verification methods:

- **Reference model A)**:
  Directly supplied energy sources **inseparably** include the renewable properties of the production facility. Both are transmitted together.
- **Reference model B)**:
  In the coupling of energy and property, the renewable property **remains notionally coupled** to the energy carrier during physical mixing. When a corresponding quantity of energy is withdrawn from the mixture, this property is transferred to this quantity in the balance sheet. The property is then transferred to the consumption installation together with this energy supply.
- **Reference model C)**:
  With a **book & claim** procedure, the property is transferred to the consumption facility by simple **virtual allocation** of the certificate ("invalidation").

Table 4 compares the three reference models.

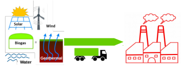
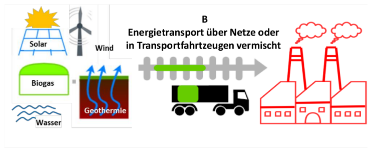
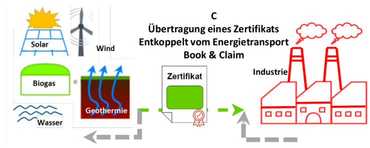
5 Verification Methods for Renewable Energies

Section 3 described to which targets the use of renewable energy can be accounted. Based on this, three fundamental reference models were presented in section 4. In the following section, the **verification methods** are described in more detail and **classified in the sourcing models**. This gives an overview and helps to better distinguish and classify the forms of reference. The following **verification methods** are described:

- Verification of direct sourcing
- Mass balancing
- Recognition of renewable electricity from the grid according to Art 27 (3) RED II (2018)
- Guarantees of origin for energy disclosure for final consumers.

The primary energy factor calculation as a possibility to allocate renewable heat contributions by means of an energy performance indicator is also briefly considered. Table 5 provides an overview of the assignment of the verification methods to the reference models described in section 4.

Table 4: Comparison of the sourcing models

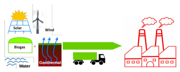
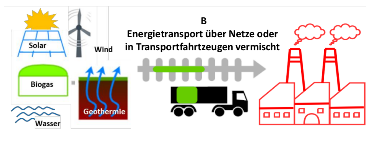
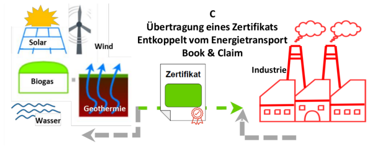
Direct Sourcing of Renewable Energy	Coupling of Energy Delivery and Renewable Property	Decoupling of Energy Delivery and Renewable Property
		
Direct connection from the production to the consumption plant.	Transport of renewable energy from production to consumption plant, via a common infrastructure, fed with energy from different sources.	Transfer of the renewable property by book & claim certificate from the production plant to the energy consumer or supplier. Production facility to energy consumers or suppliers. A physical transport connection is not required.
Mixing with energy from other energy sources is impossible.	Physical mixing with other Energy carriers during transport.	Abstraction from energy carrier transport. Consumption of grey energy (local mix).
The renewable property is inseparable from the energy and is delivered directly with it.	The renewable property is transported fictitiously or on balance together with the energy carrier.	The renewable property is separated from the energy carrier and transferred to the certificate.

5.1 Verification of Direct Sourcing

Under the assumption that the consumption is covered by a directly connected plant (reference model A, section 4), the verification maps the respective plant configuration. For third parties, this makes it comprehensible that the total output can only be renewable energy. If necessary, individual input flows or energy flows within the overall plant may still be desprибed or measured in order to fulfil further criteria for recognition. The balance sheet drawn up via this system essentially depicts material and energy flows.

The contribution of renewable energy from a direct connection may be apparent without proof of the energy source supplied. For example, in the case of a solar thermal system, it may be sufficient to submit a system plan without later measuring the amount of energy generated by it. However, if the amount of energy has to be quantified, e.g. for the calculation of subsidy payments,

Table 5: Verification methods for renewable energy

Direct Sourcing of Renewable energy	**Coupling of Energy Delivery and Renewable Property**	**Decoupling from Energy Delivery and Renewable Property**
		
■ Proof may not be required ■ Meter verification ■ Audit (external)	■ Mass balance ■ Verification for electricity according to Art 27 (3) of RED II ■ Coupled guarantees of origin	■ Guarantees of origin ■ Voluntary certificate systems e.g. for biomethane

meter measurement and meter reading is necessary. A meter will also be required by default if another company supplies and bills the energy, e.g. as waste heat. Depending on the situation, an external audit with a plant inspection may also be necessary. An external audit is, for example, required in the EEG for biomass deliveries to the operator of the fermenters. An external audit may also be necessary for the proof of sustainability for direct sourcing.

A special case of direct procurement is the self-consumption of a production plant: In this case, part of the generated energy is consumed by the plant itself as part of the production process, e.g. when operating a converter with the plant's solar power or heating the feedwater separator of a biogas plant with the biogas produced in it. The amount of energy is usually not measured or even marketed, so no certificates are issued for these quantities. When calculating the total output, the net energy output of the electricity generation plant is used, minus the auxiliary energy input. If auxiliary energy is sourced from the grid, this is accounted for as an input.

5.2 Mass Balancing

With the help of mass balancing according to Art 30 of RED II (2018), the transport of **biomass** (e.g. as renewable gas or liquid fuel) is made **traceable to its origin**. In this system, mixing with raw materials or fuels from other origins is facilitated in the shared transport system. Under the mass balance system, an input-output balance is made on the amount of energy or substance, i.e. the amount **taken out (output)** is balanced against an **added amount (input)**. The amount of energy is then fictitiously assumed to be equal to the amount of energy removed (output). When applying the balancing rules, it is then fictitiously assumed that the quantity of energy taken out corresponds to the quantity added. A mass balance extends from original production to consumption and allows for mixing, processing and transport with other substances and energy carriers. The mass balance method thus maps the **transport of energy carriers** or substances (reference model B, see section 4). It is not a direct tracking of the physical energy flow, but a balancing of the masses.

Mass balance systems were already introduced in RED I (2009) to monitor that (also imported) fuels comply with European **sustainability criteria** (van de Staaij et. al., 2012). In RED II (2018), the application of mass balance systems was further stipulated in Art 30 and the scope of application was expanded to include the monitoring of minimum GHG savings. In addition, it is clarified that mass balancing as a method ensures that an amount of energy is only **simply counted towards the national RED targets**. Important to understand: In contrast to the national targets, multiple accounting via multipliers is permitted for the sub-targets in the transport sector, e.g. for advanced biofuels (section 3.1).

The monitoring of sustainability criteria becomes particularly complex if the country of production has a different understanding of sustainability than the RED. This applies, for example, to biodiesel that is delivered over long distances from Asia to Germany. In this case, voluntary systems are used:
Mass balance systems can be organised by **member states** ("national mass balance schemes") and by the **private sector ("voluntary mass balance systems")**. The requirements for this are defined in Art 30 RED II (2018) (or Art 18 RED I (2009)). The EU Commission regularly publishes the voluntary schemes recognised in accordance with these requirements (Europäische Kommission, 2021). Voluntary systems enable market participants to demonstrate sustainability criteria, e.g. according to the rules of the RED, even if no government regulations ensure reliable monitoring for this in the country of origin concerned. In addition, **mass balancing** across the **entire value chain**, including all conversion steps, **is prescribed** for calculating the minimum GHG requirements. This balancing can be a complex undertaking, which the voluntary systems can then solve.

The voluntary nature of these systems means that the same plant operator can have his production processes certified according to the rules of **several different systems** at the same time. This may allow **multiple registration** of the same quantity, which can be exploited fraudulently. In practice, this danger is minimised if the same certification body certifies according to all systems, or if the certification bodies involved align their findings. In future, the EU-wide **Union database** is to fill this gap.

Sustainability certificates for biofuels are managed in Germany in the **Nachhaltige Biomasse System ("Sustainable Biomass System", "nabisy",** nabisy.ble.de) of the Federal Agency for Agriculture and Food. In this register, biofuel quantities have been recorded along the entire value chain since 2013 and thus made traceable. The basis for registration are audit reports of the voluntary systems, which confirm compliance with the sustainability criteria in (agricultural) production. Furthermore, the greenhouse gas balance is important, which is made in accordance with the RED requirements over the entire life cycle. Registration in nabisy is a prerequisite for the recognition of an energy supply as a renewable fuel (RES-T) at the quota office of the German customs office within the framework of the 38th BimSchV.

