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Proposals for energy disclosure for electricity, gas, hydrogen, heating and cooling as a blueprint for a European solution

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Abstract: Proposals for energy disclosure for electricity, gas, hydrogen, heating and cooling as a blueprint for a European solution

The report provides a comprehensive overview over potential benefits of energy disclosure across electricity, gas, hydrogen, and heating/cooling, and proposes and applies a methodology for evaluating existing or proposed disclosure systems. The key findings emphasise that while disclosure systems significantly enhance consumer information and market transparency, major gaps remain—most notably the lack of harmonised criteria, verification mechanisms, and the ability to communicate additionality and temporal correlation. The analysis shows substantial disparities in maturity across sectors, with electricity disclosure comparatively advanced and other energy carriers still only developed on a more basic level. The study further demonstrates that modern disclosure must evolve from static reporting tools to dynamic, interoperable systems to support decarbonisation pathways and to align with all requirements deriving from broader EU frameworks such as CSRD, RED III, and RFNBO.

Recommendations outlined in the report call for a modernisation of disclosure rules to match a renewable-dominated energy system, along with harmonised European guidance to create more consistency across energy carriers and jurisdictions. Policymakers should integrate disclosure design with broader regulatory instruments, enhance interoperability of tracking systems, and support innovative concepts through research and regulatory alignment. The report's structured analytical framework—including benefit-based criteria, sub-criteria, and an automated Excel evaluation tool—offers actionable guidance for benchmarking and improving existing disclosure systems and for informing the next generation of EU-wide disclosure architecture.

Kurzbeschreibung: Vorschläge zur Energiekennzeichnung für Strom, Gas, Wasserstoff, Wärme und Kälte als Praxisvorbild für eine europäische Lösung

Der Bericht bietet einen umfassenden Überblick über den potenziellen Nutzen von Energiekennzeichnung für Strom, Gas, Wasserstoff sowie Wärme und Kälte. In dem Bericht wird eine Methodik zur Bewertung bestehender oder vorgeschlagener Kennzeichnungssysteme vorgestellt und angewendet. Die wichtigsten Ergebnisse zeigen, dass Kennzeichnungssysteme zwar die Verbraucherinformation und die Markttransparenz erheblich verbessern, aber dennoch erhebliche Lücken bestehen bleiben – insbesondere das Fehlen harmonisierter Kriterien, Überprüfungsmechanismen und die mangelnde Fähigkeit, Zusätzlichkeit und zeitliche Korrelation zu kommunizieren. Die Analyse zeigt erhebliche Unterschiede im Umsetzungsstand für die verschiedenen Sektoren, wobei die Kennzeichnung im Strombereich vergleichsweise weit fortgeschritten ist, während andere Energieträger noch auf geringerem Niveau entwickelt sind. Die Studie zeigt ferner, dass sich die moderne Energiekennzeichnung von statischen Berichterstattungsinstrumenten zu dynamischen, interoperablen Systemen entwickeln muss, um Dekarbonisierungsstrategien zu unterstützen und alle Anforderungen zu erfüllen, die sich aus umfassenderen EU-Rahmenwerken wie CSRD, RED III und RFNBO ergeben.

Zentrale Empfehlungen umfassen eine Modernisierung der Energiekennzeichnungssysteme, um sie an ein von erneuerbaren Energien dominiertes Energiesystem anzupassen, sowie die Notwendigkeit, harmonisierte europäische Leitlinien zu entwickeln, um mehr Einheitlichkeit zwischen den Energieträgern und Rechtsordnungen zu schaffen. Die Politik sollte die Ausgestaltung der Energiekennzeichnung in umfassendere Regulierungsinstrumente integrieren, die Interoperabilität von Tracking-Systemen verbessern und innovative Konzepte durch Forschung und regulatorische Angleichung unterstützen. Der strukturierte analytische Rahmen des Berichts – einschließlich nutzenbasierter Kriterien, Unterkriterien und eines automatisierten Excel-Bewertungstools – bietet umsetzbare Leitlinien für das Benchmarking und für die Identifikation konkreter Vorgaben für die Verbesserung bestehender Kennzeichnungssysteme innerhalb der EU.

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List of abbreviations

Abbreviation	Explanation
AIB	Association of Issuing Bodies
BLE	Bundesanstalt für Landwirtschaft und Ernährung
BNetzA	Bundesnetzagentur (German regulatory authority)
CCF	Corporate Carbon Footprint
CDP	Carbon Disclosure Project
CSDDD	Corporate Sustainability Due Diligence Directive
CSRD	Corporate Sustainability Reporting Directive
dena	Deutsche Energie-Agentur (German Energy Agency)
DPP	Digital Product Passport
DSO	Distribution System Operator
EAC	Energy Attribute Certificates
EASE	The European Association for Storage of Energy
EECS	European Energy Certificate System
EmpCo	Empowering Consumer Directive
ERGaR	European Renewable Gas Registry
ESRS	European Sustainability Reporting Standard
EU	European Union
EU ETS	EU Emissions Trading System
GCD	Green Claims Directive
GHG	Greenhouse Gas
GO	Guarantee of Origin
GRO	Guarantee of Renewable Origin
H&C	Heating and Cooling
PCF	Product Carbon Footprint
PoS	Proof of Sustainability
RE(S)	Renewable Energy (Sources)
RED	Renewable Energy Directive
REPA	Renewable Energy Purchase Agreement
RES	Renewable Energy Source(s)
RES-E	Electricity from Renewable Energy Sources
RFNBO	Renewable Fuels of Non-Biological Origin

Abbreviation	Explanation
SBTi	Science-Based Target Initiative
TSO	Transmission System Operator
UDB	Union Data Base
US	United States (of America)
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Executive Summary

Purpose and context

This report presents a **methodology for evaluating energy origin disclosure concepts** as a model for identifying the improvement potentials in national and European disclosure frameworks. Developed under the auspices of the German Environment Agency, this report responds to the growing importance of energy disclosure as renewable energy becomes mainstream and as consumers, corporations, and governments demand more transparent and credible energy information.

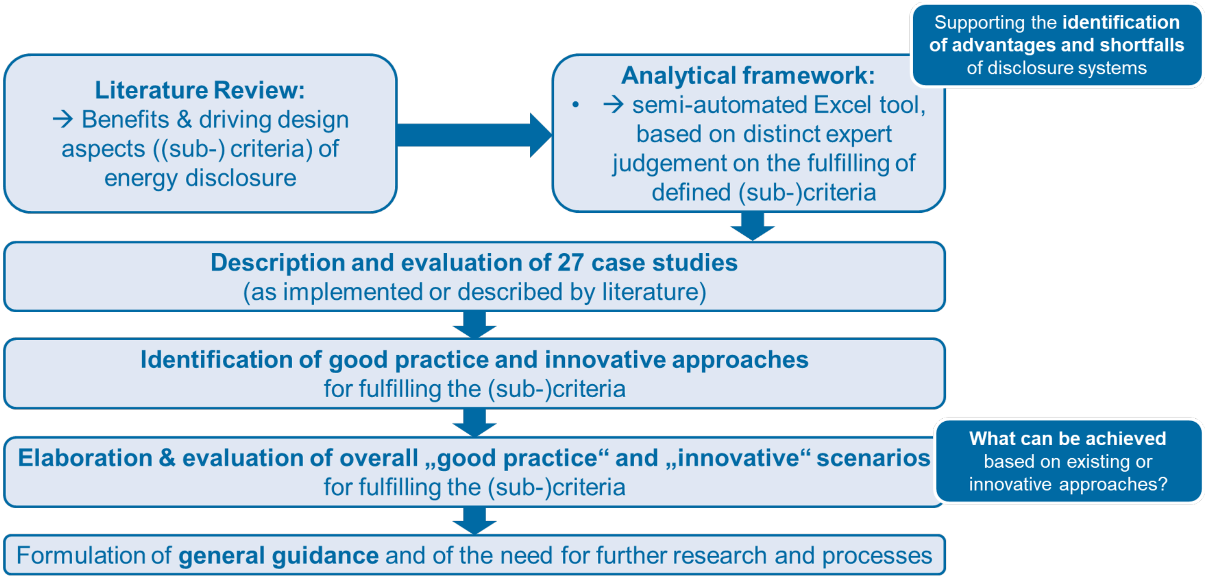
Approach and analytical framework

A comprehensive **analytical framework** was developed to link disclosure design features to their potential benefits for four stakeholder groups: households, organisations, plant operators, and society as a whole. The analysis was applied to energy disclosure systems for different energy types, namely electricity, gases as well as heating and cooling.
The approach includes:

1. **A systematic literature review** to identify the potential benefits of energy disclosure systems and relevant criteria which should be fulfilled in order to achieve these benefits.
2. **Establishing an analytical framework** in the form of a semi-automated Excel tool, suitable for describing energy disclosure systems systematically and evaluating the respective fulfilment of the defined criteria with a view to the related benefits.
3. **Case study analysis** of 27 existing and innovative disclosure concepts across energy types and countries.
4. **Applying a structured Excel-based evaluation tool** to assess the extent to which different concepts fulfil the defined benefits.
5. **Synthesising good and innovative practices** into design scenarios to analyse potential improvements of disclosure systems based on existing show-cases and innovative approaches as proposed by literature studies.
6. Formulating general **guidance for policymaker**s and identifying the need for further research.

This methodological approach is shown in Figure 1 below.

Figure 1: Methodological approach for developing and applying the analytical framework in this project



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

Key findings

The analysis conducted according to the outlined approach leads to the following key results:

Disclosure systems can provide manifold benefits to the different stakeholder groups

Disclosure systems for electricity, gases as well as for heating and cooling provide manifold benefits for the stakeholder groups households, organisational consumers, plant operators (and investments in plants) as well as for society as a whole. Identified benefits are illustrated in Figure 2.

Figure 2: Potential benefits of energy disclosure systems for different stakeholder groups

Households

- Consumers can make an **active choice supporting the energy transition**
- Consumers **get emotionally involved and feel empowered** in the context of energy transition
- Consumers **become aware of the environmental effects** of their own energy consumption
- Consumers can **focus their energy supply on regional / domestic origin**
- Consumers can **make a statement on individual preferences** by choice of energy supply

Organisations

- Making **procurement decisions** based on information contained in energy disclosure
- Allowing for **impactful** decarbonisation strategies
- Facilitating **Renewable Energy Purchase Agreements**
- **Enabling compliance** with GHG accounting standards and low carbon initiatives
- **Ensuring compliance** with regulatory requirements
- Hedging against **CO_2 prices**
- Meeting **stakeholder expectations**, mitigating **reputational risks** and demonstrating **leadership**
- Providing **unique green claims for marketing** products or services

Plant operators

- Fulfilling the formal prerequisites for **market participation**
- Enabling **revenues and planning security** from long-term REPAs
- Revenues from **green attribute sales** in short-term markets
- Additional value through **regional renewable energy**
- Customer **acquisition and loyalty**
- Transfer of green attributes from energy inputs to energy outputs in **conversion processes**
- Fulfilling **reporting requirements** placed on plant operators

Society as a whole

- Contribution to the **energy transition**
- Contribution to the **reduction of public cost** of the energy transition
- Contribution to **GHG emission reductions** of energy production
- Contribution to **reduction of bureaucracy** and to **efficiency of administrative action**
- Incentive for a **consistent development of system infrastructure**
- **Synergies with alternative purposes** besides disclosure, like target and support

Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

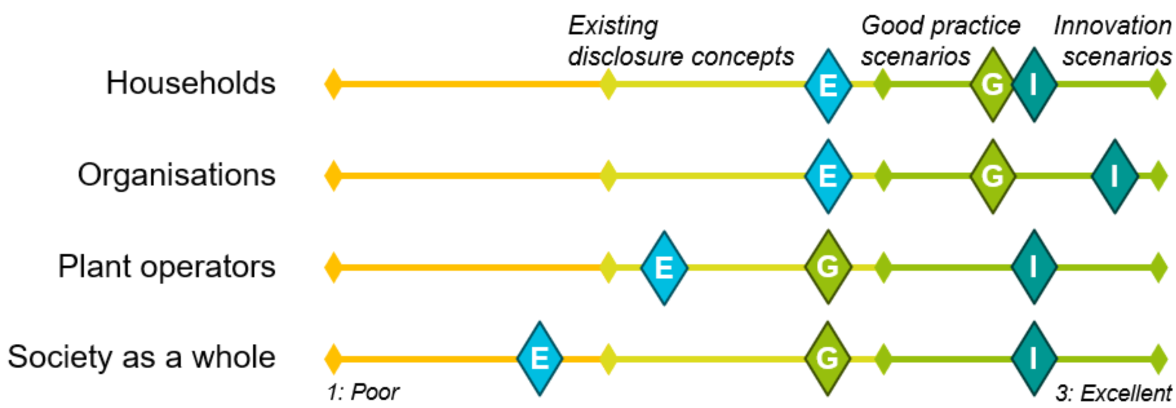
Disclosure systems already deliver clear benefits, but limitations persist

The comparative analysis of the 27 case studies indicates that current disclosure systems already deliver clear benefits, particularly in terms of informing consumers and enhancing market transparency. At the same time, limitations persist as many systems lack coordinated regulation, verification mechanisms, and mechanisms to communicate additionality or temporal correlation.

While electricity disclosure is already relatively advanced, disclosure for gases, hydrogen, and heating/cooling remains fragmented and underdeveloped for the time being.

Nevertheless, there are already substantial improvement potentials within the current legal framework: several EU Member States have implemented high-quality disclosure practices that could be scaled up across the EU. While these elements can be adopted without legislative change on the EU level, more innovative enhancements may require targeted adjustments to EU regulations and closer alignment of rules across related policy domains. An indication of the potential to improve existing disclosure systems by applying currently implemented good practice examples and applying innovative concepts as described in literature is shown in Figure 3.

Figure 3: Potential to improve the existing disclosure concepts (E) from currently implemented good practice examples (G) and from innovative concepts (I) described in the literature



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

Digitalisation and automation are a 'no-regret' recommendation

A tiered development pathway for disclosure systems is proposed. The first priority is the digitalisation and automation of data flows. Digital tools can deliver highly detailed information – directly to consumers in a user-friendly manner. This allows consumers and organisations to filter for attributes that matter to them, improve decision-making, and better align their energy procurement with climate goals and updated GHG accounting standards. Digitalisation also reduces the administrative burden and enables stronger market incentives for renewable generation, making it a 'no-regret' measure with broad societal benefits.

Improving transparency and access to tracked information can support the energy transition

The second priority is **improving transparency and access to tracked information**. Households and organisations can only influence the energy transition if they clearly understand the origins of their energy. To support this, suppliers should provide easy-to-understand explanations of key parameters (such as regionality, additionality, and age of plants), while public or NGO-driven ranking tools should help consumers compare energy products. Organisations operating across multiple markets also need technical tools – particularly APIs — to manage Guarantee of Origin portfolios efficiently.

Standardising the tracking instrument used for all renewable claims prevents double counting and increases credibility

A third recommendation is to **standardise the tracking instrument used for all renewable energy claims**. Currently, suppliers must use GOs, but corporate consumers sometimes rely on looser contractual instruments. Ensuring that all claims – corporate or supplier – are backed by GOs would prevent double counting and ensure the credibility of market-based renewable consumption. Even when corporates use PPAs, these must be accompanied by the correspond-ding GOs to avoid inconsistencies.

Stricter geographical and temporal boundaries can be implemented upon better understanding

While **stricter geographical and temporal boundaries** for disclosure, such as limiting claims to specific bidding zones or requiring monthly or hourly matching promise to contribute to several benefits, the implications of such reforms need to be further analysed. Before reforms are implemented, practical impacts should be assessed by studying existing examples (e.g. RFNBO criteria, revised GHG Protocol guidance, or monthly matching rules as already existing in individual countries). These assessments should also consider how voluntary market behavior might change under mandatory transparency requirements.

Interactions between disclosure systems and policy target accounting need to be assessed

Another priority is to **evaluate interactions between disclosure systems and policy target accounting**. While disclosure and target accounting are closely aligned in the gas and heating/cooling sectors, the electricity sector traditionally handles them separately. Proposals to align electricity target accounting with disclosure could create dependencies on cross-border attribute trading, complicating national RES target achievement. Any move toward closer integration therefore requires careful impact analysis to avoid undermining policy incentives while still empowering consumers to influence the transition.

Further information can be conveyed by Guarantees of Origin (GOs)

Regarding the underlying tracking infrastructure, the report emphasises strengthening the GO system by **expanding the range of information integrated into GOs**, such as sustainability criteria, RFNBO compliance, indirect emissions, PPA relationships, and sub-hourly production timestamps. These additions, supported by revised EN 16325:2025 and EECS rules, would future-proof disclosure in an energy system with higher renewable shares and stronger sector coupling.

Better coordination of tracking frameworks is key for gases

For gases, where both GOs and Proofs of Sustainability (PoS) exist, **better coordination of tracking frameworks** is needed. The coexistence of multiple registries increases administrative costs and risk of inconsistent claims. Integrated solutions that serve both disclosure and target accounting would significantly enhance reliability and administrative efficiency.

Institutionalise exchange and cooperation between disclosure authorities

In order to enhance mutual learning and to support convergence, a structured platform for dialogue and cooperation among policy makers, national disclosure public authorities, system designers, supervisors, and stakeholders is recommended, enabling voluntary harmonisation and shared learning.

Conclusions and outlook

The study demonstrates that well-designed energy disclosure systems can function not only as reporting tools but also as drivers of transparency, consumer empowerment, and decarbonisa-tion. Through a structured evaluation framework linking stakeholder benefits to measurable criteria, the project identified key gaps in current disclosure practices, which remain largely informational and insufficiently support impact-oriented aspects such as additionality and temporal correlation. The findings underline the need to modernise disclosure rules in line with a predominantly renewable energy system, to leverage good practices already implemented in Europe, and to strengthen harmonised EU guidance. By integrating disclosure with broader policy instruments, policymakers can enhance its systemic role. Overall, the project provides a solid analytical basis for reform and highlights that disclosure must ultimately serve broader societal and environmental objectives.

Zusammenfassung

Zweck und Kontext

Der Bericht bietet einen umfassenden Überblick über den potenziellen Nutzen der Energiekennzeichnung für Strom, Gas, Wasserstoff sowie Wärme und Kälte. In ihm wird eine Methodik zur Bewertung bestehender oder vorgeschlagener Energiekennzeichnungssysteme vorgestellt und angewendet. Er wurde im Auftrag des deutschen Umweltbundesamtes entwickelt und trägt der wachsenden Bedeutung der Energiekennzeichnung Rechnung, da erneuerbare Energien zunehmend zum Mainstream werden und Verbraucher*innen, Unternehmen und Regierungen transparente und glaubwürdige Energieinformationen fordern.

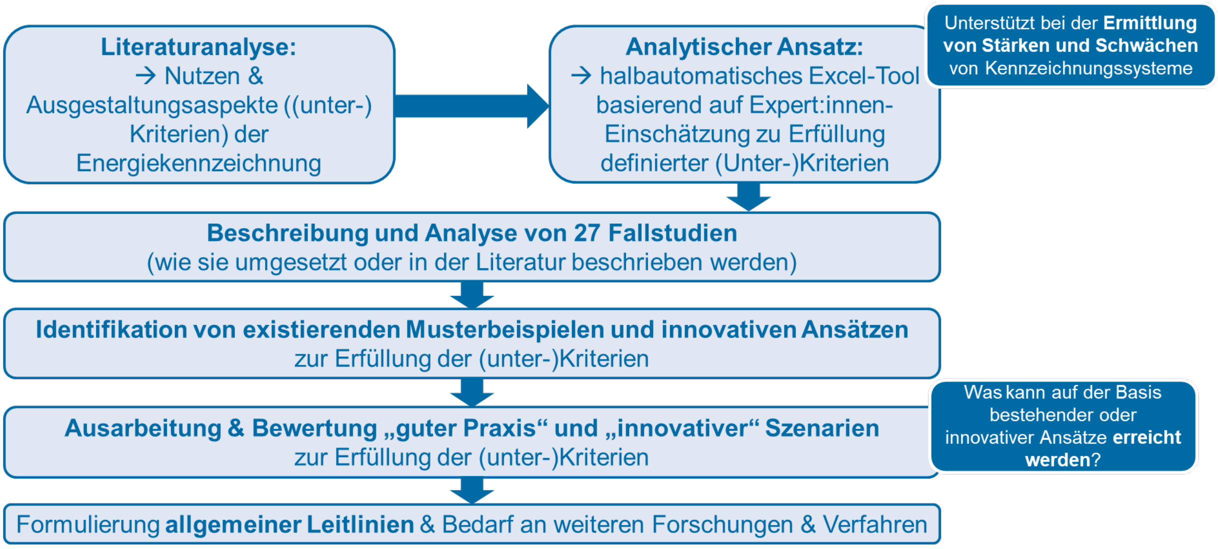
Ansatz und Analyserahmen

Es wurde ein umfassender Analyserahmen entwickelt, um die Merkmale der Energiekennzeichnung mit ihrem potenziellen Nutzen für die vier Stakeholder-Gruppen Haushalte, Organisationen, Anlagenbetreiber und die Gesellschaft als Ganzes zu verknüpfen. Die Analyse wurde auf Energiekennzeichnungssysteme für die verschiedenen Energiequellen Strom, Gas, Wärme und Kälte angewandt.
Der Ansatz umfasst:

1. Eine **systematische Literaturanalyse** zur Ermittlung der potenziellen Vorteile von Energiekennzeichnungssystemen und der relevanten Kriterien, die erfüllt werden sollten, um diese Vorteile zu erreichen.
2. **Entwicklung eines analytischen Ansatzes** in Form eines halbautomatischen Excel-Tools zur systematischen Beschreibung von Energiekennzeichnungssystemen und zur Bewertung der jeweiligen Erfüllung der definierten Kriterien im Hinblick auf den damit verbundenen Nutzen.
3. **Fallstudienanalyse** von 27 bestehenden und innovativen Kennzeichnungskonzepten für verschiedene Energiequellen und Länder.
4. **Anwendung eines strukturierten, Excel-basierten Bewertungstools**, um zu beurteilen, inwieweit verschiedene Konzepte die definierten Vorteile erfüllen.
5. **Synthese von guten und innovativen Praktiken** in Form von Ausgestaltungsszenarien, um potenzielle Verbesserungen der Kennzeichnungssysteme auf Grundlage bestehender Musterbeispiele und innovativer Ansätze, wie sie in Literaturstudien vorgeschlagen werden, zu analysieren.
6. **Formulierung allgemeiner Leitlinien** für politische Entscheidungsträger*innen und Ermittlung des weiteren Forschungsbedarfs.

Dieser methodische Ansatz wird in Abbildung 4 unten dargestellt.

Figure 4: Methodischer Ansatz für die Entwicklung und Anwendung des analytischen Rahmens in diesem Projekt



Quelle: Eigene Darstellung der Autor*innen, Oeko-Institut, Hamburg Institut, Enunda.

Zentrale Ergebnisse

Die Analyse, die nach dem skizzierten Ansatz durchgeführt wurde, führt zu den folgenden zentralen Ergebnissen:

Kennzeichnungssysteme können den verschiedenen Stakeholdergruppen vielfältige Vorteile bieten

Kennzeichnungssysteme für Strom, Gase sowie Wärme und Kälte bieten vielfältige Vorteile für die Stakeholdergruppen Haushalte, organisatorische Verbraucher, Anlagenbetreiber (inkl. Investitionen in Anlagen) sowie für die Gesellschaft als Ganzes. Die identifizierten Vorteile sind in Abbildung 5 dargestellt.

Figure 5: Potenzieller Nutzen von Energiekennzeichnungssystemen für verschiedene Interessengruppen

Haushalte	• Verbraucher:innen können eine **aktive Wahl treffen**, um die Energiewende zu unterstützen • Verbraucher:innen werden **emotional eingebunden** und fühlen sich im Kontext der Energiewende gestärkt • Verbraucher:innen werden sich **der Umweltauswirkungen** des eigenen Energieverbrauchs bewusst • Verbraucher:innen können ihre Energieversorgung auf **regionale / heimische Herkunft** ausrichten • Verbraucher:innen können durch die Wahl der Energieversorgung eine Aussage über **ihre individuellen Präferenzen treffen**
Organisationen	• **Beschaffungsentscheidungen** auf Grundlage von in Energiekennzeichnung enthaltener Informationen • Ermöglicht **wirkungsvolle** Dekarbonisierungsstrategien • Erleichtert **erneuerbare Stromkaufvereinbarungen** • **Ermöglicht die Einhaltung** von THG-Bilanzierungsstandards und kohlenstoffarmen Initiativen • **Gewährleistet die Einhaltung** gesetzlicher Vorschriften • Absicherung gegenüber **CO_2-Preise** • Erfüllt die **Erwartungen von Interessengruppen**, **mindert Reputationsrisiken** und demonstriert **Führungsrolle** • Bietet **umweltbezogene Aussagen für die Vermarktung** von Produkten oder Dienstleistungen
Anlagenbetreiber	• Erfüllung der formalen Voraussetzungen für die **Marktteilnahme** • Ermöglichung von **Erträgen & Planungssicherheit** aus langfristigen REPAs • Erlöse aus **Verkauf grüner Attribute** in kurzfristigen Märkten • Zusätzliche Wertschöpfung durch **regionale erneuerbare Energien** • **Kundengewinnung und -bindung** • Übertragung grüner Attribute von Energieinputs auf Energieoutputs in **Konversionsprozessen** • **Erfüllung der Berichtspflichten** der Anlagenbetreiber
Gesellschaft als Ganzes	• Beitrag zur **Energiewende** • Beitrag zur Verringerung **der volkswirtschaftlichen Kosten** der Energiewende • Beitrag zur **Verringerung der THG-Emissionen** bei der Energieerzeugung • Beitrag zum **Bürokratieabbau & zur Effizienz der Verwaltung** • Anreiz für einen konsequenten **Ausbau der Netzinfrastruktur** • **Synergien mit alternativen Zwecken** neben der Kennzeichnung, wie Zielerreichung und Unterstützung

Quelle: Eigene Darstellung der Autor*innen, Oeko-Institut, Hamburg Institut, Enunda.

Kennzeichnungssysteme bieten bereits klare Vorteile, allerdings mit Einschränkungen

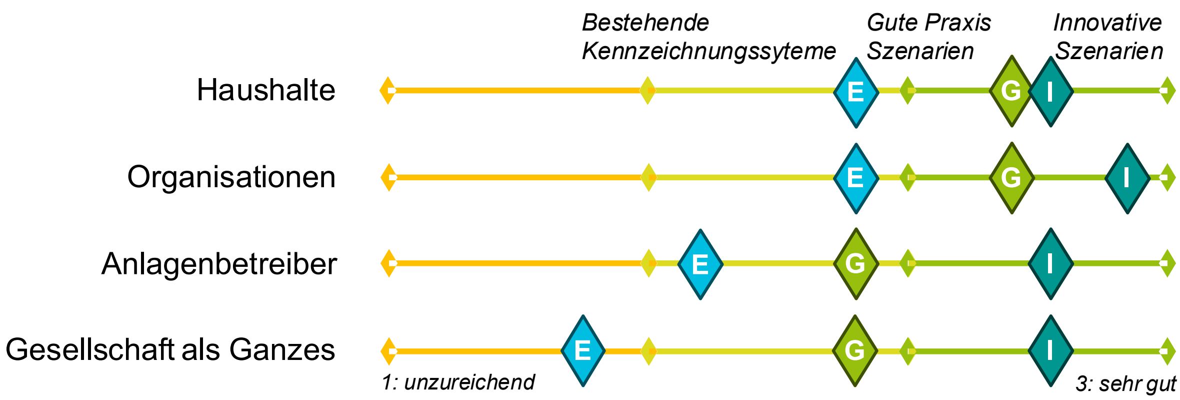
Die vergleichende Analyse der 27 Fallstudien zeigt, dass die derzeitigen Kennzeichnungssysteme bereits deutliche Vorteile bieten, insbesondere im Hinblick auf die Information der Verbraucher*innen und die Verbesserung der Markttransparenz im Vergleich zu einem Referenzfall ohne solche Kennzeichnungssysteme. Gleichzeitig gibt es aber auch Grenzen: So fehlt es vielen

Systemen an einer koordinierten Regulierung, an Überprüfungsmechanismen sowie an Mechanismen zur Mitteilung der Zusätzlichkeit oder zeitlichen Korrelation.

Während die Kennzeichnung von Strom bereits relativ weit fortgeschritten ist, bleibt die Kennzeichnung von Gasen, Wasserstoff und Wärme/Kälte vorerst fragmentiert und weniger weit fortgeschritten.

Dennoch gibt es innerhalb des derzeitigen Rechtsrahmens ein erhebliches Verbesserungspotenzial: Mehrere EU-Mitgliedstaaten haben hochwertige Kennzeichnungspraktiken eingeführt, die EU-weit ausgeweitet werden könnten. Diese Elemente können ohne Gesetzesänderungen auf EU-Ebene übernommen werden. Innovativere Verbesserungen könnten jedoch gezielte Anpassungen der EU-Verordnungen und eine engere Angleichung der Vorschriften in verwandten Politikbereichen erfordern. Abbildung 6 veranschaulicht das Potenzial zur Verbesserung bestehender Kennzeichnungssysteme durch die Anwendung derzeit umgesetzter Beispiele bewährter Verfahren, sowie innovativer Konzepte, wie sie in der Literatur beschrieben werden.

Figure 6: Potenzial zur Verbesserung bestehender Kennzeichnungskonzepte (E: existing concepts) durch derzeit umgesetzte Beispiele für bewährte Verfahren (G: good practice) und durch in der Literatur beschriebene innovative Konzepte (I: innovative concepts)



Quelle: Eigene Illustration der Autor*innen, Oeko-Institut, Hamburg Institut, Enunda.

Digitalisierung und Automatisierung sind eine „No-regret"-Empfehlung

Es wird ein mehrstufiger Entwicklungsplan für Kennzeichnungssysteme vorgeschlagen. Die erste Priorität ist die Digitalisierung und Automatisierung des Datenflusses. Digitale Werkzeuge können Verbraucher*innen auf benutzerfreundliche Weise direkt sehr detaillierte Informationen liefern. Dadurch können Verbraucher*innen und Organisationen nach den für sie wichtigen Attributen filtern, ihre Entscheidungsfindung verbessern und ihre Energiebeschaffung besser mit den Klimazielen und den aktualisierten Treibhausgasbilanzierungsstandards in Einklang bringen. Die Digitalisierung verringert zudem den Verwaltungsaufwand und schafft stärkere Marktanreize für die Erzeugung von Energie aus erneuerbaren Quellen. Dadurch wird sie zu einer „No-regret"-Maßnahme mit breitem gesellschaftlichen Nutzen.

Verbesserung der Transparenz und Zugang zu rückverfolgbaren Informationen kann die Energiewende unterstützen

Die zweite Priorität ist die Verbesserung der Transparenz sowie des Zugangs zu rückverfolgbaren Informationen. Nur wenn Haushalte und Organisationen die Herkunft ihrer Energie genau kennen, können sie die Energiewende beeinflussen. Versorger sollten leicht verständliche Erklärungen zu wichtigen Parametern wie Regionalität, Zusätzlichkeit und Alter der Anlagen bereitstellen. Öffentliche oder vereinsbetriebene Ranking-Tools sollten Verbraucher*innen dabei unterstützen, Energieprodukte zu vergleichen. Organisationen, die auf mehreren Märkten tätig sind, benötigen außerdem technische Hilfsmittel – insbesondere APIs –, um ihre Herkunftsnachweisportfolios effizient zu verwalten.

Die Vereinheitlichung des Nachverfolgungsinstruments, das für alle erneuerbaren Ausweisungen genutzt wird, verhindert Doppelzählungen und erhöht die Glaubwürdigkeit.

Eine dritte Empfehlung ist die Vereinheitlichung des Nachverfolgungsinstruments für alle Angaben zu erneuerbaren Energien. Derzeit müssen Lieferanten HKNs verwenden, während sich Firmenkunden manchmal auf weniger strenge vertragliche Instrumente verlassen. Die Sicherstellung, dass alle Ansprüche, ob von Unternehmen oder Lieferanten, durch HKNs gestützt werden, würde Doppelzählungen verhindern und die Glaubwürdigkeit des marktbasierten Verbrauchs erneuerbarer Energien gewährleisten. Selbst wenn Unternehmen PPA verwenden, müssen diese von den entsprechenden HKNs begleitet werden, um Unstimmigkeiten zu vermeiden.

Strengere geografische und zeitliche Beschränkungen können bei besserem Verständnis umgesetzt werden

Strengere geografische und zeitliche Beschränkungen für die Kennzeichnung, wie beispielsweise die Begrenzung von Ansprüchen auf bestimmte Gebotszonen oder das Erfordernis eines monatlichen oder stündlichen Abgleichs, versprechen zwar mehrere Vorteile, doch müssen die Auswirkungen solcher Reformen weiter analysiert werden. Vor der Umsetzung sollten die praktischen Auswirkungen anhand bestehender Beispiele bewertet werden, wie etwa die RFNBO-Kriterien, die überarbeiteten Leitlinien des THG-Protokolls oder die monatlichen Abgleichsregeln, die in einzelnen Ländern bereits existieren. In diese Bewertungen sollte auch einfließen, wie sich das freiwillige Marktverhalten unter verbindlichen Transparenzanforderungen ändern könnte.

Wechselwirkungen zwischen Kennzeichnungssystemen und politischer Zielrechnung müssen evaluiert werden

Eine weitere Priorität ist die Bewertung der Wechselwirkungen zwischen den Kennzeichnungssystemen und der politischen Zielrechnung. Während die Kennzeichnung und Zielrechnung in den Sektoren Gas und Wärme/Kälte eng aufeinander abgestimmt sind, werden sie im Stromsektor traditionell getrennt gehandhabt. Vorschläge zur Angleichung der Bilanzierung von Stromzielen an die Kennzeichnung könnten zu einer Abhängigkeit vom grenzüberschreitenden Handel mit Attributen führen und somit die Erreichung der nationalen EE-Ziele erschweren. Jeder Schritt in Richtung einer engeren Integration erfordert daher eine sorgfältige Folgenabschätzung, um zu vermeiden, dass politische Anreize untergraben werden, während Verbraucher*innen weiterhin die Möglichkeit haben, die Energiewende zu beeinflussen.

Weitere Informationen können durch Herkunftsnachweise (HKNs) vermittelt werden

In Bezug auf die zugrundeliegende Infrastruktur für die Rückverfolgung hebt der Bericht die Stärkung des Herkunftsnachweissystems durch die Erweiterung des Spektrums der in Herkunftsnachweise integrierten Informationen hervor. Dazu zählen Nachhaltigkeitskriterien, die Einhaltung der RFNBO, indirekte Emissionen, PPA-Beziehungen und Zeitstempel für die Produktion auf Stundenbasis. Diese Ergänzungen werden durch die überarbeitete EN 16325:2025 und die EECS-Vorschriften unterstützt und würden die Kennzeichnung in einem Energiesystem mit höheren Anteilen erneuerbarer Energien und einer stärkeren Sektorenkopplung zukunftssicher machen.

Bessere Koordinierung von Tracking-Systemen ist der entscheidende Faktor für Gase

Für Gase, für die sowohl HKNs als auch Nachhaltigkeitsnachweise (PoS) existieren, ist eine bessere Koordinierung der Nachverfolgungssysteme erforderlich. Die Koexistenz mehrerer Register erhöht die Verwaltungskosten und das Risiko widersprüchlicher Angaben. Integrierte Lösungen, die sowohl der Kennzeichnung als auch der Zielbilanzierung dienen, würden die Zuverlässigkeit und Verwaltungseffizienz erheblich steigern.

Institutionalisierung des Austauschs und der Zusammenarbeit zwischen den zuständigen Stellen für die Kennzeichnung

Um das gegenseitige Lernen zu fördern und die Konvergenz auf Basis freiwilliger Harmonisierung zu unterstützen, wird eine strukturierte Plattform für den Dialog und die Zusammenarbeit zwischen politischen Entscheidungsträger*innen, nationalen Kennzeichnungsbehörden, Systementwickler*innen, Aufsichtsbehörden und Interessengruppen empfohlen.

Schlussfolgerungen und Ausblick

Die Studie zeigt, dass gut konzipierte Energiekennzeichnungssysteme nicht nur als Berichterstattungsinstrumente, sondern auch als Triebkräfte für mehr Transparenz, die Stärkung der Verbraucher*innen sowie die Dekarbonisierung fungieren können. Mithilfe eines strukturierten Bewertungsrahmens, der die Vorteile für die verschiedenen Interessengruppen mit messbaren Kriterien verknüpft, wurden im Rahmen des Projekts die wichtigsten Lücken der derzeitigen Kennzeichnungspraxis ermittelt. Diese ist nach wie vor weitgehend informativ und unterstützt wirkungsorientierte Aspekte wie Zusätzlichkeit und zeitliche Korrelation nur unzureichend. Die Ergebnisse unterstreichen die Notwendigkeit einer Modernisierung der Energiekennzeichnungssysteme, um sie an ein von erneuerbaren Energien dominiertes Energiesystem anzupassen sowie die in Europa bereits umgesetzten bewährten Verfahren zu nutzen und die harmonisierten EU-Leitlinien zu stärken. Durch die Integration der Energiekennzeichnung in umfassendere politische Instrumente können politische Entscheidungsträger*innen die systemische Rolle der Kennzeichnung stärken. Insgesamt bietet das Projekt eine solide analytische Grundlage für Reformen und macht deutlich, dass die Energiekennzeichnung letztlich breiteren gesellschaftlichen und ökologischen Zielen dienen muss.

1 Introduction

1.1 Background

Since the liberalisation of the electricity market and through the continuous evolution of European energy policy objectives, energy consumers have assumed a more central role in the energy transition. This development has been accompanied by increasing environmental and climate awareness regarding the impact of energy consumption.

On the regulatory level, instruments have been established — particularly within the European legal framework — to provide consumers with information about their energy consumption, including attributes such as the energy mix and environmental impacts. A fundamental distinction exists between accounting mechanisms (tracking, backend) and information disclosure (frontend) to consumers.

The Renewable Energy Directive (RED) introduced the mandatory use of Guarantees of Origin (GOs) for electricity from renewable sources. With the implementation of Article 19 of RED II, GOs now also apply to renewable gases (including hydrogen) and heating/cooling. Some European countries have extended these systems to non-renewable energy carriers. The operational implementation largely follows the European Energy Certificate System (EECS), managed by the Association of Issuing Bodies (AIB). The ongoing standardisation process under EN 16325 has further harmonised these systems. Similar certificate systems have also evolved outside Europe.

For renewable gases, the recast EU Gas and Hydrogen Directive mandates that suppliers disclose renewable gas supply through GOs. Thus far, renewable gas disclosure has primarily relied on mass balance accounting, which continues to be mandatory for compliance with RED III targets and national support schemes (in Germany, for instance, Proofs of Sustainability are issued by the Federal Office for Agriculture and Food's (BLE) Nabisy registry, while mass balancing certifycates used in the context of further criteria checks for national support schemes are issued by the German Energy Agency's (dena) Biogasregister platform. GOs for disclosure will be issued by the German Environment Agency). On a European level, the AIB facilitates the standardised transfer of GOs across borders between account holders who are registered with governmentally-appointed GO-issuing bodies. The European Renewable Gas Registry (ERGaR) facilitates the cross-border certificate transfers of non-governmental certificates. The Union Database has been established as a key tool for accounting for policy targets and facilitates GHG registration following the method of 'mass balance chain of custody' and preventing double counting.

For heating and cooling, RED III and the recast Energy Efficiency Directive mandates transparency regarding the energy mix and environmental impacts of district heating and cooling networks. However, unlike in the electricity and gas sectors, no direct linkage to the GO system under Article 19 RED III currently exists.

Several fundamental accounting approaches apply to energy disclosure:

- Certificate-based book and claim models
- Mass balance models
- Contract-based approaches with varying verification mechanisms
- Implicit disclosure through statistical default values (e.g. residual mixes)

Beyond consumer disclosure, energy disclosure information also impacts policy instruments such as electromobility incentives and renewable hydrogen support schemes. Additionally, corporate sustainability reporting increasingly relies on accurate energy disclosure to ensure transparency and comparability, particularly within market-based vs. location-based approaches.

The Corporate Sustainability Reporting Directive (CSRD), effective since 2023, significantly expands corporate sustainability disclosure requirements and refers to the European Sustainability Reporting Standard (ESRS) for the reporting method. The Corporate Sustainability Due Diligence Directive (CSDDD), adopted in May 2024, mandates companies to assess human rights and environmental impacts across their value chains, and refers to the framework of CSRD/ESRS. The Empowering Consumers Directive, which takes effect in September 2026, further regulates energy disclosure and environmental claims in marketing (as does the proposed Green Claims Directive which is currently on hold).

Future challenges include harmonising energy disclosure systems for global energy trade (e.g. hydrogen) and integrating sector coupling mechanisms to align different energy carrier accounting systems.

Beyond consumer information, energy disclosure systems serve additional purposes, notably in renewable energy (RE) support schemes and compliance with energy policy targets. Addressing the diverse demands on energy disclosure requires a harmonised, coordinated approach.

1.2 Objectives

This project '*Proposals for energy disclosure for electricity, gas, hydrogen, heating and cooling as a practical model for a European solution'* aims to create a sound basis for discussion for political decision-makers, responsible authorities, market participants, NGOs, research and other stakeholders in order to promote the design of improved, well-coordinated and more harmonised European energy disclosure for these three different energy types, and possibly beyond. In addition, a reusable methodological framework for analysing the utility of energy disclosure for different groups in society will be developed. Based on this analysis, elements with potentials for improvement are identified.

This framework should help in the evaluation of future concrete regulations for energy disclosure. The analysis is based on a broad understanding of energy disclosure, which includes the verification of the origin of energy carriers (accounting instruments and mechanisms, tracking as the 'backend' of energy disclosure) and the presentation of corresponding information to different stakeholder groups (with the parameters and format of the displayed information as the ''frontend'' of energy disclosure).

1.3 How to read this report

This report presents the results of the research conducted in this project, thereby mostly following the individual working steps. In the following, the structure of this report is outlined in order to increase the understandability of the rationale behind it and to improve navigation through the report.

Chapter 2: Analytical framework

This chapter describes the approach to an extensive literature study which has been conducted as a starting point for the project. The aim of this literature research was to identify potential benefits of different disclosure systems for different stakeholder groups, namely households, organisation (in the sense of institutional consumers), plant operators and society as a whole. The literature analysis also aimed to identify specific beneficial aspects of disclosure systems ("criteria") which contribute to the fulfilment of these benefits.

Furthermore, this chapter describes the methodological framework which has been developed and applied in order to provide for a clearly structured description and evaluation of different disclosure systems, and individual elements of such systems. Besides the application of this methodological approach and the elaboration of results as outlined in the report, a major feature is the provision of a separate Excel tool,[1] which facilitates a semi-automated description and evaluation of disclosure systems and can also be used to evaluate future disclosure design regulations.

Chapters 3 to 6: Benefits of energy disclosure for households/organisations/plant operators/society as a whole, and related criteria.

This chapter provides a comprehensive overview of the benefits as identified in the literature research which may derive from energy disclosure systems for the different stakeholder groups households, organisations (in the sense of institutional consumers), plant operators as well as for society as a whole.

It also provides a short assessment of the relevance of the individual benefits with a view to the different energy types – electricity, gases and heating and cooling. Furthermore, it proposes criteria which have been found to be relevant to be fulfilled as a contributing factor for achieving the different benefits.

Chapter 7: Detailing criteria for evaluation of disclosure concepts

Chapter 7 disaggregates the identified high-level criteria as described in the earlier chapters into what we called 'sub-criteria'. These are defined based on the processed literature and the expertise in the consortium with the ambition to have more objectively assessable criteria in the sense of specific design features of disclosure systems.

These sub-criteria therefore serve two purposes: on the one hand, the fulfilment of these sub-criteria can be practically used as an indicator for the fulfilment of the high-level criteria, and therefore for the fulfilment of the different benefits. On the other hand, they can be used as a guiding recommendation for policy makers which policy options should be implemented in disclosure systems for further improvement.

Chapter 8: Overview and evaluation of energy disclosure concepts

This chapter provides an overview of 27 case studies of energy disclosure systems as implemented in different countries as well as for innovative approaches as described by reports, articles or other publications. The evaluation builds on the analytical framework as established by the project, including the consideration of the different benefits, criteria and sub-criteria as defined by the earlier chapters. The overview also summarises the high-level results of the applied Excel evaluation sheet, showing to what extent the different benefits (and related sub-criteria) seem well-served by the analysed case studies, and where this seems not to be the case.

Chapter 9: Takeaways regarding the improvement potentials

This chapter explains the definition of different scenarios which build on either identified good practice approaches in analysed countries or also include innovative design approaches as identified from the literature study. Furthermore, it provides an analysis based on the Excel tool evaluation of these scenarios, showing to which extent existing disclosure schemes can be improved if good practices from exemplary cases currently in place were to be generalised and if innovative approaches from the literature were also to be adopted.

[1] The Excel tool is available online at https://doi.org/10.5281/zenodo.19096941.

Chapter 10: Key lessons from good and innovative practices for enhancing the benefits of energy disclosure

While chapter 9 provides a description and analysis of different scenarios based on the identified good practice and innovative approaches, chapter 10 provides on a more general level key lessons of the analysis relating to the different sub-criteria within both the good practice scenarios and the innovation scenarios, clustered along the structure of six different design elements of disclosure systems. This clustering should allow policy makers to have a condensed overview of relevant aspects (i.e. sub-criteria) which relate to these design elements when discussing potential improvements of disclosure systems on a more general level.

The more disaggregated basis for this compilation – the list of identified good practice examples or beneficial innovative approaches – is provided in Annex B (Annex II).

Chapter 11: Recommendations for further developing disclosure

Based on the analysis of good practice and innovative scenarios presented in chapter 9 and on the description of key lessons as outlined in chapter 10, this chapter 11 summarises the condensed recommendations stemming from the project work for further improving energy disclosure systems in Europe. While the two earlier more detailed chapters particularly address system designers for disclosure and tracking systems, chapter 11 in its condensed form aims at high-level policy makers.

Chapter 12: Considerations for further research

This chapter provides an overview of issues which need further research and analysis for assessing and implementing specific policy options in the field of energy disclosure systems. Like chapter 11, this chapter 12 builds on the detailed elaborations from chapters 9 and 10. However, its content particularly aims at research organisation and funding institutions.