The German Renewable Energy Sources Act (EEG, 2021), the Energy in Buildings Act ((GEG, 2020)) and the Fuel Emissions Trading Act (BEHG, 2019) contain each a **national mass balance definition** for **biomethane in the natural gas grid**. According to this, biomethane can be fictitiously routed through the natural gas grid if (private) mass balance systems are used in the process according to the definition of the Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (2012). So-called "independent databases" prove compliance with certain criteria at the production plant. The largest of these voluntary systems is the Biogas Register Germany (www.biogasregister.de) of the Deutsche Energie-Agentur GmbH. It was established in 2010 in cooperation with 14 companies from the biomethane sector and covers most of the German production of renewable gases. Every year, around 10 TWH of renewable gas production are registered, together with the criteria recorded in audit reports. The main application is verification for the Renewable Energy Sources Act (EEG, 2021). Other recognitions, e.g. ETS, take place to a limited extent (dena, 2020). The Biogas Register Germany has entered into bilateral cooperation agreements for the exchange of book & claim certificates for biomethane with several registers in Europe: with the Austrian biogas register of Austrian Gas Clearing and Settlement AG (AGCS), with the Danish biogas register of Energinet and with the UK register Green Gas Certification Scheme of Renewable Energy Assurance Limited.

In addition to the Biogas Register Germany, there is also e.g. the **BiMaS** (Biomethane Mass Balance System, www.green-navigation.de) of Green Navigation GmbH. In the case of simple 1:1 relationships between production & consumption plant, the mass balance can be done e.g. via an environmental audit.

5.3 Verification for Renewable Electricity According to Art 27 (3) RED II

For sourcing of **electricity for electro-mobility** or for the **production of H2 or synthetic fuels**, Art. 27 (3) of RED II (2018) formulates requirements for the proof of renewable electricity to be accounted when transported through the electricity grid. The framework leaves many details open, which will be further defined in a delegated act at the time of writing. In order for a **quantity of electricity** to be recognised **as fully renewable when it is withdrawn from the electricity grid**, these four criteria are specified as prerequisites (Europäische Kommission, 2020):

- **Supply contract for electricity**:
  The supply of a quantity of electricity must be contractually agreed, e.g. via a Power Purchase Agreement (PPA).
- **Simultaneity**:
  electricity production & consumption occurred simultaneously
- **Geographical correlation**:
  Production & consumption are close to each other from an electricity grid perspective, i.e. “on the same side in respect of congestion" in the grid.
- **Additionally**:
  Demand contributes additionally to the use or financing of renewable energy.

The electricity grid is thus understood as a grid with transport capacities and bottlenecks. Regardless of the actual flow of electrons, this proof states that **this specific amount of electricity** may have flowed through the grid from the production plant to the consumption plant at this time. In this way, the amount of electricity supplied is coupled with the renewable property, and thus a **fictitious supply of electricity** by the grid is mapped (reference model B, section 4).

5.4 Guarantees of Origin

The guarantee of origin system according to Art 19 of RED II (2018) (or Art 15 of RED I (2009)) is a **simplified verification procedure**. It was created as a uniform EU-wide **consumer protection instrument** in order to be able to allocate renewable properties to final consumers supplied via the electricity grid. This serves as a basis for triggering demand impulses for the balanced supply of green electricity. This enables final consumers to financially support the production of renewable energies in a targeted manner. Guarantees of origin are not intended for use in the RED target accounting of the EU member states, although an application within the framework of the subtargets in the transport sector is conceivable (Hoffmann, 2020). The guarantee of origin is freely tradable within the EU internal market for electricity (EU 2019/944, 2019).

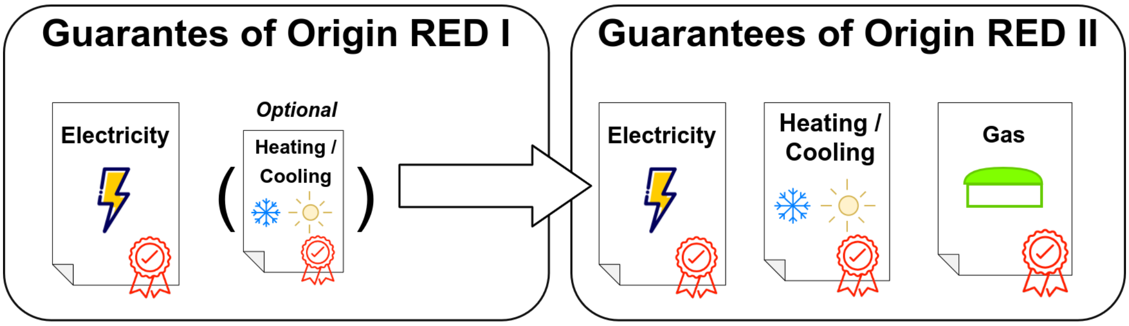


Figure 7: Guarantees of origin in RED I and RED II
RED I contained requirements for guarantees of origin for electricity and an option for heating/cooling GOs. RED II made guarantees of origin for heating and cooling mandatory and introduced guarantees of origin for gas.

RED I (2009) initially introduced guarantees of origin for electricity for the entire EU. In addition, it contained an option to introduce guarantees of origin for heating and cooling, which the member states could each introduce on their own. With RED II (2018), heating/cooling GOs were made mandatory for all member states. In addition, RED II introduced guarantees of origin for renewable gases (including hydrogen) also for the entire EU. Figure 7 visualises this development.

Guarantees of origin are issued, transferred and cancelled according to the **'book & claim' principle**:

1. **Book**: A production plant generates renewable energy, for which a guarantee of origin is issued. The energy itself is marketed as grey energy.
2. **Claim**: A consumption facility obtains energy from a local mix. According to the amount of energy consumed from the energy supply, the supplier invalidates guarantees of origin of the production facility. This allows the electricity to be claimed as renewable regardless of the local electricity mix, e.g. as 100% solar power.

This method abstracts from the **transport of energy** in the electricity grid from here, which **does not necessarily have to be physically possible**. The marketing of the energy and the renewable property takes place separately or **decoupled,** here. In this way, electricity generated or consumed in an island grid or at different times can also be marketed, for example. The guarantees of origin are valid for 12 months -- they expire after 18 months at the latest (Art. 19, RED II (2018)). More details can be found in report G2 (Styles et. al., 2021). At the EU level, the Electricity Directive ensures uniform electricity labelling regulations within the EU. Despite the uniform EU-wide framework, GOs have in some cases a quite different status in the marketing of renewable energies in the different countries. The EN 16325 standard is the exchange standard for GOs in the European framework. This standard is currently being revised.

An important contribution to the **credibility** of the products based on guarantees of origin is the verification system, which is **centrally monitored by the member states**. Especially a certificate-based system needs a trustworthy administration to ensure fraud-proof marketing.

Guarantees of origin for electricity are issued and managed centrally in Germany in the **Federal Environment Agency's Guarantees of Origin Register** (HKNR, www.hknr.de). Since the beginning of 2013, it has formed the basis for final customers in Germany to identify electricity that was not subsidised in production under the Renewable Energy Sources Act. Guarantees of origin are issued at the request of the company producing the renewable energy. Afterwards, the respective production and energy supply companies carry out a transfer and cancellation of the certificates within the register. Imports and exports of certificates within the EU (and contracting states) are also processed via the HKNR. For international transfers, the HKNR is connected to the registry node operated by the AiB.

With **optionally coupled guarantees of origin** according to §16 of the HKNRDV (2018), producers and suppliers can voluntarily prove that electricity was delivered in addition to the **transmission** of the guarantees of origin. A transmission of electricity in the **corresponding electricity grid balancing groups is mandatory** here. The coupling is limited to direct deliveries between producer and supplier. Report G2 (Styles et. al., 2021) elaborates this in more detail.

The regular guarantees of origin according to Art 19 of RED II (2018) represent a book & claim system that covers the entire EU internal market. The optional coupling and the regional guarantee supplement this guarantee with a link between renewable property and energy (each with its own focus). The German register of guarantees of origin has established the **regional guarantee** (§18ff, HKNRDV (2018)) explicitly for EEG installations as an additional function. Thus, for these plants it is ensured that the cancellation of a regional certificate marketed with the attribute "regional" remains limited to the respective region. Regional certificates can only be cancelled within a **radius of 50 km** around the postcode area of the **production plant**. The regional certificate thus represents a delivery from an EEG plant from the production plant to the supplier.

5.5 Primary Energy Factor

In the German GEG (2020), the primary energy demand is an important element in the assessment of a building. The contribution of a **heat supply** through a district **heating network** is calculated with the help of the **primary energy factor**. The respective primary energy factor is always related to the respective heat network or to the energy carrier, a connection between energy carrier and renewable property is thus given. However, this is always averaged over a longer period (calendar year/billing period) and over an entire grid. It is therefore not possible to allocate the contribution of a production plant to a specific consumer or consumption plant. Therefore, the

PEF is not a proof of transmission of renewable properties and cannot be classified under any of the reference models in section 4. Instead, the PEF has the quality of an energy indicator.

5.6 Other Certificate Systems

In addition to guarantees of origin, there are other **systems with tradable certificates** in the context of **renewable energies and climate protection**. These are downstream of the actual target accounting of the respective instrument and enable a **flexible allocation** of quotas or obligations between economic participants. According to theory, this free allocation of obligations enables an economically efficient localisation of target achievement within the framework of the markets thus created. The systems mentioned below are briefly described here as examples, but are not investigated further within the scope of this project.

- **Trading of EU Emission Allowances (EUAs) in the ETS**: While the emission of greenhouse gases is monitored in the ETS monitoring on a plant-specific basis, the entitlement to the respective GHG emission can be traded flexibly. An industrial company thus has the choice of reducing emissions through its own measures (e.g. increasing efficiency) or purchasing additionally required EUAs. On the other hand, it may work to finance an efficiency measure by selling the equivalent number of EUAs that are no longer required.
- Within the framework of the greenhouse gas reduction quota, **GHG quota** shares are calculated from the GHG savings of the renewable fuel quantities sold, which in turn are freely tradable according to a certificate principle. In this way, a mineral oil company has the choice of either acquiring quota credits or generating its own by applying renewable fuels and marketing the credits.

In addition to the variants described, other tracking methods can also be agreed in private-sector contracts. These are referred to with the term "contract-based tracking" and can also be operated with distributed ledger technologies (e.g. blockchain). They are not subject to state supervision, which makes them prone to double marketing.

5.7 Preliminary Conclusion, Challenges in the Conversion of Energy Sources

In summary, it can be stated that several verification methods exist in parallel for all the energy sources considered. The verification of a direct delivery as a trivial form of verification is an integral part of the verification process for all energy sources and forms of accounting. In the case of electricity and gas, since RED II (2018) there have been both, verification methods that aim to couple energy carrier to the proof, and the guarantee of origin system, which is based on a certificate system according to the book & claim principle. For the energy carrier heating/cooling, the certificate-based guarantees of origin are now available EU-wide. A form of verification that couples transport of heat or cooling to a verification is not provided for in RED II (2018); although the primary energy factor allows contributions from the production of renewable energies to be accounted, it is not a form of verification for the transfer of renewable energies or properties. In the case of liquid fuels, only a coupling of verification and delivery has been established so far; a book & claim form of verification does not exist.

Figure 8 shows an overview of the verification methods described so far. It is highlighted which proofs have been added in RED II (2018) compared to RED I (2009) (Art 27 (3) for electricity and guarantees of origin for gases).

In addition to the transmission between production plant and consumption, there is also the possibility that energy carriers are **converted**. Under the keyword "**sector coupling**", there is intensive discussion about the role that conversions of energy carriers can take in the context of an energy system of the future. In terms of verification, such a conversion requires that the renewable property is attributed to the end product beyond the **conversion** step so that the **end product can be accounted**. If the end product of the conversion is to be counted as renewable energy towards one of the legal targets, e.g. in the RED, corresponding minimum requirements are formulated in the laws (see section 3) and in some cases verification methods are prescribed (see section 5).

In the **conversion of energy carriers**, there are special challenges for **verification systems**, which this subsection addresses. Report GO4Industry report G4 (Sakhel and Styles, 2021) of the fundamental section addresses the use of the vaguely defined term "sector coupling" and presents the legal background of accounting in more detail. There are many **different conversion technologies** in use as part of the Energiewende and more are currently becoming established. Table 6 on page 38 provides an overview of possible conversions of the renewable energy sources under consideration and gives terms and examples of them.

Whenever an **energy carrier conversion is carried out from a direct source** (reference model A) section 4), the transfer of properties can be **accounted for together with the input and output flows**. Then the renewable property is assigned to one of the output (energy) flows and, if necessary, conversion losses or emissions are taken into account in the balance. These calculations, some of which are quite extensive, can be verified for third parties by means of an audit.

If, on the other hand, a **conversion step** takes place separately from production or consumption, the **energy carrier is transported via an infrastructure**, e.g. via the public gas or electricity grid. In this case, one challenge is to prove the transport of the energy carrier between the production, conversion and consumption plant. For this, a coupling of energy carrier and verification is necessary (reference model B, section 4), especially since a mixing with other energy carriers takes

Table 6: Terms and examples of conversion technologies for renewable energy sources
Joint presentation GreenGasAdvisors and Hamburg Institute

Conversion from ⇒ to ⇓	Electricity	Gas	Heat/Cold	Liquid fuels
Electricity		**Power-to-gas** Generation of hydrogen by means of electrolysis, possibly with methanation	**Power-to-Heat/-Cold** Heat recovery by means of heat pump, electric boiler or heating element; Cooling by means of reversible heat pump, compression refrigeration machine	**Power-to-Liquid** Production of synthetic liquid fuels (e.g. methanol) by means of electrolysis/synthetic gas production and subsequent liquefaction (e.g. Fischer-Tropsch/alcohol/methanol synthesis).
Gas	**Gas-fired power generation** (Block) (heating) power plant; PtG reverse power generation	**Methane ⇔ H_2** Methanation, steam reforming	**Heat/cold recovery** in a (block) heating (power) plant, heat pump, thermal refrigerating machine	**Gas liquefaction** of synthetic or biogas by means of various processes (e.g. Fischer-Tropsch/alcohol/methanol synthesis, etc.)
Heat/Cold	**Power generation from heat** from geothermal energy or solar thermal energy by means of heat recovery, by turbine/generator, in combined heat and power plant (with Stirling engine)		**Temperature increase** exergetic upgrading of heat by means of heat pump, solar thermal, etc.	
Liquid fuels	**Conversion of liquid fuels to electricity** in a vegetable oil CHP; PtL reconversion		**Heat/cold generation** Vegetable oil CHP, boiler	