Chapter 13: Stakeholder feedback

This chapter addresses the general feedback received during the presentation and discussion of the project findings, which took place at the project's final event on 7 November 2025 in Brussels.

Chapter 14: General conclusion

Chapter 14 provides a short conclusion on what the project has delivered, and how its results can generally contribute to future improvements of disclosure systems.

Chapter 15: List of references

The references used in this report are listed.

Annex I: Relation between sub-criteria, criteria and benefits

This Annex details the correlations between the high-level criteria and sub-criteria per stakeholder group and per benefit.

Annex II: Showcasing the proposals for improving energy disclosure based on good practice and on innovative concepts

This Annex identifies good practices in disclosure for electricity, gases and heating and cooling, demonstrating what works in reality; it also highlights potential pitfalls and provides practical lessons for designing effective energy disclosure systems. It presents examples drawn from the countries analysed and which serve as the real-world evidence base for the recommendations that follow. These are supplemented with inspiration drawn from studies that describe innovative disclosure concepts.

Annex III: Set of search strings for literature review

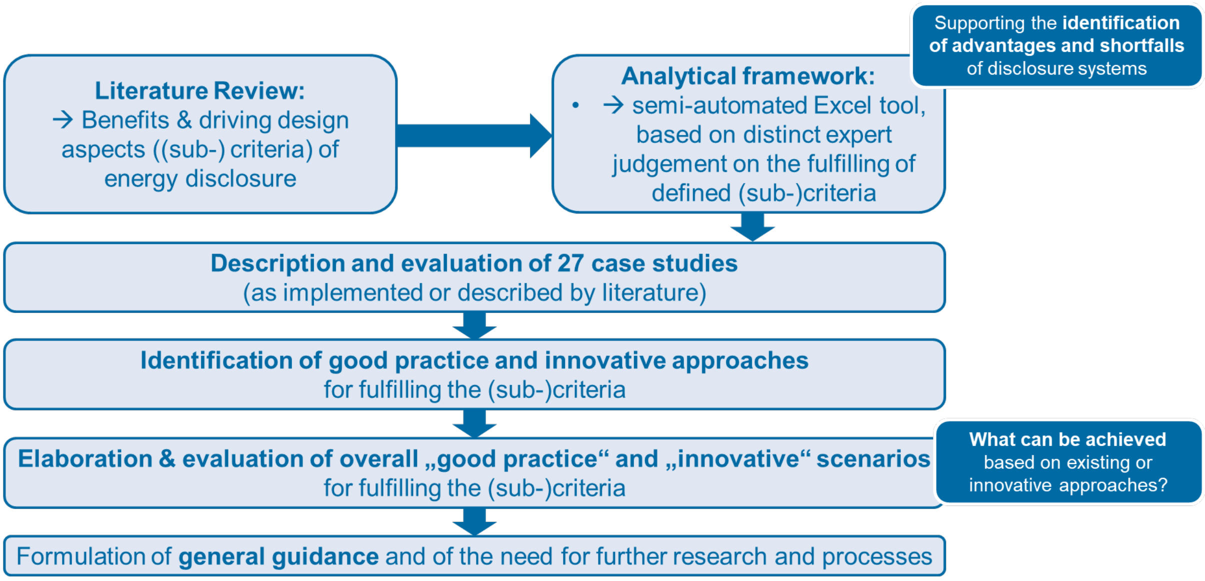
The set of search strings is listed that was used for the literature review in order to identify and analyse relevant literature.

2 Analytical framework

2.1 Overview

According to the objectives defined for this project, a structured approach for describing and evaluating disclosure systems was developed. Applying this analytical framework has led to learnings about the impacts of different design elements of disclosure systems and the formulation of recommendations and guidance for their further development. Figure 7 provides an overview of the working steps taken. The methodological approach for these working steps is explained in more detail in chapters 2.2 to 2.7.

Figure 7: Methodological approach for developing and applying the analytical framework in this project



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

2.2 Scope of study: 3 energy types and 4 stakeholder groups

In line with the title of this project titled '*Proposals for energy disclosure for electricity, gas, hydrogen, heating and cooling as a practical model for a European solution*,' three energy types are considered: electricity, gas, and heating and cooling. The energy type 'gas' both encompasses methane-based gases (natural gas, bio-methane and e-methane) and hydrogen-based gases, even though the physical supply of both types of gases might be organised in distinct energy systems.

Furthermore, four stakeholder groups of energy disclosure are considered in this study: households, organisation (in the sense of institutional consumers), plant operators and society as a whole.

2.3 Literature research

An extensive literature study was conducted as a starting point for this project. The aim of this literature research was to identify potential benefits of different disclosure systems for different stakeholder groups. The literature analysis also aimed to identify specific beneficial aspects of disclosure systems ("criteria") which contribute to the fulfilment of these benefits.

To be able to identify relevant literature, several research questions were defined. The search for relevant literature was carried out in an iterative process using a pre-defined set of search strings as a starting point. These were formulated so as to provide literature that helps to answer the overarching research questions and aims to show the potential benefits for the four different stakeholder groups and find general literature on different energy disclosure concepts:

- What requirements do households have with regard to energy disclosure?
- What requirements do organisations have with regard to energy disclosure?
- What requirements do the various types of plant operators have with regard to energy disclosure?
- What other societal requirements are there for energy disclosure?
- What concepts for energy disclosure are proposed in the literature?

Search strings were carried out within respective scientific databases (e.g. Science Direct, Scopus, EconBiz, EconStor, ResearchGate) as well as Google Scholar. Additionally, web research was conducted for scientific reports and stakeholder statements (using the search engines Google and Ecosia). Search strings that provided no or insufficient results were adapted accordingly; thereby, search strings were gradually refined. New search strings identified during the literature search were integrated in the search process (the final set of search strings can be found in Annex C). This resulted in a comprehensive literature base of 400 publications. The literature base includes sources published up to **31 January 2025**. After this date, only isolated additions were made as the project team proceeded to work with the existing results in the subsequent analysis and evaluation phases.

In the next step, literature was reviewed to select only highly relevant literature for further analysis by checking the publications in more detail against the other research questions. For this purpose, abstracts and conclusions were scanned so as to assess whether the publication could be used to answer the research questions (resulting in a selection of 29 relevant publications for households, 106 publications for organisations, 89 publications for plant operators, and 61 publications for society as a whole).

2.4 Development of the analytical framework

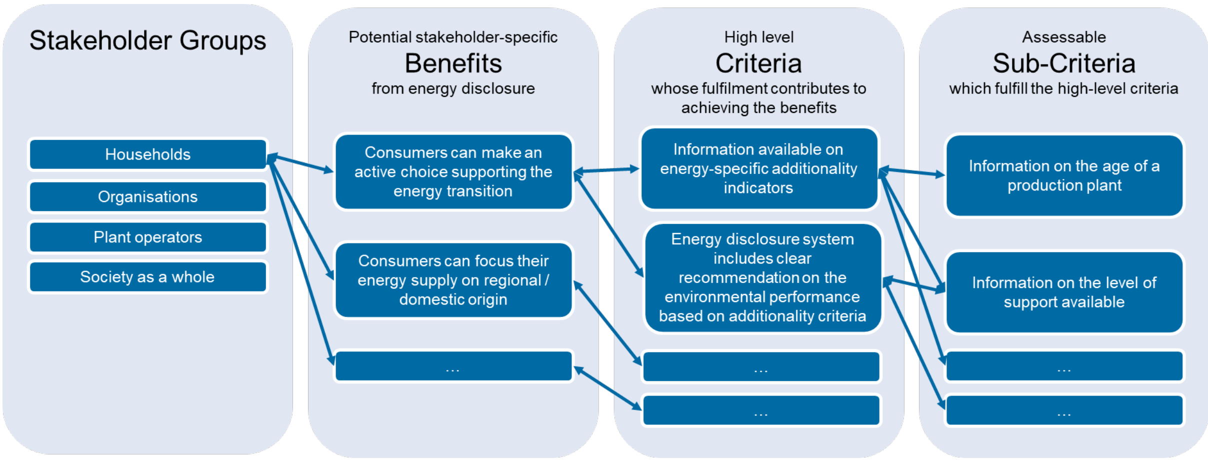
2.4.1 Overall framework, organised by benefits for stakeholder groups, criteria and sub-criteria

Based on the literature research and further expert analysis by the project team, potential benefits of different disclosure systems for the different stakeholder groups were identified. This also included identifying specific beneficial overarching aspects of disclosure systems ("high-level criteria") which contribute to the fulfilment of these benefits. As a next step, specific design features of disclosure systems ("sub-criteria") were identified which support the fulfilment of the high-level criteria and related benefits, and which allow for a sufficiently objective evaluation of different disclosure systems.

This section describes the applied methodology for developing an analytical framework allowing for this evaluation of the benefits of energy disclosure systems for various stakeholder groups.

The individual elements of the resulting analytical approach are illustrated based on exemplary content in Figure 8. The approach for specifying the benefits, the high-level criteria as well as the assessable sub-criteria is further described in sub-chapters 2.4.2 to 2.4.6. A full list of benefits, high-level criteria and assessable sub-criteria – and the relation between them – is provided in Annex A (Annex I).

Figure 8: Illustration of the analytical framework for energy disclosure systems



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

As a major feature of the developed analytical framework, an Excel tool[2] has been developed which facilitates a semi-automated description and evaluation of disclosure systems, which can also be used in order to evaluate future disclosure design regulations (see chapter 2.4.6). The establishment of the analytical framework in the mentioned Excel tool is described in chapter 2.5.

2.4.2 Deriving benefits for different stakeholder groups

To map the potential benefits that energy disclosure systems can provide for different stakeholder groups, the results of the literature evaluation are combined with theoretical considerations and practical experiences of the study's authors.

Furthermore, the indicative relevance of the individual benefits has been assessed for each of the three considered energy types. The guiding question here was: '*Is it relevant that an electricity/gas/heating and cooling energy disclosure system supports this benefit?*' This addresses two different dimensions. The first dimension is the relevance of the benefit for a certain energy type, taking energy type-specific market framework conditions into account. For instance, the benefit "achieving revenues from green attribute sales in short-term markets" is more relevant for electricity plant operators than H&C plant operators, because H&C supply contracts tend to be long-term by definition (given grid connection costs). Yet even for electricity, the literature analysis indicates a limited relevance of short-term markets revenue because of low and volatile GO prices, resulting in a "medium" relevance assessment Furthermore, as a second dimension the relevance assessment takes into account to what extent an energy disclosure system could contribute to achieving this benefit. This indicative assessment was conducted based on expert judgements by the project team, building on the findings from the literature research as well as on their professional expertise.

The results are presented in chapters 3 to 6.

2.4.3 Determining high-level criteria for assessing benefits of disclosure

Based on the literature research, high-level criteria were identified in order to assess the fulfilment of the respective benefits of various disclosure concepts. Similar to the indicative relevance of the different benefits, also an indicative relevance of the different criteria for the different energy types has been assessed based on expert judgements by the project team. Specific

2 The Excel tool is available online at https://doi.org/10.5281/zenodo.19096941.

characteristics of markets for electricity, gas and for H& C which influence this relevance, and which therefore have been taken into account for the assessment include:

- Regional dimension of infrastructure and markets
- Temporal characterisation of trade in the sense of long term vs. short term trade
- Different settlement periods for different energy types
- General market structures and level of competition
- Political and regulatory level of voluntary vs. mandatory applicability (thus influencing both price signals and market penetration)
- Expected scarcity signals
- Other price effects which depend on the criterion

Following this approach, the relevance of each criterion for the different energy types has been roughly categorised in three categories, namely high, medium and low.

Cross-stakeholder group aspects such as technical preconditions for well-functioning disclosure systems are crucial and assumed to be a baseline for all further disclosure scenarios. As such, they are not subject to detailed elaboration in the evaluation criteria within the scope of this project. An overview of such preconditions as compiled by the project team based on own experience and relevant existing literature (e.g. work done by the RE-DISS projects) is provided in Table 1.

Table 1: Common preconditions for well-functioning disclosure systems

Assessment criterion	Requirements
Reliability	Independent governance organisation (ideally appointed by the government)
	Unique claim
	Verifiable parameters and documentation on key aspects
	Third-party verification of registered data and of production data (if not fully automated)
Accuracy	Based on verified meter readings
	Third-party verification of registered data and of production data (if not fully automated)
Error and fraud resistance	Error-resistant electronic registry
	Third-party verification
	Transparent and enforceable procedures
Clarity on temporal and geographical system boundaries	

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A draft of the benefits and criteria presented in this report were discussed in an expert workshop carried out on 17 February 2025. Feedback gained during this workshop has been taken into account in this report.

2.4.4 Sub-criteria: making benefits and related high-level criteria assessable in a structured way

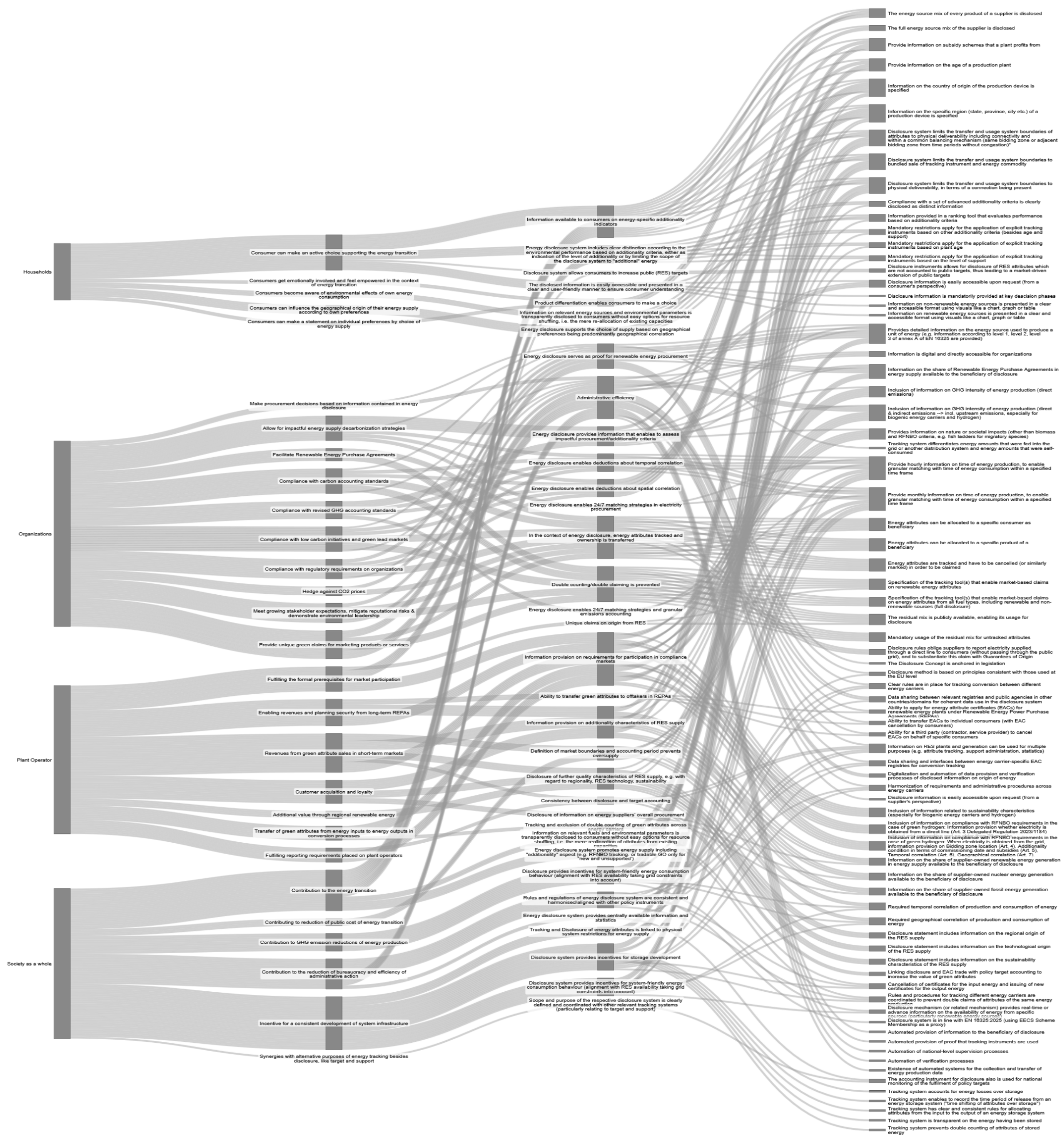
For the further work in the project, a set of sub-criteria was developed, each of which relates to assessable design features which may or may not be implemented within a given disclosure system. The clear pre-definition of different sub-criteria allows clear identification of what specific implementation approach is suitable to fulfil the high-level criteria and thereby contribute to achieving the potential benefits of disclosure systems. In effect, sub-criteria are defined in such a way that the assessment of disclosure case studies and concepts proposed in the literature can be carried out with standardised response options ('Yes'; 'Yes with restrictions'; 'No'; 'Depending on other aspects (market framework, detailed implementation, etc.)'; 'Not applicable'; 'No conclusion'). Thus, the structured description of a disclosure system based on the combination of these pre-defined sub-criteria enables a semi-automated evaluation of different energy disclosure systems against the previously defined criteria for beneficial concepts per stakeholder group.

As a comprehensive list of relevant design features, the sub-criteria offer a structured overview of practical and theoretical approaches and enable a comparison based on relevance and usefulness for different stakeholder groups. Moreover, they function as a toolbox for concept development, helping to identify best practice elements that provide high stakeholder benefit and should therefore be considered when designing new concepts.

2.4.5 Overview of the logical link between benefits, high-level criteria and sub-criteria

The identified high-level criteria and sub-criteria have been structured and partly streamlined according to their practical relevance for the energy disclosure aspects that they help to assess. More specifically, this means that a given sub-criterion may relate to different high-level criteria if it contributes to fulfilling several of those. Similarly, a given criterion can relate to different benefits for different stakeholder groups. For illustration purposes, the resulting logical linkages between all these aspects is shown in Figure 9, and more details are provided in Annex A (Annex I).

Figure 9: Illustration of the non-exclusive hierarchy between stakeholders, benefits, high-level criteria and sub-criteria within the analytical framework



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

An overview of identified benefits, high-level criteria and related sub-criteria per stakeholder group is provided in chapter 3.1 for household consumers, in chapter 4.1 for organisations (in the sense of institutional consumers), in chapter 5.1 for plant operators and investments in energy production plants, and in chapter 6.1 for society as a whole.

2.4.6 Developing an Excel tool for the structured description and automated indicative evaluation of disclosure systems

An Excel tool was developed based on the defined benefits, high-level criteria and related sub-criteria. This fulfils different objectives.

Firstly, it allows for a structured description of different disclosure systems for electricity, gases and heating and cooling based on the given fulfilment of the different sub-criteria. This is to be assessed by experts based on their knowledge and understanding of a given scheme, and their assessment of whether this form of implementation fulfils the defined sub-criterion.

Secondly, it allows for an automated indicative evaluation of one or several disclosure schemes based on this input. This is because the tool automatically links the provided input on the fulfilment of the sub-criteria to the fulfilment of the related high-level criteria and benefits per stakeholder group.

The application of the tool and a more detailed specification of its functionalities are provided in chapter 2.5.

The Excel tool is available online at https://doi.org/10.5281/zenodo.19096941 .

2.5 Applying the analytical framework to describe and evaluate energy disclosure systems

The analytical framework described in chapter 2.4 was applied to describe and evaluate different energy disclosure systems (or conceptual approaches for such systems) as described below.

In the initial working phase and the literature review, a broad understanding of disclosure was adopted. This enabled consideration of not only supplier disclosure as the purpose but also the perspective of target and corporate accounting as well as, to some extent, support systems.

The subsequent working steps (evaluation of energy disclosure concepts and development of beneficial energy disclosure concepts) focus on energy disclosure concepts for consumer information by energy suppliers, and relevant corporate disclosure concepts for climate or sustainability reporting. The evaluated concepts were selected in coordination with the German Environment Agency.

As a first step, each of the selected disclosure systems was described by checking the consistency of the disclosure system against the pre-defined sub-criteria in a standardised excel table. Thereby the specific way in which different aspects are implemented in a given disclosure system is described. The extent to which the individual pre-defined sub-criteria are reflected by the specific disclosure systems and concepts was assessed according to the following categories:

- Yes,
- Yes, with restrictions,
- No,
- Depending on other aspects (market framework, detailed implementation, etc.),
- Not applicable,
- No conclusion.

An assessment was carried out for 15 existing disclosure systems, for five disclosure concepts for climate or sustainability reporting and for seven innovative disclosure concepts as described by the literature. The assessment was conducted based on online and literature research on the concepts and existing expertise of the project team according to their best knowledge. A textual summary of the analysed disclosure systems and concepts is provided in chapter 8.

As a next step, this standardised description was used to assess the fulfilment of the benefit-related criteria elaborated in chapters 3-6 in a structured way. An indicative automated ranking of the level of fulfilment for individual criteria and related benefits was derived for all analysed disclosure systems and concepts according to the following methodological steps:

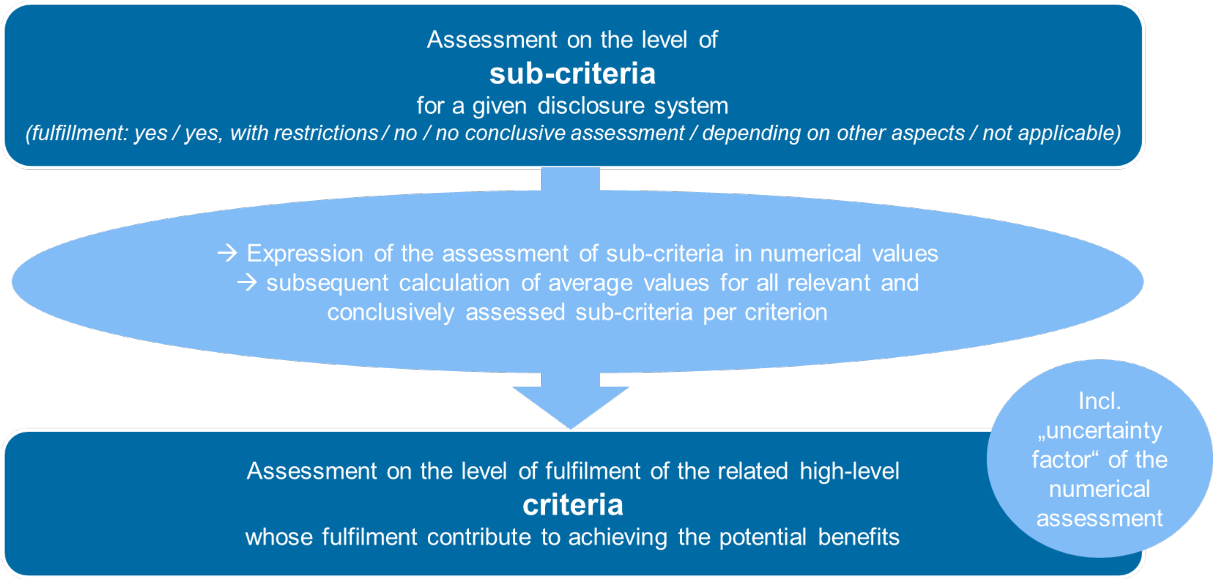
1. For all conclusive assessments numerical values are applied: 3 for 'Yes,' 2 for 'Yes with restrictions,' and 1 for 'No'.
2. For all pre-defined sub-criteria relating to one specific criteria, for which a conclusive assessment was derived for a given disclosure system/concept, the average value was calculated. Assessments marked as 'not applicable' were excluded entirely from consideration, and those deemed 'non-conclusive' were not included in the average calculations.
3. This average value is used as an indicator for the level of the overall advantageousness of the respective disclosure system/concept for each stakeholder group, ranging from 1 (no consistency with the relevant pre-defined sub-criteria) to 3 (full consistency with the relevant pre-defined sub-criteria). Average values per sub-criterion help to identify those sub-criteria that are already well-reflected in the examined disclosure schemes and that provide benefits to the different stakeholder groups.

It should be noted that this methodology does not reflect whether a conclusive answer was only given for a limited number of relevant pre-defined sub-criteria, or for all of them. This might result in a situation in which the full consistency with one relevant sub-criterion defines the overall average value for this criterion, while several other relevant sub-criteria might not have been assessable, meaning that they were assessed as 'depending on other aspects' or 'no conclusive assessment'. Unanswered sub-criteria thus do not contribute to the assessment score, but introduce uncertainty, as it remains unknown whether their inclusion would have improved or worsened the result. In order to take such uncertainty into account, an 'uncertainty factor' was calculated for each evaluation criterion for each disclosure system/concept according to the following additional steps (a higher uncertainty factor indicates the greater uncertainty of the automated evaluation result):

4. The total number of sub-criteria with an unclear assessment ('depending on other aspects' or 'no conclusion') was divided by the total number of sub-criteria related to a given criterion. The sub-criteria assessed as 'not applicable' were not taken into account.
5. The result is provided as a percentage along with the average value as a result of step 3, in order to highlight the level of uncertainty ('uncertainty factor') of the provided result.

This evaluation approach is shown in Figure 10.

Figure 10: Approach to evaluating individual energy disclosure systems



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

This approach allows, to the extent possible, for an automated indicative evaluation of disclosure systems based on clearly-structured descriptions of such disclosure systems. This was pre-defined as a requirement of this project. This evaluation provides insights into the extent to which a given disclosure system or concept leads to the fulfilment of criteria which indicate potential benefits for different stakeholder groups. Main findings from this evaluation of different disclosure systems and concepts are described in chapter 8.

However, it should be noted that this approach has some limitations which are important to bear in mind when interpreting the results.

- The evaluation results strongly depend on the quality of data input for the individual sub-criteria, and the necessary individual pre-assessment by the responsible expert in order to define the assessment (e.g. 'Yes,' or 'Yes with restrictions'). Inevitably, this also depends to some extent on the subjective views of the expert, which means that there are some limitations in terms of the comparability of results when different experts are involved.
- All pre-defined sub-criteria are weighted uniformly in this methodology with a view to their relevance for the related high-level criterion, while in practice it could be argued that some sub-criteria are more relevant than others. However, such a prioritisation is again highly complex and subject to individual preferences, and therefore not included in the given approach.
- Several of the given pre-defined sub-criteria may interact or influence each other or be to some extent alternative or complementary to each other. It is also difficult to reflect this complexity in such a strictly formalised evaluation approach.
- The pre-defined sub-criteria are primarily developed from an energy disclosure perspective, with a strong emphasis on electricity. As a result, they are not easily applicable to certain concepts, particularly innovative ones that extend beyond energy disclosure and involve aspects of corporate disclosure. These concepts do not align well with the analytical framework, which makes it challenging to derive meaningful results. Furthermore, such innovative concepts are mostly described by a few key features only, while the overall performance still depends very much on the detailed implementation of other aspects. This leaves a high level of uncertainty for the respective evaluation.

- Finally, there are restrictions in evaluating the linkages between different disclosure systems, either in the geographical or in the technical dimension. Such an evaluation would depend very much on the definition and the knowledge about the specifications of the respective other, linked disclosure system, which can also only be covered to a limited extent by the given approach.

Therefore, the results provided by the Excel tool should be understood as indicative results, which allow particularly positive aspects of different disclosure concepts to be identified that are considered beneficial for the stakeholder groups. It can thereby stimulate critical discussion about the extent to which different disclosure concepts and their respective design specifications contribute to the potential benefits of different stakeholders, and how disclosure systems can improve in the future.

The 27 analysed case studies are described in chapter 8. General descriptions of the respective disclosure systems are included, as well as summaries of the respective evaluation results derived from the Excel evaluation tool.

2.6 Identification of good practice and innovative approaches, and analysis of ‘good practice’ and ‘innovative’ scenarios

Applying the analytical framework as described in chapter 2.5 allows overall findings to be derived. These finding relate to how well the different existing disclosure concepts (or those proposed by the literature) provide benefits to the different stakeholder groups, and which sub-criteria are already well-reflected by the different disclosure concepts that underpin the well-provided benefits. More specifically, it also allows for the comparative identification of examples of where and how individual aspects of disclosure systems are particularly well-established or proposed. Results for this analysis for the 27 case studies are provided in chapter 8.4.

Building on these findings, two different sets of scenarios for energy disclosure systems were compiled for each of the three different energy types:

- One ‘good practice scenario,’ including identified examples of good practice for the different sub-criteria aspects from disclosure systems that have been implemented. This scenario allows assessment of the extent to which the different benefits can be achieved by building on established procedures and approaches.
- One ‘innovation scenario,’ which also includes further innovative approaches for the different sub-criteria aspects from the analysed innovative proposals gathered in the literature study. This scenario allows assessment of the extent to which the different benefits can also be achieved by implementing such innovative literature-based approaches.

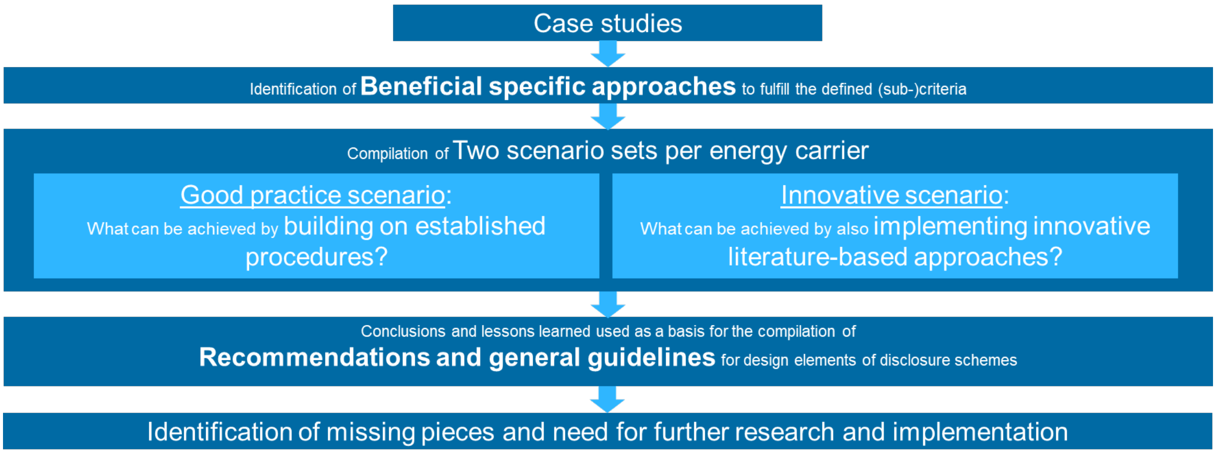
These three ‘good practice scenarios’ and three ‘innovation scenarios’ were assessed in the same way as the individual existing disclosure schemes and innovative proposals (see the previous sub-chapter).

The numerical indication of how well the individual pre-defined sub-criteria are reflected in these six scenarios helps assess whether the scenarios provide greater benefits to the stakeholder groups than the individual existing disclosure schemes and innovative proposals. Average values per sub-criterion help identify the sub-criteria that offer the most significant improvement potential. The results of this structured analysis are provided in chapter 9.2.

The detailed overview of these compiled scenarios and the respective ‘showcase’ examples for implementing the individual sub-criteria is provided in Annex B: Annex II. These examples are intended to serve as inspiration or as a blueprint for further improving existing disclosure systems, and for gaining further coordination and harmonisation of these schemes in Europe.

The methodological approach for the development of the two sets of scenarios per energy carriers based on the analysed case studies is shown in Figure 11.

Figure 11: Methodological approach for developing recommendations, guidelines and the need for further research based on the case studies analysed



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

2.7 Formulation of general guidance, and the need for further research and processes

The essence of the key lessons and general guidelines for developing disclosure schemes further is provided in Figure 11 based on the findings described above. As an outcome of the research, six different design elements of disclosure systems were identified that are crucial for providing improved disclosure benefits. The different sub-criteria can be clustered within the following pillars:

- Clarity and consistency in energy disclosure purposes,
- The institutional anchoring of disclosure,
- The system boundaries of energy disclosure,
- The type of information provided,
- Information on additionality indicators, and
- The format of information disclosure.

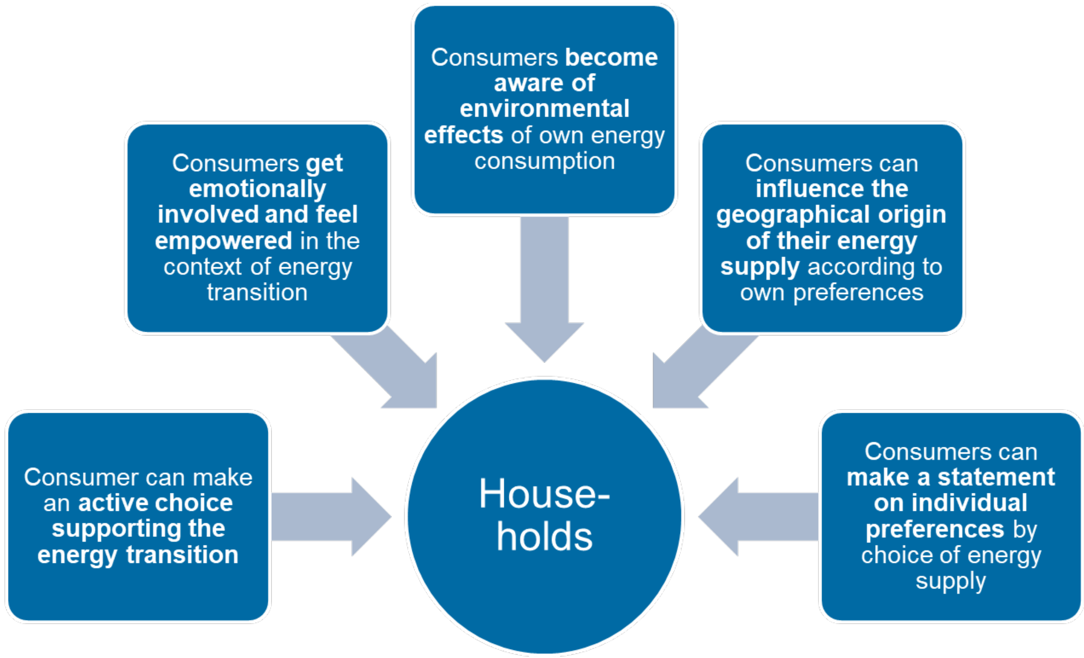
This clustering should give policy makers a condensed overview of the relevant aspects (i.e. sub-criteria) that relate to these design elements when discussing potential improvements of disclosure systems more generally. The key lessons and guidelines are presented in chapters 9.3 and 11.

3 Benefits of energy disclosure for households, and related criteria

3.1 Overview

With a view to the potential benefits which can be achieved from the perspective of households, an overview is provided in Figure 12 and more details are shown in Table 2 below. This table also includes a list of the high-level criteria as well as beneficial sub-criteria which support the fulfilment of these criteria.

Figure 12: Identified potential benefits of energy disclosure systems for households



Source: Authors' own illustration, Oeko-Institut.

Table 2: Benefits of energy disclosure for households and relevant criteria

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
Consumer can make an active choice supporting the energy transition	E: high G: medium H&C: medium	Information available to consumers on energy-specific additionality indicators	E: high G: medium H&C: low	• The energy source mix of every product of a supplier is disclosed • The full energy source mix of the supplier is disclosed • Provide information on subsidy schemes that a plant profit from • Provide information on the age of a production plant • Information on the country of origin of the production device is specified • Information on the specific region (state, province, city etc.) of a production device is specified • Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion) • Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity • Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
		Energy disclosure system includes clear distinction according to the environmental performance based on additionality criteria, either as indication of the level of additionality or by limiting the scope of the disclosure system to ''additional'' energy	E: high G: medium H&C: medium	Option 1: • • Compliance with a set of advanced additionality criteria is clearly disclosed, either as distinct information (yes/no) or indicating the degree of criteria compliance • • Information provided in a ranking tool that evaluates performance based on additionality criteria Option 2:

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
				• Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support) • Mandatory restrictions apply for the application of explicit tracking instruments based on plant age • Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support
		Disclosure system allows consumers to increase public (RES) targets	E: high G: medium H&C: medium	• • Disclosure instruments allows for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets
		The disclosed information is easily accessible and presented in a clear and user-friendly manner to ensure consumer understanding	E: high G: medium H&C: medium	• Disclosure information is easily accessible upon request (from a consumer’s perspective) • Disclosure information is easily accessible at key decision phases • Information on non-renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table. • Information on renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table. • Information provided in a ranking tool that evaluates performance based on additionality criteria
Consumers get emotionally involved and feel empowered in the context of energy transition	E: high G: medium H&C: medium	Product differentiation enables consumers to make a choice	E: high G: medium H&C: medium	• The energy source mix of every product of a supplier is disclosed • The full energy source mix of the supplier is disclosed
Consumers become aware of environmental effects of own energy consumption	E: high G: medium H&C: medium	Information on relevant energy sources and environmental parameters is transparently disclosed to consumers without easy	E: high G: medium H&C: medium	• Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
		options for resource shuffling, i.e. the mere re-allocation of existing capacities		bidding zone or adjacent bidding zone from time periods without congestion)'' • Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity • Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
Consumers can influence the geographical origin of their energy supply according to own preferences	E: high G: high H&C: high	Energy disclosure supports the choice of supply based on geographical preferences being predominantly geographical correlation	E: high G: high H&C: high	• Information on the country of origin of the production device is specified • Information on the specific region (state, province, city etc.) of a production device is specified. • Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)'' • Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity • Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
Consumers can make a statement on individual preferences by choice of energy supply	E: high G: low H&C: low	Product differentiation enables consumers to make a choice	E: high G: medium H&C: medium	• The energy source mix of every product of a supplier is disclosed • The full energy source mix of the supplier is disclosed

3.2 Consumers can make an active choice supporting the energy transition

A relevant underlying motivation for consumers choosing specific energy offers is their desire to make a positive contribution to the energy transition (Backstrom et al., 2024; Council of European Energy Regulators [CEER], 2023; Hauser et al., 2019; Insight Exchange, 2013; ofgem, 2013, 2014a; Wallbott et al., 2021). Such a contribution to energy transition is particularly the case when the installation of new RES capacities is clearly incentivised.

However, based on the information provided by energy disclosure systems, this is not straightforward to fulfil. The most significant restriction is that allocating and disclosing renewable energy sources in systems with a significant proportion of renewables leads to a particular effect: the reshuffling of existing technologies according to individual consumers' preferences (see e.g., Ascui et al., 2021; Ballentine et al., 2022; Bjørn et al., 2022a, 2022b; Brander et al., 2018; Budden & Morris, 2024; Fisher et al., 2024; Ma & Duan, 2024). This is specifically the case for electricity, but also applies to other energy types in principle. Therefore, the demand by consumers for a specific product (which is disclosed as renewable) usually does not directly stimulate the further development of renewables. For that purpose, energy disclosure systems need specific features supporting so-called "'additionality" aspects in order to meet this ambition. Such additionality features are currently mostly applied in the framework of green energy labels (Mulder & Zomer, 2016; ofgem, 2013; Seebach et al., 2015; Yearwood et al., 2021). By purchasing such energy products based on such additionality criteria, consumers could then fulfil their intention to contribute to energy transition.

Relevance of the benefit for different energy types

Electricity: Many consumers want to show their support for the energy transition by choosing a green electricity product. The benefit is therefore very important for electricity. Disclosure schemes can be very important for this reason. This is at least the case if the disclosure system includes additionality. This is important as long as the supply of RES-E is greater than the active demand for it, so that resource shuffling is possible without additionality.

Gas: The same applies to gas as far as biomethane, hydrogen or other RFNBO-gases are concerned. In the case of hydrogen and other RFNBO-gases, it is particularly important to distinguish between different types of production (e.g. green vs. blue, etc.). However, hydrogen and other RFNBO-gases are unlikely to play a major role in the residential sector, while biomethane is usually explicitly marketed as such and its availability is limited in many countries. Therefore, the relevance is rated as medium.

Heating and cooling (H&C): At the moment, the benefit is of low relevance to DH. Even if H&C systems are geographically limited, consumers could make an active contribution to decarbonisation though, at least in large district heating networks and provided that product diversification is allowed. However, and similar to electricity there can be a shift in resources (resource shuffling) if the active demand for green heat can be met by existing installations that produce climate-friendly heat. A disclosure system that includes elements of additionality can therefore help consumers to contribute to the energy transition. However, in small H&C systems with a limited number of generation units, the relevance of this is low.

Proposed criteria:

<u>Information available to consumers on energy-specific additionality indicators</u>

One quite common approach to define "'additionality" is to apply fuel-source specific criteria which should prefer the production of new sustainable energy over and above the status quo in order to make this production visible and to establish a "'premium market segment". Usually, a distinction is applied according to the plant age and the level of support of the produced energy (Yearwood et al., 2021). These criteria are also applied as a central element to demonstrate additionality in the context of European RFNBO legislation (Erbach & Svensson, 2023; Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin, 2023; RED II, 2018).

However, by showing such information it is not necessarily evident to consumers that these aspects are particularly relevant with a view to "'additionality". Therefore, it is important that this information is backed by information and explanation on how this relates to additionality in a clear and transparent way.

Another way to approach this would be a restriction of all energy which can be explicitly tracked by the energy disclosure system according to pre-defined additionality criteria. By doing so, any choice of supply which is taken by consumers in order to deviate from a default would automatically lead towards an "'additional" offer (see also benefit "Energy disclosure system promotes energy supply including "additionality" aspect (e.g. tradable GO only for "'new and unsupported" described below). If such a pre-defined restriction on "additional" energy applies in the disclosure system, obviously no detailed differentiation has to take place within the disclosure system itself. Furthermore, if a geographical limitation is applied, this restricts the risk of resource shuffling, and therefore reduces the need for additionality criteria.

<u>Energy disclosure system includes clear distinction according to the environmental performance based on additionality criteria, either as indication of the level of additionality or by limiting the scope of the disclosure system to "'additional" energy</u>

The meaning and relevance of additionality criteria as outlined above is not easily understood by consumers. For that reason, it could be an appropriate way to reduce complexity by clearly disclosing a final and transparent assessment or ranking of the respective energy tariff or supplier. This could e.g. be based on a "'label-like" recommendation in the context of the disclosure statement, a public ranking of tariffs according to additionality criteria (CEER, 2023; Yearwood et al., 2021). Another option would be the clear disclosure of the level of additionality (e.g. share of new and unsupported production) according to a common scale on the disclosure statement, e.g. the share of new and unsupported renewable electricity. In the UK, the British regulator ofgem had proposed that suppliers should disclose their level of additionality based on an annual report (ofgem, 2013, 2014b).

<u>Disclosure system allows consumers to increase public (RES) targets</u>

In the current EU framework, the disclosure system based on GO does allow for a pan-European trade of GO, and the claim of the respective RES-attributes by individual consumers. But at the same time, any specific demand by consumers and potential related increase of RES production would always take place within the public RES targets. In the end, when assuming that the targets are to be achieved in any case, any effort by individual consumers to achieve additionality therefore can be considered being a relieve of public support systems and public effort which would have taken place otherwise. In order to allow for a mechanism that a voluntary consumer can contribute to additional RES over and above the public targets, governments would have to commit to such an "'opt-out" of RES volumes in principle, and the respective RES volumes would have to be identifiable. Although such an approach can be considered being highly complex and politically controversial, it would be a very stringent way to allow for additionality. A proposal how this could be implemented has been presented by Timpe et al. (2017) and Seebach and Timpe (2020b).

<u>The disclosed information is easily accessible and presented in a clear and user-friendly manner to ensure consumer understanding.</u>

Depending on the approach for achieving this benefit and the related level of required consumer understanding, the way of presentation towards end consumers may become crucially relevant.

3.3 Consumers get emotionally involved and feel empowered in the context of energy transition

The freedom of choice by consumers according to individual preferences and a related personal involvement and identification with energy transition could be perceived by consumers as a benefit in itself. Hanimann et al. (2015) argues that consumption of green electricity is a public good, the only personalised benefit is an intrinsic 'feel good' feeling that consumers may get if they purchase a contract for the purpose of identity signalling.

Relevance of the benefit for different energy types

The intrinsic 'feel-good' factor that consumers may get from purchasing a contract for the purpose of identity signaling could apply to all three types of energy. Disclosure schemes are a good way of highlighting product features that contribute to the intrinsic 'feel good' factor. In many countries, the market share of renewables in electricity supply is greater than that of gas and H&C. For this reason, the relevance of the benefit is rated high for electricity and medium for gas and H&C.

Proposed criteria:

<u>Product differentiation enables consumers to make a choice</u>

The energy disclosure system needs to allow for a differentiation of products according to criteria which the consumers consider relevant (irrespective of their understanding on aspects like additionality).

3.4 Consumers become aware of environmental effects of own energy consumption

A criticism of energy disclosure systems, particularly in the context of certificate-based book & claim systems, applies to the easy mechanism of resource shuffling. This means the easy reallocation of existing RES and other preferable attributes to those consumers who show specific demand, without a relevant incentive to change the overall system e.g. by adding new RES capacities (see e.g., Ascui et al., 2021; Ballentine et al., 2022; Bjørn et al., 2022a, 2022b; Brander et al., 2018; Budden & Morris, 2024; Fisher et al., 2024; Ma & Duan, 2024). This effect can also be referred to as "greenwashing' (Hauser et al., 2019). Depending on the design of the disclosure system, this effect can be limited, therefore leading to an increased awareness of consumers on the environmental effects of their energy consumption, without "an easy way out' (Brander et al., 2018; Seebach & Timpe, 2023).

Relevance of the benefit for different energy types

Resource shuffling is possible in the energy system whenever the supply of a certain characteristic (e.g. renewable energy generation) exceeds the active demand for it. This is particularly the case for electricity but can also play a role in large H&C networks. Biomethane is usually marketed explicitly (i.e. not blended into a general gas mix). In the case of hydrogen and other RFNBO-gases, this issue will not play a role in the foreseeable future for domestic use. Nevertheless, independent from the energy type specific market relevance, but depending on their design (especially their backend), disclosure systems can make appropriate distinctions for all three energy sources.

Proposed criteria:

Information on relevant energy sources and environmental parameters is transparently disclosed to consumers without easy options for resource shuffling, i.e. the mere re-allocation of existing capacities

The system design does focus on overall effects of the given energy system where the consumer is located. This can include e.g. the following aspects:

- limitation of transferability of energy attributes between geographical areas;
- a preference of mass balance approaches, "bundled' tracking approaches or location-based default values over flexible book&claim accounting approaches.

3.5 Consumers can influence the geographical origin of their energy supply according to own preferences

A relevant aspect for consumers, at least in the electricity sector, when choosing their energy supply can be the geographical origin of this energy. This can relate to the country of production, but also be a regional preference on the smaller scale (CEER, 2023; Lehmann et al., 2023; Wallbott et al., 2021)

Relevance of the benefit for different energy types

Electricity and gas can be transported over long distances via large transmission networks. The geographical origin of the place of production can therefore be a differentiating factor in these markets. In the case of gas, different importing countries may also play a role. If a disclosure system identifies the place of production/origin, this can help consumers to choose products based on the geographical origin. For electricity and gas, the relevance is therefore high. H&C networks, on the other hand, are always geographically limited (even the very large ones). However, disclosure systems may still choose to allow attribute transfer beyond the boundaries of H&C networks. The relevance is therefore also rated as high.

Proposed criteria:

Energy disclosure supports the choice of supply based on geographical preferences being predominantly geographical correlation

The information on the geographical origin of the energy supply has to be documented, tracked, and made available to the consumer in a transparent way.

However, while on the one hand it seems preferrable to increase the freedom of choice for consumers also based on geographical information, most of the consumers obviously have a preference for production stemming from their own region or country. Although this demand can be supported by increased transparency on the geographical origin, consumers still face a high level of complexity for a low-interest product like energy supply. Therefore, this intention of consumers could also be supported by having a restricted tradability of attributes across geographical regions. This particularly applies for heating and cooling grids with clearly limited technical boundaries.

3.6 Consumers can make a statement on individual preferences by choice of energy supply

Irrespective of any considerations on additionality and actual influence on energy transition, a relevant argument for consumers' freedom of choice based on fuel-mix information and energy disclosure is that this choice allows consumers to make a statement on their individual preferences. This can be understood as a signal that a consumer in principle supports the idea of renewables by choosing a renewable product (Hauser et al., 2019). With a view to public statistics of such consumer choices, this signal can be understood by markets and by policy makers as an indicator for the acceptance of renewables. But obviously it also could allow consumers to express a preference for nuclear or even fossil products.

Relevance of the benefit for different energy types

Demand for renewable electricity plays a particularly important role in the electricity market. Motivation in the electricity market can come from a clear vote in favour of renewable energy, but also from a rejection of electricity from fossil fuel and nuclear power plants. A disclosure scheme can play an important role here. In the gas market, there is no comparable positioning for or against specific gas qualities. Biomethane is also marketed as such, so a disclosure scheme would have little effect. There is also no comparable positioning in the H&C sector. Therefore, the relevance is considered high for electricity and low for the other two energy types.

Proposed criteria:

<u>Product differentiation enables consumers to make a choice</u>

The energy disclosure system needs to allow for a differentiation of products according to criteria which the consumers consider relevant (irrespective of their understanding on aspects like additionality).

4 Benefits of energy disclosure for organisations, and related criteria

4.1 Overview

Based on the literature assessment, it can be concluded that the benefits of energy disclosure and associated energy tracking instruments for organisations are mainly based on their information function and verification as well as facilitation functions derived from this.

The consumer information function, which is attributed to energy disclosure by the Renewable Energy Directive (Art. 19 (1) RED II)[3] in conjunction with the Internal Electricity Market Directive (EU) 2019/944 (Annex I No. 5)[4], also benefits organisations in their consumer role and provides them a reliable source of information on energy origin. Organisations benefit, as energy disclosure enables to

- Making procurement decisions based on information contained in energy disclosure
- Allowing for impactful energy supply decarbonisation strategies

In terms of direct renewable energy (RE) procurement organisations benefit from energy disclosure in a facilitation function, when it enables the conclusion of

- Renewable Energy Purchase Agreements.

Building on the information function of energy disclosure, it can also serve as a verification tool for organisations in various obligatory or voluntary reporting contexts. Organisations hence benefit from energy disclosure, as it enables

- Compliance with greenhouse gas (GHG) accounting standards
- Compliance with revised GHG accounting standards
- Compliance with low carbon initiatives and green lead markets
- Compliance with regulatory requirements
- Hedging against CO_2 prices (in certain energy carrier-specific cases).

The verification function of energy disclosure further benefits organisations in the context of stakeholder engagement and market positioning, as by being able to prove the attributes of used energy organisations are able to

- Meeting growing stakeholder expectations, mitigating reputational risks and demonstrating environmental leadership
- Providing unique green claims for marketing products or services.

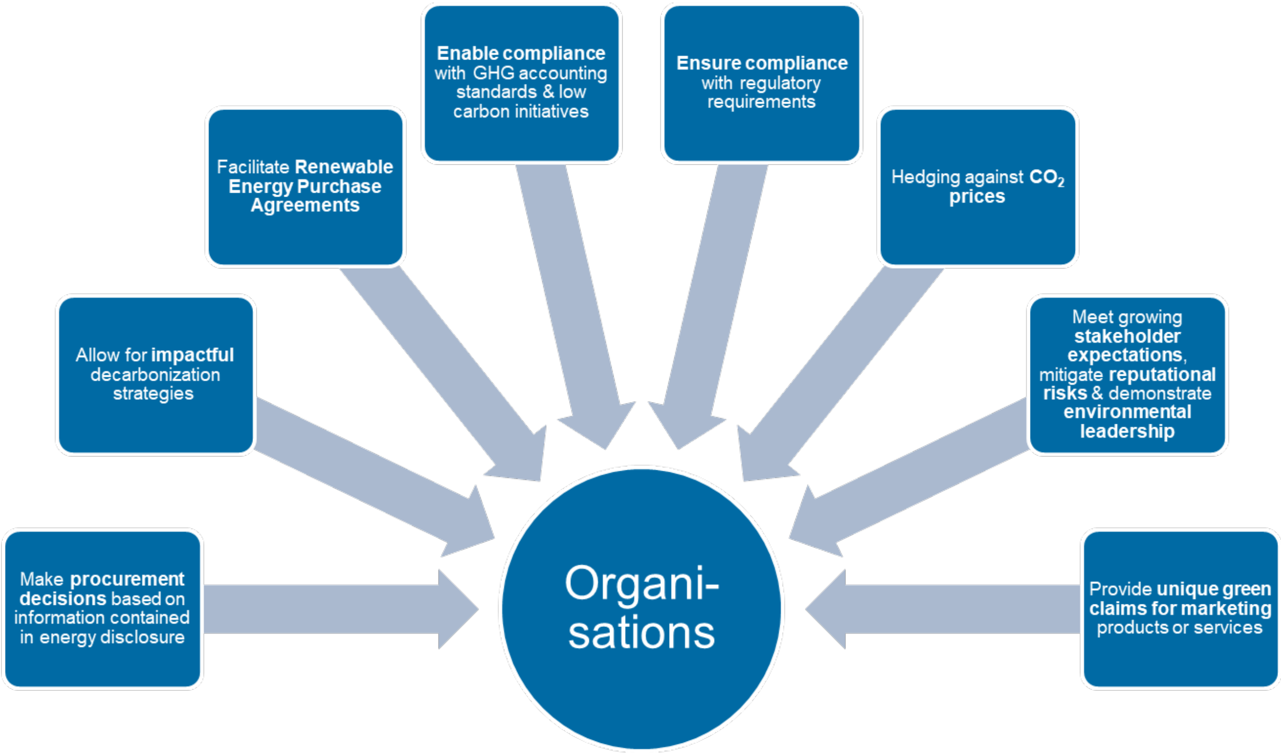
3 DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast).

4 DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast).

In the following section we give an overview of the findings from the literature assessment discussing the identified benefits of energy disclosure for organisations and derived criteria for evaluating energy disclosure concepts. Figure 13 provides an overview of the identified benefits.

Table 3 provides an overview of identified benefits from the literature assessment and the derived evaluation criteria. It also shows beneficial sub-criteria that contribute to the fulfillment of the evaluation criteria for energy disclosure concepts.

Figure 13: Identified potential benefits of energy disclosure systems for organisations



Source: Authors' own illustration, Hamburg Institut.

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Table 3: Benefits of energy disclosure for organisations and derived criteria for energy disclosure

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
Make procurement decisions based on information contained in energy disclosure (see 4.2)	E: high G: high H&C: high	Energy disclosure serves as proof for renewable energy procurement	E: high G: high H&C: high	• Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
		Administrative efficiency	E: high G: high H&C: high	• Information is digital and directly accessible for organisations • Disclosure information is easily accessible upon request (from a consumer's perspective)
Allow for impactful energy supply decarbonisation strategies (see 4.3)	E: high G: currently not relevant H&C: medium	Energy disclosure provides information that enables to assess impactful procurement/additionality criteria	E: medium G: low H&C: low	• Provide information on the age of a production plant • Provide information on subsidy schemes that a plant profits from • Provide detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure • Inclusion of information on GHG intensity of energy production (direct emissions) • Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen) • Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
		Energy disclosure serves as proof for renewable energy procurement	E: high G: high H&C: high	• Tracking system differentiates energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed
		Energy disclosure enables deductions about temporal correlation	E: medium G: low H&C: low	• Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
		Energy disclosure enables deductions about spatial correlation	E: high G: medium H&C: high	• Information on the country of origin of the production device is specified • Information on the specific region (state, province, city etc.) of a production device is specified
		Energy disclosure enables 24/7 matching strategies in electricity procurement	E: medium G: low H&C: low	• Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Facilitate Renewable Energy Purchase Agreements (see 4.4)	E: high G: currently not relevant	In the context of energy disclosure, energy attributes tracked and ownership is transferred	E: high G: high H&C: high	• Energy attributes can be allocated to a specific consumer as beneficiary

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
	H&C: medium			• Energy attributes can be allocated to a specific product of a beneficiary • Energy attributes are tracked and have to be cancelled (or similarily marked) in order to be claimed
		Double counting/double claiming is prevented	E: high G: high H&C: high	• Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes • Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)The residual mix is publicly available, enabling its usage for disclosure • Mandatory usage of the residual mix for untracked attributes
Compliance with GHG accounting standards (see 4.5)	E: high G: medium H&C: high	Energy disclosure serves as proof for renewable energy procurement	E: high G: high H&C: high	• Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
		Energy disclosure enables deductions about temporal correlation	E: medium G: low H&C: low	• Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
		Energy disclosure enables deductions about spatial correlation	E: high G: medium H&C: high	• Information on the country of origin of the production device is specified • Information on the specific region (state, province, city etc.) of a production device is specified
		In the context of energy disclosure, energy attributes tracked and ownership is transferred	E: high G: high H&C: high	• Energy attributes can be allocated to a specific consumer as beneficiary • Energy attributes can be allocated to a specific product of a beneficiary • Energy attributes are tracked and have to be cancelled (or similarily marked) in order to be claimed • Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin
		Double counting/double claiming is prevented	E: high G: high H&C: high	• Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes • Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure) • The residual mix is publicly available, enabling its usage for disclosure • Mandatory usage of the residual mix for untracked attributes

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
		ninistrative efficiency	E: high G: high H&C: high	• Inclusion of information on GHG intensity of energy production (direct & indirect emissions → incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
Compliance with revised GHG accounting standards (see 4.5.1)	E: medium G: medium H&C: medium	Energy disclosure provides information that enables to assess impactful procurement/additionality criteria	E: medium G: low H&C: low	• Provide information on the age of a production plant • Provide information on subsidy schemes that a plant profits from • Provide detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
		Energy disclosure enables deductions about temporal correlation	E: medium G: low H&C: low	• Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide hourly information on time of energy production, to enable granular matching with time of energy consumption
		Energy disclosure enables deductions about spatial correlation	E: high G: medium H&C: high	• Information on the country of origin of the production device is specified • Information on the specific region (state, province, city etc.) of a production device is specified

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
		Energy disclosure enables 24/7 matching strategies and granular emissions accounting	E: medium G: low H&C: low	• Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Compliance with low carbon initiatives and green lead markets (see 4.5.2)	E: high G: medium H&C: medium	**Energy disclosure would need to enable energy accounting that follows the requirements from low carbon initiatives and green lead markets. As these mostly refer to GHG accounting standards, see benefit 'Compliance with GHG accounting standards'.**		
Compliance with regulatory requirements on organisations (see 4.6)	E: high G: medium H&C: medium	Energy disclosure serves as proof for renewable energy procurement	E: high G: high H&C: high	• Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
		Energy disclosure enables deductions about temporal correlation	E: medium G: low H&C: low	• Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
		Energy disclosure enables deductions about spatial correlation	E: high G: medium H&C: high	• Information on the country of origin of the production device is specified

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				• Information on the specific region (state, province, city etc.) of a production device is specified
		In the context of energy disclosure, energy attributes tracked and ownership is transferred	E: high G: high H&C: high	• Energy attributes can be allocated to a specific consumer as beneficiary • Energy attributes can be allocated to a specific product of a beneficiary • Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed • Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin
		Administrative efficiency	E: high G: high H&C: high	• Inclusion of information on GHG intensity of energy production (direct & indirect emissions → incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
Hedge against CO2 prices (see 4.7)	E: low G: medium H&C: high	Energy disclosure serves as proof for renewable energy procurement	E: high G: high H&C: high	• Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
		In the context of energy disclosure, energy attributes tracked and ownership is transferred	E: high G: high H&C: high	• Energy attributes can be allocated to a specific consumer as beneficiary • Energy attributes can be allocated to a specific product of a beneficiary • Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership (see 4.8)	E: high G: high H&C: high	Energy disclosure serves as proof for renewable energy procurement	E: high G: high H&C: high	• Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
		In the context of energy disclosure, energy attributes tracked and ownership is transferred	E: high G: high H&C: high	• Energy attributes can be allocated to a specific consumer as beneficiary • Energy attributes can be allocated to a specific product of a beneficiary • Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
		Double counting/double claiming is prevented	E: high G: high H&C: high	• Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes • Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure) • The residual mix is publicly available, enabling its usage for disclosure

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				• Mandatory usage of the residual mix for untracked attributes
		Administrative efficiency	E: high G: high H&C: high	• Information is digital and directly accessible for organisations • Disclosure information is easily accessible upon request (from a consumer's perspective)
Provide unique green claims for marketing products or services (see 4.9)	E: high G: medium H&C: medium	Energy disclosure serves as proof for renewable energy procurement	E: high G: high H&C: high	• The Disclosure Concept is anchored in legislation • Disclosure method is based on principles consistent with those used at the EU level • Clear rules are in place for tracking conversion between different energy carriers • Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
		In the context of energy disclosure, energy attributes tracked and ownership is transferred	E: high G: high H&C: high	• Energy attributes can be allocated to a specific consumer as beneficiary • Energy attributes can be allocated to a specific product of a beneficiary • Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
		Double counting/double claiming is prevented	E: high G: high H&C: high	• Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes • Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				• The residual mix is publicly available, enabling its usage for disclosure • Mandatory usage of the residual mix for untracked attributes
		Administrative efficiency	E: high G: high H&C: high	• Information is digital and directly accessible for organisations • Disclosure information is easily accessible upon request (from a consumer's perspective) • Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs) • Ability to transfer EACs to individual consumers (with EAC cancellation by consumers) • Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers

Source: Authors’ own representation, Hamburg Institut based on a literature assessment.

4.2 Make procurement decisions based on information contained in energy disclosure

Whether driven by market dynamics, competition, or regulatory frameworks like the CSRD[5] Directive or the EU Taxonomy[6], companies face significant pressure from multiple fronts to set ambitious climate targets that surpass national GHG reduction goals. Reducing emissions from the energy supply by actively managing energy procurement is usually one of the first measures to be taken (Hauser et al., 2019; see e.g., Strüker et al., 2022; Styles et al., 2023; Wimmers & Madlener, 2024). Often there are even own targets assigned to procuring renewable energy. For example, more than 500 organisations have committed to corporate reduction targets via the SBTi that aim for the complete decarbonisation of electricity procurement by 2030 at the latest (Science Based Targets initiative [SBTi], 2025).

In order to fulfil emission reduction target commitments by renewable energy procurement, companies benefit from the transparency of respective energy disclosure (Piebalgs & Jones, 2020; Styles et al., 2021). Hereby it is a prerequisite, that energy disclosure enables informed procurement decisions (Aasen et al., 2010; Ogunsuji et al., 2024). As, for example, nuclear power is mostly not perceived as environmentally friendly – although it comes at zero direct emissions from energy production –, it is important for organisations, that energy disclosure is transparent on different production technologies, so that informed decisions can be made (Hauser et al., 2019). This information needs to be clear and easy to understand and displayed in a way that supports these preconditions, in order to make informed energy procurement decisions (Aasen et al., 2010; Sakhel, Mundt, & Sünkel, 2022).

Relevance of the benefit for different energy types:

To date, renewable energy procurement targets tend to focus more on electricity than heating and cooling or gas. However, being able to make informed procurement decisions is also relevant for the latter two energy carriers. As product differentiation is less established for H&C than gas, the relevance of the benefit is assessed as high for electricity and gas and medium for H&C. For gas purchases, it is important to note that the market-based GHG accounting approach is currently not applicable (but might become so if GHG accounting rules are revised, see 4.5), but green gas product procurement may still form part of renewable energy procurement strategies beyond GHG accounting.

Proposed criteria:

Hence, in order to determine whether the benefit of making procurement decisions based on information contained in energy disclosure is fulfilled, the following criteria must be met:

- Energy disclosure serves as proof for renewable energy procurement
- Administrative efficiency

4.3 Allow for impactful energy supply decarbonisation strategies

Especially in the context of electricity procurement, many stakeholders are of the opinion that renewable energy procurement without further quality distinctions does not lead to a reduction

5 DIRECTIVE (EU) 2022/2464 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting.

6 REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2020 on the establishment of a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088.

in overall GHG emissions. This is because green electricity procurement does not necessarily mean that new renewable energy production capacities are built. In most cases, energy amounts from already existing plants are purchased via green energy contracts (see e.g., Ascui et al., 2021; Ballentine et al., 2022; Bjørn et al., 2022a, 2022b; Brander et al., 2018; Budden & Morris, 2024; Fisher et al., 2024; Ma & Duan, 2024). Hence, corporate decarbonisation strategies need to be based on impactful renewable energy procurement strategies, if they aim to be perceived as reliable.

Impactful procurement is usually considered to be the purchase of green energy with certain quality criteria – mostly known as additionality criteria (Sakhel, Mundt, & Sünkel, 2022). In the electricity sector, several energy labels emerged that demonstrate the additionality of certain electricity products, such as EKOenergy (EKOenergy, 2022), Grüner Strom Label (GSL) (Grüner Strom Label e.V., 2021), ok-power (OK Power, 2023), and many others. There are also labels for renewable gas existing (e.g., EKOenergy, 2024; Grüner Strom Label e.V., 2022). EKOenergy goes a step further by setting up a label for heating and cooling (EKOenergy, 2021). Organisations that want to pursue an impactful purchasing strategy can use these labels for guidance, when purchasing renewable energy. However, for organisations with high consumption levels, procuring the required quantities of certified energy can become significantly expensive due to the sheer volume needed. In contrast, organisations with lower consumption may find these options more suitable. Energy labels are even more relevant in the context of private end consumers (see Chapter 3).

In terms of impactful corporate renewable energy procurement strategies, other guidelines or initiatives setting additionality criteria are relevant, such as the technical criteria for green electricity procurement by RE100 (RE 100 et al., 2022) or the electricity procurement guidelines by WWF (World Wide Fund For Nature [WWF], 2021), the German Environment Agency (AssmannPfeiffer Rechtsanwälte, 2022) or the procurement principles by the 24/7 Carbon Free Energy Compact (United Nations High-Level Dialogue on Energy & Energy Compact (n.d.)). An energy disclosure system would need to be able to provide the needed information to assess these additionality criteria, so that companies can use it to demonstrate impactful procurement in accordance with these guidelines. Additionality criteria set by these guidelines as well as in respective literature mostly refer to:

- Information on plant age (AssmannPfeiffer Rechtsanwälte, 2022; Jansen, 2017; Mulder & Zomer, 2016; Paris et al., 2024; Piebalgs & Jones, 2020; RE 100 et al., 2022; Ricks et al., 2023; WWF, 2021)
- Subsidy information (AssmannPfeiffer Rechtsanwälte, 2022; Ricks et al., 2023; WWF, 2021)
- Detailed information of used technology (AssmannPfeiffer Rechtsanwälte, 2022; RE 100 et al., 2022; WWF, 2021)
- Information on production location (AssmannPfeiffer Rechtsanwälte, 2022; Pototschnig, 2021; RE 100 et al., 2022; Sakhel, Mundt, & Sünkel, 2022)
- Information on production time (Pototschnig, 2021; RE 100 et al., 2022; WWF, 2021)
- Information on the contract (e.g. PPA concluded) (Piebalgs & Jones, 2020; RE 100 et al., 2022; Sustainability Roundtable Inc., 2023; WWF, 2021)

It is worth noting that in the context of the revision of GHG accounting standards more detailed information on how to test for additionality are evolving, such as those discussed by Schäfer et al. (2025) This underlines the need for flexible and robust disclosure systems that can accommodate evolving definitions and expectations.

Furthermore, hourly and location-specific matching of energy supply and energy consumption is often perceived as an option to enable organisations making more precise claims regarding their energy procurement and direct their investments into more impactful procurement policies. (see e.g., D. Miller, 2022, pp. 12 f; Sakhel, Mundt, & Sünkel, 2022; WWF, 2021). In modelling studies, hourly and location-specific matching has been proven to reduce energy system emissions in comparison to annual matching of renewable energy production and consumption (see e. g., Langer et al., 2024; Riepin, 2022; Riepin & Brown, 2024; Xu et al., 2021; Zeyen et al., 2024).

The World Business Council for Sustainable Development (WBCSD) even suggests to include further sustainability criteria in order to ensure that organisations' energy procurement and hence, decarbonisation strategies are reliable and overall 'nature-positive' (World Business Council for Sustainable Development [WBCSD] & Boston Consulting Group [BCG], 2023, p. 21), which would serve the benefit of being able to pursue impactful decarbonisation strategies. This would mean that energy disclosure would also need to deliver information on additional aspects like e.g. the asset life cycle impacts, nature impacts (e.g. land-system change) or societal impacts of procurement decisions, as per WBCSD (2023, pp. 13, 21). In this context also the concept of marginal emissions per 1 MWh or 'avoided emissions' is introduced (see e.g., WattTime, 2022; WBCSD & BCG, 2023, p. 19)

Many companies, instead of or in addition to renewable energy procurement, also build own on-site renewable energy production plants. Hence, it would be a benefit for organisations, if energy disclosure would allow to also disclose their own energy production, so that it is verifiable in the context of decarbonisation strategies accordingly. The possibility to include energy amounts that were not fed in a grid within energy disclosure would be a pursuant prerequisite (Hauser et al., 2019; RE 100 et al., 2022; Sakhel, Mundt, & Sünkel, 2022).

Relevance of the benefit for different energy types:

The discussion on impactful procurement in the context of GHG accounting of purchased energy is particularly relevant in the case of electricity. To a lesser degree, it also applies to H&C, given that the GHG Protocols Scope 2 guidance for electricity extends to this energy carrier (see 4.5). For gas purchases, the market-based accounting approach is currently not applicable, so the benefit is currently not of relevance but might become so if GHG accounting rules are revised (see 4.5.1).

Proposed criteria:

Hence, in order to determine whether the benefit of energy disclosure to allow to pursue impactful energy supply decarbonisation strategies is fulfilled, energy disclosure must meet the following criteria:

- Energy disclosure provides information that enables to assess impactful procurement/additionality criteria
- Energy disclosure enables deductions about spatial correlation
- Energy disclosure enables deductions about temporal correlation
- Energy disclosure enables 24/7 matching strategies in electricity procurement

As impactful energy supply needs to be proven to several stakeholders, also the following criterion becomes relevant:

- Energy disclosure serves as proof for renewable energy procurement

4.4 Facilitate Renewable Energy Purchase Agreements

Another benefit energy disclosure holds for organisations is to enable Renewable Energy Purchase Agreements (REPA) to support corporate decarbonisation strategies. With the growing demand of renewable energy due to increased reporting obligations towards organisations, the role of REPA in corporate decarbonisation strategies becomes more and more important, especially in the context of electricity supply (Deutsche Energie Agentur [dena] & Marktoffensive Erneuerbare Energien, 2023). A REPA is a long-term contract between a renewable power producer and a buyer, where the buyer agrees to purchase electricity at certain price conditions for a specified period and can cover a wide range of contract types (see Chapter 5.3). REPAs provide financial stability for renewable energy projects and support organisations in securing renewable energy targets and meeting decarbonisation goals. Depending on the contract structure, REPAs can – especially in the context of electricity – serve as an energy price hedging mechanism (see e.g., Bachus, 2023; Backstrom et al., 2024; Broom et al., 2020; dena & Marktoffensive Erneuerbare Energien, 2024; WBCSD, 2016). REPA seem to be perceived as a credible effort in decarbonising an organisation's activities, at is has been proven that the announcements of REPAs are wealth creating for companies' owners, meaning that announcing a (virtual) REPA leads to positive stock return (Hundt, 2024, p. 1197).

However, to facilitate REPAs, energy disclosure, respectively the set-up of a renewable energy certificate system is crucial (see e.g., Sakhel, Mundt, & Sünkel, 2022; WBCSD, 2016). It needs to be assured that the produced renewable attributes of the produced energy are transferred into the customer's ownership and no other customer benefits from these renewable attributes (see e.g., Kemper, Styles, Mundt, et al., 2024; RE-Source & EnergyTag, 2022; Styles et al., 2021). If there is no energy supplier involved in a REPA (e.g. in the case of a virtual REPA, see 5.3), energy disclosure respectively GO systems need to ensure GO cancellation is still possible in such a constellation. The right to cancel GOs for organisations would be an option to ensure that the transfer of attributes is also enabled in the context of REPA with no energy supplier involvement (Styles et al., 2023). Furthermore, as the conclusion of a REPA aims at reducing GHG emissions and mostly serves as a measure to achieve ambitious climate goals, energy disclosure in the context of REPA indirectly also needs to follow market-based criteria set by GHG accounting standards (see Table 5), so that the emission reduction effects can be displayed within the respective organisations' GHG inventory.

The same applies to district heating and cooling where heating or cooling purchase agreements can be an integral part of ambitious corporate climate strategies. Also, in this case the benefit of reliable and credible decarbonisation strategies can only be realised, if respective energy disclosure is in place. Energy disclosure needs to ensure that energy attribute ownership can be transferred and that energy attributes are only marketed once (Styles & Claas-Reuther, 2022, 2023).

The aspect of a granular energy disclosure is also being discussed in connection with REPA. One reason for this is, that also REPA are subject to annual matching, which means that it is not possible to ensure that all the electricity consumed in the framework of a REPA stems from renewable sources as in times of undersupply also fossil-based electricity is sourced (Nord Pool et al., 2023; Riepin & Brown, 2024).

Relevance of the benefit for different energy types:

REPAs are particularly established in the electricity sector so far, making the benefit of high relevance for electricity. To a lesser degree, it might become more relevant for H&C, given that the GHG Protocols Scope 2 guidance for electricity already extends to this energy carrier (see 4.5). For gas purchases, the market-based accounting approach is currently not applicable, so the benefit is currently not of relevance but might become so if GHG accounting rules are revised (see 4.5.1).

Proposed criteria:

- All in all, energy disclosure can fulfil the benefit of facilitating REPAs, thereby advancing corporate decarbonisation strategies. To realise this benefit, the following criteria must be met, as they represent key enabling aspects for the facilitation of REPAs: <u>Double counting/double claiming is prevented</u>
- <u>In the context of energy disclosure, energy attributes tracked and ownership is transferred</u>

4.5 Enable compliance with GHG accounting standards

In recent years, Greenhouse Gas (GHG) emissions accounting has significantly gained importance (Hazaea et al., 2023). Increasing societal awareness for corporate sustainability performance puts organisations under higher scrutiny. Furthermore, it has led to information on corporate climate change impacts being an increasingly important criterion for surviving in competitive markets (Aiuto et al., 2024) and accessing funding (Eccles & Klimenko, 2019). As GHG footprint calculations on both the product and the organisational level become expected practice (Meinrenken et al., 2022; WBCSD, 2024), a range of GHG accounting standards have emerged, aiming to foster comparability and transparency of GHG inventories.

The GHG Protocol Standards have been established as the commonly used system for developing GHG inventories (World Resources Institute [WRI] & WBCSD, 2025b). Many other environmental disclosure frameworks build upon the GHG Protocol, explicitly reference it or align closely with its structure and principles. However, especially in the context of Product Carbon Footprint (PCF) calculations many organisations also rely on the ISO framework for GHG accounting (e.g., ISO 14067, ISO 10464-1). In the context of the Corporate Carbon Footprint (CCF), emissions are categorised as Scope 1, Scope 2 and Scope 3 emissions[7], whereas a PCF considers emissions from different life cycle stages. However, both approaches can be effectively aligned. Following a Scope-based approach, indirect emissions from purchased electricity as well as heating and cooling have to be accounted following Scope 2 accounting rules, whereas direct emissions from gas combustion would be accounted for within Scope 1. Other energy-related upstream emissions would be accounted for under Scope 3. In this context, energy disclosure plays a crucial role, providing the necessary data inputs for both drawing up and verifying the parts of organisations' GHG inventories and sustainability reports that cover energy related GHG emissions (Mundt et al., 2019; Styles et al., 2021).

GHG accounting standards lay out general GHG accounting principles as well as data quality standards, that would indirectly apply to energy disclosure when used in the context of GHG accounting. General accounting principles encompass relevance, completeness, consistency, transparency and accuracy (see e.g., International Organization for Standardization [ISO] 14067, p. 33f; ISO 14064-1, p. 23f; Together for Sustainability, 2024, p. 13; WBCSD & WRI, 2004, p. 4). These are quite general overarching principles that align with technical preconditions for energy disclosure systems as will be defined during this project. The same applies for data quality criterion reliability. Besides, the criteria technological as well as geographical and temporal representativeness are listed as data quality criteria in several GHG accounting standards

[7] Scope 1 covers direct emission sources owned or controlled by an organisation, such as onsite combustion. Scope 2 covers indirect emissions from purchased energy, whereas Scope 3 covers all other indirect emissions from the upstream or downstream value chain. This also includes upstream emissions from energy production (World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) (2004, 2011, 2015)).

(Andreasi Bassi et al., 2023, p. 24f; Catena-X Automotive Network e.V [Catena-X], 2023, p. 33; WBCSD & Partnership for Carbon Transparency, 2023, p. 41; WBCSD & WRI, 2015, p. 54).

In terms of specific Scope 2 accounting rules, there are two different approaches existing on how to account for emissions from purchased energy: the location-based as well as the market-based accounting approach (for more detail see Kemper, Styles, Mundt, et al., 2024). Whenever an organisation has or decides to report under the market-based approach, energy disclosure is an essential precondition as a contractual instrument conveying information on the supplier-specific energy attributes.[8] Several standards for GHG Accounting – regarding both the organisational and the product level as well as general and industry specific frameworks – encourage organisations to use the market-based approach for emissions accounting whenever possible (see Table 4).

Table 4: The market-based approach in common GHG accounting frameworks

Standard	Requirements
Corporate Carbon Footprint (CCF) Standards	
ISO 14064-1 – Greenhouse gases – Part 1: Specification with guidance at the organisation level (ISO)	Requires the use of the location-based approach while allowing for the additional disclosure of market-based emissions.
GHG Protocol Scope 2 Guidance (WBCSD & WRI, 2015)	Requires the disclosure of both location- and market-based Scope 2 emissions (dual reporting).
European Sustainability Reporting Standards (ESRS)[9]	Requires the disclosure of both location- and market-based Scope 2 emissions (dual reporting).
Product Carbon Footprint (PCF) Standards	
GHG Protocol Product Life Cycle Accounting and Reporting Standard (WRI & WBCSD, 2011)	Favors the use of geographically specific emission factors, irrespective of whether a market- or location-based approach is used.
ISO 14067 – Carbon Footprint of Products (ISO))	Hierarchisation of accounting approaches favors the market-based approach.
EU Product Environmental Footprint (PEF) Methodology[10]	Demands the use of market-based emission factors which are hierarchised with the lowest quality option being the EU residual mix.
TfS Guideline (Together for Sustainability, 2024)	Favors the use of the market-based approach, the location-based approach not being mentioned.
Catena-X Product Carbon Footprint Rulebook (Catena-X, 2023)	Demands the use of market-based emission factors which are hierarchised. Only if no supplier-specific emission factors nor a residual grid mix are available should the location-based grid-mix be used.

Source: Authors' own summary, Hamburg Institut.

The aforementioned standards which require the adoption of a market-based approach formulate criteria for the contractual instruments underlying the determination of market-based

8 While the location-based approach also relies on grid-average emission factors derived from national or regional electricity statistics—which could be interpreted as a form of energy disclosure—it follows a fundamentally different logic. Since this work focuses on energy labelling concepts within energy markets, and not on the comparative analysis of accounting approaches, the location-based method is not further addressed here.

9 COMMISSION DELEGATED REGULATION (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards.

10 COMMISSION RECOMMENDATION (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations.

emission factors. These criteria can be regarded as equally applying to energy disclosure concepts as the latter lays the foundation for any contractual instrument. While the standards show slight variations in phrasing the precise criteria, most of the sector specific standards are based on or refer directly to either the ISO standards (ISO 14067; ISO 14064-1) or the GHG Protocol Scope 2 Guidance (see e.g., Andreasi Bassi et al., 2023, p. 26f; Catena-X, 2023, p. 22f; European sustainability reporting standards (ESRS), 2023, p. 99; Global Steel Climate Council, 2024, p. 24; GRI, p. 11f; Together for Sustainability, 2024, p. 48). The ISO standards as well as the GHG Protocol Scope 2 Guidance compromise largely overlapping criteria. In this report, the criteria as listed in the GHG Protocol Scope 2 Guidance are used as the foundation for further elaborations and are summarised in Table 5.

Table 5: GHG Protocol Scope 2 Quality Criteria for contractual instruments used in the market-based method

Requirement	GHG Protocol Scope 2 Guidance
Convey attributes	Provide information on the emissions rate related to the production of the procured unit of energy.
Attribute tracking	Ensure redemption, retirement or cancellation on behalf of the reporting entity to avoid double counting.
Temporal correlation	Ensure a close temporal correlation between energy production and consumption. This requires accurate information on the time of generation.
Market location	Ensure that energy production and consumption take place within the same market.
Double counting / Double claiming	Rule out that other instruments allow for making attribute claims based on the same unit of energy generation.
Residual mix	Include information on the residual mix, providing information on the emission attributes of unclaimed or publicly shared energy.
Supplier-specific emission factors	In case supplier-specific emission factors are based on contractual instruments, their correspondence with the supplied energy must be verified on behalf of the reporting entity.
Direct line to production plant	In case the generation plant is directly connected to the energy customer, it must be ruled out that the characteristics of the produced energy have been sold off to third parties via contractual instruments, ensuring uniqueness of the reported claim.

Source: (WBCSD & WRI, 2015, p. 60).

In terms of accounting for gas, there are fewer specific guidelines provided relating to energy disclosure. However, with regards to biogas the same quality criteria apply as laid down within the GHG Protocol Scope 2 Guidance with regards to the market-based approach (WRI, 2023). In the context of the current review of the GHG Protocol accounting standards, it is discussed whether a market-based approach in general should also be applicable for Scope 1 and Scope 3 accounting (Greenhouse Gas Protocol [GHG Protocol] et al., 2024).

However, to ensure comprehensive GHG accounting for energy, organisations must not only calculate Scope 2 emissions and adhere to the respective quality criteria, but must also account for energy-related upstream emissions (categorised under Scope 3.3 based on the scope logic) (see e.g., Catena-X, 2023; ISO; SBTi, 2024; Together for Sustainability, 2024; Wirtschaftsvereinigung Stahl, 2024; WBCSD & WRI, 2011). These include, for example, mining and transport of fuels to the production facility or grid losses. To estimate these emissions, organisations can either rely on the energy mix provided by a supplier to make approximations, or they could receive the relevant data directly from energy disclosure, which may be more advantageous for organisations as it would provide a reliable source of information. This means that energy disclosure would need to provide information in a way that allows for the clear distinction and allocation of emissions between Scope 2 and Scope 3.3 as a critical aspect for accurate and transparent reporting. However, this is not common practice in current energy disclosure systems. For example, in Germany as per the BDEW[11] guideline on electricity disclosure (Bundesverband der Energie- und Wasserwirtschaft e.V [BDEW], 2024), electricity suppliers only need to provide information on direct GHG emissions from electricity production, omitting other energy related emissions.

Relevance of the benefit for different energy types:

Compliance with GHG accounting standards is particularly high for electricity and H&C, to which the GHG Protocol Scope 2 guidance applies. In terms of accounting for gas, there are fewer specific guidelines provided relating to energy disclosure. However, with regards to biogas the same quality criteria apply as laid down within the GHG Protocol Scope 2 Guidance with regards to the market-based approach (WRI, 2023). In the context of the current review of the GHG Protocol accounting standards, it is discussed whether a market-based approach in general should also be applicable for Scope 1 and Scope 3 accounting (GHG Protocol et al., 2024).

Proposed criteria:

All in all, in order to be able to fulfil the requirements from GHG accounting standards in terms of energy accounting and to realise the benefit of being compliant with these standards, energy disclosure needs to meet the following criteria:

- Double counting/double claiming is prevented
- Energy disclosure enables deductions about spatial correlation
- Energy disclosure enables deductions about temporal correlation
- Energy disclosure serves as proof for renewable energy procurement
- In the context of energy disclosure, energy attributes tracked and ownership is transferred

Given the complexity of data collection for GHG accounting, energy disclosure must also be easily accessible. Hence, the criterion

- Administrative efficiency

must be met.

4.5.1 Enable compliance with revised GHG accounting standards

The market-based accounting approach has been criticized to not provide accurate and relevant GHG information, as reduced Scope 2 emissions due to EAC purchase do not necessarily induce an actual contribution to the energy transition, by for example, increased RE production (see e.g., Brander & Bjørn, 2023; Brander et al., 2018; G. Miller et al., 2022; Paris et al., 2024). Hence, there is an increasing insistence for a reassessment and revision of especially the market-based accounting approach arising, as its effectiveness and credibility are being increasingly scealised. Claims usually relate to the introduction of further criteria like additionality, causality or impact

[11] Association of the German energy and water industry

assessment (WRI, 2023). While additionality refers to whether a renewable energy purchase leads to new clean energy generation that would not have occurred otherwise, causality emphasises whether the purchase directly causes a measurable reduction in grid emissions. Both concepts aim to strengthen the credibility and climate relevance of energy-related emission claims, yet they address different dimensions of impact (see e.g. Brander and Bjørn (2023)). These discussions can especially be followed in the context of the review of the GHG Protocol standards, as this process is documented publicly (GHG Protocol et al., 2024; GHG Protocol, WRI, & WBCSD, 2023; WRI & WBCSD, 2025a)[12].

It is crucial for organisations to closely monitor these discussions and possible future changes to GHG accounting methods, as these pose a risk to most decarbonisations goals, since these are based on a certain GHG accounting framework (Paris et al., 2024, p. 9). On the other hand, these could also reduce the risk of being accused of greenwashing when accounting for energy (Moss et al., 2024). Changes to energy accounting rules also imply evolving requirements for energy disclosure from an organisational perspective. From the discussions on revising GHG accounting practices, two key aspects of necessary adjustments with implications for energy disclosure can be identified: introducing additionality criteria[13] to GHG accounting practices and increased granularity in GHG accounting.

Additionality criteria are often required when discussing an improvement of energy accounting approaches (see e.g., Brander et al., 2024; Brander & Bjørn, 2023; GHG Protocol, WBCSD, & WRI, 2023, 2024; GHG Protocol, WRI, & WBCSD, 2023; Moss et al., 2024). Hence, prospectively energy disclosure would need to be able to provide the needed information to assess additionality. Information that is needed can be found in respective literature or the guidelines for impactful renewable energy procurement (see Chapter 4.3).

Besides additionality, granular time and location criteria for accounting GHG emissions from energy purchases are proposed in the context of updating GHG accounting frameworks (see e.g., Ballentine et al., 2022; Fisher et al., 2024; GHG Protocol, WRI, & WBCSD, 2023). This would mean that energy disclosure would need to provide granular information in terms of production time, as well as location and would indirectly also be required to provide more granular information on production amounts, as these would decrease, if granular information on time and location were introduced.

For further information on the current status of GHG Protocol Scope 2 Guidance revisions see the analysis and evaluation GHG Protocol Scope 2 Guidance revisions in chapter 8.3.3.6.

Relevance of the benefit for different energy types:

The development of a revised GHG accounting methodology under the GHG Protocol is still ongoing. Publication of the revised Scope 2 standard is expected for 2027, and its implementation will most likely phase in over several years (Huckins, 2025). As a result, the relevance for all energy carriers is assessed as medium.

Proposed criteria:

In order to enable organisations to benefit from compliance with future GHG accounting requirements resulting from ongoing revisions, additional criteria must be met:

- Energy disclosure enables 24/7 matching strategies and granular emissions accounting
- Energy disclosure enables deductions about spatial correlation

12 The assumptions presented in the following section of this chapter reflect the status of discussions as of the literature review's cut-off date being 31st of January 2025.

13 See chapter 4.3 on impactful decarbonisation strategies.

- Energy disclosure enables deductions about temporal correlation
- Energy disclosure provides information that enables to assess impactful procurement/additionality criteria

4.5.2 Enable compliance with low carbon initiatives and green lead markets

In response to increasing demands for organisations to contribute to sustainable development and climate change mitigation, several voluntary carbon reduction initiatives have emerged. Whereas the Science Based Targets initiative (SBTi) supports companies in setting science-based emission reduction targets aligned with a 1.5° reduction pathway (SBTi, 2024), CDP Worldwide (former Carbon Disclosure Project) encourages organisations to disclose data on their environmental and climate performance, aiming to contribute to increased transparency in that regard (Carbon Disclosure Project [CDP], 2025). Joining SBTi or CDP allows companies to demonstrate climate leadership, enhance transparency, align with science-based targets, and gain access to resources and incentives that drive long-term sustainability and competitive advantage (CDP, 2025; SBTi, 2024). However, these initiatives also set specific requirements on GHG accounting and hence, requirements for energy disclosure (see Table 6).

More recently, the concept of green lead markets is gaining traction. A core idea behind this system is to drive demand for materials and products with low carbon footprints, increasing transparency and developing a differentiation scheme for classifying products of low climate impact. In this way, they are to drive investments and assist decarbonisation in hard-to-abate sectors such as steel, cement or chemicals. Basis for the development of green lead markets is a uniform definition of what constitutes a low-carbon product or material. In Germany, this process has been initiated by the Ministry for Economic Affairs and Climate (Bundesministerium für Wirtschaft und Klimaschutz [BMWK], 2024). Furthermore, sector-specific guidelines are under development or have been developed by the relevant industry associations (Verein Deutscher Zementwerke e.V [vdz], 2025; Wirtschaftsvereinigung Stahl, 2024). These guidelines formulate data demands regarding organisations‘ energy-related activities, which translate into requirements for energy disclosure (see Table 6).

Table 6: Energy accounting requirements in low-carbon initiatives and green lead market guidelines

Initiative / Guideline	Requirements regarding energy disclosure
Low Carbon Initiatives	
Carbon Disclosure Project (CDP) (2024a, 2024b)	The CDP guidance refers to the GHG Protocol Scope 2 Guidance as the underlying reporting framework. Companies are required to perform dual reporting of Scope 2 emissions in case they operate in markets providing the possibility for disclosing market-based emissions. A hierarchy of market-based emission factors is established, positioning energy attribute certificates and other contractual instruments as the preferable option. Contractual instruments used for disclosing Scope 2 emissions must meet specified quality criteria which are identical to the quality criteria established in the GHG Protocol Scope 2 Guidance (see Table 5).

Initiative / Guideline	Requirements regarding energy disclosure
Global Reporting Initiative (GRI) (Global Reporting Initiative [GRI], 2016, 2025)	The Global Reporting Initiative (GRI) provides a comprehensive framework for sustainability reporting. The GRI Standards are developed through a global multi-stakeholder process and offer a modular structure that enables organisations to disclose their environmental, social, and economic impacts in a consistent and comparable manner. The standards are divided into Universal, Sector, and Topic Standards. Among the Topic Standards, the standard 'GRI 305: Emissions' (GRI) specifically addresses the disclosure of greenhouse gas emissions and refers to the GHG Protocol as the methodological basis for calculating and categorising Scope 1, Scope 2, and Scope 3 emissions. GRI 305: Emissions (GRI) requires a dual reporting of Scope 2 emissions, if possible, within the respective market location.
Science Based Targets initiative (SBTi) (2024)	The SBTi Corporate Net Zero Standard requires companies to adhere to the GHG Protocol Scope 2 Guidance for defining their science-based targets. Organisations can decide whether they set their targets based on the location- or the market-based approach but must ensure consistency in tracking progress. Terms for emission accounting refer to the rules of the GHG Protocol, hence, the quality criteria established in the GHG Protocol Scope 2 Guidance (see Table 5) are applicable. Renewable energy procurement targets are an accepted alternative to Scope 2 emission targets, with a reference to the technical criteria by RE100 (RE 100 et al., 2022). These criteria refer to electricity, purchased heat and steam are to be accounted as Scope 1 emissions.
Green Lead Markets	
Green Lead Markets Concept Paper (BMWK, 2024)	Requires producers to take a cradle-to-gate approach in the calculation of carbon footprints, leading to the inclusion of Scope 1, Scope 2 and upstream Scope 3 emissions. Refers to the relevant sector-specific initiatives with regards to accounting rules.
Low Emission Steel Standard (LESS) (Wirtschaftsvereinigung Stahl, 2024)	Scope 2 emissions: Allows for adopting a market-based approach for calculating the product carbon footprint if backed up with guarantees of origin (for electricity, biogas, and when available, hydrogen). Furthermore, upstream emissions related to energy production (Scope 3.3) should be reported. These are determined following the GHG Protocol or ISO accounting framework.
Cement Carbon Class (CCC) Label (vdz, 2025)	Requires producers to verify the use of renewable electricity as an input to cement production via contractual instruments.

Source: Authors' own summary, Hamburg Institut.

Most of the initiatives or guidelines for green lead markets refer to the GHG Protocol for detailed guidance on energy emission accounting. Hence, they pose similar requirements on energy disclosure. However, these mostly focus on electricity accounting and the sourcing of green hydrogen. Here it is also referred to the principles of Scope 2 accounting (cf. Wirtschaftsvereinigung Stahl, 2024).