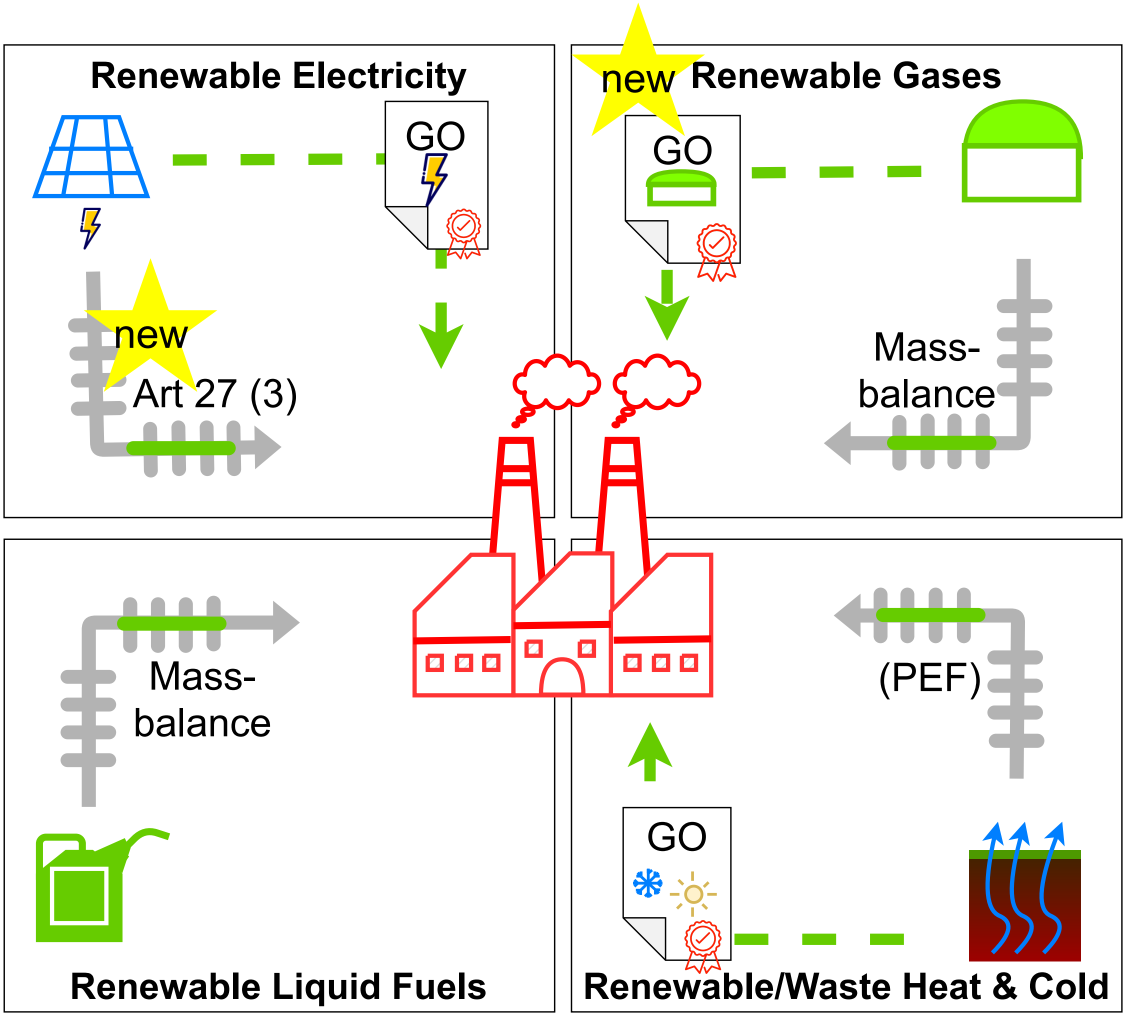


Figure 8: Verification methods of the energy forms for energy deliveries.
Direct deliveries are possible for all forms of energy. Innovations in RED II are marked with an asterisk.

place. These transport verifications are then used in further balancing, if necessary. A sequence of several conversion and transport processes may require a chain of several verification steps and the use of different verification systems.

Another challenge is that **certain renewable properties** may need **to be reassessed** in the course of conversion and transport. Some of the possible properties remain unchanged in a possible transfer, while others change. The **permanent properties** include in particular:

- the energy source
- the plant of origin and

- the production period.

Additional criteria, e.g. compliance with sustainability criteria in the production of biomass, also remain unchanged in the case of conversion.

Changes to the properties due to an energy carrier conversion must be taken into account, e.g.

- If energy consumption or GHG emissions of the conversion are considered in a GHG accounting
- when conversion losses are recognised, or
- if criteria relating to the conversion facility itself are to be demonstrated.

For these variable properties, recorded properties may have to be changed or additional evidence be provided in an intermediate step. This may require a separate audit for the conversion plant.

6 Comparison of Verification Methods

In the previous sections, verification systems were distinguished and classified according to their application. This section compares the verification methods described. The Report G2 Styles et. al. (2021) adds to this analysis by elaborating to what extent the role of the guarantee of origin system can be expanded.

For the various actors involved in renewable energy verification, different issues are important. This section compares the verification systems regarding the following requirements:

- **EU member states**
  For the EU member states and their institutions, the correct **creditability** to their own targets is central. In addition, a high degree of **accuracy** is required, as the evidence may justify payments from public budgets. As the expansion of renewable energies continues, **integration** into the transport system has become an increasingly important issue.
- **Private final consumers**
  For private final consumers, the focus is on a **high degree of freedom of choice** and the possibility to define their own criteria. It is also important that the final consumer **is not burdened with any administrative work**.
- **Industrial companies**
  Industrial companies are often globally integrated and therefore require a global scope for their energy sourcing. A certain amount of **administrative effort** in the verification process is accepted if an incentivised or stipulated **accountability** is achieved. Depending on the situation, further requirements may cover verification of **additional criteria**, a **broader choice** or for **system-integrated forms of verification**.

In the following, the verification systems are classified and compared on the basis of the requirements described. Table 7 provides an overview of what is described in detail in the following subsections.

Table 7: Overview on the performance of verification methods

Verification method	Accountable in RED II	Admin. Effort	Unit of measurement	Balance period	Geograph. Range	Transport system integration	Freedom of choice
Direct source	Yes	low	None	None	local	not required	None
Mass Balancing	Yes	high	as delivery	„appropriate" / 3-12 months	Worldwide	Network connection / transport vehicles	limited
Art 27 (3)	Yes	predictably high	kWh	very short / 1 h	Regional	Power grid	limited
PEF		high	–	Year	local	Heat transport	limited
Guarantees of Origin	None	low	MWh	expiry after 18 months	third countries with agreement	detached	high

6.1 Target Accounting in RED

The verification systems differ greatly in the role they play in relation to the achievement of national targets in the RED.

In the case of **direct energy** sourcing, the structure of the plant in particular can be used to determine whether the energy generated from it can be recognised as renewable within the meaning of the RED. If necessary, further criteria, e.g. on the sustainability of the substrates used or on greenhouse gas balances, must be taken into account. Directly sourced renewable energy **can usually be counted towards national targets without further requirements** on the verification system.

If energy carriers from renewable sources are to be accounted **after a transport, a coupling of energy carrier and verification is required**. Thus, for biomass, e.g. in the form of biomethane or renewable liquid fuels, **creditability** can be ensured with a **mass balance system**. For a recognition of renewable electricity transported through the public grid in the transport sector, the application of the extended criteria according to **Art 27 (3) of RED II (2018)** are provided for. This applies to the production of electricity-based fuels.

The **guarantees of origin** according to Art. 19 RED II (2018) have no function for the national contributions of the member states to the overall RED target according to the definition in Art. 19 (2). Therefore, **no RED target accounting can take place on the basis of a GO cancellation**. The cancellation of guarantees of origin to achieve national quotas and support systems is not directly ruled out in legislation. Nevertheless, from the point of view of a member state, it makes little sense if the renewable energies promoted in this way are not counted towards its own target achievement.

The RED provides for two different concepts of how **target accounting and GO issuance** can intertwine: On the one hand, GOs can help to operate renewable energy plants economically **outside of state support**. This already works today in some niches where the revenues from energy and GOs are sufficient for operation. On the other hand, some member states use guarantees of origin to **relieve the financial burden on their state support systems**. Then, for example, a feed-in tariff is calculated in such a way that it only becomes economical together with GO marketing. In tenders, marketing of GOs can also be allowed, which can then lower the price of the bids accordingly. The **guarantees of origin can be distinguished by a defined characteristic** which indicates whether the production has received state support or not. This results in different products and price levels.