Relevance of the benefit for different energy types:

Given the focus of low carbon initiatives so far, the relevance is particularly high for electricity and medium for gas and H&C.

Proposed criteria:

Accordingly, the criteria used to assess the benefit of compliance with GHG accounting standards can also be applied to evaluate the fulfilment of benefit associated with the compliance with low-carbon initiatives and green lead markets:

- Double counting/double claiming is prevented
- Energy disclosure enables deductions about spatial correlation
- Energy disclosure enables deductions about temporal correlation
- Energy disclosure serves as proof for renewable energy procurement
- In the context of energy disclosure, energy attributes tracked and ownership is transferred
- Administrative efficiency

4.6 Ensure compliance with regulatory requirements on organisations

With the European Green Deal aiming to transform the EU into a sustainable, low-carbon economy, a wide range of policies and regulations were introduced. Many of them contain reporting requirements that organisations need to adhere to (Baehr et al., 2024). These are primarily focusing on GHG emissions. However, the requirements indirectly necessitate energy disclosure, as energy consumption is often one of the largest contributors to GHG emission inventories. Hence, energy disclosure can help organisations to mitigate regulatory risks (O'Shaughnessy et al., 2021; Paris et al., 2024). As shown in Figure 14 some of these regulations refer to established GHG accounting standards, while others rely on EU-specific frameworks, such as the EU Product Environmental Footprint (PEF) and Organisation Environmental Footprint (OEF). Additionally, there are regulations that introduce their own methodologies for determining the GHG emissions associated with energy consumption. These methodologies indirectly establish requirements for energy disclosure by defining how energy-related emissions should be assessed.

The EU Environmental Footprint methods composed of the **Product Environmental Footprint (PEF)** and **Organisation Environmental Footprint (OEF)**, were developed by the European Commission in 2013[14] and updated in 2021[15]. Their goal is to provide harmonised rules for conducting a reliable and transparent assessment of the environmental impacts of products and organisations throughout the life cycle. The Commission continues to promote the development of the Environmental Footprint methods and embeds them in more and more legal texts, however the policy implementation of PEF & OEF remains unclear. The PEF & OEF provide detailed guidance and requirements on how to assess the environmental impact of a product or an organisation. One of the covered aspects is electricity use, which shall be assessed following a market-based accounting approach, meaning that respective energy disclosure towards an organisation is required. Criteria for assessing energy emissions following a market-based accounting approach are laid down within the PEF/OEF methodology. These align with the ones set out by the **GHG Protocol Scope 2 Guidance** as explained above. Hence, similar requirements are being posed on energy disclosure (see Table 5).

[14] COMMISSION RECOMMENDATION of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations (2013/179/EU).

[15] COMMISSION RECOMMENDATION (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations.

The **Corporate Sustainability Reporting Directive (CSRD)**[16] adapts the already existing Non-Financial Reporting Directive (NRFD) with the aim of putting sustainability reporting on a par with financial reporting. Part of the CSRD are uniform EU standards for sustainability reporting, the European Sustainability Reporting Standards (ESRS) which are laid down in a delegated regulation.[17] The ESRS E1, which defines the disclosure criteria for the area of 'climate change', is crucial for the energy disclosure requirements, in particular disclosure requirement E1-5 'Energy consumption and mix' as well as disclosure requirement E1-6 'Gross Scopes 1, 2, 3 and Total GHG emissions'. Within the disclosure requirement E1-5 it is specified that the reporting unit shall provide information on its energy consumption and mix. Within the disclosure requirement E1-6 it is specified that the disclosure on gross Scope 2 GHG emissions shall include the gross location-based Scope 2 GHG emissions and the gross market-based Scope 2 GHG emissions. In case of market-based Scope 2 emissions an energy disclosure is required, as emissions are assessed on the basis of contractual instruments providing information on the energy attributes. The ESRS E1 standard refers to the **GHG Protocol Scope 2 Guidance** regarding criteria for a market-based assessment. This again translates into similar requirements being posed on energy disclosure (see Table 5).

The **Corporate Sustainability Due Diligence Directive (CSDDD)**[18] lays down rules on obligations for companies regarding actual and potential human rights adverse impacts and environmental adverse impacts, as well as liability for violation of those obligations. The CSDDD also lays down rules on the obligation for companies to adopt and put into effect a transition plan for climate change mitigation which aims to ensure compatibility of the business model and of the strategy of the company with the transition to a sustainable economy and with the limiting of global warming to 1,5 ° Celsius in line with the Paris Agreement. Among other things the transition plan shall contain absolute emission reduction targets for greenhouse gas for scope 1, scope 2 and scope 3 greenhouse gas emissions for each significant category. Here the requirements for **accounting for energy emissions and their implications for energy disclosure from the CSRD** apply. Article 22 (2) CSDDD states that when compiling a transition plan in accordance with the CSRD the transition plan obligation according to CSDDD is considered fulfilled. Hence, again, GHG Protocol quality criteria for market-based accounting would be applicable, as the **CSRD respectively its ESRS E1 standard refers to the GHG Protocol Scope 2 Guidance**.

The **EU Taxonomy**[19] regulation contains criteria for determining whether an economic activity shall qualify as environmentally sustainable. One of the 4 overarching conditions that an economic activity has to meet in order to qualify as environmentally sustainable is that an economic activity makes a significant contribution to at least one of the climate and environmental objecttives set out in the regulation while at the same time not causing significant harm to any of the other objectives. The Climate Delegated Act[20] contains a list of economic activities and technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation, and for determining whether that

16 DIRECTIVE (EU) 2022/2464 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting.

17 COMMISSION DELEGATED REGULATION (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards.

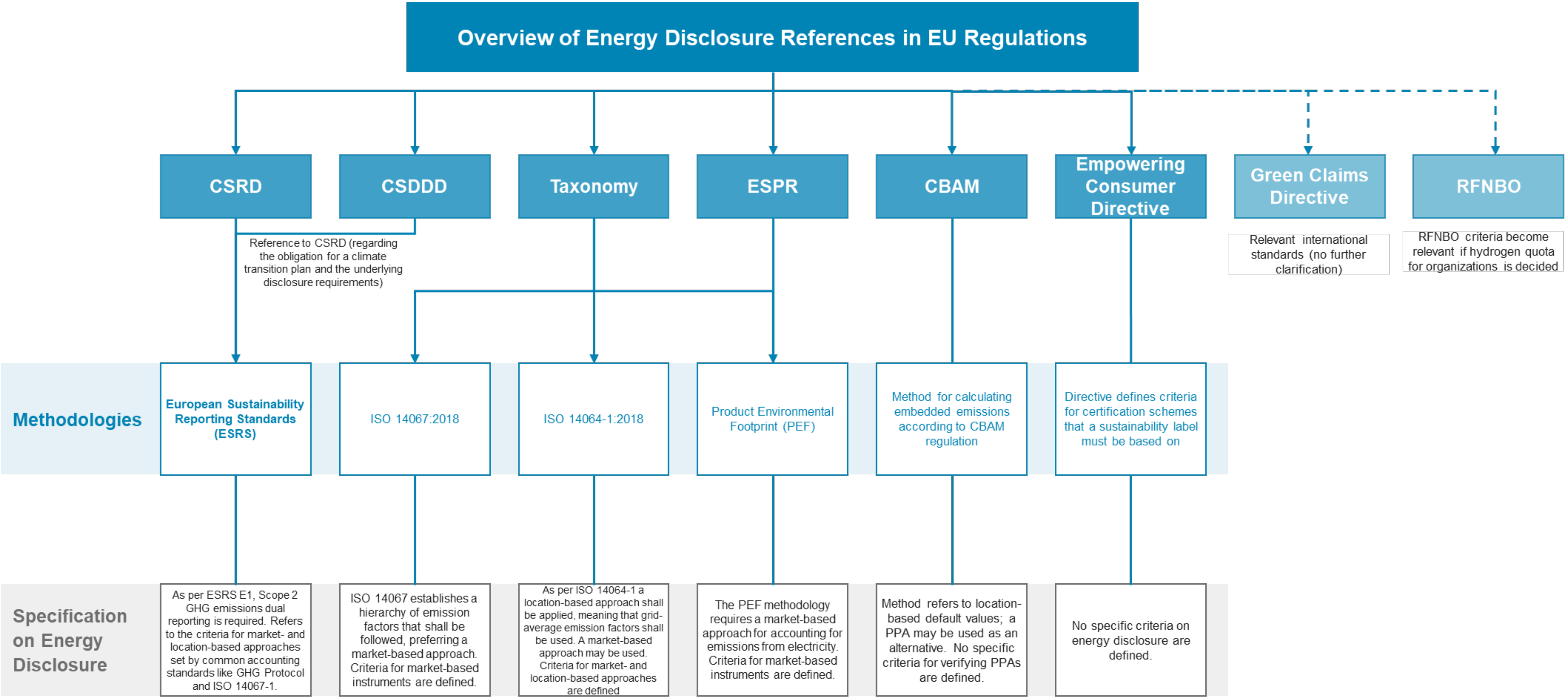
18 DIRECTIVE (EU) 2024/1760 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 June 2024 on corporate sustainability due diligence and amending Directive (EU) 2019/1937 and Regulation (EU) 2023/2859.

19 REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2020 on the establishment of a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088.

20 COMMISSION DELEGATED REGULATION (EU) 2021/2139 of 4 June 2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives.

economic activity causes no significant harm to any of the other environmental objectives. For some of the energy-related activities, such as electricity generation from geothermal energy or production of H&C from renewable non-fossil gaseous and liquid fuels, life cycle GHG emissions thresholds are defined that must be met for the respective activity to qualify as a substantial contribution to climate change mitigation. Regarding the methodology to calculate the life cycle GHG emissions, the delegated act refers to the **PEF methodology** (its 2013 version) or alternatively to **ISO 14067:2018 or ISO 14064-1:2018**, providing criteria for market-based accounting approaches that enable to derive requirements posed on energy disclosure in this context. As these are similar to the ones posed by the GHG Protocol Scope 2 Guidance, the latter will be used in the additional work (as explained in Chapter 4.2).

Figure 14: Overview of Energy Disclosure References in EU Regulations relevant to organisations



Source: Authors' own summarising illustration based on the mentioned regulations, Hamburg Institut.

The **Ecodesign for Sustainable Products Regulation (ESPR)**[21] replaces the Ecodesign Directive and establishes a framework for setting ecodesign requirements on specific product groups. The regulation introduces new requirements that cover the entire life cycle of a product, such as durability, reusability, resource efficiency, but also information requirements such as identifying the carbon footprint and environmental footprint. This information is to be made fully or partially accessible to relevant actors in the product life cycle through the introduction of digital product passports, tailored to the respective product group. The specific requirement level of the individual sustainability aspects will be defined by delegated legal acts, which the Commission will be empowered to issue. Regarding the environmental footprint, which is part of the product aspect of environmental impacts, the regulation refers to the **PEF methodology** (its 2021 version) or other scientific methods developed by international organisations, widely tested in collaboration with different industry sectors and adopted or implemented by the Commission in other Union law. As these are similar to the ones posed by the GHG Protocol Scope 2 Guidance, these will be used in the course of the further work (as already explained in Chapter 4.2).

The **Carbon Border Adjustment Mechanism (CBAM)**[22] can be referred to as a complementary instrument to the EU ETS, as CBAM is intended to gradually replace the free allocation of emission allowances under the EU ETS. Under the CBAM companies must purchase CBAM certificates for defined goods and raw materials that are imported into the EU. This is intended to ensure that emissions from products, so-called embedded emissions, are also priced into imported products. Annex IV of the CBAM regulation lays down the methods for calculating embedded emissions. It refers to location-based default values, but as an alternative an off-grid PPA may be used as well, which makes the disclosure and transfer of respective energy attributes necessary. However, this would mainly be relevant for stakeholders outside of the EU (third countries). Hence, the requirements for energy disclosure that could be derived from CBAM are not taken into account when deriving criteria for energy disclosure concepts based on the benefits for organisations.

The **Green Claims Directive (GCD)** is aimed to address greenwashing and protect consumers and the environment. The GCD is still within the legislative process on EU level and therefore the following content is based on the proposal by the Commission.[23] The core content of the GCD proposal is the regulation of minimum standards for the content, verifiability and communication of environment-related advertising statements (Green Claims). This affects advertising statements about products or the company itself. The GCD proposal also contains specifications for the use of environmental labels. Within the proposed rules on the assessment to substantiate explicit environmental claims it is required to rely on widely recognised scientific evidence, use accurate information and take into account relevant international standards. To this point there is no further specification regarding energy disclosure references. However, the proposal contains the possibility for the Commission to adopt delegated acts to supplement the requirements for substantiation of explicit environmental claims. As of June 2025, the legislative process has encountered major setbacks. The planned trilogue negotiations were cancelled due to unresolved political disagreements, particularly concerning its applicability to small and medium-sized enterprises (SMEs). However, the proposal has not been formally withdrawn. In the meantime, enforcement of greenwashing regulations continues under existing EU legislation, such as the Empowering Consumers Directive, which is set to take effect in September 2026.

21 REGULATION (EU) 2024/1781 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC.

22 REGULATION (EU) 2023/956 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 10 May 2023 establishing a carbon border adjustment mechanism.

23 Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on substantiation and communication of explicit environmental claims (Green Claims Directive).

The **Empowering Consumer Directive (EmpCo)**[24] is a directive that adapts two existing EU directives: the Unfair Commercial Practices Directive (UCPD) and the Consumer Rights Directive (CRD). The EmpCo aims for better protection against greenwashing (by adapting the UCPD) and improving information on durability and repairability (by adapting the CRD). The changes to the UCPD become relevant with regard to energy disclosure requirements by adapting the annex to the existing UCPD. The annex includes new commercial practices which are considered unfair in all circumstances. One of those commercial practices consists of displaying a sustainability label that is not based on a certification scheme or not established by public authorities. The EmpCo also sets out criteria for certification systems. For example, compliance monitoring for traders must follow an objective process and be carried out by an independent third party, whose competence and independence are based on international, EU-wide, or national standards and procedures, and who is independent of both the system owner and the trader.

Another regulatory aspect that could become of relevance for energy disclosure from organisations' perspective addresses the use of green hydrogen within industry. Within the updated **Renewable Energy Directive (RED III)**[25] the new Article 22a requires member states to significantly increase the share of renewable fuels of non-biological origin (RFNBO) in the industry sector. The Commission Delegated Regulation (EU) 2024/1408[26] stipulates that the Delegated Regulation on RFNBO[27] applies to all sectors which means that the EU Commission decided to adopt the accounting rules from transport for industry as well. It is not yet clear which instruments the member states intend to use to increase the consumption of green hydrogen in industry to the required level. However, if a hydrogen quota will be introduced for companies in the industrial sector, energy disclosure (in a broad sense, including the use of mass balancing information) will play a central role in proving that the specifications for the electricity used to produce green hydrogen have been met and that green hydrogen can be counted towards the specified target (Hoffmann et al., 2024). In that case it would be necessary that energy disclosure would be able to provide verification towards the set criteria for RFNBO (see also 5.7).

Besides, energy disclosure is becoming increasingly relevant in the context of industry subsidies or tax reductions, as it serves to claim the use of renewable energy. Often these are – especially for industry – tied to renewable energy use. The German electricity price compensation (Bundesministerium der Justiz, 2024) can be taken as an example here. It is based on the EU state aid principles and hence, organisations obtaining electricity price compensation are obliged to show they provide an environmentally beneficial service in return, such as sourcing renewable energy.

Relevance of the benefit for different energy types:

The comparatively higher relevance of electricity procurement for GHG balances means that the relevance of compliance with regulatory requirements is also particularly high for electricity. The relevance for gas and H&C is assessed as medium.

24 DIRECTIVE (EU) 2024/825 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 February 2024 amending Directives 2005/29/EC and 2011/83/EU as regards empowering consumers for the green transition through better protection against unfair practices and through better information.

25 DIRECTIVE (EU) 2023/2413 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources and repealing Council Directive (EU) 2015/652.

26 COMMISSION DELEGATED REGULATION (EU) 2024/1408 of 14 March 2024 amending Commission Delegated Regulation (EU) 2023/1184 as regards aligning a technical term with Directive (EU) 2018/2001 of the European Parliament and of the Council.

27 COMMISSION DELEGATED REGULATION (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

Proposed criteria:

Several regulatory instruments impose environmental reporting requirements on organisations, primarily focusing on GHG emissions. Energy disclosure can be beneficial for organisations by enabling them to provide the necessary information and serve as proof of renewable energy procurement, forming the basis for demonstrating low GHG emissions. To achieve this, the following criteria must be met:

- Energy disclosure serves as proof for renewable energy procurement
- In the context of energy disclosure, energy attributes tracked and ownership is transferred
- Energy disclosure enables deductions about spatial correlation
- Energy disclosure enables deductions about temporal correlation

Given the complexity of data collection for GHG accounting, energy disclosure must also be easily accessible. Hence, the criterion

- Administrative Efficiency

must be met.

4.7 Hedging against CO_2 prices

Against the background of rising CO_2 prices for fossil fuels, organisations benefit from switching to renewable energy. For gas and heating&cooling in particular, there are cases where energy disclosure information becomes relevant for organisations as consumers.

With the EU Emissions Trading System (ETS I[28] and ETS II[29]) the EU introduced a comprehensive CO_2 pricing in the EU, currently covering industry, power generation, aviation and maritime transport (EU ETS I). A steadily increasing carbon price can be observed and is expected to further rise (BloomberNEF, 2025; European Commission, 2024; Twidale, 2024). The EU ETS II will set CO_2 prices on fossil fuels for the building as well as the transport sector from 2027 onwards. Meaning that suppliers of fossil fuels for these sectors are required to purchase CO_2 certificates, which increases the cost of fossil fuels, ultimately making gas as well as heating and cooling more expensive.

In the context of H&C supply, purchasing renewable energy has the potential to protect against price increases of fossil-based energy due to rising CO_2 prices (Kemper, Styles, Schickling, & Werner, 2024; Styles & Claas-Reuther, 2022, 2023). While in the electricity market, prices are determined by the merit order model, meaning that increased generation costs due to rising CO_2 prices are reflected in the final electricity market price, the situation is different for heating and cooling. At least in Germany, respective regulation (e.g. AVBFernwärmeV[30], CO2KostAufG[31]) is interpreted in such way as it is not allowed to pass on rising prices for fossil fuels to consumers or residents that purchase renewable heat (cf. Kemper, Styles, Schickling, & Werner, 2024).

[28] DIRECTIVE 2003/87/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC.

[29] DIRECTIVE (EU) 2023/959 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 10 May 2023 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading system.

[30] Verordnung über Allgemeine Bedingungen für die Versorgung mit Fernwärme vom 20. Juni 1980 (BGBl. I S. 742), die zuletzt durch Artikel 1 der Verordnung vom 13. Juli 2022 (BGBl. I S. 1134) geändert worden ist.

[31] Kohlendioxidkostenaufteilungsgesetz vom 5. Dezember 2022 (BGBl. I S. 2154).

Hedging against CO_2 prices would also be relevant for organisations in the context of biogas combustion. An organisation that combusts gas for H&C production or purchases gas for its vehicle fleet, could benefit from lower biogas prices compared to conventional gas in the future, when CO_2 prices further increase. Furthermore, when an organisation combusts biogas in a plant that is obliged under the EU ETS I, emission allowances could be saved up, as biogas can be excluded from the EU ETS II, if it is accounted for through mass balancing. In both cases, the mode of renewable energy tracking is determined by regulation in the context of target accounting, which in the EU is focused on mass balancing for gases, rather than EACs.

Relevance of the benefit for different energy types:

In the context of the EU ETS II, the benefit of hedging against CO2 prices is particularly relevant for gas and H&C. Regarding electricity, price hedging via long-term contracts becomes more relevant in this context (see Chapter 4.4).

Proposed criteria:

In order to realise the benefit of hedging against CO_2 prices, energy disclosure would need to be usable for proving renewable energy supply and hence, must meet the following criteria:

- Energy disclosure serves as proof for renewable energy procurement
- In the context of energy disclosure, energy attributes tracked and ownership is transferred

4.8 Meeting growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership

Organisations face growing stakeholder expectations with regard to the sustainability of an organisation's activities and procurement (Hauser et al., 2019; Sakhel, Mundt, & Sünkel, 2022; Strüker et al., 2022; WBCSD & BCG, 2023). The 'environmental image' of organisations is becoming increaseingly relevant for customers, when it comes to deciding on a company and on purchasing its products (Aasen et al., 2010, p. 7925; Hauser et al., 2019; Rahbauer et al., 2016, p. 1192), and hence, a relevant competition criterion for organisations. Especially in terms of energy purchases stakeholders pose broad sustainability requirements on organisations (Hauser et al., 2019; WBCSD & BCG, 2023, p. 12).

In order to satisfy stakeholder demand for renewable and/or sustainable energy procurement, appropriate reporting on the characteristics of energy procurement is necessary. To this end, organisations benefit from energy disclosure, as it can provide information on the procured energy (Aasen et al., 2010). However, it has to be assumed that energy disclosure is perceived as credible and trustworthy and needs to be accessible by respective stakeholders (Aasen et al., 2010; Rahbauer et al., 2016; van Dam & Ugarte, 2020).

Another benefit of energy disclosure for organisations is the opportunity to demonstrate a pioneering role in environmental protection. However, ambitious climate targets and emission reduction measures as well as public commitments to purchase renewable energy only create a pioneering role for organisations, if this can be demonstrated by means of respective energy disclosure (Sakhel, Mundt, & Sünkel, 2022).

The current electricity disclosure system in the EU based on GOs is facing criticism from customers and other stakeholders regarding its credibility. Greenwashing concerns are existing towards organisations that purchase green electricity backed by GOs (Moss et al., 2024; Nord Pool et al., 2023). This can on the one hand be explained by the significant role that green electricity products backed by GOs from Norway play in the European market, which is not perceived as credible by some customers due to the physical discrepancies in electricity distribution (Nord Pool et al., 2023). On the other hand, due to the annual matching of GOs to the electricity consumption, it cannot be guaranteed that an organisation used 100 % renewable electricity throughout the year. This fact serves as an argument for greenwashing accusations, if 'annual matching [is] used for marketing claims' (Nord Pool et al., 2023). Some stakeholders see the chance to overcome trust issues trough granular energy disclosure in relation to time and location (Moss et al., 2024; Nord Pool et al., 2023).

When discussing environmental leadership and meeting stakeholder expectations, also the already described discussion around adding additionality criteria in order to promote impactful energy procurement needs to be mentioned here (see Chapter 4.3).

Relevance of the benefit for different energy types:

The benefit is potentially relevant for all energy carriers.

Proposed criteria:

In order to realise the benefits of meeting growing stakeholder expectations, mitigating reputational risks, and demonstrating environmental leadership, energy disclosure must serve as reliable proof of renewable energy procurement. Accordingly, the following criteria must be met:

- Double counting/double claiming is prevented
- Energy disclosure serves as proof for renewable energy procurement
- In the context of energy disclosure, energy attributes tracked and ownership is transferred

Furthermore, it must be accessible and usable for addressing the diverse needs of various stakeholders. Therefore, also the following criterion must be fulfilled:

- Administrative efficiency

4.9 Unique green claims for marketing products or services

Many customers communicate growing expectations regarding the sustainability and climate-friendliness of a product or a service (see e.g., Ascui et al., 2021; Hauser et al., 2019; Rahbauer et al., 2016; Strüker et al., 2022). Organisations attempt to meet these demands by offering products or services that are claimed to be green or climate friendly, often due to the use of green electricity (O'Shaughnessy et al., 2021; Rahbauer et al., 2016). However, there is a lack of harmonised, credible and communicable labels for products that are produced by using green electricity – or, in general, green energy (Rahbauer et al., 2016). But, as organisations often demand a price premium for such products, their green or climate-friendly attributes should be verifiable (Heeß et al., 2024). This issue is addressed by the EU by introducing the GCD and EmpCo, which hold organisations accountable and can impose penalties for non-compliance respectively misleading green product marketing.

In this context, an adequate energy disclosure is essential as a fundamental prerequisite, meaning that it must serve as a basis for verifying green energy claims associated with green-labelled products. For instance, this can be achieved by reflecting the ownership of energy attributes through the use of relevant certificates (D. Miller, 2022).

In order to make green claims credible, these should be legally enforceable and exclusive (Bird et al., 2017). In terms of energy disclosure, this means that legal anchoring is needed to ensure credibility of claims. In addition, exclusive tracking and cancellation of energy amounts is a requirement for energy disclosure in the context of credible green claims, meaning that attributes are directly assigned to a customer or a product (Styles et al., 2023). An international alignment of these requirements regarding energy disclosure principles would be necessary, in order to ensure interoperability of disclosure systems and a the possibility to maintain a complete chain of custody along the whole value chain (Sakhel & Styles, 2022; Strüker et al., 2022; Styles et al., 2021). Currently, organisations are facing the challenge that different national conditions prevail (Hauser et al., 2019).

Furthermore, the aspect of granularity is also discussed in the context of credible claims of green energy use. As per Ballentine et al. (2022), the reflection of physical deliverability constraints through more granular information in the context of energy disclosure can lead to more credible claims. This is also underlined by the European Association for Storage of Energy (EASE), that states that granular GOs would be needed to ensure transparency and accuracy when making product or production related green energy claims (The European Association for Storage of Energy [EASE], 2024). As per EASE (2024), this could also ensure compliance with the EU Green Claims directive.

Another requirement is the administrative efficiency of such verification processes. Organisations need to be able to easily handle energy disclosure in such a way that it supports verifying the renewable energy input for e.g. a green product line. Providing organisational consumers with a digital access to energy disclosure information could facilitate integrating such information into organisations' reporting and verification processes, potentially enhancing administrative efficiency for organisations. Furthermore, a cancellation right for organisational consumers enabling them to cancel the EACs for the claimed energy within a green product by themselves could further simplify respective verification processes (cf. Styles et al., 2023). These benefits would need to be weighed against a potential increase in administrative burden on the side of EAC issuing bodies.

Relevance of the benefit for different energy types:

The focus of literature on energy disclosure in the context of green claims mainly focuses on electricity (see also 4.5.1), but the factors outlined above also apply to gas and H&C in principle. The relevance for electricity is therefore assessed as high, and as medium for gas and H&C.

Proposed criteria:

In order to enable organisations to make unique green claims when marketing their products or services and thereby benefit from meeting the growing demand for credible, climate-friendly offerings, the following criteria must be met:

- Double counting/double claiming is prevented
- Energy disclosure serves as proof for renewable energy procurement
- In the context of energy disclosure, energy attributes tracked and ownership is transferred

To ensure practical applicability, such verification processes must be straightforward and efficient. Consequently, also the following criterion must be met:

- Administrative efficiency

4.10 Outlook: Benefits for municipalities

Municipalities play a pioneering role in the use of renewable energy and climate-friendly economic activity. Low-emission administration as well as municipal enterprises with ambitious climate goals are essential to live up to this role model function. In addition, municipalities are responsible for meeting territorial climate targets, which in turn contribute to the targets on national and EU level. It is the responsibility of local governments to implement, monitor and report on the achievement of politically set local climate targets and related measures (Hauser et al., 2019). These climate targets are applied to CO_2 emissions from sources within the respective boundaries, i.e. the municipal territory. The focus here is mainly on energy-related emissions. Territorial accounting methods can follow the source principle, which includes all emission sources in a territory, or the polluter pays principle, which refers to all emissions resulting from energy consumption in that territory. Both principles can be monitored by using local statistical data. Widely used in Germany is the BISKO (Bilanzierungs-Systematik Kommunal) standard (Hertle et al., 2019) as accounting approach for municipalities. This approach favours the use of the location-based approach to enable comparability among municipalities. The market-based accounting approach is irrelevant in the context of territorial accounting methods, hence, in this context municipalities do not benefit from energy disclosure or pose requirements on energy disclosure.

However, municipalities benefit from energy disclosure in the context of their pioneering role in the use of renewable energy as well as climate-friendly activities in general. Especially, impactful procurement strategies followed by public authorities and organisations are an important tool to contribute to the energy transition and reduce GHG emissions (AssmannPfeiffer Rechtsanwälte, 2022). In order to monitor the GHG footprint of public authorities and municipal enterprises, GHG accounting standards like the ISO 14064-1 or the GHG Protocol become relevant for municipalities. In this context, public authorities as well as municipal enterprises share the same benefits from energy disclosure as other organisations (see previous chapters).

Nevertheless, energy disclosure – particularly granular GOs – will gain relevance in the context of territorial accounting. There are ambitious municipal strategies existing for achieving 100 % carbon-free energy, for example, in Paris, London and Copenhagen (C40 Cities, 2024). Achieving 24/7 Carbon Free Energy requires precise energy monitoring and tracking, which suggests that advanced tracking methods might play an increasing role in future territorial accounting practices. For energy disclosure, this means that granularity and real-time information could become a relevant requirement from the perspective of municipalities in the future.

5 Benefits of energy disclosure for plant operators and investments in plants, and related criteria

5.1 Overview

Based on the literature assessment, two fundamental functions of energy disclosure and associated energy tracking instruments can be distinguished, which give rise to several benefits for plant operators and energy suppliers: an information function and a financing function.

In Europe, the **consumer information function of energy disclosure** and GOs is legally anchored in the Renewable Energy Directive (Art. 19 (1) RED III) in conjunction with the Internal Electricity Market Directive (EU) 2019/944 (Annex I No. 5) and Internal Gas Market Directive (EU) 2024/1788.[32] Its aim is to ensure that consumers receive reliable information on renewable energy shares of their energy, while excluding double marketing and double claiming of renewable energy attributes. The information function of energy disclosure is acknowledged also in literature focusing on international contexts.

The **financing function of energy disclosure** and associated energy tracking instruments derives from the information function but is distinct from it. It describes the expectation that consumer choices based on the provided information affect market prices and revenues that plant operators can receive, consequently influencing the composition of the energy generation mix.

With regard to investment decisions in renewable energy plants, there are two different ways for the financing function to take effect (cf. WBCSD & WRI, 2015):

- **Long-term contract for the supply of green energy attributes via a Renewable Energy Purchase Agreement (REPA):** REPAs create a contractual link between a renewable energy producer and an energy consumer or trader (e.g. a utility). As long-term contracts, they reduce price and offtake risks for plant operators, investors and creditors. Besides generating revenue streams for renewable energy plants, they have an important role in reducing finance costs of investments. That said, REPAs can take a range of different forms, including virtual REPAs with an unbundled sale of energy and green attributes, and physical REPAs which cover physical energy deliveries (either from onsite or offsite plants) and attribute transfers.
- **Aggregate effects of demand for green energy attributes:** here, revenue streams for renewable energy plants originate from the sale of green attributes in short-term markets, without a long-term contractual relationship. Green attributes may be sold unbundled from energy volumes (e.g. in the case of unbundled GO or, more general, EAC sales), or bundled (e.g. in case of mass balancing of gases and liquid fuels). Aggregate demand effects take place, if EAC prices or price premiums achievable with green energy products are high enough to affect the relative competitiveness of different energy sources and technologies, thereby altering the composition of the generation mix.

Accordingly, two types of benefits for plant operators can be distinguished relating to the **financing function** of energy disclosure:

- **Enabling revenues and planning security from long-term REPAs**

[32] DIRECTIVE (EU) 2024/1788 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 June 2024 on common rules for the internal markets for renewable gas, natural gas and hydrogen, amending directive (EU) 2023/1791 and repealing Directive 2009/73/EC (recast).

- **Revenues from green attribute sales in short-term markets**

Besides acting as the basis for a possible financing function, the **consumer information function** of energy disclosure also gives rise to **non-financial benefits**:

- It can enable plant operators to **fulfil the formal prerequisites for market participation**, by addressing legal requirements or fundamental customer demands.
- It may promote **customer acquisition and loyalty**.
- It may increase the local acceptance of renewable energy plants and thereby reduce project implementation barriers. As part of the financing function, there may be additional revenues achievable for energy supply from local/regional plants. Both aspects are summarised in the benefit **additional value through regional renewable energy**.

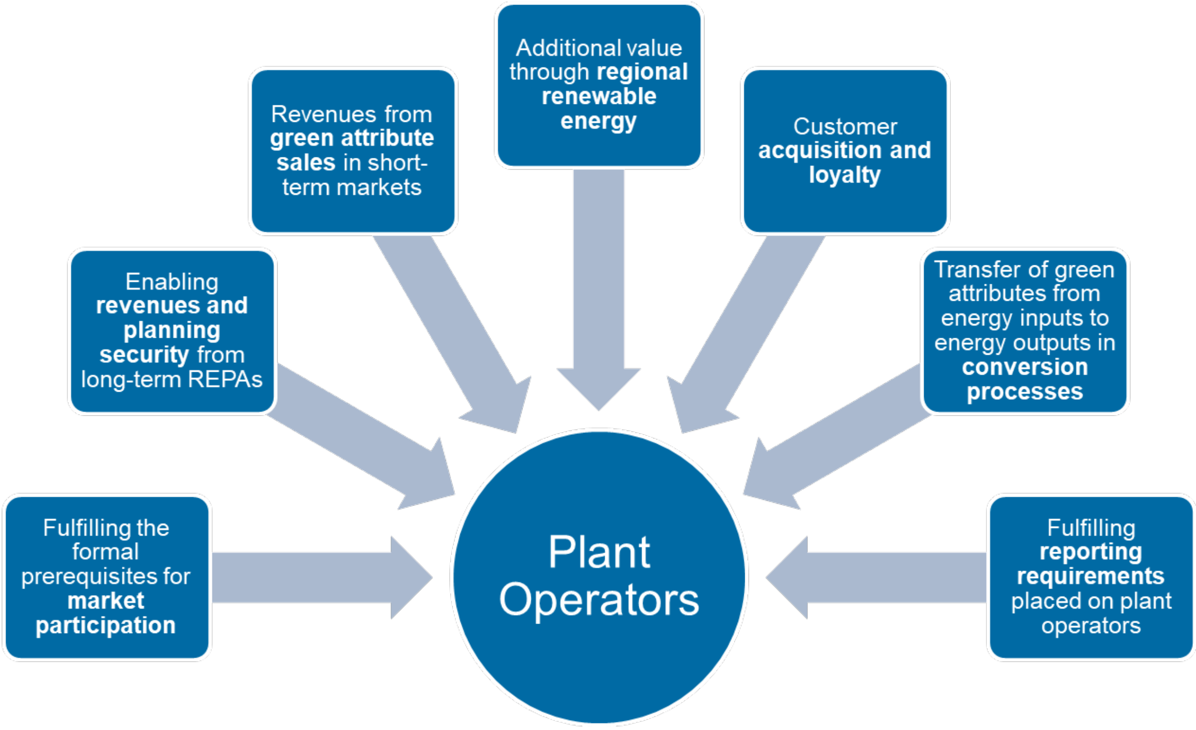
Furthermore, conversion plant operators represent a special, but increasingly relevant stakeholder group for energy disclosure information. Here, energy plant operators also act as energy consumers, using energy input in the form of one energy carrier (e.g. electricity) to produce output in the form of another energy carrier (e.g. gas, heating or cooling). Here, benefits of energy disclosure relate to the **transfer of green attributes from energy inputs to energy outputs in conversion processes**.

As an extension of the information function, energy disclosure and renewable energy tracking instruments can also provide benefits in the context of **fulfilling reporting requirements placed on plant operators**.

In the following section, we provide an overview of the discussion of the listed benefits in the literature and derive implications for evaluation criteria. Figure 15 provides an overview of the benefits.

Table 7 provides an overview of the identified benefits and derived evaluation criteria based on the literature assessment. It also shows a set of beneficial sub-criteria that contribute to the fulfillment of the respective evaluation criteria.

Figure 15: Identified potential benefits of energy disclosure systems for plant operators



Source: Authors’ own illustration, Hamburg Institut.

Table 7: Benefits of energy disclosure for plant operators and investments in plants and derived criteria of energy disclosure

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
Fulfilling the formal prerequisites for market participation	E: high G: high H&C: high	Unique claims on origin from RES *(note: supports all other benefits for plant operators)*	E: high G: high H&C: high	• Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes • The residual mix is publicly available, enabling its usage for disclosure
		Administrative efficiency (note: supports all other benefits for plant operators)	E: high G: high H&C: high	• Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics) • Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system • Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking • Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy • Harmonisation of requirements and administrative procedures across energy carriers • Disclosure information is easily accessible upon request (from a supplier's perspective)
		Information provision on requirements for participation in compliance markets	E: medium G: high H&C: medium	• Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen) • Provides information on nature of societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				• Inclusion of information on GHG intensity of energy production (direct & indirect emissions → incl. upstream emissions, especially for biogenic energy carriers and hydrogen) • Inclusion of information on GHG intensity of energy production (direct emissions) • Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen - Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months. - When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7)
		Conformity with voluntary standard requirements and further key consumer requirements: see benefits for organisations		
Enabling revenues and planning security from long-term REPAs	E: high G: medium H&C: high	Ability to transfer green attributes to off-takers in REPAs	E: high G: medium H&C: medium	• Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs) • Ability to transfer EACs to individual consumers (with EAC cancellation by consumers) • Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
		Information provision on additionality characteristics of RES supply	E: high G: medium H&C: low	• Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure • Provide information on subsidy schemes that a plant profits from • Provide information on the age of a production plant • Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure • Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure • Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure
		Information provision on requirements for participation in compliance markets	E: medium G: high H&C: medium	• Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen) • Provides information on nature of societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species) • Inclusion of information on GHG intensity of energy production (direct & indirect emissions → incl. upstream emissions, especially for biogenic energy carriers and hydrogen) • Inclusion of information on GHG intensity of energy production (direct emissions) • Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				- Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months. - When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7)
		Conformity with organisations' requirements, given the relevance of organisations as off-takers: See benefits for organisations		
Revenues from green attribute sales in short-term markets	E: medium G: low H&C: low	Definition of market boundaries and accounting period prevents oversupply	E: high G: low H&C: low	• Required temporal correlation of production and consumption of energy • Required geographical correlation of production and consumption of energy • Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
		Information provision on additionality characteristics of RES supply	E: high G: medium H&C: low	• Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure • Provide information on subsidy schemes that a plant profits from

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				• Provide information on the age of a production plant • Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure • Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure • Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure
		Disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability	E: high G: medium H&C: medium	• Provides detailed information on the energy source used to produce a unit of energy (e.g., information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Disclosure statement includes information on the regional origin of the RES supply • Disclosure statement includes information on the technological origin of the RES supply • Disclosure statement includes information on the sustainability characteristics of the RES supply
		Consistency between disclosure and target accounting	E: medium G: high H&C: medium	• Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green attributes • Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
		Information provision on requirements for participation in compliance markets	E: medium G: high H&C: medium	• Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen) • Provides information on nature of societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species) • • Inclusion of information on GHG intensity of energy production (direct & indirect emissions → incl. upstream emissions, especially for biogenic energy carriers and hydrogen) • Inclusion of information on GHG intensity of energy production (direct emissions) • Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen - Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months. - When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7)
Customer acquisition and loyalty	E: medium G: medium H&C: medium	Information provision on additionality characteristics of RES supply	E: high G: medium H&C: low	• Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure • Provide information on subsidy schemes that a plant profits from

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				• Provide information on the age of a production plant • Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure • Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure • Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure
		Disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability	E: high G: medium H&C: medium	• Provides detailed information on the energy source used to produce a unit of energy (e.g., information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Disclosure statement includes information on the regional origin of the RES supply • Disclosure statement includes information on the technological origin of the RES supply • Disclosure statement includes information on the sustainability characteristics of the RES supply
		Disclosure of information on energy suppliers’ overall procurement	E: medium G: low H&C: low	• Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure • Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure • Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
Additional value through regional renewable energy	E: medium G: medium H&C: low	Disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability	E: high G: medium H&C: medium	• Provides detailed information on the energy source used to produce a unit of energy (e.g., information according to level 1, level 2, level 3 of annex A of EN 16325 are provided) • Disclosure statement includes information on the regional origin of the RES supply • Disclosure statement includes information on the technological origin of the RES supply • Disclosure statement includes information on the sustainability characteristics of the RES supply
Transfer of green attributes from energy inputs to energy outputs in conversion processes	E: high G: high H&C: high	Information provision on requirements for participation in compliance markets	E: medium G: high H&C: medium	• Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen) • Provides information on nature of societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species) • Inclusion of information on GHG intensity of energy production (direct & indirect emissions → incl. upstream emissions, especially for biogenic energy carriers and hydrogen) • Inclusion of information on GHG intensity of energy production (direct emissions) • Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen - Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months. - When electricity is obtained from the grid, information provision on Bidding zone

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7)
		Tracking and exclusion of double counting of green attributes across energy carriers	E: high G: high H&C: high	• Cancellation of certificates for the input energy and issuing of new certificates for the output energy • Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
Fulfilling reporting requirements placed on plant operators	E: medium G: medium H&C: medium	Consistency between disclosure and target accounting	E: medium G: high H&C: medium	• Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green attributes • Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
		Information provision on requirements for participation in compliance markets	E: medium G: high H&C: medium	• Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen) • Provides information on nature of societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species) • Inclusion of information on GHG intensity of energy production (direct & indirect emissions → incl. upstream emissions, especially for biogenic energy carriers and hydrogen) • Inclusion of information on GHG intensity of energy production (direct emissions)

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type	Beneficial sub-criterion
				• Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen - Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months. - When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7)

Source: Authors' own representation, Hamburg Institut based on a literature assessment.

5.2 Fulfilling the formal prerequisites for market participation

When participating in PPA or short-term markets for green attributes, providing energy disclosure information is a prerequisite for plant operators' participation in renewable energy markets (Habsburg, 2024; Harsch et al., 2021; O'Shaughnessy, 2024; Sakhel, Styles, et al., 2022; WBCSD, 2016) – regardless of whether additional revenue streams can be realised or not. It is critical for plant operators that the energy disclosure information they provide and the tracking instruments they employ meet legal and consumer requirements.

Relevance of the benefit for different energy types:

Allowing plant operators to fulfil the formal prerequisites of market participation is a benefit of energy disclosure which applies equally to electricity, gases and heating and cooling.

Proposed criteria:

Unique claims on origin from RES

The obligation on plant operators to provide information on the attributes of energy generation is the foundation of the consumer information function of energy disclosure. In order to fulfil this function, consumers and society at large have requirements regarding the quality of the data provided (e.g. accuracy and reliability, see sections 3, 4 and 6). As a mirror requirement to this, plant operators have an interest that the information they provide meets legal requirements (e.g. European and national regulations concerning energy tracking and disclosure) as well as customer requirements, to enable PPA and short-term green attribute markets to function. Here, a key requirement is that the disclosure and tracking system enables unique claims on the origin from energy supply from renewable energy sources (RES). This is a prerequisite which enables customers to place value on associated green attributes, and for plant operators to realise such value through revenue streams. In Europe, the legal framework for the disclosure and tracking system and its enabling of unique claims on the origin of energy from RES are defined by the Renewable Energy Directive (Art. 19 (1) RED II) in conjunction with the Internal Electricity Market Directive (EU) 2019/944 (Annex I No. 5) as well as the Internal Gas Market Directive (EU) 2024/1788.

The ensuring of unique claims on the origin from RES is equally important for electricity, gases and heating and cooling.

Information provision on requirements for participation in compliance markets

Especially for markets which are shaped by policy incentives, e.g. GHG reduction or renewable energy quotas, proving compliance with regulatory requirements is an important prerequisite for market participation. Here, revenue opportunities for plant operators depend on energy generation to be countable towards policy targets. In the European context, this is particularly relevant for RFNBO (Renewable Fuels of Non-Biologic Origin) and advanced biofuels and biogas where technology-specific targets for the transport sector (see Art. 25 RED III) and industry sector (focusing on RFNBO, see Art. 22a RED III) apply (with mass balancing as the required tracking tool). In the context of target accounting, the RED III (as the RED II beforehand) imposes comprehensive requirements on the proof of sustainability related to biogenic energy carriers (including e.g. criteria for land use and raw materials), which are used directly by end consumers or converted in other energy carriers (see 5.7). According to the RED III and associated delegated acts (see 5.7), RFNBO must comply with specific RFNBO criteria; RFNBO and other renewable energy carriers like biogenic fuels and electricity must additionally exhibit life-cycle greenhouse gas emission savings (of at least 65% depending on sector and fuel/energy carrier) compared to a fossil fuel comparator, which must be proven throughout conversion processes. Other regulations require the indication of total energy-related CO_2 emissions, as it is for example the case in the context of EU ETS (EU Emissions Trading Systems)-related declarations. For this reason, disclosure/certificate systems which play a role in target accounting should facilitate the evidence of CO_2 emissions and/or savings (Fraunhofer FIT, 2022).

In the European context, information provision on requirements for participation in compliance markets is particularly relevant for gases and liquid fuels, in the context of target accounting.

Administrative efficiency

Beyond the ability of energy tracking and disclosure to enable market participation, a key requirement for plant operators is that relevant information can be provided with as little administrative effort as possible. This point is emphasised, for instance, in statements of plant operators' and energy suppliers' interest associations to relevant policy development processes (AGFW | Der Energieeffizienzverband für Wärme, Kälte und KWK e. V., 2024; BDEW, 2022, 2023; Verband Kommunaler Unternehmen [VKU], 2024). In this regard, an important aspect is the efficient use of provided information – i.e. if information on RES generation and its attributes is required for multiple purposes (e.g. disclosure, target accounting, statistics), administrative costs to plant operators can be reduced by interfacing and data sharing between associated registries and public agencies involved. Also, the digitalisation and automation of data provision and verification processes play an important part.

The requirement of administrative efficiency applies to electricity, gases and heating and cooling equally. For plant operators and energy suppliers active in the production of multiple energy carriers, a harmonisation of requirements and administrative procedures across energy carriers is an important further aspect of reducing administrative burdens. Moreover, data sharing between energy carrier-specific RES tracking registries is gaining even more importance for achieving administrative efficiency.

5.3 Enabling revenues and planning security from long-term REPAs

Especially in the electricity sector, long-term Power Purchase Agreements (PPAs) are increasingly becoming established as an instrument to reduce price and – in case of physical PPAs – quantity risks both on the side of energy producers and consumers. A similar role could be played by long-term purchase agreements for gas or H&C from renewable energy sources (REPAs). Art. 15 Abs. 8 RED III requires member states to assess regulatory and administrative barriers to long-term REPAs, remove unjustified barriers and promote their uptake. So far, available literature on the link between energy disclosure and long-term purchase agreements focuses on the more established PPAs.