6.2 Administrative Effort

The administrative effort required for the actors involved in the verification process varies greatly between the verification methods. The background is explained below and visualised in Figure 9:

In the case of **direct delivery** of energy quantities, the effort for recording and further verification is minimal and may even **be omitted** altogether. In some cases, plants must fulfil further criteria,

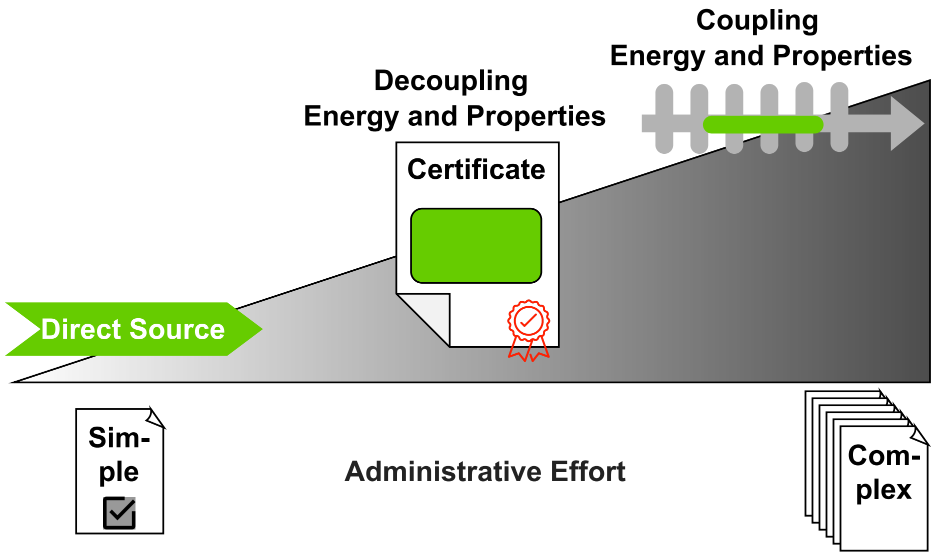


Figure 9: Verification systems performance vs. administrative effort

which can then be verified, for example, by external audits. For **energy labelling**, e.g. of green electricity products, the verification process is kept **very simplified** (book & claim, see subsection 5.4) A production facility receives guarantees of origin for the energy produced there (which has been marketed as "grey"). An energy supply company cancels the required quantity of guarantees of origin for all its customers. An allocation to an individual final consumer or even a consumption facility is not necessary. The cancellation is carried out independently of the physical energy transport and the time of consumption. As a rule, final customers are only informed about the for associated energy sources in their energy bill.

Comparatively complex is the verification of the coupling of energy carrier and verification for energy deliveries that are **transported in the public supply grid** or in comparable systems, such as mass balancing or electricity verification according to Art 27 (3) RED II (2018). The energy delivery is (fictitiously) tracked through the energy system and an individual allocation to a consumption facility is made. Mixing with energy flows from other sources and with different properties means that every transmission, every conversion and every transfer must be contractually documented and, if necessary, balanced.

6.3 Accuracy

The verification systems differ in terms of their accuracy, in terms of their accounting periods and in terms of the requirement for measurement accuracy (Figure 10).

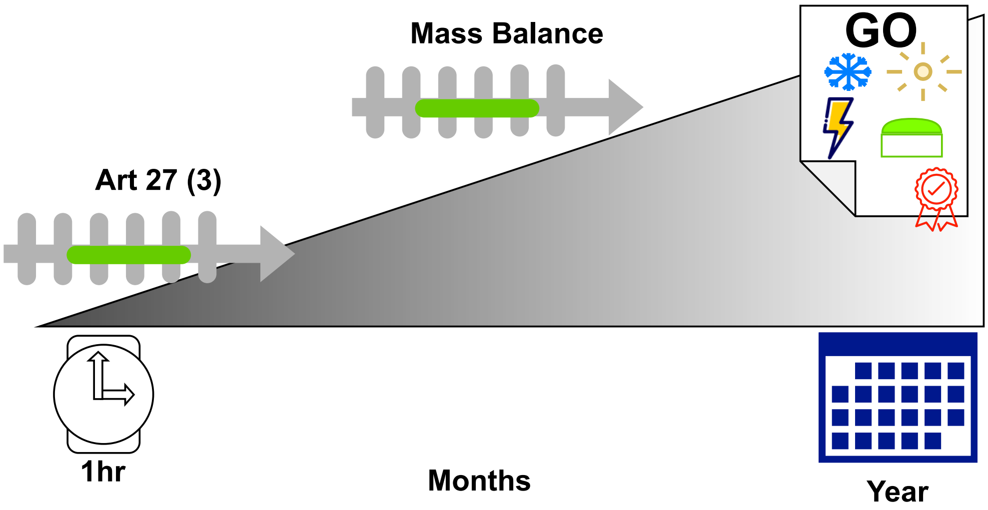


Figure 10: Balancing periods of verification systems

For **guarantees of origin**, Art 19 of the RED II (2018) provides for a lifetime of 12 months from the production of the energy unit concerned. Member States shall ensure that all guarantees of origin which have not been cancelled lose their validity no later than 18 months after the production of the energy unit. Member States may take cancelled guarantees of origin into account when calculating their residual energy. An extension of 18 months is allowed for the cancellation and allocation of guarantees (see HKNRDV (2018), Art. 30).

Guarantees of origin are issued in the standardised unit of 1 MWh. A subdivision into smaller units is not provided for, even if, for example, billing is done in kWh. The invalidation of guarantees of origin for final consumers is carried out in summary for all deliveries of a supplier, e.g. within the framework of a green electricity product. This simplified verification enables the system to be used even if individual consumption is less than 1 MWh.

For transported biomass that is to be verified with **mass balance systems**, the accounting period in RED II (2018) is vaguely specified as "**within a reasonable period of time**". Since the verification can only be transferred together with a defined delivery, the lifetime of the verification is closely related to the conclusion of the delivery itself. In principle, such proof could be valid for any length of time, e.g. if a delivery of liquid biofuels is stored in a tank for a correspondingly long time. In practice, biofuels in the voluntary mass balance systems are subject to **verification periods of 3 months** within which a fuel has to be placed on the market. For a mass balance of biomethane, a generous period of **one calendar year** is defined in the German legal framework, including a possibility to carry over a share into the following year.

Evidence for an **electricity supply** according to Art 27 (3) of the RED II (2018) shall, among other things, prove the "temporal correlation". The details are still being worked out at the time of writing. First drafts provide for an immediate use of these proofs within a rather **short balancing period of 1 calendar hour**. This means that a rather short lifetime of the verification can be assumed.

The verification systems for transported energy **use** the respective **measured and billed energy unit** of production or delivery as the unit of measurement. The unit used here is what is used as the billing unit between the parties. In the case of a direct delivery, the energy delivery is determined by **simple metering**, if applicable. Deliveries through the public transport network (including the gas/electricity network) can be **verified with the meters** and **measurement units** used by the network operator, in accordance with the uniformly regulated market throughout Europe. For example, for a delivery of electricity or gas **through the public grid**, the **kWh is the unit of measurement**. For deliveries of liquid fuels, a m^3 or other quantities may be used instead as the unit of measurement of the verification system.

6.4 Geographical Range

The verification methods to be investigated vary in their suitability for bridging geographical distances between production and consumption facilities: they are presented in table 8 as an overview.

Table 8: Geographical range of the verification methods

Verification Method	Geographical range
Direct delivery	Local
Mass balance	Transport grid related: Europe Voluntary systems: Worldwide
Verification of electricity according to Art 27(3)	Power grid (referring to grid congestion/price zone)
Guarantee of origin according to Art. 19	EU + Third countries with agreement

In the case of **direct deliveries**, the delivery and thus the possible verification is very narrowly limited in its range by the direct connection, e.g. by the power cable from the solar cell to the consumption system. Similar to direct deliveries, heat deliveries are also geographically limited in their range due to the dimensions of their heat network or their heat supply.

Mass balancing maps the transport of the amount of energy or substance, respectively. Accordingly, the range depends on the transport routes of the form of energy. For the voluntary systems, mass balance certificates for **global trade chains** are common. Based on these certificates, vegetable oils, for example, can also be imported from outside Europe and accounted for within Europe.

Mass balance certificates for biomass (e.g. biomethane) that represent a transport via the public supply network, Germany and other Member States use the possibility to define their own mass balance term. In this case, the transferability strongly depends on the respective national regulations of the target country. This text confines itself to the statement that such transfers are possible in principle throughout Europe, but often require special solutions.

For **electricity** verified under **Art 27 (3) RED II (2018)**, a "**geographical correlation**" between production and consumption must be demonstrated. What this means exactly is still being worked out. The RED II already specifies as a framework that it will be more of a **regional scope**. The decisive factors here are possible network bottlenecks and possibly also price zone boundaries in the electricity market area within which the electricity certificate may be transmitted.