For consumers, PPAs can offer price stability over a defined period of time (in case of fixed-price contracts), or reduce price risks to a specified agree if price corridors or indices are part of contract conditions (Backstrom et al., 2024; Broom et al., 2020; Chrysikopoulos et al., 2024; Hilpert, 2018). Also, they reduce uncertainty over whether energy supply with certain attributes is available long-term (Chrysikopoulos et al., 2024; LDES Council, 2022), which can be particularly relevant for organisations with targets related to energy procurement and Scope 2 emissions (see section 4). For producers, PPAs reduce revenue risks and (in case of physical PPAs) offtake risks (Backstrom et al., 2024; Broom et al., 2020; Harada & Coussi, 2020; LDES Council, 2022; O'Shaughnessy, 2024, 2025; WBCSD, 2016). Long-term predictability of revenue streams lowers the risk of RES projects, improving access to financing and financing conditions. Given the capital-intensity of most RES plants, a lower rate of return demanded by capital providers translates directly to lower overall project costs.

For electricity plants that do not receive public support, the existence of a PPA with predictable and long-term income streams is often a precondition for acquiring finance for investments and facilitating the bankability of projects (Broom et al., 2020; Lehmann, Müller, et al., 2021; Seebach & Timpe, 2023; WBCSD, 2016). Besides the role of PPAs in securing financing for new RES projects, they can also contribute to making the continued operation of post-subsidy plants financially viable (dena et al., 2020; Harada & Coussi, 2020; Lehmann, Müller, et al., 2021). Even for plants receiving public support, the existence of a long-term purchase contract can reduce financing costs, thereby reducing the necessary level of support and support costs.

As a result, PPAs are an important element of the EU's electricity market reform (European Council, 2024), to strengthen the market-component of RES financing, realise price stability for consumers and contribute to RES expansion (see also dena & Marktoffensive Erneuerbare Energien, 2024; Michalski, 2019; WBCSD, 2016).

PPAs (or, more generally, REPAs) can cover a wide range of contract types and conditions, starting with the definition of "long-term' (Backstrom et al., 2024; Harada & Coussi, 2020; Hilpert, 2018). Accordingly, agreement on contract details can be lengthy and complex, e.g. with regard to risk allocation (Hilpert, 2018), and tends mainly to be viable for larger organisational energy consumers (in particular corporate energy buyers). Physical PPAs cover the sale of agreed electricity generation quantities, which are physically injected into transmission grids (with offsite PPAs) or direct transmission lines (onsite PPAs), with specified nodal connections or balancing areas and delivery times. Offsite PPAs typically involve electricity utilities as intermediaries, to match supply to consumers' load profiles (Backstrom et al., 2024). For virtual PPAs, contract terms can vary considerably (Backstrom et al., 2024; Hilpert, 2018). Here, RES producers sell their electricity to the wholesale market (potentially employing separate physical PPAs), and contractual PPA partners source their electricity separately. The core of virtual PPAs is usually some form of financial hedging such as a contract for difference (CfD), where the consumer pays the producer when reference wholesale electricity market prices are below an agreed strike price; if prices are above the PPA strike price, the producer pays the consumer, allowing for a mutual mitigation of risks.

Reflecting the diversity of contract types and conditions, the role of energy disclosure and EACs also varies. In physical PPAs, EACs associated with contracted energy quantities may or may not be assigned a specified value. In some cases, they are bundled with electricity deliveries with no separate value ascribed (Andrews & Moss, 2023). However, the transfer of EACs or their cancellation on the offtaker's behalf is considered a crucial precondition for entering into a PPA with a renewable energy plant (O'Shaughnessy, 2024, 2025; e.g. WBCSD, 2016; WBCSD & WRI, 2015) – only in this way, the energy consumer can claim the green attributes in a manner that complies with disclosure regulation in the EU and international GHG accounting standards (see section 4). In this way, EACs become the prerequisite for the realisation of revenues from RES plants' energy sales, even if the EACs are not assigned a value by themselves or a low value. Likewise, virtual PPAs can cover the transfer of EACs, or EACs might be sold separately by the RES producer, in which case the PPA partner does not acquire any green attributes under the contract. On the other hand, there can also be long-term contracts covering the unbundled sale of EACs, without a CfD element regarding electricity prices; for producers this may provide certainty about EAC prices over a period of 15–20 years, enabling them to include revenues in financial projections for investments, as one element of total revenue (Hardison et al., 2020; O'Shaughnessy, 2024, 2025).

Relevance of the benefit for different energy types:

For electricity, the importance of PPAs for derisking investments is well-established (see above). For gases and H&C, REPAs are less well-established to date. However, with H&C, the connection to a grid tends to be a long-term investment decision for consumers by default. H&C supply is frequently organised as a vertically integrated monopoly (i.e. the operation of plants, grid and supply to customers is carried out by one utility), where the profitability of the grid as a whole depends on the number and load of connected consumers. As a result, both consumers and suppliers are interested in long-term contracts as a standard mode of energy supply, even if these are not REPAs with individual plants in a strict sense, but rather long-term supply contracts with utilities owning a portfolio of renewable and non-renewable plants. Benefits associated with REPAs, such as enabling revenues and planning security, also apply to the marketing of green H&C products in the form of long-term contracts (Kemper, Styles, Schickling, & Werner, 2024; Styles & Claas-Reuther, 2022, 2023). Energy disclosure and tracking can be used to allocate green attributes of plants to specific consumers, enabling green price premiums and/or customer acquisition and loyalty effects (see 5.5). Therefore, the relevance of benefits from REPAs is assessed as high for electricity and H&C, but medium for gases, where there is higher uncertainty on the future role of long-term contracts.

Proposed criteria:

<u>Ability to transfer green attributes to off-takers in REPAs</u>

Energy disclosure plays a central role in enabling and facilitating the transfer of green attributes in PPAs and, more generally, REPAs. Given the relevance of corporate consumers as REPA off-takers, RES plant operators offering PPAs have an interest that energy disclosure information and tracking instruments meet the requirements corporate consumers place on them – this covers the exclusion of double counting and adherence to further quality criteria which allow the market-based approach to GHG accounting to be applied (see section 4). Similarly, other criteria which facilitate REPA use by organisations as energy consumers are also relevant for plant operators, as their fulfilment may widen the market for REPAs. An example are low administrative costs for handling EACs and energy disclosure information, e.g. through cancellation rights for unbundled EACs procured via long-term contracts/virtual REPAs. In these cases, EACs are procured from a different plant than actual energy supply; if cancellation rights are limited to energy suppliers, corporate consumers need to contract the service of their energy supplier to cancel the EACs they themselves procure (Styles et al., 2023). This results in additional costs and coordination efforts. In corporate energy procurement, REPAs are particularly established in the electricity sector so far, so the relevance of being able to transfer green attributes to off-takers is particularly high for electricity.

<u>Information provision on additionality characteristics of RES supply</u>

Compared to aggregate demand effects from purchasing unbundled EACs or green energy products, REPAs with new and/or unsupported plants can be considered an 'high impact' form of procurement, as they directly contribute to the financing and de-risking of RES plants outside of support mechanisms (dena & Marktoffensive Erneuerbare Energien, 2024; LDES Council, 2022; Michalski, 2019; Seebach & Timpe, 2023). RES producers offering REPAs therefore have an interest in information on REPA existence being visible as part of energy disclosure information. This may be summarised as information provision on the 'additionality' of RES procurement, if REPAs are an element of operationalising additionality. In the European regulatory context, this has so far been primarily established in the case of RFNBO requirements with regard to the role of PPAs in the EC's Delegated Act on RFNBO production (EU 2023/1184, see 5.7). Also, the role PPAs as part of 'impactful procurement' is relevant in organisations decarbonisation strategies and associated standards and initiatives (see section 4). As a result, the relevance of this criterion is high particularly for electricity, whereas in the case of gases it mainly plays a role in the conversion context so far (see 5.7). For H&C, increasing the visibility of PPAs in the context of Power-to-Heat or Power-to-Cold processes may also become relevant, but does not yet feature in the scientific or political discussion.

Information provision on requirements for participation in compliance markets

If consumers must prove being supplied with renewable energy with certain characteristics in the context of a quota obligation or support scheme, this can be an important driver for concluding a REPA. In this context, plant operators offering REPAs have an interest that energy disclosure provides information on whether supplied energy meets the requirements for participation in compliance markets. For renewable gases, markets have so far been shaped significantly by regulatory requirements (see 5.2), making this criterion particularly relevant for gases.

5.4 Revenues from green attribute sales in short-term markets

Short-term markets enable the trade of green attributes unbundled or bundled with underlying energy quantities. Such trading can take various forms, e.g. attribute sales via an exchange, over-the-counter (OTC) sales using brokers as intermediaries or online OTC trade platforms, or bilateral contracts (e.g. a green energy contract between an energy consumer and supplier which can be cancelled given a pre-defined notice period). The key distinction to a REPA is the absence of a multi-year offtake agreement which is long-term enough to significantly lower a plants' revenue risks.

Relevance of the benefit for different energy types:

Compared to gas and H&C, voluntary, disclosure-driven green electricity markets are much more established internationally – consequently, as with REPAs, available research on the revenue effects of short-term markets focusses on electricity. In principle, green attribute markets enable aggregate demand effects – by expressing their preferences through a higher willingness to pay for green electricity products (or unbundled EACs), consumers could in theory affect the income of energy producers, the relative prices achievable with renewable and non-renewable generation options and thereby, in aggregate and longer term, affect the composition of the energy generation mix (Bachus, 2023; Dagoumas & Koltsaklis, 2017; dena & Marktoffensive Erneuerbare Energien, 2023; Hamburger & Harangozó, 2018; O'Shaughnessy, 2024).

However, a large body of research indicates that revenues of short-term green attribute sales have so far been ineffective in promoting RES investments to a significant degree (Andrews & Moss, 2023; Brander et al., 2018; Gillenwater, 2013; Gillenwater et al., 2014; Hamburger, 2022; Hamburger & Harangozó, 2018; Herbes et al., 2020; Hulshof et al., 2019; Langer et al., 2024; Martinsen & Mouilleron, 2020; Mulder & Zomer, 2016). Therefore, the relevance of the benefit for electricity is assessed as medium rather than high.

Proposed criteria:

To identify criteria to assess whether energy disclosure promotes revenues from attribute sales in short-term markets, it is insightful to analyse why short-term green attribute sales have so far been falling short of promoting RES investments to a significant degree. Studies highlight three key reasons for this: low average prices of EACs, high price volatility and the fact that RES expansion so far has been strongly support-driven.

Voluntary green electricity markets, such as for GOs or RECs, have so far suffered from an oversupply (i.e. supply exceeding voluntary demand); this has resulted in low average prices of EACs. In Europe, the abundance of GOs from Norwegian hydropower is a contributing factor to this (Martinsen & Mouilleron, 2020; Mulder & Zomer, 2016; Wimmers & Madlener, 2024). Holzapfel et al. (2024) find that in countries with high RES shares, such as Norway or Iceland, consumer interest in GOs tends to be low, contributing to a GO trade deficit in such countries and the oversupply of the European market.

Moreover, short-term EAC markets tend to display high price volatility. Even if temporarily significant attribute prices can be achieved, this means that project developers cannot count on reliable revenue streams from EAC sales, preventing positive impacts on projects' bankability and, therefore, on financing opportunities and costs (Gillenwater, 2013; Gillenwater et al., 2014; Hardison et al., 2020; Moss et al., 2024).

In Europe, RES-based electricity production remains largely support-driven (Badouard et al., 2022; Galzi, 2023; Herbes et al., 2020). According to Art. 19 RED II/III, the market value of GOs needs to be taken into account when determining support levels (unless Member States opt not to issue GOs for supported generation, as is the case with electricity in Germany). If subsidy levels are administratively reduced or competitively determined (either in a tendering scheme or a tradable green certificate system), plant operators may receive revenues by selling GOs, but in the absence of this option they would have received higher subsidies. As long as the market value of GOs is taken into account adequately, it is therefore secondary for plant operators if GOs are issued for supported production or not (at least from the perspective of GO revenues – in their information function, GOs for supported generation might still enable PPAs covering electricity sales as well). This is even more evident if GOs for supported electricity production are not issued to the producer but auctioned by the state. In all these cases revenues from short-term GO sales have the effect of reducing public support costs, rather than being a relevant financing element for RES projects. If producers have to choose between receiving GOs and public support, they are more likely to choose the latter, as the impact on revenues and risk-reduction tends to be more significant (Galzi, 2023). Also in the US, the compliance REC market tends to provide more attractive revenues than the voluntary one (Gillenwater et al., 2014).

However, Jansen (2017) highlights that as RES grow closer to achieving competitiveness with non-renewable power sources, even small revenues from EAC sales will become more relevant in closing cost gaps and therefore in influencing investment decisions. An increase in voluntary demand for green electricity may contribute to higher and more stable revenues, if it outgrows the current oversupply of the market (Jansen et al., 2016; Martinsen & Mouilleron, 2020). Focusing on the US market, O'Shaughnessy (2024) finds that as project development tends to be highly competitive, even comparatively small projected revenue streams from REC sales impact projects' implementation chances. In particular, project developers may combine long-term contracts with selling a share of green attributes in short-term markets, creating a financial hedge against risks in either market. Also, short-term EAC markets provide future income opportunities once initial long-term offtake contracts have expired.

A number of studies emphasise that as RES markets mature and market-based financing components become more relevant, EAC short-term markets should be reformed to enable more significant revenue streams for producers. The following three main reform dimensions can be distinguished, providing criteria for assessing energy disclosure concepts:

- <u>Definition of market boundaries and accounting period prevents oversupply:</u> Studies propose this could be achieved by introducing spatial and temporal matching requirements between green electricity production and consumption. With regard to the to the temporal dimension, a shift to hourly instead of annual matching is proposed (Energy Track and Trace, 2022; EnergyTag, 2021; European Network of Transmission System Operators for Electricity [ENTSO-E], 2022; Langer et al., 2024; Lorenz et al., 2022). Instead of using the internal market boundary as a spatial system limit, options include focusing on bidding zones or taking interconnector capacities into account, to consider market barriers with an impact on transmission grid stability (Aurora Energy Research, 2024; ENTSO-E, 2022; Holzapfel et al., 2024).

- Strengthening quality differentiation of energy disclosure information, by increasing the visibility of certain quality characteristics of renewable energy supply (Lorenz et al., 2022; Sakhel, Styles, et al., 2022; Schweins, 2015; Seebach & Timpe, 2020a). Primarily, two dimensions can be distinguished: Information provision on additionality characteristics of RES supply and disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability. For instance, Dutch consumers display a significantly higher than average willingness to pay for GOs from Dutch wind power plants (Martinsen & Mouilleron, 2020), same as Swiss consumers for Swiss hydropower certificates (Lorenz et al., 2022).
- Improving the consistency between disclosure and target accounting: Linking disclosure and EAC trade with policy target accounting could increase the value of green attributes (Holzapfel et al., 2024). This would have to be accompanied by measures to prevent international EAC trade to cause countries to miss RES targets, such as limiting cross-border trade to physical electricity transmission capacities. A precondition for achieving consistency between disclosure and target accounting is that disclosure systems fulfil the criterion information provision on requirements for participation in compliance markets, so that plant operators can indicate that the energy supplied qualifies not only for voluntary markets but can also be considered in the context of target accounting.

All three reform dimensions and associated criteria are primarily discussed in the context of electricity so far. Based on the number and results of studies available, the definition of market boundaries and accounting period as well as quality differentiation are assessed as high for electricity. The harmonisation of disclosure and target accounting is discussed less widely and was assessed as low in the context of the project's online stakeholder work.

The relevance of market boundaries and accounting period for gas is yet uncertain, because of the prevalence of mass balancing in relevant compliance markets so far, with a stronger link between trade of attributes and energy quantities compared to electricity. Its relevance is therefore assessed as low. In the H&C context with its predominantly local, closed grids, the question whether grid boundaries (i.e. the existence of a grid connection between energy producer and supplier) are taken into account in disclosure is expected to be of high relevance for demand and supply dynamics (Styles & Claas-Reuther, 2023; van Stein-Callenfels et al., 2020; Verwimp et al., 2020). However, the relevance of revenues in short-term markets is assessed as low overall for H&C, given the importance of long-term contracts, leading to a low relevance rating for this criterion for H&C.

The relevance of quality differentiation for gases and H&C in voluntary markets is assessed as medium, given limited practical experiences with EAC systems so far – theoretically, findings from electricity market studies seem applicable.

With green gas markets, so far bundled sales of green attributes and energy quantities dominate in the context of compliance markets (e.g. GHG reduction or renewable energy quotas, with mass balancing as tracking instrument prescribed by the RED II/III). It remains to be seen whether with the implementation of gas disclosure rules in the RED III in combination with the Internal Gas Market Directive (EU) 2024/1788, voluntary markets for green attributes based on consumer information will develop (BDEW, 2020; Deutscher Verein des Gas- und Wasserfaches e.V [DVGW], 2024). Also the development of green H&C products is in it's infancy (Kemper, Styles, Schickling, & Werner, 2024; Styles & Claas-Reuther, 2022) – district heating and cooling and other forms of grid-based H&C supply, marketing one product to all customers with a uniform attribute mix is still the norm. Since with both energy carriers, voluntary markets as enabled by the RED II's introduction of GOs enter a context with a high relevance of regulations concerning RES supply and usage, a harmonisation of disclosure and target accounting appears of relevance. This particularly applies to the case of gases, where a coordination is necessary between GOs and mass balancing as RES tracking instruments, to avoid double counting (Verwimp et al., 2023). The relevance of consistency between disclosure and target accounting and associated information provision on requirements for participation in compliance markets is therefore assessed as high particularly for gases.

5.5 Additional value through regional renewable energy

The literature provides different results on the effect of regional energy generation on the value and acceptance of (new) renewable energy plants for customers. While some studies suggest that regionality plays a role, which is rather subordinate (Bengart & Vogt, 2021; Kalkbrenner et al., 2017; Lehmann, Sloot, et al., 2021), other research provides evidence that regionality in energy supply can be about as important as the origin mix of energy sources (Lehmann et al., 2023). However, the question whether regionality is valued may be strongly dependent on the observed consumer group and price is still found to be (one of) the most decisive attributes in energy tariffs. Nevertheless, these studies show that regional renewable energy products, which are certified respectively, may be positively related with customer perception or actions in terms of interest in and acceptance of renewables, willingness to pay, sales potential and an advantageous image towards the energy supplier/utility (Lehmann, Müller, et al., 2021; Lehmann et al., 2023; Peters et al., 2018).

Besides the finding that some consumers do actually value regionality in the provided energy supply, it is also shown that regionality may offer new opportunities for increasing the acceptance of renewable energy (plants) through community motivations like e.g. the direct involvement of actors in community energy initiatives or indirect financial participation through a subsidy for regional electricity purchases (Kalkbrenner & Roosen, 2016; Lehmann, Müller, et al., 2021; Sloot et al., 2019). Moreover, acceptance of renewable energy may also be the result of concern for long-term industry competitiveness. Since industry is often a relevant energy consumer, regional energy production as part of the regional value creation may create a location advantage. Hence, acceptance for renewable energy expansion may improve if renewable energy is not only generated, but also consumed regionally in the industrial value chain (Kahles & Kahl, 2020; Lehmann, Müller, et al., 2021).

In consequence, although the positive effects of regional energy production and supply may be limited, it is advantageous for certification/disclosure systems to be endowed with the possibility to display a regionality component by carefully determining what criteria constitute regionality (e.g. what distance between energy generation and consumption would be considered as regional). Currently, this information is for example available through ordinary GOs that include the location of the energy generation plant as one of the minimum details that a GO must contain (see e.g. Association of Issuing Bodies (2024b)). However, to make this information more visible or the underlying value more accessible, portfolios of GOs with the regionality attribute would have to be compiled by energy providers. Additionally, in the German electricity sector, regional certificates[33] allow the verification of electricity from plants located in the region of the end consumer, but only in case these energy amounts are subsidised (while the issuance of GOs is only possible for non-subsidised energy amounts). Specific regional certificates also prevent the necessity for the creation of a large number of customised regional portfolios (Kahles & Kahl, 2020). Since, according to the German regulation, it is not possible to issue and receive both GOs

[33] These were introduced in Germany with Renewable Energy Act (EEG) 2017.

and regional certificates for the same amount of energy, it is also not possible to label energy as regional and automatically renewable at the same time, which impedes the provision and communication of a product certified as renewable energy from regional generation (Kahles & Kahl, 2020). Such incidences should be considered in the making of certification systems that track regionality characteristics.

Relevance of the benefit for different energy types:

Given the inconclusiveness of studies on this benefit overall, its relevance is assessed as medium for electricity and gases and low for H&C. In principle, regionality makes especially sense in the case of electricity, since the latter may be produced very far from the point of consumption, which may have negative impacts, e.g. on grid stability, or may be too abstract to conceive. Though gas grid congestions or imbalances may not be of such great relevance, regional supply may be valued through other motivations. In the H&C sector, regionality is given per se, since district heating takes place on a local level (as long as grid boundaries are reflected in disclosure). These assessments were confirmed by the project's stakeholder workshop (with relevance for electricity being assessed as either high or low). For further consideration in the context of design specifications, the topic of standarising the display of information on regionality was raised.

Proposed criteria:

Alongside other aspects of quality differentiation, regionality is integrated into the criterion <u>disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability</u>. The overall relevance of the criterion is rated as high for electricity, medium for gases and medium for H&C, taking the respective importance of regionality, technology and sustainability information in the context of other benefits into account (see 5.5-5.6).

5.6 Customer acquisition and loyalty

Green energy products do not necessarily have to be marketed at a price premium. In liberalised energy markets, energy supply utilities compete for customers not only by price, but also quality characteristics of their products and services. In the electricity sector, cases can be observed internationally where green electricity is offered at the same price as a standard electricity product, or even at a lower price (Hast et al., 2015; MacDonald & Eyre, 2018). If EACs are available at a low price, the measure can be implemented at limited cost to a utility, with positive expected effects on image and customer acquisition and loyalty.

Relevance of the benefit for different energy types:

This benefit is primarily relevant for liberalised electricity markets. However, in the literature, it plays a secondary role to revenue-oriented considerations, so that its overall relevance is assessed as medium. In Europe, gas supply is liberalised as well, but given the role of mass balancing in target accounting, green attributes tend to be more costly than in the electricity GO market. It remains to be seen whether this will be changed by the introduction of gas GOs. In accordance with feedback from the project's online stakeholder workshop, the relevance of this benefit for gases is therefore assessed as medium. In grid-based heating or cooling supply, markets are frequently organised as vertically integrated monopolies rather than liberalised markets (Engelmann et al., 2021). However, offering a green, carbon free H&C product can be an important tool in competing with decentralised heating or cooling supply options – with or even without a price premium (Kemper, Styles, Schickling, & Werner, 2024; Styles & Claas-Reuther, 2023). Especially in the case of corporate consumers with a sizable H&C demand and ambitious climate strategies, providing verifiable green H&C can be a necessary condition for acquiring customers or preventing their exit from the grid. Gaining or keeping such a contract can be critical for profitability of grid operation as a whole, so offering a green product without additional costs compared to a standard product can be a strategically necessary marketing decision for the supplier. Given the specific context of this use case, which however can be highly relevant for individual grids, the relevance of the benefit is assessed as medium.

Proposed criteria:

Disclosure of information on energy suppliers' overall procurement

Besides offering green electricity products at a competitive price, some suppliers make the strategic decision to switch all their offered products and tariffs to 100 % renewable electricity backed by EACs (Andrews & Moss, 2023; Energie & Management [E&M], 2022). Here as well, the motivation lies in attracting new customers and retaining existing ones. By offering 100 % renewable products or product portfolios, suppliers hope to provide a "warm glow' satisfaction to consumers as a way to promote customer engagement and loyalty (MacDonald & Eyre, 2018). Besides the product mix, disclosing the total energy mix of an energy utility provides an indication of its procurement behavior, which can influence customers choices between companies (BDEW, 2024; Schudak & Wallbott). Also, the provision of additional information e.g. concerning investments in own RES plants, or fossil fuels or nuclear energy production capacities can be relevant in this regard (Schudak & Wallbott).

Disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability

Besides providing information on energy utilities' overall procurement portfolio, the provision of additional quality characteristics of the energy supplied as part of energy tracking and disclosure can also be relevant for customer acquisition and loyalty – for instance, regarding sustainability characteristics or the regional context of energy provision (BDEW, 2020; Wallbott et al., 2021). Displaying sustainability characteristics is viewed as particularly important for energy disclosure on renewable gases, especially biomethane (BDEW, 2020), where said information is a prerequisite for energy supply to count towards regulatory requirements and policy targets. However, as a form of promoting consumer loyalty and engagement, the provision of sustainability information can also be relevant for other forms of biomass supply or other RES technologies, to prove (e.g. via labeling) that potential conflicts with nature protection aims have been mitigated, for instance in the context of hydropower projects. Limited research is available on the specific effect of quality differentiation on customer loyalty and acquisition, so the relevance is assessed as medium for electricity and gas as liberalised markets and low for H&C as a non-liberalised market.

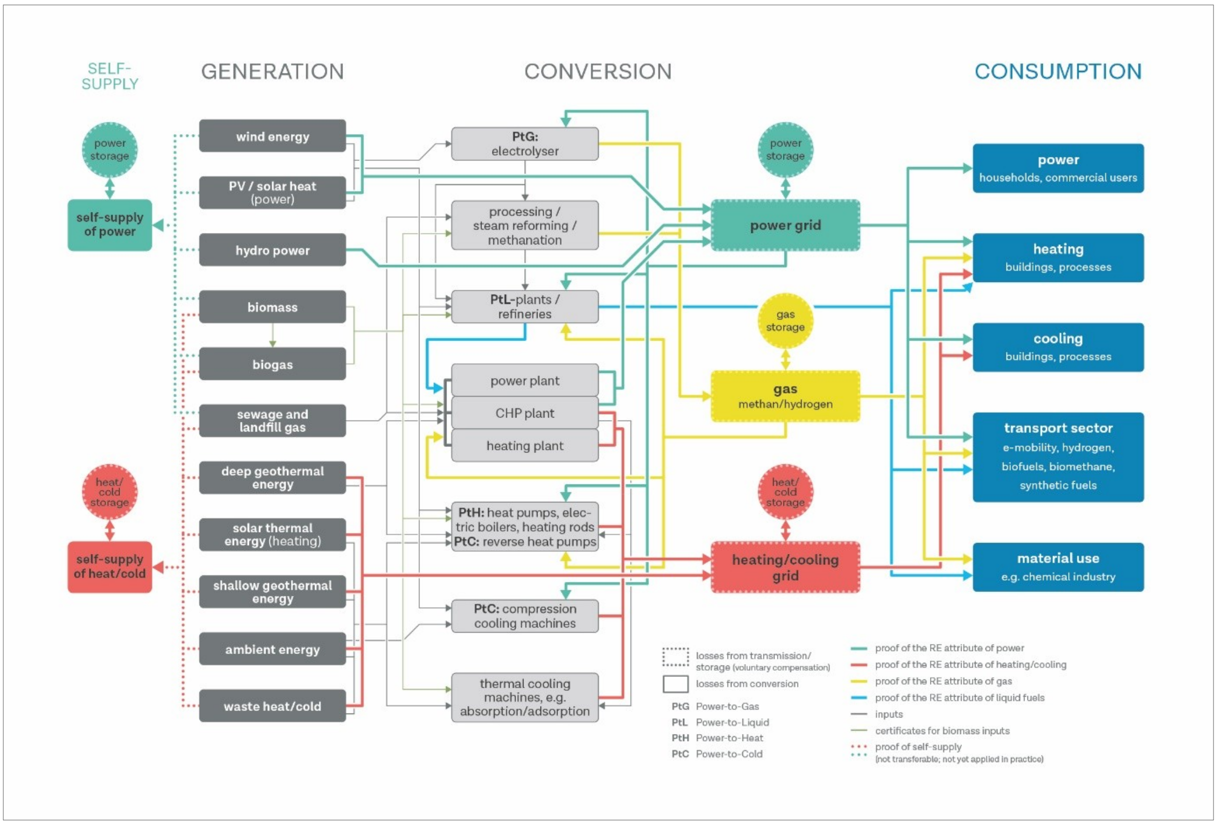
Information provision on additionality characteristics of RES supply

While research on customer acquisition and loyalty places less focus on this aspect, information provision on additionality can potentially also be relevant, given its role in supporting consumers in making an active choice in promoting the energy transition (see 3.2).

5.7 Transfer of green attributes from energy inputs to energy outputs in conversion processes

With the second Renewable Energy Directive (EU) 2018/2001 ('RED II'), the established GO system for electricity was expanded to GO systems for gases such as biomethane, synthetic gases, hydrogen and low-carbon gases (e.g. low-carbon hydrogen based on natural gas) as well as heating and cooling from renewable energies. In the case of thermal energy, the establishment of GO systems provides a legally secure basis for the marketing of green heating and cooling products. In the case of gases, GOs will be used as a certification system alongside mass balance-based systems. These certificates are not only relevant in certifying the origin and preventing the double-marketing of the (renewable) attributes of a specific energy carrier, but they also enable certification in energy conversion processes, i.e. the transfer of energy from one type of energy carrier to another type of energy carrier. Figure 16 depicts possible energy carrier conversion pathways, including electricity-based gas generation (especially production of green hydrogen), electricity-based heating and cooling generation, gas-based heating and cooling generation and gas-based electricity generation. In a broader sense, conversion between gas types (e.g. hydrogen-based ammonia production) and between heating and cooling (e.g. heat-based cooling production) are also possible energy conversions (Sakhel & Styles, 2022).

Figure 16: Renewable energy attribute certification and conversion pathways



Source: Sakhel and Styles (2022).

GOs and other certification systems like mass balancing enable both the demonstration of the renewable origin of the input energy used in these processes as well as the certification of the output energy (ENTSO-E, 2022; Harsch et al., 2021; Velazquez Abad & Dodds, 2020). However, to execute this task, attribute disclosure or certification systems, respectively, must fulfil certain prerequisites, which are based on the recommendations of the EECS Rules, the recommendations of the REGATRACE project (AIB, 2024b; Verwimp & Aalto, 2022; Verwimp et al., 2021), as well as on the specifications of the CEN-EN16325 standard.

In order to certify renewable output energy, the renewable attribute must be transferrable from the input to the output energy. This may be realised by the cancellation of renewable energy certificates of the input energy and the issuing of new certificates for the output energy (while taking conversion and other losses into account) (AIB, 2024b; Verwimp & Aalto, 2022). To avoid the risk of multiple counting/marketing of renewable attributes, the cancellation of input certificates should be executed before the issuing of new certificates for the output.

Further, if they are to be used in a target accounting context, disclosure/certificate systems shall be designed in a way that they support actors in demonstrating legal compliance. In this regard, on the one hand, input energy for conversion use may have to fulfil regulatory requirements that have to be proven by certification systems. Especially in the case of input electricity for green hydrogen production, certification systems should be linkable to PPAs (power purchase agreements) (CE Delft, 2022; dena & Marktoffensive Erneuerbare Energien, 2023) and provide granular information on electricity production time and amount as well as detailed information on additionality (i.e. the fact whether a plant is newly installed and not governmentally supported) and geographic location (to determine geographic and temporal correlation of power and gas production, i.e. altogether these constitute the proof of sustainability or RFNBO criteria) (EnergyTag, 2021; Lorenz et al., 2022; Schittekatte et al., 2023; Skov & Schneider, 2022; Thaler et al., 2024), since these are regulatory requirements formulated by the RED II and the corresponding delegated acts.[34] Moreover, RFNBO (Renewable Fuels of Non-Biologic Origin) and other renewable energy carriers like biogenic fuels and electricity must comply with life-cycle greenhouse gas emission savings (of at least 65% depending on sector and fuel/energy carrier), which must be proven throughout conversion processes. As described under 5.3, disclosure/certificate systems should therefore facilitate information provision on CO_2 emissions and/or savings, is used in the context of target accounting (Fraunhofer FIT, 2022).

Compliance of plant operators and other actors with requirements of e.g. the above-mentioned regulations, can be demonstrated through certification systems that enable the inheritance of information on/characteristics of the 'old' to the 'new' energy (Verwimp & Aalto, 2022; Verwimp et al., 2021). In this regard, information on energy inputs used in conversion plants (e.g. if single or multiple inputs are used, of which qualities these are, etc.) as well as measurement data on the generated output should be recordable and synthesisable for the purpose of determining and documenting the energy source information of the output and the output's ability to satisfy regulatory requirements. Besides legal compliance, characteristic inheritance enables the production and declaration of different input and corresponding output qualities, which is a feature that is valued by market actors (Dolci et al., 2019; Kuhn & Koop, 2023). Operators of output/conversion plants could hence choose input energy with different qualities (that are recorded on the certificates) and in turn produce output with different qualities.

Relevance of the benefit for different energy types:

Summarising, disclosure/certificate systems can facilitate the legally consistent certification of energy that is the result of a conversion of already certified input energy, as well as the transfer of this input's characteristics to the corresponding output, which are important processes for actors when demonstrating compliance with regulatory requirements or voluntary targets. The relevance of this benefit is assessed to be high for all energy carriers.

Proposed criteria:

In order to enable the transfer of green attributes from energy inputs to energy outputs in conversion processes, it is necessary that the disclosure system provides for <u>tracking and exclusion of double counting of green attributes across energy carriers</u>. This is of high relevance for electricity, H&C and gases. In order to assess whether conversion outputs meet regulatory requirements placed on them, energy disclosure also has to fulfil the role of <u>information provision on requirements for participation in compliance markets</u>, especially in case of renewable gases.

[34] COMMISSION DELEGATED REGULATION (EU) 2023/1184 and 2023/1185 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.

5.8 Fulfilling reporting requirements placed on plant operators

Energy utilities and plant operators are subject to numerous reporting requirements. These comprise not only the legally required energy disclosure statements (using GOs, see 5.2), but also the provision of information to statistics agencies or the compilation of sustainability reports, in which utilities provide information on the environmental performance of their energy plant parks (e.g. emission intensity, renewable share, types of energy carriers, etc.). Besides the renewable attribute of reported energy, more detailed characteristics could be disclosed. This comprises for example information whether electricity fulfills RFNBO criteria or whether biogenic energy is certified with a proof of sustainability as described in section 5.2, which would exceed the current legal GO disclosure requirements.

District heating and cooling suppliers also face various voluntary and mandatory reporting requirements, e.g. regarding the energy mix or share of renewable energy sources in heating and cooling grids or the associated GHG emissions (Kemper, Styles, Schickling, & Werner, 2024; Styles & Claas-Reuther, 2023). Beyond disclosure, proving compliance with legal heating grid decarbonisation requirements or reporting in the context of subsidy schemes are examples for use cases. Using energy disclosure respectively EACs could provide a reliable verification instrument towards these reporting obligations with the potential to simplify and digitise verification processes in the context of reporting requirements (cf. Kemper, Styles, Schickling, & Werner, 2024). As an example, reporting requirements for H&C suppliers in Germany are currently met by various verification mechanisms and processes. Using energy disclosure respectively EAC as the central verification instrument has the potential to harmonise reporting requirements and significantly reduce the administrative burden for H&C suppliers. Especially in the context of full disclosure of H&C grids, direct access to the EAC registry for relevant public authorities could further enhance enforcement processes and reduce administrative burden on plant operator side. EAC inherit the potential to digitise verification processes through a direct data exchange between the registry and public agencies in charge of H&C regulation, support programs or statistics, thus providing further simplification potential with regards to reporting requirements (cf. Kemper, Styles, Schickling, & Werner, 2024).

Relevance of the benefit for different energy types:

Synergies regarding reporting requirements are potentially relevant for all energy carriers but can be considered a co-benefit for plant operators rather than a benefit derived directly from the information and financing functions of energy disclosure. Consequently, the relevance of the benefit is assessed as medium for all energy carriers.

Proposed criteria:

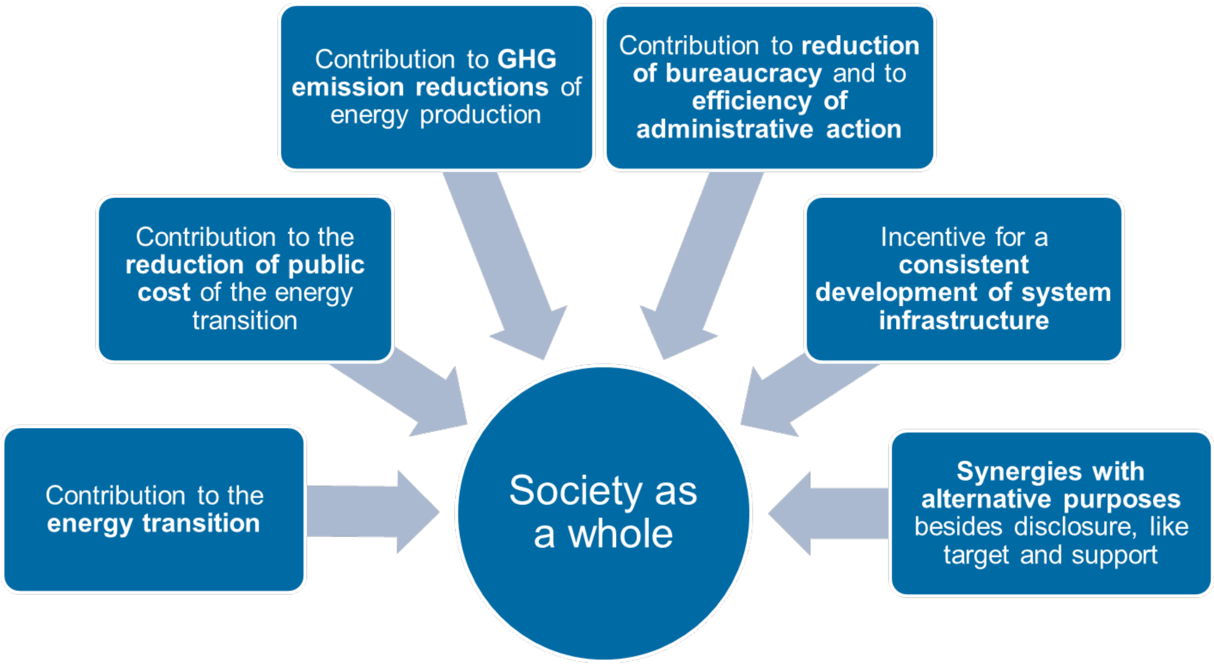
The usability of disclosure information for reporting in different contexts can be maximised if there is consistency between disclosure and target accounting, and if energy disclosure fulfils the role of information provision on requirements for participation in compliance markets.

6 Benefits of energy disclosure for society as a whole, and related criteria

6.1 Overview

With a view to the potential benefits which can be achieved from the perspective of society as a whole, an overview is provided in Figure 17 and in Table 8 below. This table also includes a list of the relating high-level criteria as well as beneficial sub-criteria which support the fulfilment of these criteria.

Figure 17: Identified potential benefits of energy disclosure systems for society as a whole



Source: Authors' own illustration, Oeko-Institut.

Table 8: Benefits of energy disclosure for society as a whole and relevant criteria

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
Contribution to the energy transition	E: high G: medium H&C: medium	Information available to consumers on energy-specific additionality indicators (similar households)	E: high G: medium H&C: medium	• The energy source mix of every product of a supplier is disclosed • The full energy source mix of the supplier is disclosed. • Provide information on subsidy schemes that a plant profits from • Provide information on the age of a production plant • The energy source mix of every product of a supplier is disclosed • The full energy source mix of the supplier is disclosed • Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)’’ • Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity. • Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
		Energy disclosure system includes clear distinction according to the environmental performance based on additionality criteria, either as indication of the level of additionality or by limiting the scope of the disclosure system to ‘‘additional’’ energy (similar households)	E: high G: medium H&C: medium	• Option 1: - Compliance with a set of advanced additionality criteria is clearly disclosed, either as distinct information (yes/no) or indicating the degree of criteria compliance. - Information provided in a ranking tool that evaluates performance based on additionality criteria • Option 2:

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
				- Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support) - Mandatory restrictions apply for the application of explicit tracking instruments based on plant age - Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support
		Disclosure system allows consumers to increase public (RES) targets (similar households)	E: high G: medium H&C: medium	• Disclosure instruments allow for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets
		Information on relevant fuels and environmental parameters is transparently disclosed to consumers without easy options for resource shuffling, i.e. the mere reallocation of attributes from existing capacities (similar households for the benefit '''Consumers become aware of environmental effects of own energy consumption''	E: high G: low H&C: medium	• Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)'' • Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity • Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
		Energy disclosure system promotes energy supply including "additionality" aspect (e.g. RFNBO tracking. or tradable GO only for "new and unsupported')	E: high G: medium H&C: medium	• Option 1: - Compliance with a set of advanced additionality criteria is clearly disclosed, either as distinct information (yes/no) or indicating the degree of criteria compliance. - Information provided in a ranking tool that evaluates performance based on additionality criteria • Option 2:

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
				- Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support) - Mandatory restrictions apply for the application of explicit tracking instruments based on plant age - Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support.
		Energy disclosure system is particularly robust in the case of high financial stakes	E: high G: medium H&C: medium	n.a. (see robustness as common precondition)
Contributing to reduction of public cost of energy transition	E: medium G: medium H&C: medium	Definition of market boundaries and accounting period prevents oversupply (see benefit “Revenues from green attribute sales in short-term markets’ / plant operators)	E: high G: high H&C: high	• Required temporal correlation of production and consumption of energy • Required geographical correlation of production and consumption of energy • Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Contribution to GHG emission reductions of energy production	E: high G: medium H&C: medium	Disclosure provides incentives for system-friendly energy consumption behaviour (alignment with RES availability taking grid constraints into account)	E. high G: high H&C: medium	• See the following five sub-criteria as also listed further below for the criterion “Tracking and Disclosure of energy attributes is linked to physical system restrictions for energy supply”. - Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)’’

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
				- Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity. - Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present. - Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame - Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame. • Information on the country of origin of the production device is specified • Information on the specific region (state, province, city etc.) of a production device is specified • Required temporal correlation of production and consumption of energy • Required geographical correlation of production and consumption of energy • Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)
Contribution to the reduction of bureaucracy and efficiency of administrative action	E: medium G: medium H&C: medium	Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments	E: medium G: medium H&C: medium	• Disclosure system is in line with EN 16325:2025 (using EECS Scheme Membership as a proxy) • Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics) • Cancellation of certificates for the input energy and issuing of new certificates for the output energy

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
				• Clear rules are in place for tracking conversion between different energy carriers • Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking • Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system • Disclosure method is based on principles consistent with those used at the EU level. • Harmonisation of requirements and administrative procedures across energy carriers • Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
		Administrative efficiency	E: high G: high H&C: high	• Automated provision of information to the beneficiary of disclosure • Automated provision of proof that tracking instruments are used • Automation of national-level supervision processes • Automation of verification processes • Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy • Existence of automated systems for the collection and transfer of energy production data
		Energy disclosure system provides centrally available information and statistics	E: high G: high H&C: high	• Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
				• The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets
Incentive for a consistent development of system infrastructure	E: high G: medium H&C: medium	Tracking and Disclosure of energy attributes is linked to physical system restrictions for energy supply	E: high G: high H&C: high	• Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion) • Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity • Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present. • Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame. • Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
		Disclosure system provides incentives for storage development	E: high G: low H&C: medium	• See the following five sub-criteria listed as also listed above for the criterion “Tracking and Disclosure of energy attributes is linked to physical system restrictions for energy supply” - Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)’’ - Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
				- Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present - Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame - Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Tracking system accounts for energy losses over storage • Tracking system enables to record the time period of release from an energy storage system (‘‘time shifting of attributes over storage’’) • Tracking system has clear and consistent rules for allocating attributes from the input to the output of an energy storage system • Tracking system is transparent on the energy having been stored • Tracking system prevents double counting of attributes of stored energy • Cancellation of certificates for the input energy and issuing of new certificates for the output energy • Clear rules are in place for tracking conversion between different energy carriers • Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking • Harmonisation of requirements and administrative procedures across energy carriers • Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
		Disclosure system provides incentives for system-friendly energy consumption behaviour (alignment with RES availability taking grid constraints into account)	E: high G: high H&C: medium	• See the following five sub-criteria as also listed above for the criterion “Tracking and Disclosure of energy attributes is linked to physical system restrictions for energy supply” - Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion) - Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity - Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present - Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame - Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame • Information on the country of origin of the production device is specified • Information on the specific region (state, province, city etc.) of a production device is specified • Required temporal correlation of production and consumption of energy • Required geographical correlation of production and consumption of energy • Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)

Benefit	Relevance of benefit for energy type [E/G/H&C]	Criterion	Relevance of criterion for energy type [E/G/H&C]:	Beneficial sub-criterion
Synergies with alternative purposes of energy tracking besides disclosure, like target and support	E: low G: high H&C: low	Scope and purpose of the respective disclosure system is clearly defined and coordinated with other relevant tracking systems (particularly relating to target and support)	E: low G: high H&C: low	• The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets

Source: Authors' own compilation, Oeko-Institut.

6.2 Contribution to the energy transition

Energy transition, including the increased deployment of renewable energy, is a major challenge for our society as a whole in order to strive towards affordable, sustainable and climate-friendly energy supply with reduced import dependencies. Contributing to this development is also a relevant motivation for consumers to make informed decisions about their energy supply (Hauser et al., 2019; Wallbott et al., 2021).

This can for example mean an increased overall effort, for example to install and finance renewable capacities. But it could also mean increased societal acceptance, as motivated consumers get emotionally further involved when choosing a 'green' contract. Furthermore, these 'green consumers' could reduce the need for public support by providing individual financing contributions for receiving RES production. In this respect, the basic precondition for such an additionality benefit is that the willingness to pay by consumers is sufficient to make a difference compared to the extra cost of RES energy.

However, such an effect of additionality is not straight-forward to be fulfilled based on the information which is provided by energy disclosure systems. The most prominent restriction is that the allocation and disclosure of renewable energy sources in systems with a relevant share of renewables leads particularly to the effect of resource shuffling of attributes from existing plants according to the preferences of individual consumers. This is specifically the case for electricity but also applies in principle to other energy types. In markets with an oversupply of green attributes, like the European GO market, the demand by consumers for a specific product (which is disclosed as renewable) usually does not directly stimulate the further development of renewables (see section 5.4). For that purpose, energy disclosure systems need specific features supporting so-called 'additionality' aspects in order to meet this ambition. Such additionality features are currently mostly applied in the framework of green energy labels (see e.g. (Mulder & Zomer, 2016; Yearwood et al., 2021). Other measures to reduce oversupply in green attribute supply may be the definition of market boundaries and accounting periods, see section 6.3.