Guarantees of origin according to Art 19 of RED II (2018) can be issued for production **within the EU and its contracting states**. They are then transferable without restriction within this area. As things stand at present, this includes not only the EU-27 but also the signatory states Norway and Iceland. The United Kingdom (UK) dropped out with Brexit and Switzerland has also no longer participated in this market since 2020 (European Commission 2020). A readmission or inclusion of further states is possible after a corresponding contract has been concluded. Due to the decoupling of the guarantees from the energy supply, there is in principle no reason why guarantees of origin outside the area should not be invalidated. However, this possibility is not considered further in this project.

6.5 Integration into the Transport System

The degree of coupling of the certificates to the energy carriers reflects a different degree of integration in the handling of the physical transport system used in the transmission of the energy or renewable property. This is also expressed in the extent to which transport losses on the path between the production and consumption facility are taken into account. The extent of losses on the way through the energy system can be considerable in some cases and have a large and varied impact.

Examples are:

- **Transport losses**
  Biomethane emissions (gaseous methane) have a significant negative impact on climate. Heating/cooling networks have losses when transmitted over long distances due to the loss of thermal energy (heat/cold input into the environment) as well as for operationg pumps.
- **Conversion losses**
  When producing H_2 from electricity, a considerable amount of the original energy is lost due

to the process.

- **Storage losses**
  The process of charging an energy storage device, maintaining the charge and returning the energy is subject to losses. This applies to all storage systems, but the losses vary depending on the storage technology.

Depending on the verification system used, these losses may or may not be taken into account.

In the case of a **direct connection** between the RE production plant and the conversion unit, the energy system is not further used. Therefore, measurement and proof of the amount of energy originally produced is not essential for recognition (see section 4). Occurring **losses** due to storage, conversion or transport are part of the production process. They are included **in an economic balance sheet**, and thus may have an effect on the economic efficiency of the plant, but do not play a role in the verification.

One example is the on-site electricity generation of biogas for the EEG, where only the electricity production is measured and verified. The efficiency of the internal transport, storage and conversion processes within the plant is not taken into account, for example, when calculating the EEG remuneration.

When energy is **fed into a public grid**, the feeder receives the right to withdraw a corresponding amount of energy. Any grid-related losses are allocated to grid operation, but not to energy supply. As a rule, the **grid operator pays for these losses** and, if necessary, passes the costs on to all users of the grid via grid charges. When verification is coupled to the **transported energy**, each transformation must be **recorded and balanced** with its transformation losses. This is done in the mass balancing method of national or voluntary systems with the help of auditors, e.g. in the preparation of a greenhouse gas balance.

The **book & claim system** for guarantees of origin according to Art. 19 RED II (2018), follows an approach abstracted from the energy system (see subsection 5.4). Here, there is per se no direct reference to physical energy flow and energy storage. The methodological design abstracts **from transport, conversions or losses**. If the degree of coupling of guarantees of origin to the functionality of real transport, conversion or storage systems is to be increased, a system still to be defined is required. The optionally coupled guarantees of origin from the German legal framework have so far dealt with transport via networks, but not with storage or conversion processes.

6.6 Verification of Additional Criteria

Final customers often have their own additional requirements that go beyond the pure "renewable" or "low-priced" characteristic. These additional requirements can serve to distinguish one (green electricity) product from others. Various criteria and their relevance for final consumers are analysed in report G 2 (Styles et. al., 2021). Examples for additional criteria can be:

- specific energy sources e.g. solar power
- Plant characteristics e.g. small plants or new plants
- Geographical location e.g. energy from the region
- Cultivation of the biomass substrates e.g. sustainability criteria, origin

Additional criteria can be verified through additional external audits. However, the established verification systems already map many criteria, so this is not always necessary.

For the guarantee of origin according to Art 19 RED II (2018), the minimum information that must be included is specified by law. This information is contained directly on the guarantee of origin and is transported with it to the final customer. Table 9 quotes these definitions from RED II. The EN 16325 standard for the exchange of guarantees of origin in Europe also contains further optional criteria that can be used.

Table 9: Information contained in guarantees of origin according to Art 19 (7) RED II

(7) A guarantee of origin shall specify at least:

a) the energy source from which the energy was produced and the start and end dates of production;

b) whether it relates to:

   i. (electricity;

   ii. (gas, including hydrogen; or

   iii. heating or cooling;

c) the identity, location, type and capacity of the installation where the energy was produced;

d) whether the installation has benefited from investment support and whether the unit of energy has benefited in any other way from a national support scheme, and the type of support scheme;

e) the date on which the installation became operational; and

f) the date and country of issue and a unique identification number.

Additional criteria play a major role in the **marketing of guarantees of origin** in energy labelling products. They are a central **differentiator** for the various energy products and are usually defined by or for private final customers. Energy suppliers offering green electricity products, for example, often specify additional criteria that are not included in the guarantee of origin itself. This is then ensured through the selection of certain production plants (e.g. new plants), through independently verified quality seals or contractual regulations such as audits.

A significant "final customer" is the **state** itself, which sets its **own criteria** for renewable energy that is to be remunerated or recognised. The criteria laid down in laws are of particular importance, as they are the basis for state recognition and, if applicable, the payment of subsidies. For example, the use of **mass balance systems** is prescribed for these criteria in RED II (2018) as well as in national laws:

- **Sustainability criteria** in the production of biomass
- **GHG minimum savings** for fuels and combustibles
- the various versions of the **EEG** contain a **large number of additional criteria**, e.g. on the possible substrates in a biogas plant (BiomasseV)

If the verification of a requirement is more complex, e.g. when calculating a proportionate methane yield from the substrate quantities used, this is carried out by **environmental verifiers** or other auditors. The verification of electricity according to Art 27 (3) RED II (2018) is considered very complex due to the additional criteria (see section 5.3).

6.7 Consumer Choice

The verification methods used differ greatly in the options regarding the energy source they offer to final consumers.

When energy is supplied via a physical **direct line**, there is by nature **no choice** as to the origin or criteria of the energy used. The connection used, e.g. an electricity cable, a gas pipeline or a heat supply pipeline, physically delivers exactly the energy that was fed into the system.

If renewable **energy sources** can be **transported** (with coupling to verification), the **choice of origin increases** compared to direct delivery, as the energy can now be obtained from different sources. The sourcing options here are **limited by the physical transport system**: An island grid can only supply those consumers that are connected to it. In addition, longer distances cause losses due to the transport itself, which can make delivery uneconomical. Besides all this, the choice is also limited by the fact that a supply contract on quantity, delivery and transport is required between producers and consumers (possibly via a trader). Thus, a consumer can only source energy with a link between the production and the consumption plant with

- a physical transport route,
- a transport option sufficiently economical, and
- a contractual agreement (possibly via an intermediary).

The consumer is therefore **limited** in the selection for the source of the energy (with additional criteria if necessary) to production facilities that can be **reached by the transport system**.

With **certificate systems** such as the guarantee of origin according to Article 19 of RED II (2018), the final consumer has the **highest freedom of choice**. Since the transport of the energy itself does not play a role, guarantees of origin from the entire territory of the EU and contracting states can be used. An energy supply company can therefore freely define criteria according to which it designs a green electricity product, in particular

- the production facility (e.g. plant/operator/...) independent of the energy transport and
- the energy source (e.g. solar power) independent of the energy mix on site

First and foremost, final customers can choose their electricity mix in terms of a technology mix (e.g. solar power, wind power, etc.) and **change it flexibly** at any time: This can be done by choosing a new supplier/product or, in part, also within a flexible product.

An **important restriction** of the choice in RED II (2018) is that in energy labelling only **guarantees of origin can be cancelled according to their energy form**, i.e. electricity guarantees of origin for electricity labelling, gas guarantees of origin for gas labelling and heat/cold guarantees for heat/cold labelling.