Relevance of the benefit for different energy types:

As described in section 3.2, the benefit is particularly relevant for electricity. This is because RES-E supply exceeds explicit voluntary market demand in most countries. For gas and H&C, the relevance is considered medium. For gas, this is mainly due to the fact, that the potential for biomethane is limited, and hydrogen and other RFNBO-gases are unlikely to play a major role in the consumer-related sectors. For H&C, it is due to the fact, that disclosure schemes are only likely to play a role in larger H&C systems with a mix of renewable and non-renewable heating and cooling sources.

Proposed criteria:

<u>Information available to consumers on energy-specific additionality indicators (similar households)</u>

See chapter 3.2 for further descriptions.

<u>Energy disclosure system includes clear distinction according to the environmental performance based on additionality criteria, either as indication of the level of additionality or by limiting the scope of the disclosure system to "additional" energy (similar households)</u>

See chapter 3.2 for further descriptions.

<u>Disclosure system allows consumers to increase public (RES) targets (similar households)</u>

See chapter 3.2 for further descriptions.

Information on relevant fuels and environmental parameters is transparently disclosed to consumers without easy options for resource shuffling, i.e. the mere reallocation of attributes from existing capacities (similar households for the benefit "Consumers become aware of environmental effects of own energy consumption")

See chapter 3.4 for further descriptions.

Energy disclosure system promotes energy supply including "additionality" aspect (e.g. RFNBO tracking or tradable GO only for "new and unsupported")

For example, this is the case for tracking RFNBOs like renewable hydrogen based on the Renewable Directive for the purpose of target accounting (European Commission 2023).

According to this criterion, only such electricity sources which are compatible with specific additionality criteria are eligible to be tracked and disclosed at all in a tracking scheme, at least with a view to the possibility of so-called explicit tracking, and the marketing of tariffs according to specific energy attributes. By doing so, any choice of supply which is taken by consumers in order to deviate from a default would automatically lead towards an 'additional' offer. For the case of target accounting of renewable fuels of non-biological origin (RFNBOs), e.g. renewable hydrogen only is to be tracked and accounted in case that it has been produced based on additional renewable fuels [35] (Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin, 2023). This approach would imply a revision of residual mix calculation methodologies, as attributes from plants not meeting additionality criteria would need to be included in the residual mix.

For the case of guarantees of origin, it could also be discussed if tradable GOs are only to be issued for plants which have been put into operation after a specific cut-off date, and which are free of public support.

Energy disclosure system is particularly robust in the case of high financial stakes

When financial incentives (e.g. triggered by increased willingness to pay, or by public support systems) increase, the mechanism to increase robustness of the overall system has to improve simultaneously in order to prevent fraud and misuse of the system. This can build on aspects like a sound legal basis, mechanisms to prevent multiple counting, third-party verification, public governance by a central institution and appropriate penalties.

6.3 Contributing to reduction of public costs of the energy transition

Consumers that are willing to pay voluntarily for new shares of renewable energy are directly financing RES expansion. Therefore, public support costs are reduced while reaching the same share of renewable energy. This also increases overall economic welfare, when assuming that consumers with a higher-than-average willingness to pay for RES supply derive a higher-than-average benefit from it.

Researchers are also discussing the thesis that energy disclosure respectively RES certificates have the potential to maximise economic efficiency of RES expansion (Hamburger, 2019). However, to work effectively, the oversupply of RES certificates would need to be prevented, as this leads to low certificate prices, which is proven by research to not help drive RES expansion. Accordingly, in the current system facing oversupply this theory could not be proven by (Hamburger, 2019, 2022).

[35] It should be noted that this refers to the standard situation in most production countries, also further specific options may apply e.g. in grids with very high shares of renewables or very low average emission factors.

Relevance of the benefit for different energy types:

It can be assumed that the willingness to pay for green energy products can make a measurable contribution to the expansion of renewable energy, but not to the extent that public subsidies could be significantly reduced. This applies to all three types of energy. The relevance is therefore rated as medium.

Proposed criteria:

Definition of market boundaries and accounting period prevents oversupply

(see the criteria on the benefit 'Revenues from green attribute sales in short-term markets' for plant operators in section 5.4).

6.4 Contributing to GHG emission reduction of energy production

The effect on total system emission reductions due to EACs purchased was examined in particular for the electricity sector, and here especially in the context of electricity use for hydrogen production, as part of several energy system modelling studies. Results indicate that significantly higher emission reductions can be realised by mapping hourly matching of electricity demand and consumption in comparison to annual matching scenarios (see e.g. (Langer et al., 2023; Ricks et al., 2023; Xu et al., 2023; Zeyen et al., 2024)). To harness the identified system emission reduction potential of hourly matching, energy disclosure would need to accurately reflect this by being designed sufficiently granular. However, in this context it should be discussed to which extent disclosure can be a driver for this benefit, or just is to be considered a downstream documentation of the matching of supply and demand.

Relevance of the benefit for different energy types:

For electricity, the related problem mostly results from merit order effects in the electricity market, and is rated "high'. For gas and heating and cooling this may be relevant in a conversion context, when electricity is used as an input. Relevance is rated as "medium' for these energy types.

Proposed criteria:

Disclosure system provides incentives for system-friendly energy consumption behaviour (alignment with RES availability taking grid constraints into account)

If consumers receive signals to adjust their energy consumption in a flexible way in order to increase their consumption in times of high RES availability and to decrease in times of low RES availability, this can avoid merit-order driven operation of fossil fuels, and therefore reduce GHG emissions. The extent to which energy disclosure can incentivise and signal flexibility to consumers should be considered, e.g. when granular information on energy production is provided in order to allow for hourly matching.

6.5 Contribution to the reduction of bureaucracy and efficiency of administrative action

Energy disclosure systems can be applied in different regulatory frameworks and overlap with various other policy instruments. Bureaucracy and the efficiency of public administrative action (and of administrative action by the affected market stakeholders) can be reduced compared to alternative scenarios, depending on how the related energy disclosure systems are designed and implemented.

Relevance of the benefit for different energy types

For all three types of energy, a combination of energy disclosure and support instruments is conceivable (Pototschnig & Conti, 2021). For example, RES quotas can be implemented for electricity as well as for green gases and H&C. Above all, the implementation of the quota systems can be facilitated by the utilisation of disclosure systems. There are also no discernible differences between the energy types with regard to the automation of processes within the respective disclosure systems. On the other hand, the calculation of a residual mix and tracking is mainly relevant for electricity and to a lesser extent for gas. However, due to the spatial limitation, residual mix calculation is not a significant process for H&C, unless disclosure does not take grid boundaries into account – in this case, residual mix calculation is necessary to avoid double counting (Verwimp et al., 2022). All three types of energy are subject to extensive reporting requirements, which disclosure systems can help to fulfil. The same applies to statistical evaluations and presentations.

Proposed criteria:

<u>Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments</u>

This includes on the one hand the alignment of definitions, rules and methods to the extent reasonable with existing standards and tapping potential synergies between different policy systems. This can mean that e.g. a RES Support Registry and a GO registry are building on the same registration data for RES plants, and similar aspects.

<u>Administrative efficiency</u>

This includes first and foremost the inclusion of automatic metering, electronic registries and automated metering-based issuing. Use of existing information for the automated generation of energy disclosure statements or individual access of consumers on disclosure information (e.g. in relation to the GO registry) could be considered. But other aspects can also be relevant.

<u>Energy disclosure system provides centrally available information and statistics</u>

Such information is relevant in order to maintain public statistics, to perform or supervise the calculation of residual mix information, or to fulfil other public obligations. The availability of such information is closely related to the central governance over tracking and disclosure mechanisms with a view to the exclusion of double counting.

6.6 Incentive for a consistent development of system infrastructure

In order to develop a future-proof renewable energy system, energy production, consumption, storage and related means of transport (being grids or – for the case of gas – also potentially other means) have to be consistently developed. Assuming that the energy demand which is guided by energy disclosure systems, can provide market signals for the development of any of those elements, it seems reasonable that the energy disclosure system is linked to physical restrictions for this energy supply. In the context of target accounting of RFNBOs, the European regulation requires that the mass balance approach is applied for RFNBOs regulation (RED II, 2018). As a consequence, only RFNBOs are claimed in the EU which are actually being imported into the EU, potentially also stimulating the establishment of further transport capacities.

Relevance of the benefit for different energy types:

The benefit described is of relevance to all three energy sources. In the case of electricity, the relevant infrastructure includes the electricity grid, storage and supply- and demand-side flexibilities; for gases and H&C, the relevant grids and storage facilities in particular. Backup capacities also play an important role for H&C. However, in order to support the corresponding benefits, energy disclosure would need to provide information about the system benefits. In currently established system, e.g. in the EU or US, energy disclosure usually refers to products and their characteristics, while a system benefit linked to product characteristics is usually not covered. Nevertheless, if disclosure schemes are linked to physical restrictions or a spatial correlation of supply and demand, this may at least create incentives to expand networks, at least in the case of electricity and gas. For electricity, the relevance is rated high, because of the importance of incentives for storage systems, which in the case of gas are already established for security of supply reasons; for gas, the relevance is therefore ranked medium. For H&C, the relevance is also ranked high because the question of whether grid boundaries are taken into account in the disclosure scheme or not has a major impact on whether disclosure generates incentives for RES expansion in a grid-by-grid-context.

Proposed criteria:

<u>Tracking and Disclosure of energy attributes is linked to physical system restrictions for energy supply</u>

This means that energy attributes cannot be transferred in case that the energy system does not allow for an actual transport of the respective amount of energy from the point of production to the point of consumption. However, there might be a differentiation on how strict this is interpreted. For example, one could refer to the plain technical connection (e.g. in the case of electricity or gas grids) or to the documentation of supply to the point of consumption (i.e. by demonstrating the absence of grid congestions), or to geographically defined market zones (e.g. bidding zones in case of electricity). One could also consider the level of temporal correlation applied here, meaning whether the criteria relates to real-time delivery or to a longer reference period (e.g. being on a monthly or even annual basis).

Further criteria relate to whether the <u>disclosure system provides incentives for storage development</u>, and whether the <u>disclosure system provides incentives for system-friendly energy consumption behavior</u> (that is, an alignment of consumption choices with RES availability taking grid constraints into account).

6.7 Synergies with alternative purposes of energy tracking besides disclosure, like target and support

Energy disclosure (in the broad sense of tracking energy attributes and providing information on it) can have different purposes. Besides consumer information (disclosure in a stricter sense) this can be target accounting or the verification for policy implementation and monitoring (like for renewable energy support systems). For electricity, these purposes are clearly distinguished in (RED III, 2023). The Renewable Directive clearly states that the trade of guarantees of origin should not have any impact on target accounting and that guarantees of origin should be distinguished from support certificates. But accounting for energy quantities towards renewable energy targets of the RED for consumption sectors such as industry (Art. 22a RED II), H&C (Art. 23 RED II), or transport (Art. 25 RED II) also is based on disclosure systems, which therefore also face a high relevance due to the level of financial implications (RED II, 2018).

Proposed criteria:

<u>Scope and purpose of the respective disclosure system is clearly defined and coordinated with other relevant tracking systems (particularly relating to target and support)</u>

This criterion firstly addresses whether there is clarity on the scope and purpose of each disclosure system, which should allow to avoid double counting issues and further inconsistencies. This is also important to maintain overall credibility of disclosure systems and higher-level policies. Moreover, it also takes into account whether regulations, definitions, governance and also market processes are established in a way which allow for tapping synergies between similar processes in different regimes.

7 Detailing criteria for evaluation of disclosure concepts

Further detail is needed on the above-listed criteria for assessing fulfilment of the benefits in order to enable an actionable evaluation.

Based on the literature studied and the expertise available in the consortium, the following list of sub-criteria were composed, each of which relates to assessable design features which may or may not be implemented within a given disclosure system. The clear pre-definition of different sub-criteria allows clear identification of what specific implementation approach is suitable to fulfil the high-level criteria and thereby contribute to bringing about the potential benefits of disclosure systems. In effect, sub-criteria are defined in such a way that the assessment of disclosure case studies and concepts proposed in the literature can be carried out with standardised response options ('Yes'; 'Yes with restrictions'; 'No'; 'Depending on other aspects (market framework, detailed implementation, etc.)'; 'Not applicable'; 'No conclusion') Thus, the structured description of a disclosure system based on the combination of these pre-defined sub-criteria enables a semi-automated evaluation of different energy disclosure systems against the previously-defined criteria for beneficial concepts per stakeholder group. Annex A (Annex I) shows to which criteria the sub-criteria relate.

Table 9: List of the sub-criteria used to systematically describe and evaluate disclosure systems

List of the sub-criteria used to describe and evaluate disclosure systems
The energy source mix of every product of a supplier is disclosed
The full energy source mix of the supplier is disclosed
Provide information on subsidy schemes that a plant profits from
Provide information on the age of a production plant
Information on the country of origin of the production device is specified
Information on the specific region (state, province, city etc.) of a production device is specified
Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information
Information provided in a ranking tool that evaluates performance based on additionality criteria
Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)
Mandatory restrictions apply for the application of explicit tracking instruments based on plant age
Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support

List of the sub-criteria used to describe and evaluate disclosure systems
Disclosure instruments allow for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets
Disclosure information is easily accessible upon request (from a consumer's perspective)
Disclosure information is mandatorily provided at key decision phases
Information on non-renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table
Information on renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table
Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
Information is digital and directly accessible for organisations
Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
Inclusion of information on GHG intensity of energy production (direct emissions)
Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
Tracking system differentiates energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed
Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Energy attributes can be allocated to a specific consumer as beneficiary
Energy attributes can be allocated to a specific product of a beneficiary
Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)
The residual mix is publicly available, enabling its usage for disclosure
Mandatory usage of the residual mix for untracked attributes
Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin
The Disclosure Concept is anchored in legislation
Disclosure method is based on principles consistent with those used at the EU level

List of the sub-criteria used to describe and evaluate disclosure systems
Clear rules are in place for tracking conversion between different energy carriers
Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)
Ability to transfer EACs to individual consumers (with EAC cancellation by consumers)
Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers
Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking
Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy
Harmonisation of requirements and administrative procedures across energy carriers
Disclosure information is easily accessible upon request (from a supplier's perspective)
Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).
Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure
Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure
Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure
Required temporal correlation of production and consumption of energy
Required geographical correlation of production and consumption of energy
Disclosure statement includes information on the regional origin of the RES supply
Disclosure statement includes information on the technological origin of the RES supply
Disclosure statement includes information on the sustainability characteristics of the RES supply
Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green attributes
Cancellation of certificates for the input energy and issuing of new certificates for the output energy

List of the sub-criteria used to describe and evaluate disclosure systems
Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)
Disclosure system is in line with EN 16325:2025 (using EECS Scheme Membership as a proxy)
Automated provision of information to the beneficiary of disclosure
Automated provision of proof that tracking instruments are used
Automation of national-level supervision processes
Automation of verification processes
Existence of automated systems for the collection and transfer of energy production data
The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets
Tracking system accounts for energy losses over storage
Tracking system enables to record the time period of release from an energy storage system ("time shifting of attributes over storage")
Tracking system has clear and consistent rules for allocating attributes from the input to the output of an energy storage system
Tracking system is transparent on the energy having been stored
Tracking system prevents double counting of attributes of stored energy

Source: authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda

The following chapter discusses the analysis of existing and innovative disclosure concepts against this list of sub-criteria, and the related high-level criteria and benefits.

8 Overview and evaluation of energy disclosure concepts

Energy disclosure concepts refer to the various ways in which information about the source of energy, its emissions, and related environmental impacts is communicated from one party to another. The purposes of energy disclosure can vary, yet generally aim to ensure transparency, accountability, and informed decision-making across different sectors of the energy market. Energy origin disclosures are vital for consumers, businesses, governments, and organisations seeking to understand and evaluate the environmental and sustainability impacts of their energy choices and practices.

8.1 Overview of the current implementation of energy disclosure

This chapter provides an overview of some relevant energy disclosure concepts, outlining the current practices and innovative approaches for informing about the origin of energy. It did not analyse all existing disclosure concepts and didn't deep dive into the systems of all European countries, but focussed on a selection that enables highlighting relevant aspects. The study takes a global perspective while paying particular attention to European regulations governing energy disclosure obligations. The subsequent evaluation assesses the compatibility of existing energy disclosure concepts with the above identified benefits to identify potential opportunities for enhanced impact of energy disclosure.

8.1.1 Context for existing energy disclosure systems

8.1.1.1 Obligation on suppliers to disclose energy sources on their invoices

At the core of energy disclosure is the obligation for energy suppliers to inform consumers about the origin of the energy they provide—typically through invoices or annual energy statements. This process, known as *ex post disclosure*, occurs after the energy has been supplied and verified, often using Guarantees of Origin (GOs). While suppliers are the primary actors responsible for disclosure, energy disclosure frameworks across EU member states recognise that other entities—such as corporate consumers and end users—may also make claims about the origin of the energy they use. In many countries, only suppliers are authorised to cancel GOs, but some frameworks allow end users or companies to cancel GOs themselves. This adds a layer of flexibility and supports more active involvement from businesses seeking to manage and report on their energy sourcing directly. These differences reflect the diverse regulatory and practical approaches taken across member states, tailored to national priorities and energy market structures.

A key regulation driving energy disclosure in Europe is Annex 1§5 of the **IEM Directive 2019/944**, which mandates that **suppliers disclose the energy mix of their electricity**, including the environmental impact in terms of CO_2 emissions and radioactive waste. The Gas and Hydrogen Directive 2024/1788 Annex 1§5 partially mirrors this requirement on gas suppliers, namely to disclose on their invoices the sources of renewable and low-carbon gases. These directives require that renewable energy be backed by Guarantees of Origin (GOs), which serve as proof of the energy's renewable source. Note that member states retain some flexibility in how they implement these requirements, resulting in variations in how supplier disclosure obligations are applied across Europe.

EU member states vary significantly in their approaches to disclosure obligations concerning the origin of supplied and consumed energy across different energy carriers. In **Sweden**, the obligation to disclose the origin of energy applies only to electricity suppliers, with no legal requirement for other energy carriers such as gas or heat. **Estonia** also mandates origin disclosure for all electricity suppliers; while for gas, the disclosure requirement applies only when the gas is used as a transport fuel. In contrast, in **Finland** all energy suppliers, producers, or users who market renewable energy—regardless of the energy carrier, including electricity, gas, hydrogen, and heating and cooling—are required to disclose the origin of the energy they supply or consume. These differences reflect the varying degrees of commitment among member states to ensuring transparency across the full spectrum of energy carriers.

8.1.1.2 Full Disclosure versus GOs and residual mix

One of the primary distinctions in energy disclosure frameworks is the method by which energy sources are tracked and disclosed. Some countries, such as **Austria**, **France**, **the Netherlands**, and **Switzerland**, rely solely on Guarantees of Origin (GOs) for full disclosure of energy consumption, ensuring that every unit of energy is accounted for with verifiable proof of its origin. This approach provides a high level of transparency for consumers, enabling more informed decisions about the sustainability of their energy use.

Other countries use a combination of GOs and additional metrics like the **residual mix** to represent the remaining energy that is not attributed to a specific renewable source. This residual mix, defined in Article 2 of the Renewable Energy Directive (RED) as the aggregate energy mix of sources not linked to specific renewable generation and not allocated to consumers through guarantees of origin, is calculated differently across countries. While many EU states follow the AIB residual mix methodology, **Germany** uses a dual mix system, attributing the environmental qualities to consumers depending on their contributions to public funding, and **Sweden** applies a Nordic Mix across the region. According to RED II (Article 19.8), suppliers not disclosing via GOs must use the residual mix unless specific support mechanisms apply. Under RED III, EU member states are now required to publish the residual mix annually. These differing approaches to mix calculation and disclosure reflect the complexity of energy transparency frameworks across the EU. In either calculation method, it is essential to prevent that environmentally beneficial energy is counted more than once, to maintain credibility of the energy mix attributed to any consumer (whether through guarantees of origin or the residual mix).

8.1.1.3 Chain of Custody Tracking mechanisms

Beyond differences in calculating and applying a residual mix, EU member states also vary in how Guarantees of Origin (GOs) are operationalised along the supply chain. On the one hand, the most common mechanism is the book-and-claim model, where GOs are traded separately from physical energy and can be claimed by suppliers regardless of the actual energy flow. On the other hand, some countries are moving towards models that incorporate elements of mass balance or coupled tracking, which differ from the book-and-claim model by requiring a closer link between the physical or contractual flow of energy and the corresponding GOs, rather than allowing full separation between energy delivery and certificate claims. **Germany**, for example, has adopted a dual disclosure system that links certain GOs more closely to public funding schemes and specific energy flows, enhancing traceability. Similarly, in **Austria**, the Power Exchange (EXAA) offers a "10:15 Classic Auction – Green Power," where GOs are coupled with the physical delivery of electricity, directly linking the traded renewable energy to its origin certificate.

8.1.1.4 Correlation between production and consumption period

There are also differences in how GOs can be used over time. Most countries allow GOs to be used for a period of 12 to 18 months after the energy is produced. However, the specifics of temporal matching vary. Some countries, such as **Spain** and **Germany**, require annual matching based on the calendar or disclosure year. **France** applies monthly matching, and **Denmark** is set to launch an hourly matching pilot in 2025. These matching mechanisms, while technically more complex, contribute to more precise alignment between energy generation and consumption periods.

8.1.1.5 Way of conveying information to consumers

The way disclosure information is communicated to consumers is another area where practices differ. Some member states have introduced standardised templates to ensure consistency – for example, **Austria** requires a fixed format for supplier disclosures. In other countries, suppliers have more freedom to decide how disclosure information is presented. This flexibility allows for tailored communication strategies, while standardisation supports comparability.

Digital tools provided by public authorities also enhance consumer engagement and transparency. In regions such as **Flanders**, online platforms like "GreenCheck" allow individuals to view the source mix of their electricity consumption based on verified GOs. **Estonia** provides a similar service through its Renewable Energy Information System (green.elering.ee), accessible via personal accounts within the GO registry. Additional tools, like **Flanders**' "origin comparator," allow consumers to compare energy suppliers’ disclosed energy mixes following the annual disclosure process. Price comparison tools in some countries also include pre-disclosure estimates of suppliers’ energy sources.

8.1.1.6 Purposes of energy tracking

In some member states, systems differentiate between energy disclosure for consumer information and tracking for policy target accounting. For example, **Estonia** has implemented a dual-purpose system for gas GOs. After a GO is cancelled for disclosure purposes, a separate consumption certificate is issued, which can be used solely for meeting national transport sector obligations. This approach avoids double counting and maintains the integrity of both disclosure and policy compliance. In many other countries, disclosure and target accounting are not integrated yet.

There are also intermediate approaches to integrating energy disclosure with policy compliance mechanisms. As certain policy targets depend on compliance with dedicated criteria, in these systems, a Guarantee of Origin (GO) may include a reference to a Proof of Sustainability (PoS) – a document that confirms the energy meets specific sustainability criteria and is therefore eligible to be counted towards national or EU policy targets. In some countries, such as **Estonia**, this linkage is mandatory for gas GOs, ensuring that every certificate used for disclosure also carries verified sustainability credentials. In others, like **Finland** and **Spain**, referencing a PoS is optional, allowing for more flexibility depending on the purpose of the GO. Meanwhile, some systems, such as in **Belgium-Flanders**, do not yet provide the technical option to include a PoS reference within the GO structure.

8.1.1.7 Exported renewables are replaced with the residual mix

Public discussions around energy disclosure sometimes focus on net-exporting countries like **Norway** and **Iceland**, especially in the context of Guarantee of Origin markets. Furthermore, these countries consistently meet all EU disclosure obligations, and high export volumes simply reflect their substantial renewable energy production. As with all member states, suppliers in these countries must disclose the origin of supplied electricity using GOs or, where applicable, the residual mix published by the national authority.

8.1.1.8 Disclosure by corporates: different regulatory framework as for suppliers

In parallel with supplier obligations, corporate disclosures play an increasingly important role in advancing transparency in energy sourcing and use. Prior to the implementation of the **Corporate Sustainability Reporting Directive** (CSRD) and its accompanying **European**

Sustainability Reporting Standards (ESRS), many companies voluntarily reported their energy use and associated greenhouse gas emissions. These voluntary efforts varied widely in depth and comparability, making it difficult to assess corporate climate performance at scale. With the introduction of CSRD-ESRS, large companies and listed SMEs operating in the EU will be required to disclose standardised, verifiable information on energy consumption, origin, and emissions. ESRS requires corporates to back their market-based renewable energy consumption with "contractual instruments like GOs". Generally, in Europe there is much voluntary practica by corporates of indeed using GOs but supervision of corporate disclosure is not organised the same way as supplier disclosure, risking inconsistencies in the underlying accounting methods. Analysing corporate energy reporting alongside supplier disclosure frameworks provides a more complete picture of how energy origin is tracked and communicated throughout the economy.

8.1.1.9 Unity in diversity

Overall, the diversity in disclosure systems across Europe illustrates the flexibility of the framework and the different ways countries adapt it to national contexts. While approaches may vary, they all contribute to a shared goal of increasing transparency, consumer empowerment, and accountability in the energy system.

8.1.2 Existing disclosure concepts described, analysed and evaluated based on criteria and sub-criteria

The following chosen disclosure concepts as outlined in Table 10 for further analysis and evaluation in general cover these critical elements mentioned above, ensuring that they address the diverse and sometimes differently implemented aspects of energy disclosure across Europe. This approach is taken in order to help identify key trends, challenges, and good practices in the energy disclosure frameworks, offering a nuanced understanding of the systems in place.

Figure 18 also provides an overview map over the analysed case studies as implemented in European countries.

Table 10 List of existing disclosure systems as well as of corporate reporting systems which are described and evaluated under the analytical framework of the project

Electricity disclosure:

- Sweden Electricity Supplier Obligation (see chapter 8.3.1)
- Netherlands Electricity Supplier Obligations (see chapter 8.3.1.2)
- Belgium-Flanders Electricity Supplier Obligations (see chapter 8.3.1.3)
- Norway Electricity Supplier Obligations (see chapter 8.3.1.4)
- France Electricity Supplier Obligations (see chapter 8.3.1.5)
- Denmark Electricity Supplier Obligations (see chapter 8.3.1.6)
- Austria Electricity Supplier Obligations (see chapter 8.3.1.7)
- Germany Electricity Supplier Obligations (see chapter 8.3.1.8)

Gas disclosure:

- Estonia Gas Supplier Obligations (see chapter 8.3.1.9)
- Austria Gas Supplier Obligations (see chapter 8.3.1.10)
- France Gas Supplier Obligations (see chapter 8.3.1.11)

Heating and cooling disclosure:

- Finland Heating and Cooling Supplier Obligations (see chapter 8.3.1.12)

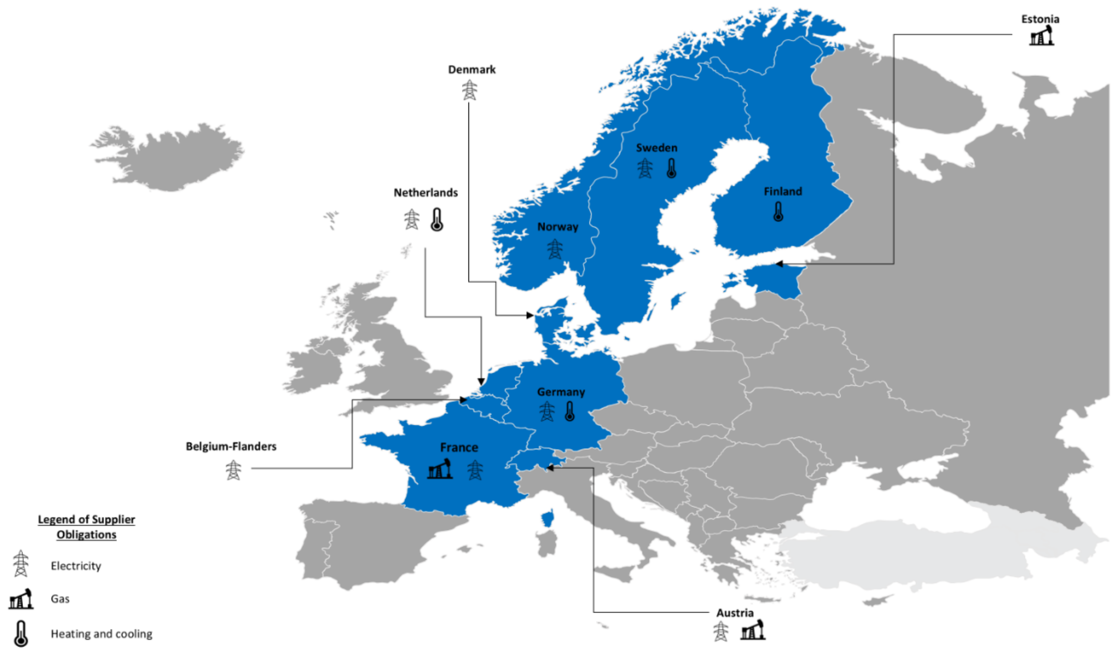
- Sweden Heating and Cooling Supplier Obligations (see chapter 8.3.1.13)
- Netherlands Heating and Cooling Supplier Obligations (see chapter 8.3.1.14)
- Germany Heating and Cooling Supplier Obligations (see chapter 8.3.1.15)

Corporate reporting:

- Corporate voluntary disclosure following GHG Protocol prior to the Corporate Sustainability Reporting Directive (CSRD) implementation (see chapter 8.3.2.1)
- CSRD-ESRS: CSRD together with the European Sustainability Reporting Standards (ESRS), refers to a comprehensive framework for mandatory sustainability reporting in the EU. It requires large companies and, over time, listed SMEs to disclose standardised information on environmental, social, and governance (ESG) topics. As a broader corporate transparency tool, CSRD-ESRS will be examined as a global complementary approach to energy disclosure—alongside supplier obligations in energy disclosure frameworks (see chapter 8.3.2.2).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Figure 18: Overview of analysed countries and energy disclosure systems



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

8.2 Overview of innovative energy disclosure concepts from the literature

8.2.1 Rationale for covering innovative disclosure concepts

Just as we analyse the energy disclosure systems used in practice, we also analysed the energy disclosure systems described in the literature. As part of this analysis, we focus on innovative systems that aim to solve the energy disclosure problems observed in practice or extend the scope of the energy disclosure systems currently in use. This dual focus allows us to explore not only how current systems function, but also how they could evolve to address persistent shortcomings, improve policy alignment, and meet emerging needs across different sectors and jurisdictions.

Several of these concepts are designed to strengthen the linkage between disclosure instruments and broader energy and climate policy objectives, such as renewable energy targets or cross-sector decarbonisation. Others focus on improving the temporal and spatial granularity of disclosures, enabling consumers and regulators to better understand when and where renewable energy is produced and consumed. Furthermore, emerging approaches explore ways to increase transparency in corporate energy use and sustainability claims, as well as to simplify verification procedures in underdeveloped sectors such as heating and cooling.

8.2.2 Innovative disclosure concepts described, analysed and evaluated based on criteria and sub-criteria

The following section presents a curated selection of innovative energy disclosure concepts drawn from recent literature. These approaches reflect a shift from static, supplier-centric models to more dynamic, integrated, and stakeholder-inclusive systems. This includes the following approaches as listed in Table 11.

Table 11 Analysed innovative energy disclosure systems as described by literature

Guarantees of Renewable Origin (GRO) mechanism based on Guarantees of Origin (GOs) – and a variant of them, the Guarantees of Renewable Origin (GROs) – as a tool for promoting the achievement of the renewable energy penetration target at least costs. The idea, developed in the Florence School of Regulation, includes renewable energy quota that stand regardless of the energy sector in which they are applied. The quota would apply to electricity, gas, hydrogen and heating and cooling. The GROs, upgraded GOs towards target accounting, could be used both for disclosure and for meeting the quota obligations, across sectors and geographies. The implementation of the proposed mechanism would require some changes in legislation and an upgrading of the current voluntary GO schemes (Pototschnig & Conti, 2021) (see chapter 8.3.3.1).
'GO beyond public targets': The European Union and Member State governments could introduce the regulatory option that markets request and use a specific type of GO which ensures that MS governments do not (or only partially) account these RES volumes towards their public RES targets. Under this option, markets would be empowered to contribute to the increase of RES production over and above the RES volumes which are produced within existing RES targets. Such an approach has been proposed by Seebach & Timpe (2020) (see chapter 8.3.3.2).
Limiting geographical boundaries within the existing Guarantees of Origin (GO) system refers to an approach that aims to better align renewable electricity tracking with national renewable energy targets. Currently, the GO system allows for international transfer, meaning a consumer in one country can claim the use of renewable electricity generated in another country. While this enables market-based consumer choice and international financing of renewable projects, it also decouples renewable electricity consumption from production at the national level. Holzapfel et al. (2024) highlight that this can significantly distort assessments of national progress towards renewable energy targets (Holzapfel et al., 2024). Their analysis shows that including cross-border GO transfer in the accounting of renewable electricity shares changes the target achievement status of 13 European countries in 2020, indicating that some countries appear to overachieve or underachieve their targets depending on whether market-based or production-based accounting is used. This discrepancy arises because the market-based approach using GOs reflects where renewable electricity is consumed (or claimed), not necessarily where it is produced. As a result, a country may seem to meet or exceed its renewable electricity (RES-E) targets through GO imports, even if its domestic renewable generation is insufficient (see chapter 8.3.3.3). To address this misalignment, several policy options have been proposed. These include: (1) International GO transfers are permitted only to the extent that they do not prevent a country from meeting its RES-E target. This would limit (but not eliminate) cross-border GO transfers, ensuring that countries primarily meet their RES-E targets through domestic generation; (2) International GO transfers are completely prohibited for national accounting purposes — GOs would have to remain within the country of generation and could not be used to demonstrate target compliance in another country; and (3) International GO transfers are allowed only where there is a corresponding physical flow of electricity between involved countries. The overarching aim of these proposals is to tie GOs more closely to physical electricity flows and national energy systems. Also, ENTSO-E has proposed to introduce similar limitations for GO transfer, based on actual trade or transmission capacity (ENTSO-E, 2022). The discussions in the context of the GHG Protocol Review might have

similar implications for energy disclosure. Some proposals reviewing the GHGP Scope 2 Guidance suggest requiring granular time and location criteria when accounting for Scope 2 emissions. This would also have an impact on the geographical boundaries of energy disclosure (GHG Protocol, WBCSD, & WRI, 2023) (see chapter 8.3.3.3).

System benefits of enhanced temporality in EACs: The traditional design of Energy Attribute Certificates (EACs) has generally relied on annual or monthly matching between energy consumption and renewable generation. However, this coarse temporal granularity can obscure the true alignment between consumption patterns and the actual availability of clean energy on the grid. In response, a growing body of research proposes enhanced temporality—such as hourly or sub-hourly matching—as a more accurate and system-beneficial approach to energy disclosure, capable of reflecting real-time grid dynamics, improving the integrity of clean energy claims, and supporting more effective integration of variable renewables (Jenkins, Princeton; Riepin, TU Berlin; IEA study; Ricks et al. 2023; Xu et al. 2023; Zeyen et al. 2024a, 2024b; Riepin and Brown 2024; Langer et al. 2024) (see chapter 8.3.3.4).

Full Disclosure for H&C grids is discussed as approach to reduce bureaucracy of verification processes in heating and cooling, based on full consumption disclosure concepts existing in the context of electricity (see e.g. RECS) (Styles and Claas-Reuther 2023, see e.g. Kemper et al. 2024) (see chapter 8.3.3.5).

Corporate disclosure following the proposal for a revised GHG Protocol Scope 2 Guidance. The GHG Protocol corporate standards are currently undergoing a comprehensive revision process (GHG Protocol et al., 2024; GHG Protocol, WRI, & WBCSD, 2023; WRI & WBCSD, 2025a). A proposal for a revised Scope 2 Guidance is expected to be submitted to stakeholder consultation in autumn 2025, including, among other aspects, requirements on temporal and geographical matching when applying the market-based approach. The proposal is presented as an example for an ambitious corporate disclosure concept which builds on several aspects from innovative supplier disclosure concepts discussed in the literature. By driving corporate energy consumer demand for specific disclosure information, the GHG protocol standards may complement supplier disclosure obligations by shaping voluntary additional information disclosure (see chapter 8.3.3.6).

Corporate disclosure following the updated RE100 Technical Criteria. RE100 is a further example of an ambitious corporate disclosure framework focusing on renewable energy procurement. Unlike the GHG Protocol Scope 2 Guidance, it does not aim to provide a basis for accurate GHG inventory accounting but emphasises procurement criteria with positive energy transition impacts. Published in March 2025, revised RE100 Technical Criteria will enter into effect in 2027 (RE 100, Climate Group, & Carbon Disclosure Project 2025). Being referred to by further reporting initiatives like the Science Based Target Initiative (SBTi), RE100 also has a high impact on corporate consumer demand for additional information disclosure by energy suppliers (see chapter 8.3.2.3).

Hydrogen under the RFNBO framework: Hydrogen and its derivatives, when produced from renewable electricity, are regulated under the EU's RFNBO (Renewable Fuels of Non-Biological Origin) framework. This framework, defined in the context of the Renewable Energy Directive and Delegated Acts (EU 2023/1184 and EU 2023/1185), establishes strict criteria for ensuring the renewable origin of electricity used for production of hydrogen and other renewable e-fuels. It introduces innovative requirements such as temporal and geographical correlation between renewable electricity used and hydrogen production, as well as the need for additionality—meaning the renewable power comes from new, dedicated sources (see chapter 8.3.2.3).

“Digital Product Passports‘ - Introduced under the Ecodesign for Sustainable Products Regulation, the Digital Product Passport constitutes a significant advancement in the European Union’s efforts to foster a circular, transparent and sustainable economy (Regulation (EU) 2024/1781 of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC, 2024). A DPP is a structured collection of product-related data and attributes across a product's lifecycle. DPPs share information for every product across the entire Value Chain (Kuhn & Koop, 2023). As part of the broader governance framework for DPPs, the European Commission intends to adopt a delegated act that will establish detailed operational requirements for DPP service providers (European Commission, 2025). The digital product passport could contain information on three of the four key elements of certification schemes: (1) the product attributes, (2) the operational setup and procedures, and (3) the chain of custody model. For a digital product passport to be useful, it would need to contain a considerable amount of information regarding product attributes and the modalities of the chain of custody model, but less information on operational setup and procedures would be needed (International Partnership for Hydrogen and Fuel Cells in the Economy [IPHE], 2024) (see chapter 8.3.2.4).

Germany draft gas disclosure obligation: In Germany, the Guarantees of Origin and disclosure scheme for gas and hydrogen is still under implementation (as of January 2026, see Umweltbundesamt [UBA], 2026). In particular, gas disclosure obligations are still at a drafting stage. The German draft gas disclosure obligation is therefore included in the analysis as an innovative rather than an existing disclosure concept (see chapter 8.3.3.7).

Reporting on additionality indicators: As an additional and innovative dimension identified in the literature, we propose the concept of "Reporting on additionality indicators". This would include metrics such as the share of power purchase agreements (PPAs), distinctions between supported and unsupported renewable electricity generation, constraints related to the age of generating plants and the application of causality tests to verify true additionality. While this aspect is not yet widely implemented in regulatory practice, it represents a forward-looking disclosure approach that could become more relevant as sustainability reporting evolves. It should be noted, however, that this dimension will not be the focus of systematic analysis within the scope of this work. Instead, it will be addressed as an excursus, offering a conceptual supplement to the main analytical framework (see chapter 8.3.3.8).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

8.3 Description and evaluation of individual disclosure concepts

8.3.1 Existing energy disclosure concepts

8.3.1.1 Sweden: Electricity supplier obligations

Description of the disclosure concept:

Sweden's electricity supplier obligation disclosure system is well-anchored in national legislation, specifically in Chapter 9, §28 of the Electricity Act, and is based on the use of **Guarantees of Origin (GOs)** and the **Nordic Residual Mix.** It ensures that electricity suppliers must disclose the origin of all electricity supplied – whether renewable, fossil-based, or nuclear – providing a legally binding framework for transparency in the energy market. The system is integrated with European norms, notably RED II and the Internal Electricity Market Directive, and Sweden's participation in the EECS scheme further ensures compatibility across borders.

Suppliers are obligated to include energy origin information in consumer bills and promotional materials. One of the system's most consumer-oriented strengths is its emphasis on visual communication. Suppliers are required to present disclosure information clearly and accessibly to consumers, typically using **circle diagrams (Swedish Energy Agency, 2023)**. The required use of circle diagrams for presenting energy mix data to consumers is a particularly effective feature, supporting transparency and informed decision-making. While the clarity and consistency of these visuals may still depend on individual suppliers' implementation, the mandated format itself signals a deliberate policy choice to prioritise consumer understanding.

The underlying tracking and verification system is technically robust and institutionally credible. GOs are centrally registered and digitally managed through the CESAR registry, which provides automated proof of certificate cancellations. **Disclosure data is verifiable by neutral third parties** such as the Energy Market Inspectorate and authorised measurement bodies, ensuring confidence in the accuracy of supplier claims. Energy production plants are also independently audited, adding another layer of transparency and reliability (Swedish Energy Agency, 2023).

However, the system has some limitations, particularly in what is required to be disclosed to consumers. While suppliers must provide basic information on the origin of electricity—broken down into renewable, fossil, and nuclear sources—more detailed data is not required. There is no obligation to disclose the age of production plants, whether they receive subsidies, or the full lifecycle greenhouse gas emissions of the energy supplied. Only direct CO_2 emissions and radioactive waste per kilowatt-hour are mandated. Information on specific renewable technologies, the geographic origin of production, and sustainability characteristics of supplied energy is recommended but not compulsory. Furthermore, the tracking of storage, time-shifting, and temporal or geographic correlation between energy production and consumption is absent.

In summary, Sweden's electricity disclosure system stands out for its legal robustness, international alignment, and user-oriented visual communication. Yet, for the disclosure system to reach its full potential, it will need to integrate more granular data and enforce stronger correlations between production and consumption.

Evaluation results:

The Swedish electricity disclosure framework provides varying levels of benefit to different stakeholder groups, with **organisations** and **plant operators** gaining slightly more advantages compared to **households** and **society as a whole**. While certain design criteria rank highly and demonstrate clear benefits, there remains a notable degree of uncertainty regarding some aspects of the system's performance.

Organisations derive significant benefits from the framework, particularly in areas such as administrative efficiency, prevention of double counting and double claiming, and the accurate tracking and transfer of energy attributes. Among these, the prevention of double claiming is especially robust, as the system exclusively uses Guarantees of Origin (GOs) as the tracking mechanism for market-based claims on renewable energy attributes. For energy supplied without tracking instruments, the mandatory use of a residual mix ensures accurate disclosure and prevents misrepresentation. However, some uncertainty exists in the assessment of administrative efficiency and attribute tracking, reflecting the complexity of these processes.

Plant operators benefit primarily from three key criteria: 'ability to transfer green attributes to off-takers under REPAs', 'unique claims on origin from RES' and 'administrative efficiency', though the latter carries some uncertainty. The Swedish system supports plant operators by enabling third parties, such as contractors or service providers, to cancel Energy Attribute Certificates (EACs) on behalf of specific consumers. It also facilitates the application for EACs for renewable energy plants under REPAs and allows the transfer of EACs to individual consumers, who retain the right to cancel these certificates to certify their renewable electricity consumption. These features contribute to revenue security and more predictable planning for plant operators through long-term REPAs. The disclosure system also provides clear specification of the tracking tools that enable market-based claims on renewable energy attributes. In addition, the residual mix is made publicly available, allowing its use for accurate energy disclosure. As a result, plant operators benefit from increased credibility and transparency in their green energy offerings, which can support customer trust, facilitate participation in green energy markets, and enhance the value of renewable energy products through reliable market-based claims.

From the perspective of **society as a whole**, the framework's benefits are linked primarily to 'administrative efficiency'. This includes the automated provision of proof that tracking instruments are in use and the deployment of automated systems for collecting and transferring energy production data. Nonetheless, some uncertainty remains due to limited publicly available information on the degree of integration and automation across all relevant systems.

Households benefit mainly from transparent disclosure of the full energy source mix provided by their electricity suppliers. This information is typically presented visually – often in a pie chart format – making it more accessible and understandable to consumers. Such transparency empowers consumers by fostering emotional engagement with the energy transition and enabling them to make informed, active choices in support of renewable energy and sustainability goals. In other words, consumers gain a sense of participation and influence in the energy market, encouraging demand for greener energy sources.

8.3.1.2 Netherlands: Electricity supplier obligations

Description of the disclosure concept:

In the Netherlands, electricity suppliers are subject to a legally mandated **full disclosure** system, which requires them to inform consumers about the origin of all supplied electricity, regardless of source. This obligation is mandated in the Dutch Electricity Act and it applies to renewable, fossil, and nuclear energy alike. The **disclosure system relies exclusively on Guarantees of Origin (GOs)**, which must be cancelled to substantiate any claim made about the origin of supplied energy (VertiCer, 2022). This ensures that each unit of electricity is only counted once and avoids double claims, thanks to the centralised and digital GO registry operated by VertiCer.

The credibility of the underlying disclosure system is further reinforced by a strong verification infrastructure. Disclosure statements, production data, and the disclosing entities themselves are all subject to **oversight by neutral and independent third parties**. The Authority for

Consumers and Markets ensures compliance with disclosure rules, while transmission and distribution system operators (TSOs and DSOs) verify the measurement of energy production before submitting it electronically to the central registry, VertiCer (VertiCer, 2022).

Suppliers must disclose the energy mix on consumer invoices and on their websites. However, the level of detail and the clarity of presentation depend largely on individual supplier practices. While basic information such as the percentage share of energy sources and associated direct CO_2 emissions and radioactive waste is mandatory, there is no obligation to break down the mix into specific technologies, geographic origin, or to include information about subsidies, plant age, or lifecycle emissions (Overheid, 2025a). Visual tools such as graphs or charts are not required, which limits the accessibility and communicative power of the disclosed data for consumers.

Additional environmental characteristics—such as compliance with sustainability criteria or granular temporal matching between production and consumption—are not mandatory from the consumer-facing disclosure. Information on energy storage and time-shifting is not included, and energy released from storage is not considered renewable under the current system.

Overall, the electricity disclosure framework in the Netherlands is institutionally well-defined and comprehensive in legal scope, ensuring all energy claims are traceable and substantiated via a single national registry. But from a consumer perspective, the system falls short of providing intuitive, detailed, and actionable information about the electricity they purchase.

Evaluation results:

The evaluation of the Netherlands electricity disclosure framework indicates that the current system is most beneficial to **plant operators** and **organisations**, while offering significantly fewer advantages to **households** and **society as a whole**.

Plant operators benefit significantly from the Netherlands' disclosure framework. Three core criteria that scored very highly in the evaluation are the 'ability to transfer green attributes to off-takers in REPAs,' 'tracking and exclusion of double counting of green attributes across energy carriers' and the ability to make 'unique claims on origin from RES'. These criteria are foundational for any system that aims to enable plant operators to credibly and uniquely market the renewable attributes of their electricity production. The Dutch system ensures that energy produced by a plant and its associated environmental attributes can be clearly separated, tracked, and assigned to a specific buyer, without overlap or duplication in claims across electricity, gas, or other energy vectors.

For **organisations**, the framework performs especially well in preventing double counting and double claiming of energy attributes, which is essential for credible renewable energy procurement and GHG accounting. In the Netherlands, this is achieved through a full disclosure system, which requires that all electricity –whether from renewable or non-renewable sources – be tracked through Guarantees of Origin (GOs). These tracking tools are the sole basis for market-based claims about the source of electricity, ensuring that every unit of energy disclosed to consumers is fully corroborated by a corresponding certificate. This approach creates a high degree of trust, traceability, and standardisation across the system.

The framework also supports the use of energy disclosure as verifiable proof of renewable energy procurement. This is enabled by several key design elements. The tracking system differentiates between electricity fed into the grid and electricity that is self-consumed, ensuring that all renewable production – whether centrally supplied or consumed on-site – is accounted for accurately. The disclosure methodology is firmly embedded in national legislation and is harmonised with EU principles, such as those outlined in EN 16325, ensuring consistency and comparability across borders. Moreover, the system allows for interoperability and data sharing between registries and relevant authorities, both within the Netherlands and internationally, promoting coherent data use and alignment with international energy markets and disclosure practices.

In contrast, the system offers limited benefits to **households** and **society as a whole**. Several important criteria aimed at enhancing consumer transparency, public empowerment, and environmental integrity are not fulfilled. For instance, information on energy sources and environmental parameters is not transparently disclosed in a way that prevents resource shuffling—the practice of reallocating existing renewable capacity without leading to new investments. This limits the consumer's ability to distinguish between genuinely additional green electricity and standard supply.

Furthermore, the disclosure system in the Netherlands does not include a clear distinction based on environmental additionality. There is no mechanism to indicate whether the electricity being purchased supports new renewable capacity or merely reflects existing generation. As a result, consumers are unable to assess the actual impact of their choices in terms of driving the energy transition.

8.3.1.3 Belgium-Flanders: Electricity supplier obligations

Description of the disclosure concept:

In Belgium-Flanders, the electricity disclosure system is governed by a strong legal and institutional framework that ensures robust oversight, transparency, and traceability. At the core of the system are Guarantees of Origin (GOs), which serve as the official tracking instrument for renewable electricity. The regional energy regulator, Vlaamse Nutsregulator, (formerly VREG), oversees the entire disclosure process, ensuring that suppliers accurately report the energy sources used to produce the electricity delivered to consumers. This includes mandatory fuel mix disclosure by suppliers, both on electricity bills and in promotional materials, as well as the publication of verified supplier information by Vlaamse Nutsregulator through public-facing tools such as the Origin Comparator EECS Scheme Member (2024a). This **online platform allows consumers to easily compare the energy source mix of different electricity products and suppliers**, helping them make informed decisions.

A notable strength of the Flemish disclosure system lies in its high level of digitalisation and automation. Production data from renewable energy installations is automatically collected and submitted monthly by grid operators to registrars. This allows for timely and centralised recording of disclosure-relevant information. Additionally, Vlaamse Nutsregulator provides an interactive web tool known as the Green Check, which **enables individual consumers to verify whether their own electricity consumption was covered by cancelled GOs**, using their personal EAN identifier EECS Scheme Member (2024a). This tool reinforces the system's accountability and consumer engagement by offering real-time access to validated origin information.

The disclosure process is subject to multiple layers of third-party verification to maintain integrity. Vlaamse Nutsregulator ensures that disclosure statements submitted by suppliers reflect accurate and complete data. Measurement of qualifying energy production is verified by grid operators, who may conduct on-site inspections to validate the reliability of metering equipment and data. Furthermore, the production facilities themselves are subject to verification by independent production auditors (EECS Scheme Member, 2024a). This multilayered oversight enhances trust in the system and reduces the risk of double counting or misinformation.

The system also offers mechanisms that allow for greater consumer engagement. **Consumers or their appointed service providers can cancel GOs on their behalf using the dedicated GO**

cancellation option 'Inlevering eigen gebruik'. This enables end users to claim specific renewable energy use, providing greater transparency and control. Despite these advanced features, the disclosure does not cover important sustainability aspects such as the greenhouse gas intensity of electricity, the age or subsidy status of production plants, or the geographical origin of the energy. While the Flemish disclosure system is technically sound and administratively robust, it could be significantly improved by making the disclosed information more granular, accessible, and meaningful for consumers aiming to actively support the energy transition.

Evaluation results:

The Belgium–Flanders electricity disclosure framework provides the most substantial benefits to **plant operators** and **organisations,** while **households** and **society** as a whole receive comparatively fewer, though still notable, advantages.

Plant operators are among the primary beneficiaries of the framework. They benefit from specific features of the system. Notably, the criterion 'Ability to transfer green attributes to off-takers in REPAs' is fulfilled. This refers to the system's capacity to facilitate long-term Renewable Energy Power Purchase Agreements by allowing the application and issuance of Energy Attribute Certificates (EACs) for renewable energy plants under REPAs, the transfer of EACs to individual consumers (with the right to cancel them), and the cancellation of EACs by authorised third parties, such as contractors or service providers, on behalf of consumers. These functions are supported by a dedicated GO cancellation option within the system, which allows end users to claim specific renewable energy use and thereby ensures greater transparency and control.

In addition, the system fulfils the criterion 'Tracking and exclusion of double counting of green attributes across energy carriers'. This means that clear rules and procedures are in place for the cancellation of certificates for input energy and the issuance of new certificates for output energy. Tracking systems across different energy carriers are coordinated to prevent double claims for the same renewable energy production. Furthermore, the system meets the criteria 'unique claims on origin from RES as it includes a defined tracking mechanism that supports market-based claims on renewable energy attributes. The publication of the residual mix ensures that any untracked or unclaimed energy is properly accounted for, allowing for more accurate and reliable energy disclosure. This structured approach benefits plant operators by enabling them to clearly demonstrate the origin and environmental value of their energy, which enhances trust among consumers and business partners.

The disclosure system also provides benefit for **Organisations**. The system fulfils several evaluation criteria that directly support organisational needs related to renewable energy sourcing, disclosure, and compliance. While multiple criteria are impactful, naming just a few, 'in the context of energy disclosure, energy attributes tracked and ownership is transferred,' 'administrative efficiency' and prevention of double counting stand out and are described here in more detail.

A key strength lies in the system´s several essential features that ensure the credibility and traceability of renewable energy attributes. First, energy attributes are systematically tracked and must be cancelled—or otherwise formally marked—in order to be claimed, preventing double counting and maintaining the integrity of the system. Additionally, these attributes can be allocated to a specific consumer, allowing for clear identification of the beneficiary of the renewable energy. Importantly, the system also supports the allocation of energy attributes to a specific product of the beneficiary. This level of granularity is a key component of the Green-check (GroenCheck) concept and the underlying Green Reporting system (Groenrapportering), which includes reporting of lists of individual consumers in renewable energy contracts by suppliers, adding the respective individual consumption data by grid operators and subsequently requires GOs to be cancelled on a monthly basis for each specific product and per supplier.

The disclosure system is also described as administratively efficient, supported by a suite of well-designed digital tools. Beyond the standard disclosure requirements on electricity bills and promotional materials, the system includes platforms such as the Supplier Disclosure Dashboard and the Green Check. These interactive tools allow individual consumers to verify whether their electricity consumption is backed by renewable energy, tracked through GOs, using their unique EAN identifier. Additionally, the Origin Comparator, managed by the Flemish energy regulator (Vlaamse Nutsregulator, previously called VREG), centrally publishes and verifies the fuel mix disclosures of all electricity suppliers. This information is easily accessible and supports procurement decisions, especially for organisations aiming to align with sustainability targets.

Another important criterion, prevention of double counting, is also fulfilled. The system ensures that renewable energy attributes are only claimed once by using GOs as the sole tracking mechanism for market-based claims and applying a residual mix to untracked supplies. This structure supports a wide range of benefits, ensuring compliance with GHG accounting standards and regulatory frameworks, supporting green market initiatives, and allowing organisations to make credible green marketing claims, meet stakeholder expectations, and mitigate reputational risks.

Society as a whole gains some benefits from the framework, mainly through improved administrative efficiency and digital transparency. The same digital tools mentioned earlier—such as the Green Check and Origin Comparator—not only serve individual users but also increase the overall transparency of the electricity market. These tools allow citizens to access supplier-specific fuel mix information and verify whether their electricity was backed by GOs. Additionally, the system demonstrates a high level of automation, including the automated provision of proof that tracking instruments are used, the automation of national-level supervision processes, and the automation of verification workflows. These features support system integrity and reduce administrative overhead, even if the broader societal benefits remain more limited compared to those for organisations and producers.

Households benefit from the framework as the system does enable them to access disclosure information regarding both the energy source mix of each supplier's products and the full energy source mix of the supplier. They are also encouraged to check the correctness of their individually received disclosure by their supplier, by checking whether the supplier submitted GOs for their individual consumption, in the GreenCheck and to raise a complaint if this differs from the supplier's promises in their contract. This information allows household consumers to make choices that reflect their personal environmental values. Though not all households may have taken action to use all the available tools or engage with certificates directly, they can still express support for renewable energy by selecting electricity offers that align with their preferences, and changing supplier if the reality differs from the contractual promise – effectively turning their purchasing decisions into a form of climate-conscious action.

8.3.1.4 Norway: Electricity supplier obligations

Description of the disclosure concept:

Norway has a well-established legal framework for electricity supplier disclosure, centered on the use of GOs as the primary instrument for tracking renewable electricity. This system is mandated by law, supported by the Norwegian Energy Act and related regulations, and overseen by the Norwegian Water Resources and Energy Directorate (NVE), which ensures compliance and verification.

Suppliers are required to inform end consumers annually about the origin of the electricity they supply, based primarily on cancelled GOs recorded in the national electronic registry (NECS). **Suppliers who do not provide individual disclosure statements must instead direct consumers to NVE's residual mix in their billing and marketing materials**. Norway's system supports a book-and-claim model, allowing suppliers and third parties to hold GO accounts and cancel GOs on behalf of consumers (Statnett SF, 2023).

The underlying data are digitally accessible to suppliers, supporting transparency and administrative efficiency. However, from the consumer's perspective, the clarity and presentation of disclosure information vary by supplier. Norway does not mandate the use of visual tools (e.g. charts or graphs), detailed technology breakdowns, or information on production characteristics such as plant age, subsidy status, or sustainability attributes. There is also no requirement for time- or location-based matching of energy production and consumption. At present, energy conversion and the issuance of GOs for converted energy are not performed in Norway (Statnett SF, 2023).

Verification mechanisms are in place: NVE audits production plants and supplier disclosures, while grid companies verify production measurements. However, automation of national-level oversight and the provision of real-time or forward-looking disclosure are not yet implemented.

Norway's electricity supplier disclosure obligations rest on clear legislation and a centralised digital tracking system that ensures reliable and verifiable information on the renewable share of electricity supplied. However, the framework stops short of integrating broader sustainability indicators, real-time data, or consumer-friendly reporting tools. This reflects a strong emphasis on compliance and transparency in line with European standards, while leaving room for future enhancements in consumer engagement and advanced disclosure functionality.

Evaluation results:

The evaluation of Norway's electricity disclosure system indicates that it delivers the most substantial benefits to **organisations** and **plant operators**, while offering limited value to **households** and only a modest contribution to **society as a whole**. The design and operation of the system are primarily geared towards enabling accurate tracking and transparent reporting of renewable energy attributes, particularly through the use of Guarantees of Origin (GOs).

For **organisations**, the Norwegian disclosure framework is effective in preventing the double counting and double claiming of renewable energy attributes—an essential requirement for reliable GHG accounting. This function supports organisations in producing credible and verifiable emissions reports, which are increasingly required by international carbon standards and corporate sustainability frameworks. By ensuring the integrity of the data used for energy sourcing and emissions tracking, the system allows organisations to align with regulatory demands and low-carbon initiatives, while also addressing growing stakeholder expectations. As a result, organisations are able to make defensible environmental claims in their procurement strategies, benefit from reduced reputational risks, and position themselves as leaders in climate responsibility.

In the context of energy disclosure, the system also fulfils the criterion that energy attributes are tracked and ownership is transferred. This indicates that the fundamental mechanisms for traceability and attribution are in place. However, the evaluation notes a level of uncertainty regarding this criterion, primarily due to insufficient information available to fully assess all the underlying sub-criteria.

Plant operators also derive meaningful benefits from the Norwegian electricity disclosure framework, though to a slightly lesser extent. One of the key criteria fulfilled is the ability to transfer renewable energy attributes to off-takers through long-term REPAs. This capability directly enables revenue generation and ensures greater planning security for plant operators, who can secure stable income by contracting with corporate buyers seeking renewable electricity with certified origin.

Another fulfilled criterion relates to the ability to make unique claims about the origin of electricity from renewable energy sources. Norway's system is explicit in identifying GOs as the standard tracking instrument for such claims. It also maintains and publicly provides a residual mix, which represents the share of energy not covered by GOs. The availability of this residual mix allows both market-based and location-based disclosure approaches to function with transparency, thereby reinforcing the credibility of green claims in the Norwegian energy market. These features collectively form the foundation for market participation by ensuring that renewable attributes are not only traceable but also exclusively claimable by a single party.

In contrast, the benefits for **households** are minimal. The system does not offer any direct or tailored functionalities for individual consumers. Households are not typically positioned to engage with the GO system or make use of the detailed disclosure mechanisms in a meaningful way.

For **society**, the Norwegian electricity disclosure system offers some benefit in terms of administrative efficiency. This is primarily due to the role of the national registry, NECS, which provides automated proof—through cancellation statements—that energy tracking instruments, such as Guarantees of Origin, have been used. Additionally, the system includes automated processes for collecting and transferring energy production data. This function is managed by Elhub, Norway's centralised meter point database, which reports meter readings daily to NECS. Together, these features contribute to a streamlined and transparent data infrastructure. However, many other sub-criteria relevant to assessing broader societal benefits lack sufficient information at this time, which introduces a level of uncertainty in evaluating the full extent of the system's impact on society.

8.3.1.5 France: Electricity supplier obligations

Description of the disclosure concept:

France operates a legally robust and centralised electricity disclosure system, firmly anchored in the French Energy Code. **Guarantees of Origin (GOs) are the only legally recognised tracking instrument** for certifying the origin of electricity from all energy sources—renewable, fossil, and nuclear—when making claims to consumers. The system enforces **full disclosure** obligations, requiring suppliers to report the complete energy mix used in electricity supply. This ensures that every unit of energy is accounted for with verifiable proof of its origin, delivering a high level of transparency that helps consumers make better-informed decisions about the sustainability of their energy use.

Suppliers must indicate on their electricity bill (or an attached document) and on any promotional material related to the electricity supplied, the share of different primary energy sources used. Importantly, there must be a **specific indication of the share of renewable energy disclosed through GOs, particularly those originating from production devices supported under the French feed-in tariff system and procured via auctions** organised by EEX (EECS Scheme Member, 2024b). This adds a layer of transparency regarding public support mechanisms embedded in the disclosed energy.

France applies **monthly matching**, requiring that the GOs used correspond to the same calendar month as the consumption. While more technically demanding, this matching mechanism contributes to greater temporal alignment between energy generation and consumption, strengthening the credibility of green claims.

The system operates under a book-and-claim model, allowing suppliers, consumers, and third parties to hold accounts and cancel GOs. A public residual mix must be used for any untracked energy, avoiding double counting of attributes. The EEX registry provides centralised, digital records and automated proof of cancellation, simplifying compliance for suppliers. However, the presentation of disclosure (e.g. through visuals or charts) is not standardised and may vary across suppliers, impacting consumer clarity.

Verification is ensured through a dual system: the French Ministry of Energy audits supplier mix reports annually, and certified measurement bodies (e.g. RTE, Enedis, and local distribution companies) are responsible for verifying production data (EECS Scheme Member, 2024b).

In conclusion, France's electricity disclosure framework combines strong legal mandates, full disclosure obligation, monthly matching, centralised digital infrastructure, and cross-border compatibility. While it is highly transparent and aligned with European standards, further improvements could include more standardised consumer-facing formats and granular sustainability attributes to deepen consumer engagement and environmental impact reporting.

Evaluation results:

The evaluation indicates that France's electricity disclosure system is most beneficial for **organisations** and **plant operators**, with comparatively lesser – though still meaningful – benefits for **households** and **society as a whole**.

For **organisations**, the system effectively prevents double counting and double claiming of renewable energy attributes, a function that is essential for compliance with recognised GHG accounting standards. This reliability supports accurate and credible emissions reporting and helps organisations demonstrate their environmental performance. These system design features also ensure that organisations can confidently use the disclosure framework to meet regulatory requirements, align with stakeholder expectations, mitigate reputational risks, and demonstrate environmental leadership in procurement and reporting.

For **plant operators,** the system fulfils two core criteria essential for their participation in renewable energy markets. First, it supports the transfer of green attributes to off-takers under Renewable Energy Power Purchase Agreements (REPAs). Within the framework of the French electricity disclosure system, this means the platform is designed to facilitate the application and issuance of Energy Attribute Certificates (EACs) for renewable energy plants operating under REPAs. It enables the secure transfer of these EACs to individual consumers, who hold the right to cancel them to certify their renewable electricity consumption. Furthermore, the system allows authorised third parties – such as contractors or service providers – to cancel EACs on behalf of specific consumers, providing operational flexibility while ensuring proper consumer authorisation and compliance. Second, the system guarantees the uniqueness of claims regarding the origin of energy from renewable energy sources (RES). The French disclosure framework uses GOs to prevent double claims of attributes of the same energy production, including there is a national centralised registry in which each issued GO has a unique identification and each MWh of produced energy can only be certified once. This capability is a prerequisite for market participation, ensuring that the environmental value of generated electricity can be reliably claimed and traded, thereby unlocking a full range of market and policy-related benefits for producers.

For **households**, the French disclosure system fulfils the criterion of product differentiation with a level of uncertainty. By making the origin of electricity transparent, the system allows consumers to make informed choices based on the type of energy they wish to support. This empowers households to express individual preferences through their energy supply decisions and enables them to align their consumption with personal or ethical values. As a result, consumers become emotionally engaged and feel empowered to participate in the broader energy transition, fostering a sense of agency in relation to climate and energy policy goals.

For **society** at large, the evaluation finds that the system somewhat fulfils the criterion that centrally available information and statistics are provided through the energy disclosure framework. Although there may still be room for improvement in accessibility and integration, the existence of centralised tracking and reporting structures contributes meaningfully to the reduction of administrative burden and supports the efficiency of public sector operations. By making core disclosure data available for national energy monitoring and residual mix calculations, the system enhances transparency and supports informed policymaking.

8.3.1.6 Denmark: Electricity supplier obligations

Description of the disclosure concept:

Denmark has established a comprehensive and legally anchored electricity disclosure system, ensuring that electricity suppliers provide transparent, accurate, and accessible information to consumers. The system is primarily based on the use of **EECS Guarantees of Origin** (GOs), **HEC GOs** and **Residual Mix** as mandated by national law Danish Executive Order on Declaration of Electricity to Consumers, known as the Electricity Labelling Order (Klima- Energi-og Forsyningsministeriet, 2010).

A key strength of Denmark's approach lies in the clarity and legal assignment of the disclosure instrument, limiting it to officially recognised GOs, which must be cancelled to substantiate any green claims. This ensures reliable tracking of energy attributes and prevents double counting, supported by the Energinet Registry, which issues automated proof of GO cancellation. Suppliers are required to disclose their full energy source mix, including detailed breakdowns of renewable, fossil, and nuclear sources, using **graphical and textual formats**, ensuring consumer-friendly presentation. Importantly for consumers, the legislation ensures that if invoices are sent electronically, and the graphical fuel mix is omitted, the supplier must clearly indicate where this information is available online, typically through their website.

From an environmental transparency perspective, Denmark also mandates the **disclosure of direct emissions associated with the supplied electricity, including CO_2, CH_4, N_2O (greenhouse gases), as well as SO_2 and NO_x** (Klima- Energi-og Forsyningsministeriet, 2010)**.** This requirement is part of the standard disclosure format and allows consumers to assess the environmental impact of their electricity usage.

Furthermore, Denmark supports increasing granularity in energy attribute tracking. While not required, the **system allows for monthly and hourly GOs upon request by producers**. This enables the granular matching of energy consumption with time-specific renewable generation.

In summary, Denmark's disclosure system is legally robust, consumer-oriented, and transparent, with a strong emphasis on digital access, environmental indicators, and reliable tracking instruments. These features ensure high credibility and consumer trust, even as additional transparency on factors like production subsidies, regional origin, or plant age remains voluntary or undeveloped.

Evaluation results:

The Danish electricity disclosure framework primarily benefits **organisations** and **plant operators**, while offering significantly less advantage to **households** and the broader **society**. The system is designed to ensure accuracy, traceability, and credibility in green electricity claims, but it is less effective in supporting consumer empowerment and encouraging active participation in the energy transition.

Organisations are among the main beneficiaries of the current system, particularly due to two features that score highly in the evaluation. Firstly, the framework is strong in preventing double counting and double claiming. This is achieved through strict rules that permit only specific tracking instruments – namely, EECS Guarantees of Origin (GOs), HEC GOs, and the Residual Mix – to be used for disclosure. By limiting accepted instruments to these categories, the Danish system ensures that electricity disclosed to consumers is backed by unique and verifiable certificates. This structure effectively prevents the same renewable energy from being claimed by multiple parties, which is a common challenge in less regulated systems. The result is a high level of credibility in renewable energy procurement, which is particularly valuable for organisations making sustainability claims or engaging in environmental reporting.

Secondly, Denmark's system serves as a reliable mechanism to prove renewable electricity procurement. The framework distinguishes between electricity that has been fed into the public grid or other distribution systems and electricity that has been self-consumed. This is possible because disclosure is restricted to GOs that are issued only for energy injected into the grid. Market actors must ensure that they cancel GOs corresponding exclusively to grid-injected energy. This requirement provides a clear and trustworthy link between the renewable energy production and its consumption, ensuring that claims of using green electricity are grounded in verifiable data. Moreover, the legal foundation for disclosure, outlined in Executive Order BEK nr 1322 af 30/11/2010, further strengthens the framework by enabling organisations to make unique and reliable green claims in the context of marketing their products or services.

Plant operators also benefit considerably under Denmark's disclosure system. Three criteria are especially relevant in this regard. First, the framework allows for the transfer of green attributes in Renewable Energy Purchase Agreements (REPAs). The system enables any party – including consumers – to open an account in the GO registry and cancel certificates. This flexibility supports a wide range of voluntary market mechanisms and facilitates direct contracting between producers and consumers, enhancing the marketability of green electricity. Second, the Danish framework receives high scores for its ability to prevent double counting of green attributes across energy carriers. This is due to clear procedures that govern the cancellation of certificates for the input energy and the issuance of new certificates for the output energy, which is particularly important in cases of energy transformation (for example, converting electricity to heat or hydrogen). These measures preserve the integrity of green claims throughout the energy system.

Thirdly, The Danish electricity disclosure system enables 'unique claims on origin from RES' for plant operators as the system includes a well-defined tracking infrastructure that allows for market-based claims on renewable energy attributes. In addition, Denmark ensures the publication of a national residual mix, which is essential for accurate and transparent energy disclosure when GOs are not used. This setup provides significant benefits for plant operators, as it allows them to reliably certify the renewable origin of their electricity and make verifiable claims in the market.

In contrast, the benefits to **households** and **society** are considerably more limited. While the framework includes requirements intended to improve transparency and understanding, their practical effectiveness is constrained. For example, electricity suppliers are required to disclose the fuel composition both in textual form and through a graphical overview, following a standard format developed by the Transmission System Operator (TSO). This requirement is meant to ensure that the information presented to consumers is clear and accessible. However, the actual ease with which consumers can access and understand this information varies significantly depending on how each supplier chooses to present it on invoices or websites. As a result, the quality and clarity of the disclosure often depend on supplier-specific practices rather than being uniformly high across the board.

Moreover, the system lacks tools that could help consumers make informed and impactful choices. In particular, there is no ranking tool or accessible performance evaluation that informs consumers about the additionality of their electricity supply – that is, whether their choice of supplier contributes to the development of new renewable energy capacity. This absence means that consumers are unable to assess the real-world impact of their energy consumption decisions. Consequently, the framework does little to encourage consumers to play an active role in driving the energy transition or to make conscious decisions that support broader societal goals such as decarbonisation.

8.3.1.7 Austria: Electricity supplier obligations

Description of the disclosure concept:

Austria has implemented a legally binding, **full disclosure system** that requires electricity suppliers to declare the origin of every megawatt-hour (MWh) delivered to consumers – whether from renewable, fossil, or nuclear sources (AIB, 2024a). This obligation is grounded in national legislation, particularly the Electricity Act (§§ 71–79) and the Expansion Law. **Guarantees of Origin (GOs) serve as the sole, legally recognised tracking instrument for all energy sources**, ensuring that every unit of electricity supplied is accounted for with a corresponding, cancelled GO. Unlike many other countries, Austria does not use a residual mix, thereby reinforcing the integrity and completeness of the tracking process.

Austria's disclosure system is centralised and operates through a national GO registry, which facilitates both domestic tracking and international transfers via the AIB Hub under the EECS scheme. The registry is designed for high automation and digitalisation: **disclosure statements and cancellation proofs are automatically generated and made available to suppliers. Consumers who register online also benefit from automated access to their disclosure information.**

Electricity suppliers are required to include disclosure information on annual bills. While visual presentation of the fuel mix using charts or tables is not mandatory, E-Control – the national energy regulator – offers examples and publishes annual public disclosure reports to enhance transparency (AIB, 2024a). The actual accessibility and clarity of disclosure information from a consumer's perspective still depends on how individual suppliers present it on their websites and bills.

The system includes robust institutional oversight. E-Control supervises disclosure compliance, while regional authorities or accredited third-party auditors are responsible for verifying production plants. In cases involving electricity storage, Austria's disclosure rules ensure that energy attributes associated with stored electricity remain traceable and consistent once re-injected into the grid. The tracking system reflects the attributes of the input energy, with specific provisions to preserve them after storage, thus avoiding any double counting.

While Austria does not impose mass-balancing as a chain of custody tracking method, **suppliers are required to report the percentage of electricity and GOs purchased together – referred to as 'coupling' – on disclosure statements.** This offers a partial insight into the degree of alignment between physical supply and attribute claims.

From an environmental transparency standpoint, secondary disclosure statements may include information on direct CO_2 emissions, either from statistical data or specific production plants. However, upstream emissions, broader sustainability indicators, and claims related to additionality are not currently part of the system or are still under development (AIB, 2024a). Likewise, the system does not provide granular temporal matching, such as monthly or hourly tracking of energy production and consumption.

Only licensed electricity suppliers are permitted to cancel GOs in Austria; consumers do not have the ability to cancel certificates themselves. Despite this limitation, the system remains one of the most legally robust and administratively mature in Europe. With a comprehensive GO-based approach, centralised registry, and clear regulatory oversight, Austria ensures a high level of credibility and consistency in its electricity disclosure framework.

Evaluation results:

The Austrian electricity disclosure system provides a robust and well-structured framework for tracking and verifying the origin of electricity, with particularly strong benefits for plant operators and **organisations**, while offering comparatively fewer direct advantages for **households** and **society as a whole.**

For **plant operators**, the system provides at least two criteria with high certainty. First, it supports the prevention of double counting across energy carriers, through a structured conversion process: when energy is converted (for example, from electricity to gas), the input GOs are cancelled, and new GOs are issued for the output energy, preserving the environmental attributes of the original energy source. This traceability allows plant operators to maintain the integrity of green claims through the entire energy value chain. Second, Austria's disclosure system ensures that unique claims of renewable origin are valid – meaning that each consumption claim must be backed by corresponding GOs. This enhances transparency and creates market value for renewable attributes, enabling operators to potentially monetise their green production through GO sales.

Among stakeholder groups, **organisations** also benefit from the Austrian disclosure framework. One of the key strengths lies in the prevention of double counting or double claiming of renewable energy attributes. This is achieved through Austria's implementation of a full disclosure system, in which all electricity—regardless of origin—must be accounted for with Guarantees of Origin (GOs). Domestic GOs are tracked through the Austrian national registry, while international transactions are conducted via the AIB (Association of Issuing Bodies) Hub, ensuring a harmonised and transparent transfer process across borders.

The system also fulfils the criterion that energy disclosure serves as reliable proof of renewable energy procurement, which carries significant implications for organisational stakeholders. This reliability is ensured by several key design features: Austria's disclosure obligations are clearly anchored in national legislation, there are structured procedures in place for tracking conversions between different energy carriers (such as from electricity to hydrogen or other fuels), and the system clearly distinguishes between energy fed into public grids or distribution networks and energy that is self-consumed on-site. These provisions ensure that the energy origin information is both accurate and verifiable. As a result, organisations can confidently base their energy procurement decisions on the disclosure information, knowing it reflects genuine renewable sourcing. Furthermore, reliable disclosure enables organisations to comply with established GHG accounting standards, demonstrate alignment with low-carbon business strategies, and meet the expectations of green-oriented markets and sustainability-focused stakeholders, including customers, investors, and regulators. While the criterion regarding the tracking and transfer of energy attribute ownership is also addressed by the Austrian system, it is accompanied by a moderate level of uncertainty.

In contrast, the benefits of the Austrian disclosure system for **households** and **society** are more limited, with fewer evaluation criteria clearly fulfilled. However, one important benefit identified with high certainty is the availability of detailed information on the energy mix. Austrian suppliers are obligated to disclose both the energy source mix of each individual product and the overall energy mix of their supply portfolio. This transparency empowers consumers to make informed choices that align with their environmental values or sustainability goals. By comparing product-specific energy mixes, households can actively select electricity contracts based on renewable content, thus participating in the energy transition through market behavior.

8.3.1.8 Germany: Electricity supplier obligations

Description of the disclosure concept:

Germany has implemented a fuel mix disclosure obligation for all electricity suppliers according to EU provisions with its national energy law (EEG 2023, 2025; EnWG, 2025). The Federal Environment Agency (UBA) is the competent authority for RES GOs, while the national regulator Bundesnetzagentur (BNetzA) is responsible for electricity disclosure by suppliers.

The disclosure statements have to differ between the fuel categories renewable (domestically supported, potentially indicating also a share of regional renewable production), other renewable (based on EECS GOs), nuclear, coal as well as natural gas and other fossil sources. Furthermore, potential shares of tenant electricity are to be distinguished. The disclosure mix has to be provided for the total supplier mix, the product mix, the remaining supplier's residual mix, and the national production mix for comparison for the given disclosure year. Together with the fuel categories, the disclosure of direct emissions for CO_2 and for nuclear waste as environmental indicators is mandatory, based on standard factors per energy source. The disclosure has to be provided by suppliers on invoices, marketing material and on websites, by using consumer-friendly visual illustration.

As tracking instruments, national rules define EECS GO as mandatory tracking mechanism to be used for RES (unless domestically supported). On request of the GO traders this can be verified and documented as 'bundled GO transfer' together with a physical electricity contract. GOs have to be cancelled on the account of a registered electricity supplier, so no GO-based claims directly by consumers are possible. RES volumes which have received support from the national support scheme 'EEG' are not eligible to have GOs issued. Those shares are equally allocated on a pro rata basis to the disclosure statement for all electricity consumers. This allows for a clear visibility of at least those RES volumes which have received support in Germany, while non-supported German RES-E and imported RES-E are not further differentiated. Within the pre-defined share of domestically supported RES, suppliers can – on a voluntary basis – voluntarily differentiate the share of 'regional production', using a GO-like 'Regionalnachweis' which is only issued for supported electricity, and which indicates that the respective share of RES has been produced in the vicinity of the respective consumer. For fuels besides renewables, no clear legal rules are in place. The branch executes an ex-post allocation procedure of attributes in an iterative procedure, depending on the market volume of the different suppliers, centrally organised by the branch organisation BDEW (BDEW, 2024).

The disclosure information requires an annual matching of production and consumption, and the disclosure of the country of origin for GO-based renewable volumes. However, no further requirements on granularity apply.

At present, energy conversion and the issuance of GOs for converted energy are not performed in Germany. No storage issuance is conducted for the time being, but where storage is on the site of the RES production, GOs for the underlying RES production is only issued for electricity when being fed into the public grid and made available to the market (AIB & UBA, 2023).

Suppliers have to report their disclosure information to BNetzA and UBA so that the indicated shares of RES can be verified.

Evaluation results:

The German electricity disclosure system provides a comprehensive framework with several specific regulations, which lead to comparably high benefits particularly for households, while the evaluation shows comparatively lower benefits for organisations, plant operators and for society as a whole.

For **households**, the positive evaluation particularly is based on the broad product differentiation within electricity disclosure and the required clear and user-friendly provision of this information. Furthermore, the German system supports the choice of supply based on geographic preferences, being predominantly a high geographical correlation, and some basic information on additionality by a distinction of domestically supported RES shares towards other RES shares in the disclosure mix.

For **organisations**, the disclosure system particularly has strengths with a view to enabling deductions about spatial correlations, and to some extent also by the provision of information that enables to assess impactful procurement and additionality criteria. However, the overall evaluation towards the defined evaluation criteria is compromised particularly by lower fulfillment of the criteria on administrative efficiency (e.g. with the use of GOs being restricted to licensed suppliers), on energy disclosure being a proof for renewable energy procurement (e.g. with information being restricted to the information which is provided with the mandatory disclosure statements, which does not include information on PPAs and no comprehensive implementation of conversion rules), and on avoiding double counting (for non-renewables).

For **plant operators**, the comparatively low overall evaluation derives from comparatively low results for most of the relevant criteria. Major restrictions apply particularly for the criteria 'Ability to transfer green attributes to off-takers in REPAs' because the use of EACs is restricted to licensed energy suppliers. The evaluation on the criterion 'administrative efficiency' is particularly compromised by the outstanding implementation of measures for data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking, and an associated relative high uncertainty factor for related sub-criteria.

The evaluation of the benefits and related criteria for **society as a whole** honors as positive feature that some information is made available to consumers on energy-specific additionality indicators, so that disclosure information can contribute to empower the consumers for making a contribution to the energy transition. On the other hand, the evaluation indicates relevant shortfalls relating to the criterion on 'Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments', which is largely because the implementation of comprehensive conversion rules is still outstanding.

While the administrative efficiency is evaluated to be rather positive, the evaluation is lower than for most of the other assessed disclosure concepts.

Still, it is worth noting that for both of these criteria a relatively high uncertainty value for the assessment of the relevant sub-criteria is given.

8.3.1.9 Estonia: Gas supplier obligations

Description of the disclosure concept:

Estonia has implemented a legally anchored gas disclosure obligation for suppliers system focused specifically on renewable gas, particularly biomethane. This system is rooted in national legislation—specifically § 327 of the Energy Sector Organisation Act—which mandates that every consumer has the right to access information about their gas consumption based on Guarantees of Origin (GOs). Since biomethane in Estonia is currently used exclusively in the transport sector, the 'consumers' are fuel stations purchasing biomethane for vehicle use. The disclosure obligation applies to biomethane supplied and consumed in the transport sector, while natural gas and other non-renewable gases remain outside the mandatory disclosure regime, and the residual mix is not calculated (AIB 2025).

A key strength of the Estonian system is its **high level of digitalisation and automation**. The gas GO registry, operated by Elering AS (the TSO and Issuing Body), is integrated with smart metering and national data hubs. It automates the issuance and cancellation of GOs based on actual production and consumption data. Consumers can access this data through an online platform (biometaan.elering.ee), which enables a degree of automated proof and transparency that is relatively advanced compared to many other systems in Europe.

Importantly, **mass balancing is used as the chain of custody model**: physical biomethane must be injected into the grid before GOs can be issued, and consumption claims are only allowed when gas is physically **withdrawn from the same grid** network where it was injected. In cases where the production or consumption site is situated at a considerable distance from the physical grid, the use of a virtual grid is permitted, thereby ensuring that GOs reflect gas that is physically deliverable within the system. This ensures a strong physical correlation between production and consumption, although temporal correlation of production and consumption is not enforced.

The system is also well-integrated with other regulatory functions: **GOs serve not only for disclosure but also for national transport sector target accounting, sustainability compliance, and statistical reporting**. These **multifunctional uses of GO data** reduce duplication and streamline energy governance. Additionally, the system supports supervision and verification by independent authorities such as the Competition Authority and certification bodies, particularly concerning sustainability compliance for biomethane (AIB, 2025).

On the transparency side, however, disclosure to beneficiaries lacks granularity. Information on plant age, technology, regional origin, GHG intensity, and sustainability characteristics – although present in the registry – is not mandatorily disclosed to end users. Visualisation tools, ranking based on additionality, and information about fossil or nuclear supply shares are also not required, limiting the scope of disclosure from a consumer empowerment perspective.

Cross-border GO transfer is technically possible through AIB standards, though gas GO export/import is not yet implemented in practice. Moreover, conversion tracking (e.g. for green hydrogen or storage output) is not supported, nor are there rules for handling attributes through energy carrier transitions.

Overall, Estonia's gas disclosure system stands out for its high legal clarity, automation, and integration across regulatory functions, while its current sectoral and informational limitations suggest further potential for development – particularly in the context of full disclosure and consumer-centric transparency.

Evaluation results:

The evaluation of the Estonian gas disclosure framework indicates that the current system is most beneficial to **society as a whole**, while offering fewer advantages to **households, organisations,** and **plant operators.**

For **society**, the disclosure system fulfils the important criterion of providing centrally available information and statistics. This type of information is essential for maintaining public statistics, supervising residual mix calculations, and fulfilling broader public policy obligations. The system's design supports central governance over tracking and disclosure mechanisms, contributing to the prevention of double counting. A key benefit resulting from the fulfilment of this criterion is the reduction of bureaucratic complexity and improved efficiency in administrative actions.

A notable example of this functionality is the use of disclosure instruments for national policy monitoring. Under the regulation for national transport sector certificates, biomethane consumption reporting – used for accounting against national transport targets – is based on Guarantees of Origin (GOs), the same instruments used for consumer-facing disclosure. This integration ensures consistency, efficiency, and traceability within both public monitoring and consumer information frameworks.

Furthermore, the system ensures that relevant energy source data and environmental sub-criteria are transparently disclosed to consumers. The Estonian gas disclosure framework employs mass balancing as the chain of custody method: biomethane must be physically injected into the gas grid before GOs are issued, and these GOs can only be cancelled once actual gas consumption occurs (i.e. when gas is withdrawn from the grid). Within this framework, a virtual grid may be used where production and consumption sites are too distant from the physical grid, thereby ensuring that GOs continue to represent gas that is physically deliverable within the system. This approach guarantees that environmental claims are both credible and physically grounded, enhancing trust and transparency for **household consumers** and **society as a whole.**

Organisations and **plant operators** also derive significant benefits from the current framework though there remain features that could be further enhanced. For example, the criterion of tracking and transferring energy attribute ownership is already well addressed for **organisations**, providing a reliable basis for managing energy claims. At the same time, several other important criteria score very low. These include the ability of the disclosure system to support 24/7 matching strategies and granular emissions accounting, as well as its capacity to enable deductions about spatial and temporal correlations between energy production and consumption. The absence of these advanced capabilities limits organisations' ability to align energy procurement with real-time or location-specific sustainability goals.

8.3.1.10 Austria: Gas disclosure obligations

Description of the disclosure concept:

Austria has introduced a legally binding gas disclosure system that mandates suppliers to disclose the origin and composition of all gas delivered to end consumers. Since 2023 (for the year 2022), **suppliers must report the energy mix using Guarantees of Origin (GOs) as the core tracking instrument**, aligning with evolving EU legislation, including the recast Gas Directive (EU) 2024/1788. GOs are legally defined as the primary disclosure tool and are applicable across various gas types – renewable gas, hydrogen, synthetic gas, and natural gas (AIB, 2024a). If no GO is cancelled for a volume of gas, it must be declared as natural gas, ensuring that untracked attributes are not misrepresented.

Austria's system enables the tracking, cancellation, and automated issuance of proof for all GOs. All relevant data is digitalised, centrally stored, and accessible to both suppliers and consumers via the national registry. **Consumers can access their disclosure statements by creating a login, and suppliers receive automated cancellation confirmations that support their disclosure obligations.** The system is integrated with the EECS Gas Scheme, allowing cross-border transferability of gas GOs.

Oversight is provided by E-Control, which supervises the disclosure system and verifies supplier compliance. Measurement of qualifying gas production is conducted by authorised measurement bodies, and production plants are subject to verification by accredited third-party entities in accordance with Austria's accreditation law.

From a consumer information standpoint, the disclosure statements provide the energy source mix of each supplier and their products. In addition, suppliers are required to use visual representations such as graphs or charts for disclosure. However, disclosure information does not specify plant location, age, sustainability characteristics, or upstream emissions. Environmental data is limited to direct CO_2 emissions and radioactive waste, with broader sustainability indicators and additionality criteria not yet included (AIB, 2024a).

The system does not currently offer granular temporal matching (e.g. monthly or hourly) and does not allow consumers to cancel GOs directly – only licensed suppliers may do so.

In summary, Austria's gas disclosure framework is legally robust, digitalised, and centrally supervised, with strong alignment to EU rules and solid institutional oversight. While it ensures the traceability and integrity of claims through a standardised GO system, it still lacks consumer-facing granularity and deeper sustainability transparency.

Evaluation results:

Austria's gas disclosure framework provides solid benefits across all stakeholder groups, though it appears to offer slightly more advantages to **organisations** and **plant operators** compared to **households** and **society as a whole**. The system is well-anchored in legislation, supports accurate energy tracking, and enables credible claims around renewable gas usage. However, certain areas—particularly those relevant to broader societal benefits – remain subject to information gaps or lack of full clarity, which affects the overall strength of those aspects.

For **plant operators**, the system's most notable benefit is its approach to tracking and avoiding double counting of green attributes across energy carriers. Austria has clear rules in place to manage conversions between energy forms – such as from renewable gas to electricity or hydrogen. According to the Austrian Domain Protocol, GOs used for conversion are cancelled on the day of conversion, and new GOs for the output energy are issued accordingly. Importantly, the environmental characteristics associated with the original energy source remain unchanged in the new certificate. This process ensures integrity and traceability throughout the energy chain, giving producers and plant operators confidence that their green attributes retain their value without risk of duplication.

Organisations also benefit from the Austrian gas disclosure framework, with two criteria standing out as particularly well. The first is the role of energy disclosure as a reliable instrument to prove renewable gas procurement. This is supported by clear procedures within the Austrian system that govern the tracking of energy conversions between different carriers. The disclosure framework is firmly grounded in national legislation, ensuring legal certainty and accountability. Additionally, Austria promotes data interoperability, with mechanisms for sharing information between registries and public agencies, including across domains and borders. This ensures coherent and transparent use of data in the disclosure process, which is essential for organisations making renewable procurement claims, particularly those involved in sustainability reporting, GHG accounting, or green marketing.

The second area where organisations gain significant value is in the tracking and transfer of energy attributes. The Austrian system meets all essential criteria in this respect. Energy attributes must be cancelled (or equivalently marked) before they can be claimed by any party. Furthermore, these attributes can be allocated not only to a specific consumer but also to products offered. This level of granularity supports tailored product offerings and provides flexibility in how renewable gas claims are structured and presented. For organisations, this means greater control over how renewable energy use is communicated, which can strengthen brand credibility and customer engagement.

While **households** benefit to a lesser extent, there are still positive aspects to highlight. The most promising feature for consumers is the system's support for product differentiation, which enables informed decision-making. In Austria, gas suppliers are required to disclose both the energy source mix of each individual product they offer and their overall fuel mix. This transparency allows consumers to express their environmental values through their choice of gas supply, effectively linking individual preferences to the broader energy system. Moreover, suppliers are required to present this information using visual tools such as graphs or tables, which facilitates clearer, more accessible and more comprehensible disclosure for consumers.

From a **societal** perspective, the Austrian framework performs reasonably well, particularly in terms of administrative efficiency and the alignment of disclosure rules with other policy instruments. These aspects suggest that the gas disclosure system is not only functional but also integrated within a broader regulatory and policy context, potentially reinforcing national energy and climate objectives.

8.3.1.11 France: Gas disclosure obligations

Description of the disclosure concept:

France has established a robust legal and institutional framework governing the disclosure obligations of gas suppliers, with a strong emphasis on renewable gas, particularly biogas. The cornerstone of this system is Article L446-18 of the French Energy Code, which mandates that **only Guarantees of Origin (GOs) and Certificats de Production de Biogaz (CPBs) can be used to certify the renewable origin of gas supplied** under green offers. These instruments are required to substantiate claims made to consumers about the renewable content of the gas they purchase. **Starting in 2026, larger gas suppliers will also be required to restitute CPBs to the French State**, further reinforcing the connection between certified production and disclosed supply (European Energy Excange AG [EEX], 2025).

A defining feature of the French system is its solid legal basis and the clear designation of a responsible regulatory authority. The Direction Générale de l'Énergie et du Climat (DGEC) oversees the implementation and enforcement of GOs and CPBs, ensuring that disclosure practices are consistent and verifiable. This governance framework is supported by a multi-tiered verification process involving independent third parties. Production plants are verified by the European Energy Exchange (EEX), which acts as the Issuing Body for GOs and CPBs, with assistance from key transmission and distribution system operators such as GRTgaz, Teréga, and GRDF.

Disclosure data, which is based on the cancellation of GOs, is centrally recorded and managed by the EEX Registry, making it digitally accessible to suppliers. This enables efficient tracking, streamlines administrative processes, and ensures the traceability of green gas. Each megawatt-hour (MWh) of biogas injected into the grid is associated with a single, uniquely identifiable certificate which must be cancelled before any market claim can be made. Importantly, **CPBs are national instruments and cannot be exported**; they verify the production and consumption of biogas within France's borders (EEX, 2025).