7 Climate Protection Contributions: Voluntary, Incentivised and Obligatory

The previous sections have shown how industrial companies can contribute to national targets. As important energy consumers, industrial companies can and often want to **contribute to climate protection beyond the state-led energy transition** and compare the alternatives on offer. A climate protection effect can be achieved in different ways through

- an increase in energy efficiency in their company
- a change in the production processes right through to the products
- an increase in flexibility for current and/or forecast performance needs

but also through

- Substitution of fossil fuels through the use of renewable energies in own plants (construction / operation)
- Direct sourcing of renewable energy from neighbouring plants
- the sourcing of renewable energy from publicly available grids or by means of transport vehicles

- The acquisition of certificates to prove the renewable energy property and thus, independent of a direct physical energy transport, the use of renewable energy to support the energy supply.

The measures described above are only a few of the options for contributing to climate protection. It is not only justified, but also a necessary measure to achieve an optimal result to choose and consider the measures with regard to their climate protection effect in relation to the investments, the complexity of implementation and the time span for implementation.

Legislators in Germany define measures for climate protection and for energy use separately, even though energy demand is often closely linked to emissions. **The legislator intentionally avoids offsetting measures for climate protection against energy efficiency improvement** in order to exclude the possibility of achieving less climate protection overall by offsetting the measurement assumptions against each other. It would be disadvantageous if, for example, a reduction in energy demand in a wastewater treatment plant had a negative impact on the treatment process of the wastewater and therefore results in less environmental protection.

Furthermore, the legislator is willing to ensure that the competitiveness of companies is maintained. Thus, within its laws and ordinances, it provides for exemptions as soon as there is a danger that the **competitiveness** in certain market segments or in individual cases could be impaired beyond measure by the framework conditions set. Thus, in recent years, both in the context of international and European standards, as well as in German legislation, the screws have been tightened to increase energy efficiency and reduce environmental pollution. At the same time, financial subsidies and tax relief have been agreed in order to maintain competitiveness in rapidly changing international markets.

7.1 Motivation for Climate Protection Measures in Industry

Industrial companies already contribute to climate protection. The following section analyses different **motivations** in the context of laws and standards with regard to their freedom of choice, i.e. whether they are **mandatory, incentivised or voluntarily** pursued.

On the one hand, laws **oblige** industrial companies to make climate protection contributions. Here, sanctions require compliant behaviour and a (minimum) contribution to climate protection. Often, companies are given a certain degree of freedom with which they can fulfil the obligation. Then there is a choice in **how** the contribution is made. Within this framework, it is **usually difficult or impossible to make an additional contribution**, as the following examples show:

- **GEG (2020)**: Building regulations resulting from the Building Energy Act: The primary energy factor (PEF), which results from the choice of energy carrier, is particularly relevant here. The

choice of fuel for heating a building results in different requirements for the physical design of the building envelope.
An improved PEF can reduce the cost and effort of thermal insulation - but it can also lead to poorer insulation, which may even be counterproductive in the long run.

- **BImSchG**: Essentially, legal limits are set for the approval, construction and operation of installations. Depending on the size of the plants in which fuels are burned, different requirements apply. The compliance of these minimum standards is monitored.
  Overfulfilment of the requirements (additional climate protection effect) is always possible, but shows no immediate economic advantages. Nevertheless, in new plant construction, overfulfilment is often aimed for in order to avoid expensive retrofitting in the long term when emission limits are tightened in the future.
- **EU-ETS (2003)**: Every company is obliged to submit enough EUA allowances for all its emissions at the end of the year. otherwise, it faces heavy penalties. If a company has reduced its emissions, it can either keep the surplus certificates for future purposes or sell them to another company that needs certificates. Participation in emissions trading is mandatory for companies with thermal processes > 20 MW combustion capacity.
  An additional purchase and retirement of (unneeded) EUA allowances would prevent one-off emissions of the corresponding amount of GHGs in the year in question across the EU.
- **BEHG (2019):** Tax on the unit of energy sold (natural gas, heating oil, petrol, diesel). In the introductory phase, the emission certificates are initially sold at a fixed price that increases annually. The costs per consumed kWh resulting from this CO_2 price are derived from the specific emission factors of the respective fuels, which are laid down in the Fuel Emissions Trading Ordinance (BEHV). After the introduction phase, the supply of certificates is reduced annually and the price is formed in interaction with demand (cap & trade).
  An additional purchase and cancellation of (unneeded) nEHS certificates would have no effect in the phase-in phase. In the later cap&trade phase, the sale of a corresponding amount of fuel in the corresponding year in Germany would be prevented.

Laws or support mechanisms often also rely on **financial incentives or create economic pressure** to achieve a climate protection contribution. Often enough, entrepreneurs decide to make climate protection contributions out of their own conviction or at the request of their customers, which may then cause (limited) additional costs. For example, many companies purchase the more expensive green electricity (through guarantees of origin).

Energy and environmental management systems according to ISO 50001 or ISO 14001 are important means for industrial companies to implement climate protection contributions in an integrated way, even in larger companies (or groups). They can also be used for better marketing of their own products.

In general, **ISO 50001 certification is voluntary**. In order to benefit from compensation according to § 64 (EEG, 2021) (for electricity demand $\geq$ 5 GWh and exceeding a specific electricity cost intensity), certification according to ISO 50001 or EMAS (Eco-Management and Audit Scheme) also known as EU Eco-Audit is required. Essential features of the energy management standard DIN EN ISO 50001 are:

- Definition of boundaries, and a base line for the analysis
- Determination of energy performance indicators
- Clear assignment of responsibility to top management

According to the German Energy Services Act (EDL-G), only the energy audit according to DIN EN 16247-1 is obligatory for all German companies (except SMEs as defined by the EU). In principle, however, it is up to a company to introduce the energy management system according to DIN EN ISO 500001. This would, in contrast to the snapshot of the energy audit, help to anchor energy efficiency permanently inside the company. Beyond the direct savings on energy costs, the introduction of an energy management system can also result in savings on taxes and levies. Under certain conditions, companies in the manufacturing sector can reduce energy and electricity tax (SpaEfV) and the EEG levy (BesAG EEG) by introducing and maintaining an energy management system in accordance with DIN EN ISO 50001.

In general, certification **according to ISO 140001 is also voluntary**. The driving force for implementation are requirements of customers, communities, suppliers, regulatory authorities, non-governmental organisations and investors. Essential features of the environmental management standard DIN EN ISO 140001 are

- New ISO 14001:2015 requires companies to identify and develop adequate performance indicators for resource-intensive areas.
- Clear assignment of responsibility to top management

The ISO management standards for environmental protection ISO 140001 and for energy efficiency ISO 50001 require the establishment of a management process according to a Plan, Do, Check, Act (PDCA) cycle and the requirement for continuous improvement. Both ISO management standards include external auditing by certifying organisations. The organisations carrying out the audit and certification must be authorised by the German Akkreditierungsstelle GmbH - DAkkS to issue a certificate. The same applies in those countries that have adopted the ISO management standards as national standards.

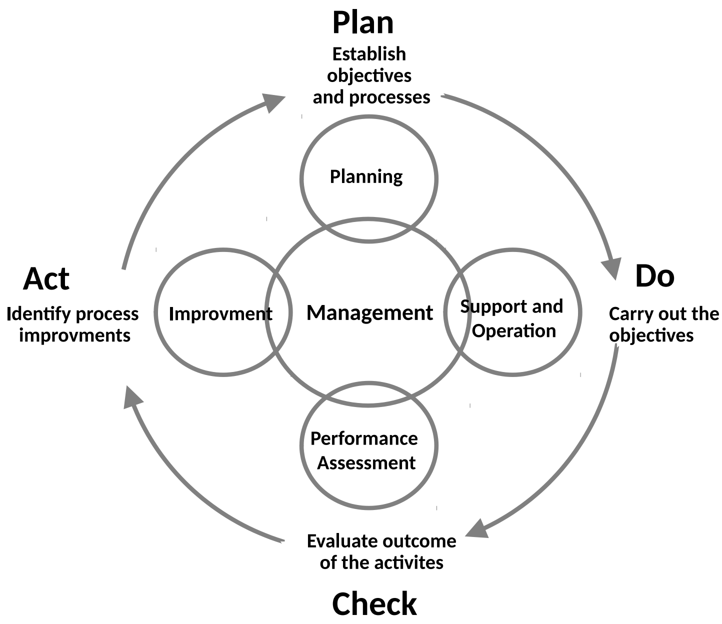


Figure 11: Plan-Do-Check Act process

7.2 Enforcement of Additional Climate Protection Contributions with Renewable Energies

Industrial companies face particular challenges in terms of decarbonisation when it comes to energy sourcing. The **switch to renewable energy** sources is here **a question of "how" and no longer of "if"**. The question arises anew as to whether the contribution should be achieved by means of renewable energy **directly**, **transported** or in the form of **certificates**. Building on the terminology and the comparison of verification systems from the previous chapters, the following subsection examines how the respective reference options can ensure an additional climate protection effect.

In the case of a **direct supply** of renewable energy, e.g. from the company's own solar thermal system or from a biogas direct line, the **climate protection effect** is achieved directly on site. The renewable energy is produced locally and used directly, which means that the measure can be clearly **assigned** to the corresponding industrial operation. The energy supply here functions independently of the public energy system and the fossil components it contains.

If renewable energy is sourced **from outside** of the production processes, the climate protection effect can be assigned to the consumption facility either by **coupling the verification** or by a **book & claim certificate, e.g. guarantee of origin**. The artificially created link between the production and consumption facility is very different in each case and thus also the way in which a climate protection effect can be assigned.

If **certificates are coupled with transported energy carrier**s, as is the case with e.g. mass balance systems and the new electricity certificate according to Art 27 (3) of RED II (2018), the energy carrier (electricity, gas, liquid fuel) is traded as a renewable commodity (e.g. per wind power PPA, as biomethane supply or regional electricity supply) in a separate **energy market segment** with its own pricing. The climate protection contribution is therefore transferred together with the energy within this market. With the application of these energy sources, the renewable property is **directly assigned to the consuming facility**, thus also the associated climate protection effect. The coupling of the renewable property to the energy carrier has the effect, among other things, that a renewable-based energy transport system can gradually emerge within the existing fossil-based system. With these (more elaborate) proofs, losses, transport and storage can also be mapped. Depending on market regulation, these deliveries can result in demand-driven energy production and consumption and participation in grid restructuring.

If **book & claim certificates**, such as RED II (2018) guarantees of origin for electricity, gas or heating/cooling are used, the energy supply and the proof of the renewable property take place independently of each other. The energy carrier is sourced as grey energy, e.g. as spot market electricity or grey gas, thus ensuring the energy supply. In addition, guarantees of origin are then acquired from a producing plant and assigned to the energy consumption of the industrial plant. The energy is priced on the **regular energy market** and the price for the renewable property is determined independently on a **separate market for guarantees of origin**.
In this model, a "grey" energy carrier is sourced, i.e. an energy carrier without further defined properties. However, the industrial company or the final customer **supports** the production plant **financially** by purchasing the guarantees of origin. A climate protection contribution is triggered if, for example, the energy sources of the production plant become competitive **in the energy market** with the help of the financial contribution compared to fossil energy sources and then displace them from the market. In the case of controllable renewable energies, e.g. hydropower or electricity from biomass, this can trigger an increase in production during operation if, for example, the electricity can be offered at a more favourable price on the spot market and there is thus more demand. The marketing of guarantees of origin for energy production from **fluctuating** sources such as sun and wind does not directly produce more energy, since there is no more sunshine, but it does improve the revenue situation, which supports such projects financially and can be advantageous in tenders.

The RED's guarantees of origin enable an allocation to a specific production facility, which means that targeted facilities with a specific desired climate protection contribution or other additional criteria can also receive direct financial support. The GO4I-reports G2 (Styles et. al., 2021) and G3 go into further possibilities of how climate protection contributions can be achieved with guarantees of origin or how these can be linked to energy sources.

7.3 Climate Protection Effect for Consumers with Guarantees of Origin

Energy disclosure regulations are intendet to give final customers the opportunity to recognise the amount of renewable energy production they are paying for. Thus they gain clarity in which renewable energy production they are investing. The following subsections briefly describes additional benefits for climate protection that guarantees of origin can bring about and their limitations.

A distinction must be made here between "**additionality**" in the sense of a generally accelerated energy transition and "**additional criteria**" for a specific product, such as sustainability criteria for biomass production or criteria that increase acceptance of the energy transition. Report G3 elaborates on the term "additionality" and the associated societal discussions. Report G2 (Styles et. al., 2021) looks at the question of what final customers expect from energy disclosure. Many final customers want to trigger additional momentum in the production of renewable energy with the help of origin labelling. Additional production is triggered indirectly via the market mechanisms described in the previous section 7.2:
The guarantee of origin acquired for the final consumers enables the operating company of the production plant to generate additional revenue, which helps to improve the competitiveness of renewable energy production on the energy market. The most important variable for effectiveness here is the price for the guarantee of origin, which is determined by supply and demand in the European market. The higher the GO price, the greater the impact on additional production. However, if final customers hope to use energy disclosure to give a significant boost to additional renewable energy production independently of the market mechanisms described above, or even to achieve an independent energy supply, they are overestimating the possibilities of guarantees of origin. This can be fulfilled with direct supply (supply model A, section 4). If energy is sourced from public grids, this can be achieved to some extent with a coupling of verification and delivery (reference model B, section 4).

Energy disclosure is often (wrongly) understood to mean **that renewable energy has been sourced (instead of: a book & claim GO is cancelled)**. In this interpretation, the renewable property may be claimed twice:

- Once with the producer, if it has been counted towards the national targets when the guarantee of origin was issued, as well as
- again with the final customer, if here (wrongly) the view is taken that this renewable energy was consumed.

In the sense of the RED II (2018), however, there is no contradiction here, since only the production itself is acounted and the invalidation of guarantees of origin is not attributed any function for the implementation of the national targets.

If guarantees of origin are issued for the production of renewable energies, this production contributes to the promotion of renewable energies in the country of origin. The reason for this is that the EU member states also want to **take into account** the expansion of renewable energies that has arisen through **voluntary** measures – outside the legal instruments. This has no effect on the promotion of renewable energies in the country of consumption (if the two are different). The remaining energy production from renewable energies can be considered "additional" from the consumer's point of view (in addition to a possible state subsidy).

Final customers often require the renewable energy in the guarantees of origin to come from **new and unsubsidised plants** and, depending on the case, to **fulfil other basic requirements**. This is made possible with the energy disclosure rules, but it is not mandatory: The commissioning date of the production plant is noted on the guarantee of origin (see Table 9). This means that green energy products can specialise in acquiring guarantees of origin from new plants, e.g. younger than 5 years. In theory, a higher price level can then be achieved in this small market segment for new plants. Other basic requirements can be covered by additional criteria.

In some special cases, guarantees of origin for renewable energy are issued in an setting without (or different) energy disclosure rules. This may be the case, for example, in contracting states (outside the EU) or when issuing and transferring GOs for self-consumption. In this case, there is a risk that the renewable property is marketed both locally by the producer and via origin labelling elsewhere. Consistent application of uniform labelling rules solves this problem.

In Germany, there is (still) a **clear separation of GO issuance** and state support mechanisms such as the **EEG** (so-called **ban on double marketing**). This strict separation is not considered necessary in other EU states. In most member states, on the other hand, **simultaneous issuance and supporting** is permitted and explicitly provided for. German final consumers could wrongly assume that the certificates of origin from other member states are only issued for unsubsidised installations. Thus, differences in the evaluation of the role of guarantees of origin arise, but the purchasing country is free to independently evaluate the applied support in the national labelling rules. When setting support rates, e.g. through auctions, the sales value of the certificates of origin is also calculated in these countries, so that the publicly financed amounts can be lower. A public **funding budget** is thus **cross-financed** by the (expected) **revenues from guarantees of origin** and can thus theoretically bring about a stronger promotion of renewable energies.

If guarantees of origin from subsidised plants in Germany are now cancelled, the German electricity customer, for example, supports the expansion of renewable energies in the country of origin, entirely within the framework of the regulations. In Germany, due to the ban on double marketing, this discussion only refers to the consumption side, not the generation side. Understanding of final customers for the climate protection effect of guarantees of origin is impeded by different concepts of the roles of guarantees of origin in the context of national support schemes.

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