The system also imposes a clear boundary on how certificates can be used. **GOs and CPBs are tied to the physical delivery of biogas**: once produced, the biogas is injected into the grid and mixed with natural gas, but the GO or CPB serves to trace its renewable attributes. Each MWh of injected biogas generates a GO or a CPB that indicates the place of production and source material. As a result, consumers can be confident that the gas attributed to them corresponds to a verified quantity of renewable biogas that has been produced and injected into the grid.

For the issuance of a CPB, producers must declare that the associated batch of biomethane complies with sustainability and greenhouse gas (GHG) emission reduction criteria. EECS GOs may optionally include information about sustainability standards such as the certification body, auditing scheme, and additional relevant data. Though this information is not currently required to be disclosed to consumers.

Nonetheless, the French disclosure system exhibits several limitations in terms of transparency and consumer communication. Visual representations of energy mix data, such as graphs or tables, are not mandatory. Furthermore, detailed data on GHG intensity, sustainability characteristics, the age or location of production facilities, or real-time and time-specific correlations between energy production and consumption, is either unavailable or not part of the disclosure requirements. This limits the ability of consumers to make fully informed choices based on environmental criteria.

Evaluation results:

France's gas disclosure framework offers a balanced level of benefit across all stakeholder groups—**organisations, plant operators, households**, and **society as a whole**. The framework is based on a mass-balancing chain of custody model, which ensures credible tracking of renewable gas attributes throughout the gas network.

The most notable strength of the system, particularly from a **societal** and **household** perspective, lies in its transparency in disclosing energy sources and environmental information. This is achieved through the use of Guarantees of Origin (GOs) and Biogas Production Certificates (CPBs), which provide a clear link between the renewable gas produced and the gas consumed by end users. Once biogas is injected into the gas grid, it becomes physically indistinguishable from natural gas, but the use of a mass-balance approach ensures that every megawatt-hour of biogas injected is documented through the issuance of a GO or CPB. These certificates include detailed information about the location of production and the feedstock used, offering consumers a transparent view of the environmental characteristics of the gas they are purchasing. Because there are no simple ways to shuffle resources or manipulate claims under this system, it supports meaningful and reliable disclosure. This contributes significantly to public awareness, helping individuals and society understand and take responsibility for the environmental impacts of their energy choices. In fact, this aspect was rated as the strongest benefit for both households and society as a whole.

Organisations also derive clear advantages from the current system, particularly in the area of energy attribute tracking and ownership transfer. In the French framework, energy attributes are assigned to specific volumes of renewable gas and must be either cancelled or clearly marked before they can be claimed by a consumer. This ensures that environmental claims related to gas consumption are based on traceable and exclusive certificates. Furthermore, the system allows these attributes to be allocated to specific beneficiaries, enabling organisations to claim the use of renewable gas in their sustainability strategies or marketing. However, despite this strong foundational structure, there remains some uncertainty in the evaluation. Certain technical details and regulatory mechanisms that influence how energy attributes are transferred or claimed could not be fully assessed at the time of analysis. This uncertainty slightly limits confidence in the system's effectiveness from the organisational perspective, even though its overall design is sound.

For **plant operators**, two criteria were particularly favourable: 'the ability to transfer green attributes to off-takers in REPAs', and 'tracking and exclusion of double counting of green attributes across energy carriers'. The system's flexibility in allowing green certificates to be assigned to different customers supports contractual models such as REPAs, which are becoming increasingly important in voluntary green gas markets. Moreover, the use of GOs and CPBs enables producers to ensure that their renewable gas can be linked to a specific end user or buyer. That said, the evaluation also flagged some uncertainty – especially in relation to the procedures needed to guarantee the prevention of double counting across different energy carriers. In particular, there was insufficient information to confirm whether the cancellation of certificates for the input energy and the issuance of new certificates for the converted output energy is explicitly defined and enforced. While the system appears robust in principle, these gaps reduce the clarity around its application in cross-carrier contexts.

8.3.1.12 Finland: Heating and Cooling disclosure obligations

Description of the disclosure concept:

There are two disclosure obligations in place for heating and cooling in Finland, the obligation to inform end-consumers via the energy bills on the source of the supplied heating and cooling and Guarantees of Origin for renewable H&C.

The Government Decree 254/2021 on consumption and billing information and allocation of costs in the field of heating, cooling and water obliges H&C suppliers to specify the source of the supplied heating and cooling in the energy bills towards the H&C end-consumers. All energy sources must be specified. As additional information, only direct emissions need to be indicated (Ministry of Justice, 2025b).

The H&C companies must display this information also on their websites, yet the detail of information provided varies from one H&C supplier to another. One H&C supplier (Vasa Elektriska, 2025) displays the ownership of the H&C sources, as well as the heat generation in real time (without providing information on the energy sources that are applied at this moment).

This specific H&C company allows consumers to opt between two H&C contracts, one of which is fully renewable. Yet no details about this mix of both offers is given.

GOs for heating and cooling are introduced by the Finnish Act on Guarantees of Origin (1050/2021) (Ministry of Justice, 2025a). This act also provides the legal context for the GOs for electricity and gases, ensuring consistency between the different GO schemes within the country. Hence, clear rules are in place for tracking conversion between different energy carriers. The act appoints the Energy Authority as the issuing body for GOs for H&C. Any end-consumer can open a GO account to manage H&C GOs.

The underlying Chain of Custody model is book-and-claim. They can be transferred freely across the country. In an information session on the introduction of GOs for H&C, it was indicated that a physical connection to the grid is not required and GOs for H&C can be used cross-border (Energy Authority of Finland [Energivaristo], 2022).

The GOs for H&C can be issued for renewable H&C sources only; they must be cancelled to proof their supply. Yet it is not necessary to cancel GOs for the proof a supply of renewable heating and cooling in case of a direct connection between H&C supply and consumption and in case all H&C sources feeding the H&C grid are renewable. No Residual Mix is calculated.

Evaluation results:

The Finnish disclosure framework for heating and cooling offers a balanced level of benefit across **all stakeholder groups**.

Organisations seem to benefit most from the framework. Four criteria contribute to this high benefit: energy disclosure serves as proof for renewable energy procurement, energy attributes that are tracked and ownership is transferred, administrative efficiency, and energy disclosure enabling deductions about spatial correlations. This is the result of the implementation of GOs for H&C from renewable sources in an open and transparent way, so that every H&C consumer can manage the GOs assigned to them in combination with mandatory information on the source of energy on the H&C supply bill.

Also **plant operators** benefit from the disclosure framework, mainly because of the ability to transfer green attributes to off-takers via the GOs for renewable H&C, double counting prevention of green attributes across energy carriers as the Finnish GO schemes for all energy carriers are harmonised, and administrative efficiency.

The **society as a whole** benefit from the disclosure framework for the same reasons.

Households benefit from the disclosure framework because the disclosed information is easily accessible and presented in a clear and user-friendly manner on their H&C bills. Moreover, some H&C companies offer different products empowering consumers to make a choice in the environmental impact of the H&C they purchase. These H&C companies tend to provide more detailed information to their consumers about the source of the supplied heating and cooling. A drawback is that Guarantees of Origin for renewable H&C can be transferred in between non-interconnected H&C grids. This could undermine the credibility of renewable H&C supply.

8.3.1.13 Sweden: Heating and Cooling disclosure obligations

Description of the disclosure concept:

In Sweden, the disclosure of the origin of the H&C sources is part of the environmental reporting of the H&C companies. In this annual report, they must indicate the heating and cooling sources applied in the previous calendar year.

Swedish H&C companies provide information according to the guidelines provided by Värmemarkandskommittén (Heat Market Committee)- a national body in which representatives of H&C companies and their consumers agree on the organisation of the H&C market and that oversees the disclosure statements by the H&C companies in Sweden. Various sources are considered: renewable fuels, fossil fuels, recycled heat, and fossil free electricity. A differentiation in CO_2-emissions from direct combustion and from transport and production of the fuels is made as well.

Yet, the implementation varies from one H&C company to another. One company also provides information on the NO_x and SO_2 emissions per district heating grid (see for instance Vattenfall (2024a)) and detailed information on the source of biomass for the whole heating and cooling supply (see Vattenfall (2024b)).

Some H&C companies allow consumers to opt for H&C from specific sources; consumers of Göteborg Energi for instance can opt for an entirely renewable heat supply next to a default heat supply (see). This H&C company informs its companies about the sources of the supplied H&C via dedicated consumer pages.

No information has been found whether the other H&C companies have automated information channels in place to inform their H&C consumers.

Sweden also prepares the implementation for Guarantees of Origin for H&C. Instigated by the update of the Renewable Energy Directive 2018/2001 in 2024, an updated Swedish regulation on Guarantees of Origin has been proposed, which does provide a context for GOs for heating and cooling next to GOs for electricity (Regeringskansliet, 2025). Currently (June 2025), this proposal is under public consultation.

The proposed GOs for H&C - if approved and implemented - will only be issued for renewable H&C sources. The Swedish Energy Agency (Energimyndigheten) would be the competent regulatory body for the proposed GOs for H&C.

Evaluation results:

The disclosure framework for H&C in the Sweden provides a robust and well-structured framework for tracking and verifying the origin of heating and cooling, with particularly strong benefits for **all stakeholder groups**, **households** in particular.

Households, and to a lesser extent **the society as a whole,** and **organisations,** benefit from the disclosure framework because the disclosed information is easily accessible and presented in a clear and user-friendly manner. The agreement made with the Swedish Heat Market Committee on how to report on the sources of the supplied H&C supports this benefit. Moreover, all energy sources must be included in the disclosure framework with sufficient detail on the generating technology and environmental impacts. In addition, some H&C companies offer different products empowering consumers to make a choice in the environmental impact of the H&C they purchase.

Plant operators also benefit from the disclosure framework because of the disclosure of additional detail on the generating technology and environmental impacts. Moreover, the planned implementation of GOs for renewable H&C is instrumental in preventing double counting of green attributes across energy carriers. At this stage, it is unclear to what extent their transfer in between non-interconnected H&C grids would be allowed.

8.3.1.14 Netherlands: Heating and Cooling disclosure obligations

Description of the disclosure concept:

There are two disclosure obligations in place for heating and cooling in the Netherlands, the ‘heat label’ and Guarantees of Origin for renewable H&C.

H&C suppliers must publish an annual report - the so-called 'Warmte-etiket', which can be translated as 'Heat label' detailing the source of the heat they have supplied to the end-consumers. This heat label applies the full disclosure model; all energy sources are given, both renewable and non-renewable ones, see for instance the Heat Labels of Vattenfall (2024c) and Eneco (2025)(in Dutch). The H&C generating technologies are detailed as well.

The Heat Label also contains some sustainability criteria: the specific CO_2 emission factor, the CO_2 savings compared to condensing natural gas boiler are given, the primary energy factor and the H&C losses of the grid. Yet, the indicators provided vary from one supplier to another although the Dutch Enterprise Agency has provided guidelines on what to report (Hamerlink Consulting, 2023; Harmelink, 2023). The legal basis imposing the publication of the Heat Label by the H&C suppliers could not be found.

Guarantees of Origin is the instrument to demonstrate the supply of renewable H&C. Suppliers must cancel these when supplying renewable H&C. The H&C GOs are designed based on the experience with GOs for renewable electricity and renewable gases in the Netherlands. All these GOs are managed by VertiCer, maximising the harmonisation between the different GO schemes implemented in the Netherlands. H&C GOs are issued by VertiCer based on monthly metering reports issued by the producer.

There are GOs for grid-based supply and for non-grid-based supply (supply on site). Producers and suppliers can open a GO account to manage the GOs on their account; yet GOs cannot be transferred in between grids that are not interconnected. Commercial H&C consumers can open an account at VertiCer to monitor which 'GOs for thermal energy from renewable sources' where cancelled for them, where they can download PDF-reports indicating the number of certificates cancelled, their ID, expire date, kind of renewable H&C source and production device.

The concept of the 'Guarantee of Origin for thermal energy from renewable sources' is enshrined in the Dutch Heat Law (Overheid, 2025c) and in the Decree on Guarantees of Origin and Certificates of the Regeling garanties van oorsprong en certificaten van oorsprong (Overheid, 2025b). The 'Authoriteit Consument en Markt' is the supervisory authority. However, their website provides very little information on the disclosure framework for renewable H&C in the Netherlands. No report evaluating the renewable H&C supply could be found.

It is unclear to what extent end-consumers are informed about the source of the H&C on their invoice. The Dutch Heat Law does not ask H&C suppliers to do so.

Despite the disclosure obligations, the disclosure information does not influence the end-consumers' H&C purchase decisions. The two H&C suppliers examined (Vattenfall and Eneco, together operating about 80 H&C networks in the major cities of the Netherlands) supply heating and cooling without giving the end-consumer to opt for H&C of specific sources. Consumers are only informed about the kind of H&C they are supplied with without that they are empowered to select the H&C sources they would like to be supplied with.

Evaluation results:

The disclosure framework for H&C in the Netherlands provides a robust and well-structured framework for tracking and verifying the origin of electricity, with strong benefits for **all stakeholder groups**.

As in Sweden, **households**, **organisations** and **the society as a whole** benefit from the disclosure framework because the disclosed information is easily accessible and presented in a clear and user-friendly manner. The Heat Label is an effective instrument to inform H&C consumers about the sources of the supplied heat in a harmonised way. The fact that all energy sources must be included with sufficient detail on the generating technology and environmental impacts underlines this benefit.

The GO scheme for H&C from renewable sources adds to this benefit for **households**, **organisations** and **the society as whole**. The restriction to transfer GOs in between interconnected H&C grids only ensures the deliverability of the claimed H&C supplies. An additional benefit for **organisations** is that they can open a GO account to monitor which GOs for renewable H&C have been cancelled for them.

Yet, a drawback is that H&C consumers in the Netherlands do not allow their end-consumers to prioritise specific H&C sources in their H&C in contrast to some Swedish and Finnish H&C companies. This restricts the empowerment of the end-consumers in the H&C sector in the Netherlands.

Also **plant operators** benefit from the GO scheme for H&C because it ensures the uniqueness of the renewable H&C supply claims and prevents double counting of environmental attributes. The harmonisation with the GO schemes for electricity and gases leads in addition to administrative efficiency.

8.3.1.15 Germany: Heating and Cooling disclosure obligations

Description of the disclosure concept:

Disclosure obligations for district heating and cooling suppliers in Germany are governed by the District heating or district cooling consumption measurement and billing ordinance (FFVAV)[36]. The regulation applies to all H&C systems and sets requirements for metering, billing, and energy disclosure.

While the regulation mandates the publication of the energy mix of a H&C grid as well as the associated GHG emissions and the primary energy factor (PEF), it is not directly linked to overarching policy targets such as those outlined in the Heat Planning Act (WPG)[37]. This results in a fragmented regulatory landscape and lack in national coordination. While responsibilities for oversight and enforcement of policy targets are delegated to state-level authorities, the enforcement of FFVAV compliance is not clearly assigned to a specific authority. While suppliers are obligated to follow the regulation, there is no designated body systematically monitoring or enforcing its implementation. Additionally, the district H&C sector lacks an independent verification body comparable to the role of grid operators in the electricity sector.

Disclosure obligations always refer to a single, closed H&C system and are therefore inherently limited to the boundaries of that specific system. Unlike in the electricity sector, disclosure in the district H&C sector is not inherently tied to a standardised tracking instrument. However, when suppliers claim to deliver renewable energy, they are legally obliged to use Guarantees of Origin (GOs) to substantiate those claims. This follows a book-and-claim model, where GOs serve as proof of renewable content. Importantly, as per Ordinance on Guarantees of Origin for Heating, Cooling and Gases (GWKHV)[38] these GOs are restricted to the specific H&C system in which they were issued, and cannot be traded or transferred across networks, reinforcing the 'one grid – one factor' principle that characterises the sector. As a result, design sub-criteria like physical connection or geographical correlation are fulfilled by default due to the closed system structure.

Although transparency towards consumers is one goal of the FFVAV, there are no standardised requirements existing regarding the format of presentation of energy disclosure or the methodologies used for calculating GHG emissions or the PEF, which can lead to inconsistencies in implementation. Furthermore, there is no independent verification body overseeing the accuracy of disclosures, and third-party audits are not required. This places the burden of compliance entirely on the suppliers themselves. However, in the context of GO issuance, some level of verification will be implemented. This suggests that while general disclosure remains unverified, the use of GOs introduces a degree of oversight at least for renewable energy claims.

In summary, while the FFVAV provides a legal basis for energy disclosure in the district H&C sector, its implementation is marked by limited standardisation, weak enforcement mechanisms, and a lack of integration with broader energy policy frameworks.

Evaluation results: The evaluation of the German H&C disclosure framework reveals that its current design is most beneficial for households, while it shows notable shortcomings in terms of being beneficial for organisations, plant operators, and society as a whole.

For **households**, the disclosure system performs particularly well. One of the main reasons for this is the inherent structure of H&C systems, which are physically closed systems. This

[36] Fernwärme- oder Fernkälte-Verbrauchserfassungs- und -Abrechnungsverordnung vom 28. September 2021 (BGBl. I S. 4591, 4831), die durch Artikel 2 des Gesetzes vom 4. Januar 2023 (BGBl. 2023 I Nr. 9) geändert worden ist.

[37] Wärmeplanungsgesetz vom 20. Dezember 2023 (BGBl. 2023 I Nr. 394).

[38] Gas-Wärme-Kälte-Herkunftsnachweisregister-Verordnung vom 25. April 2024 (BGBl. 2024 I Nr. 139).

structural feature effectively prevents resource shuffling, as the grid-bound nature of H&C systems leads to disclosure obligations setting system boundaries equaling the physical boundaries of each grid. Preventing resource shuffling is beneficial for consumers because it ensures that disclosed environmental attributes reflect the actual energy system performance, rather than being artificially reassigned, thereby increasing transparency and avoiding misleading 'greenwashing' claims (see chapter 3.4). This also applies to the **society as a whole**. Another highly rated aspect is the theoretical option to make a choice by clear product differentiation. H&C disclosure requires suppliers to disclose the energy mix for each product they offer publicly, which in principle enables consumers to make informed choices. However, in practice, most H&C systems only offer a single product, limiting the actual applicability of this feature. While the concept supports consumer choice, the sector's structural characteristics currently prevent this potential from being realised.
On the other hand, the lowest scores were assigned to sub-criteria related to consumer empowerment and policy alignment. The current disclosure system does not provide mechanisms that allow consumers to actively contribute to increasing public renewable energy (RES) targets. Furthermore, there is no distinction made between energy sources based on additionality criteria.

The absence of additionality criteria also affects the **society as a whole** and represents the lowest ranked criteria for German H&C disclosure. Without the ability to assess the additionality of delivered heating and cooling in terms of temporal granularity or information like plant age or support status, it becomes impossible to determine the system's actual contribution to the energy transition, thereby limiting its societal value.

With regards to **organisations**, the H&C disclosure obligations in Germany are beneficial as they provide administrative efficiency as per evaluation results. This is mainly because disclosure information has to be publicly accessible via suppliers' websites. However, it has to be noted that the criterion of administrative efficiency comes with a high uncertainty factor as many sub-criteria could not be assessed because the GO registry for heating and cooling in Germany is not yet implemented. Furthermore, organisations benefit from the fact that in the context of H&C energy disclosure, energy attributes are tracked, and ownership is transferred, allowing organisations to use disclosure as a basis for claiming renewable energy consumption. However, this only applies to the renewable share of energy, as tracking via GOs is only required when a specific share of renewable energy is promised by the supplier. That said, it is important to acknowledge that the criterion 'In the context of energy disclosure, energy attributes are tracked, and ownership is transferred' is rated with high uncertainty. This stems from the fact that the H&C GO system has not yet been implemented, and several sub-criteria relevant to the criterion could not be fully assessed at this stage.
At the same time, the current design of H&C disclosure does not support more advanced procurement strategies such as 24/7 matching, where energy consumption is aligned with real-time supply. This is due to the lack of temporal granularity in the disclosed data. As a result, granular emission accounting is not feasible. At the same time, 24/7 matching is predominantly a concept applying to electricity markets, whereas heat distribution via heating grids is characterised by greater temporal inertia. In the H&C context, the concept of 24/7 matching is primarily relevant for electricity-based H&C production. Furthermore, other impactful procurement approaches based on temporal correlation or additionality criteria cannot be meaningfully assessed relying on the current H&C disclosure concept.

The fact that renewable energy amounts need to be tracked via GOs when promising them towards a consumer also benefits **plant operators** and scored highest here. If plant operators want to sell a REPA, it is important that the energy attributes can be sold in the context of this agreement. However, also the criterion 'Ability to transfer green attributes to off-takers in

REPAs' shows a high uncertainty factor. This again stems from the fact that the H&C GO system has not yet been practically implemented, and several sub-criteria relevant to the criterion could not be fully assessed at this stage.

8.3.2 Selected disclosure concepts for climate or sustainability reporting

8.3.2.1 GHG Protocol Scope 2 Guidance

Description of the disclosure concept:

The GHG Protocol (GHGP) standards and guidance provide a widely used accounting and reporting framework for organisations' GHG emissions (Greenhouse Gas Protocol, World Resources Institute, & World Business Council for Sustainable Development, 2025d). This includes businesses, but also governments and other organisations. As the accounting methodology is frequently referenced in other GHG reporting frameworks or legislation (e.g. ESRS, GRI, see chapter 4.5), it has a high impact on GHG emissions reporting globally. The GHGP is administered jointly by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD).

The GHG Protocol Scope 2 Guidance provides a standardised framework for companies to account for and report **indirect greenhouse gas (GHG) emissions** from purchased electricity, steam, heating, and cooling. It distinguishes between two required accounting approaches: the **location-based method**, which uses average grid emission factors, and the **market-based method**, which reflects emissions from electricity that companies specifically procure through contractual instruments such as Energy Attribute Certificates (EACs), Guarantees of Origin (GOs), or Power Purchase Agreements (PPAs) (Sotos, 2015).

Under the market-based method, companies must meet **Scope 2 Quality Criteria**, including the requirement for geographical and temporal correlation between energy consumption and the associated energy attributes. Geographical correlation means that the contractual instruments (e.g. EACs) must be sourced from the same electricity market in which the consuming operations are located. However, the guidance defines market boundaries broadly—typically based on regional transmission organisations, power pools, or balancing areas—allowing for greater flexibility in certificate sourcing. Since these markets often extend beyond national borders, unbundled certificates can be traded across wide regions, promoting consumer choice and cost-effective renewable development. Still, companies are advised to follow the boundaries set by the relevant regulatory or certification bodies governing the certificate systems.

Temporal correlation, meanwhile, requires that certificates be issued and redeemed as close as possible to the period of actual electricity consumption. While the guidance does not define a strict timeframe (e.g. monthly or annual matching), it emphasises that the temporal alignment should be reasonable and justifiable, ensuring that reported emissions reductions reflect energy attributes from the relevant reporting period (Sotos, 2015).

The Scope 2 Guidance supports **voluntary corporate disclosure**, and while it aligns with EU-level frameworks such as the European Sustainability Reporting Standards (ESRS), it is not legally binding unless adopted into national legislation. The guidance does not prescribe a single tracking system, nor does it mandate third-party verification, though companies may reference internal or external assurance mechanisms.

Furthermore, the protocol does not address various aspects such as energy storage tracking, national policy accounting, or automation of disclosure and data sharing with authorities. It avoids mandatory reporting on the sustainability or additionality of renewable energy sources and omits detailed requirements on plant-level attributes such as location, age, or subsidy status.

Nonetheless, the GHG Protocol enforces the use of a residual mix for untracked or shared electricity to avoid double counting and ensure accurate GHG accounting. Overall, the Scope 2 Guidance provides a robust yet flexible framework for emissions disclosure, with its effectiveness largely dependent on jurisdictional context, market infrastructure, and voluntary adoption by companies.

Evaluation results:

The GHG Protocol Scope 2 Guidance is a voluntary corporate disclosure framework that provides the most substantial benefits to **organisations**, with more limited relevance for **plant operators** and minimal impact on **households** and **society as a whole**. As a corporate reporting tool, the guidance is primarily intended to support organisations in accurately accounting for emissions from purchased electricity, heat, steam, and cooling.

For **organisations**, the framework fulfills several criteria, although only one—'In the context of energy disclosure, energy attributes tracked and ownership is transferred'—is clearly beneficial without major uncertainty. Within this guidance, energy attributes can be explicitly allocated to a specific consumer or to a specific product offered. This capacity allows organisations to claim the use of renewable electricity and, in turn, benefit from various outcomes: it enables compliance with established GHG accounting standards (such as the GHG Protocol itself), supports participation in voluntary and regulatory low-carbon markets, and allows organisations to make credible environmental claims. Furthermore, it helps companies engage in Renewable Energy Purchase Agreements (REPAs) and align with stakeholder expectations on sustainability. These benefits, while tied to voluntary reporting, have practical value—helping organisations reduce reputational risks, strengthen leadership in climate action, and position themselves in green markets. Additionally, using verified renewable energy allows organisations to hedge against potential future costs of carbon by reducing their exposure to Scope 2 emissions, which may increasingly be regulated or priced.

The framework also fulfills the criteria 'administrative efficiency' and 'double counting/double claiming is prevented'. This comes with no uncertainty factor as some of the underlying sub-criteria for the criteria were not applicable to the GHG Protocol as it is a corporate disclosure concept rather than an energy disclosure concept. Hence, these findings still need to be contextualised. For instance, the availability and accessibility of information depend heavily on national systems, data availability, and the nature of contractual instruments used. In many cases, it is unclear whether relevant data is digitally accessible or standardised across markets, which limits the ability to definitively assess 'administrative efficiency'. Similarly, while the guidance offers strong principles for avoiding double counting of energy attributes, its effectiveness depends on how well market actors apply these principles in practice.

For **plant operators**, the guidance fulfills three criteria with a high level of certainty: 'ability to transfer green attributes to off-takers in REPAs', 'definition of market boundaries and accounting period prevents oversupply' and 'unique claims on origin from RES'. The first criterion ensures that energy producers can reliably transfer renewable attributes to specific off-takers through contractual instruments, facilitating participation in corporate renewable energy markets. The second criterion allows plant operators to transparently showcase the source and environmental benefits of their energy, building confidence among customers and stakeholders. The third criterion is particularly noteworthy because it is often lacking in national disclosure systems. The GHG Protocol requires that renewable energy claims must be geographically and temporally correlated with actual consumption. Specifically, contractual instruments used in Scope 2 market-based accounting must be sourced from the same market where electricity consumption occurs, and they must be issued and redeemed as close as possible to the time of energy use. This approach helps avoid market oversupply of renewable claims and supports the environmental credibility of those claims. For plant operators, this means they may have opportunities to sell renewable energy attributes (such as GOs or RECs) into short-term markets, where demand is driven by corporates seeking temporally and geographically aligned instruments. These short-term transactions can provide more frequent and predictable revenue streams, especially when long-term REPAs are not in place.

Given its focus on corporate emissions accounting, the GHG Protocol Scope 2 Guidance does not provide direct benefits to **households** and fulfills only one criterion for **society as a whole**. As a result, its impact at the consumer or societal level is limited, though its indirect influence on decarbonisation efforts may still contribute to broader climate goals over time.

8.3.2.2 CSRD-ESRS: framework for mandatory sustainability reporting in the EU

Description of the disclosure concept:

The Corporate Sustainability Reporting Directive (CSRD), together with the European Sustainability Reporting Standards (ESRS), forms the EU's legal backbone for **mandatory corporate sustainability disclosure** (Corporate Sustainability Reporting Directive (CSRD), 2022). It obliges companies to report on environmental, social, and governance (ESG) matters, with a particular focus on **energy consumption and energy mix**. This framework aims to enhance transparency and support the EU's climate and energy goals by integrating sustainability information into corporate disclosures.

Under ESRS E1-5, companies must provide detailed disclosures of energy consumption from renewable, fossil, and nuclear sources, with further breakdowns into subcategories such as biomass, biogas, hydrogen, and purchased or self-generated electricity, heat, steam, and cooling. This helps stakeholders understand companies' energy sourcing patterns and the climate impacts of their operations.

While the CSRD-ESRS permits the use of market-based claims supported by contractual instruments – such as Guarantees of Origin (GOs), Power Purchase Agreements (PPAs), or Renewable Energy Certificates (RECs) – **it does not mandate a specific, legally binding tracking instrument** for energy origin (Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards, 2023). This flexibility allows adaptation to various national systems but can lead to inconsistency across EU Member States, especially regarding attribute tracking, verification standards, or residual mix usage.

Importantly, the framework does not require temporal or geographical correlation between energy production and consumption, nor does it impose additionality criteria. It also does not mandate disclosure of power plant location, commissioning date, or information about subsidy schemes, limiting the robustness of origin claims and sustainability differentiation.

Verification is a central component of the CSRD-ESRS system. Sustainability reports must be verified by independent third parties, such as statutory auditors or accredited assurance providers. The depth and scope of this verification depend on how each Member State transposes the CSRD into national law. In addition, each Member State must designate a regulatory authority to supervise compliance with corporate reporting obligations, ensuring there is a formal oversight mechanism in place across the EU.

The CSRD-ESRS also addresses greenhouse gas (GHG) emissions intensity, **requiring disclosures on both direct and indirect emissions**, including upstream emissions relevant to biogenic fuels and hydrogen (under ESRS E1-4). Furthermore, ESRS E1-E5 addresses how companies **impact nature**, while ESRS S1-S4 focuses on their **social impacts**, ensuring a broader view of sustainability beyond carbon metrics (Commission Delegated Regulation (EU)

2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards, 2023).

Finally, the CSRD-ESRS aligns with the GHG Protocol Scope 2 Guidance, requiring companies to report both location-based and market-based emissions. If no contractual instrument exists or residual mix data is unavailable, companies must disclose that this could lead to double counting. This alignment ensures consistency with international standards while supporting improvements in corporate energy transparency.

In summary, the CSRD-ESRS provides a comprehensive reporting framework focused on transparency and accountability, but many technical and operational aspects—such as tracking systems, data accessibility, and granularity of energy origin—remain subject to national implementation choices, which can limit cross-country comparability and policy alignment.

Evaluation results:

The CSRD-ESRS disclosure concept for corporate reporting provides differentiated levels of benefit to various stakeholder groups. The primary beneficiaries are **organisations**, while **plant operators** benefit to a lesser extent. The concept has minimal impact on **society as a whole** and offers no direct benefits for **households**.

For **organisations**, the framework is assessed as fulfilling two key criteria, although both are associated with a considerable degree of uncertainty. The first is 'administrative efficiency', which is considered fulfilled because the CSRD-ESRS framework includes detailed information on the greenhouse gas (GHG) intensity of energy production. This includes both direct and indirect emissions, with particular attention to upstream emissions from biogenic energy carriers and hydrogen. This requirement is addressed under ESRS Disclosure Requirement E1-4, which focuses on targets related to climate change mitigation and adaptation. However, the uncertainty associated with this criterion is very high. This stems from the difficulty in evaluating certain sub-criteria that influence 'administrative efficiency'. For instance, it is unclear whether the reported information is easily accessible upon request from a consumer's perspective or whether it is digitally and directly accessible for organisations. These aspects depend largely on how each country implemented corporate reporting obligations under the CSRD and on the contractual mechanisms used within each jurisdiction.

A second highly ranked criterion is also considered fulfilled, albeit with some uncertainty: the traceability and transferability of energy attributes. The CSRD-ESRS disclosure framework ensures that energy attributes are tracked and must be cancelled (or equivalently marked) before they can be claimed. Furthermore, these attributes can be allocated to specific consumers as beneficiaries. However, it remains uncertain whether energy attributes can also be assigned to specific products associated with those beneficiaries. This depends on whether Guarantees of Origin (GOs) are being used and on whether the national GO system allows for energy attribute tracking at the level of individual products within a corporate consumer's portfolio. Since these systems vary significantly between countries, the ability to link energy attributes to specific products is difficult to assess uniformly under this disclosure framework.

For **plant operators,** the disclosure concept scores best regarding 'providing unique claims on the origin from RES', as the CSRD respectively the ESRS as its associated GHG accounting standard clearly specify criteria for market-based instruments including the application of the residual mix, if no market-based instrument is available. However, as the availability of the residual mix depends on the implementation of respective energy disclosure systems, this criteria comes with a high uncertainty factor. Furthermore, it fulfills the criterion 'information provision on requirements for participation in compliance markets' with no associated uncertainty. The CSRD-ESRS framework mandates the disclosure of relevant data such as the sustainability characteristics of energy inputs (notably biogenic carriers and hydrogen), GHG intensity of energy production – including direct, indirect, and upstream emissions – and broader information on environmental and societal impacts. As a result, the framework enables several concrete benefits for plant operators. These include meeting prerequisites for participation in regulated energy and sustainability markets, generating revenues and securing planning certainty through long-term Renewable Energy Power Agreements (REPAs), earning income from the sale of green attributes in short-term markets, and facilitating the transfer of green attributes from energy inputs to outputs during energy conversion processes.

By contrast, the evaluation score for **society** at large performs less well. However, methodological issues need to be considered, as evaluation criteria are framed to refer the benefits of energy disclosure rather than corporate disclosure. Greater transparency in corporate sustainability practices enhances accountability and can therefore be an important driver for companies to contribute to societal and environmental goals. Finally, **households** are not considered beneficiaries of the CSRD-ESRS disclosure concept, as the information provided is not tailored to individual consumers and is often difficult to access or interpret in a meaningful way for household-level decision-making.

8.3.2.3 Corporate disclosure following the updated RE100 Technical Criteria

Description of the disclosure concept:

The RE100 initiative sets out a voluntary but ambitious framework for companies committed to sourcing 100% of their electricity from renewable sources. Rather than representing a binding regulatory system, RE100 is a voluntary initiative defining a set of voluntary guiding principles that aim to ensure the environmental integrity and credibility of renewable electricity claims by industrial consumers.

The RE100 Technical Criteria (Version 5.0) (RE100, 2025) define eligible procurement types for renewable electricity and set criteria to ensure that these procurement methods contribute meaningfully to the energy transition. Energy Attribute Certificates (EACs) are required as the primary instrument for tracking and verifying renewable electricity consumption. Companies must procure renewable electricity backed by EACs, which must be cancelled in the same market where the electricity is consumed. Market boundaries are set country-wise, except from the single markets in Europe as well as between the United States and Canada.
Where EACs are not available, the residual mix must be applied to avoid double counting. Only electricity from plants that have been commissioned or repowered within the last 15 years is eligible in order to foster impactful procurement. While unbundled EACs are permitted, the criteria encourage geographical and temporal correlation between generation and consumption. Furthermore, sustainability requirements apply to specific energy carriers such as biomass and hydrogen.

The RE100 criteria emphasise transparency and accountability. Companies are expected to disclose their electricity consumption in a way that reflects both renewable and non-renewable sources, using the residual mix for non-renewable procurement. Furthermore, third-party verification plays a central role in the newest version of the RE100 Technical Criteria framework. Disclosure statements from companies need to be independently verified. Additionally, RE100 requires that when using claims, it needs to be ensured that in the context of the respective tracking system key plant data are independently verified.

While the initiative does not impose detailed regulatory requirements on suppliers or national disclosure systems, it builds upon existing disclosure frameworks and leverages supplier-provided information to enable a meaningful evaluation of impactful electricity procurement from consumers' perspective. By doing so, RE100 offers companies a clear orientation for aligning their sourcing strategies with global climate goals, while simultaneously creating a basis for assessing the quality and credibility of renewable electricity use.

Evaluation results:

Evaluating the RE100 Technical Criteria, it can be observed that they **benefit especially plant operators and organisations**. Whereas they seem to be **less beneficial to households and society as a whole**. This might be explained by the fact that they aim at companies supporting the energy transition by impactful procurement. This, in turn, benefits society at large as well as plant operators, as it reflects a broader commitment to sourcing renewable energy.
It is important to note that the RE100 Technical Criteria are considered an innovative concept and rather present a corporate disclosure concept than a traditional supplier energy disclosure model. Instead, they build upon existing energy disclosure frameworks. Consequently, many of the defined sub-criteria in the here chosen methodology could not be assessed, leading to a high degree of uncertainty for many criteria and many sub-criteria that were not applicable.

With a view to the **plant operators,** there are only two criteria that could be evaluated since the RE100 Technical Criteria constitute an innovative concept. These were ranked very high. For example, the requirements for geographical boundaries set by the RE100 Technical Criteria lead to benefits for plant operators, as they limit market boundaries, which helps to prevent oversupply and may lead to higher prices when selling green attributes in short term markets. Additionally, the 'Unique Claim' criterion was also highly rated, as RE100 sets clear requirements for credible and exclusive claims.

The RE100 requirements for credible and exclusive claims also benefit **organisations**, as it serves the criteria regarding the prevention of double counting and the tracking and transfer of energy attributes. This enables organisations to make credible claims regarding their renewable electricity procurement. Less beneficial for organisations is the fact that RE100 is a voluntary initiative and not legally enforceable. This leads to a low rating regarding energy disclosure serving as proof for renewable energy procurement. However, it should be noticed that this criterion mostly refers to the respective energy disclosure system on which the RE100 Technical Criteria are based when organisations disclose their electricity procurement practices. This also explains a high uncertainty factor. Many of the underlying sub-criteria allocated to this criterion could not be assessed.

In terms of **households as well as society as a whole**, the RE100 Technical Criteria are evaluated as less beneficial because the concept is aimed at corporate consumers. However, the fact that the RE100 Technical Criteria introduce a clear distinction according to the environmental performance based on additionality criteria in the context of renewable electricity procurement benefits households and society as a whole, as the energy transition is supported.

8.3.2.4 Considering GOs as input for Digital Product Passports

Description of the disclosure concept:

The Digital Product Passport (DPP), introduced as part of the Ecodesign for Sustainable Products Regulation, is a key innovation in the EU’s transition towards a circular, transparent, and sustainable economy. Replacing the 2009 Ecodesign Directive, the DPP is a central element in the new eco-design policy package aimed at improving products’ environmental performance and supporting informed consumer choices. Its main function is to provide easy, standardised, and digital access to detailed product information—including sustainability, circularity, and legal compliance attributes—throughout the entire value chain (Regulation 2024/1781, 2024).

DPPs will eventually cover 31 product groups, ranging from intermediate materials like steel and chemicals to finished goods such as refrigerators and computers. While energy products like electricity and hydrogen are not the immediate focus of the first DPP rollout, hydrogen may be included in future iterations, especially given its role as an intermediary product in many industrial supply chains. In this context, the Guarantee of Origin (GO) system already used in the energy sector is conceptually similar to a DPP, offering a clear, traceable, and standardised record of environmental attributes tied to energy production. Therefore, our analysis conceived the GO as a DPP and interpreted the DPP concept for energy tracking in a way that integrates the existing GO system principles.

Indeed, the benefit of **cancelling GOs to prove the energy source of consumed energy,** is that it secures uniqueness of a claim. A single entity issues each GO for a specific quantity of renewable energy, and once a GO is cancelled (typically by a supplier on behalf of a consumer), it cannot be used again, ensuring that no two parties can claim the same environmental benefit. This principle of uniqueness and traceability is fundamental and could serve as a model for broader DPP implementation across sectors.

Energy disclosure – such as gas or electricity labelling – plays a critical role in bridging energy sector emissions tracking with corporate sustainability metrics like Product Carbon Footprints (PCFs). Currently, firms derive much of their reported emissions data from energy disclosure systems, using information based on cancelled GOs to support renewable energy consumption claims. To avoid discrepancies, it is vital that such claims are always backed by tracking instruments that meet criteria for reliability and uniqueness, such as those found in the EN16325 standard governing GOs.

However, significant gaps remain. As EU-standardised machine-readable disclosure statements are lacking today, the EU-Commission could take the opportunity to **define how DPP link to existing energy disclosure regulation** and consider **making GO backed energy disclosure part of a DPP itself**. Doing so would help align separate frameworks and remove friction at the intersection of emissions tracking, product-level environmental claims, and broader sustainability disclosures.

To underpin this system, the European Commission plans to introduce a delegated act establishing rules for DPP service providers (European Commission, 2025). Additionally, CEN/CENELEC is working on the development of technical standards for a unified 'Digital Product Passport: System and Framework'. A key governance recommendation from experienced actors in the energy tracking domain—such as the Association of Issuing Bodies (AIB)—is that, therefore, where possible, **ensure government-backing of the passport issuance**. This would mirror the model used in the GO system, where issuing bodies are **governmentally appointed as a single issuer for its geographical domain**, thereby preventing overlaps, inconsistencies, and market fragmentation (AIB, 2024c).

Further, safeguards must be established to avoid the 'double issuance' of DPPs—that is, the creation of more than one passport representing the same environmental attribute. Strong enforcement and issuance rules are necessary to prevent such double claims, especially given the diverse actors and complex supply chains involved (AIB, 2024c). Note also the need for consistency and **prevention of double counting with the flows that are registered in the Union Database** in execution of the Renewable Energy Directive 2001/2018(EU) art. 31a. This alignment is essential to maintain data integrity across different EU regulatory instruments and ensure a cohesive system of environmental reporting.

In summary, the Digital Product Passport initiative has the potential to harmonise sustainability information across industries by building on trusted, government-backed frameworks like the GO system. With clear governance, technical standardisation, and robust linkage to existing energy disclosure regulations, DPPs could play a vital role in scaling reliable sustainability data across the European economy.

Evaluation results:

The evaluation of the Digital Product Passport (DPP) reveals that this innovative disclosure framework offers potential benefits across all stakeholder groups, with **households** appearing to benefit the most. However, a closer look at the evaluation results highlights a significant level of uncertainty across all criteria. This uncertainty largely stems from the DPP still being in its early stages of development, where many design aspects remain undefined, unclear, or heavily dependent on how the system will ultimately be implemented — a factor that could vary significantly.

Despite these uncertainties, **households** are clearly positioned as primary beneficiaries of the DPP system. One of the key advantages for consumers is the system's ability to support geographically-informed choices about energy supply. The DPP framework includes information about the country of origin of the energy-producing device, empowering consumers to align their energy choices with personal or regional preferences. This can foster a stronger connection between individuals and the source of their energy, enhancing trust and encouraging local or regional energy consumption. Furthermore, the system meets the criterion of providing transparent information about energy-specific additionality indicators — that is, whether the energy they are purchasing leads to a new dedicated renewable capacity or simply redistributes existing green energy. This enables households to make more informed decisions, actively supporting the energy transition by choosing products or suppliers that truly add new renewable capacity to the grid.

For **plant operators**, the DPP also offers notable benefits, although these come with high levels of uncertainty. The evaluation identifies three criteria with the highest scores for this group. First, the system helps secure long-term revenues and planning certainty through Renewable Energy Power Purchase Agreements (REPAs), as transparency in green attributes can be leveraged to negotiate more stable, longer-term contracts. Second, it enables short-term revenue opportunities by allowing plant operators to sell green energy attributes separately on energy markets. This creates an additional income stream from the environmental value of their production. Third, DPP can enhance customer acquisition and loyalty, as operators are better able to demonstrate the sustainability credentials of their energy. Moreover, by allowing disclosure of the regional origin of the energy, plant operators can appeal to customers looking to support local or regionally sourced renewables, thereby adding value to their offering.

At the **societal** level, the DPP system also demonstrates promising benefits. It can serve as an incentive for a more coordinated and consistent development of energy system infrastructure. By improving transparency and traceability, DPP encourages more strategic investment and development decisions across the energy value chain. Additionally, it has the potential to reduce administrative complexity and improve the efficiency of regulatory compliance and public governance — for example, by automating and standarising information flows that are currently fragmented or manual. From a broader perspective, the system contributes to the energy transition by equipping consumers with actionable information, enabling them to support more sustainable energy sources and ultimately accelerating the shift towards a low-carbon energy system.

Organisations, however, appear to benefit the least from the proposed DPP framework, primarily due to the high degree of uncertainty around its implementation and effectiveness. Nevertheless, the system still supports key compliance needs. It helps organisations align with GHG accounting standards, participate in low-carbon initiatives, meet requirements in emerging green lead markets, and respond to tightening regulatory pressures around emissions reporting and sustainability. Additionally, the DPP can be a valuable tool in crafting effective energy decarbonisation strategies by providing a more detailed and credible view of the energy used. These features can be particularly important for organisations aiming to demonstrate leadership in sustainability or seeking competitive advantages in markets increasingly shaped by environmental standards.

Overall, while the Digital Product Passport shows strong potential to benefit a range of stakeholders — particularly **households** and **plant operators** — its full impact remains uncertain due to its innovative nature and the many unknowns surrounding its final design and implementation. Nonetheless, the framework marks an important step towards greater transparency, traceability, and engagement in the renewable energy transition.

8.3.2.5 RFNBO rules

Description of the disclosure concept:

The Delegated Regulation on renewable fuels of non-biological origin defines the conditions under which fuels of non-biological origin (renewable fuels of non-biological origin - RFNBOs) can be counted as renewable within the accounting to sector specific RES targets in the EU (Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin, 2023). For countries without a largely decarbonised electricity system that are not allowed to use unlabelled grid electricity for the electrolysis of RFNBOs in accordance with Article 4, strict requirements are placed on the procurement of renewable electricity via a PPA:

- Additionality (Article 5): the electricity used for hydrogen production should come from renewable energy sources that are additional to existing capacity. This means that new plants must be built to ensure that the electricity source for hydrogen production is not diverted from existing demand. These new plants must be commissioned within 36 months of the start of hydrogen production.
- Temporal correlation (Article 6): Electricity generation from renewable sources must be correlated in time with the hydrogen production process. This means that the renewable electricity generated must be utilised in the same period in which the hydrogen is produced. This temporal correlation ensures that the electricity actually comes from renewable sources and not from the general power grid at times when renewable electricity is less available. After the end of a transitional period until the end of 2029 the correlation requirement shifts from monthly to hourly correlation.
- Geographical correlation (Article 7): The renewable electricity must come from a geographically close source to ensure that it is used efficiently and sustainably for hydrogen production. As a rule, this means that the hydrogen production facilities and the renewable energy sources must be located within the same bidding zone. This is to prevent non-renewable electricity from being used to bridge distances.

Besides these rules, further options are defined for the sourcing of electricity for supply via a direct line, for highly de-carbonised electricity grids, or for special grid situations (with temporal RES spilling).

Furthermore, Article 8 stipulates that fuel producers must provide reliable information to demonstrate that the above requirements are met. (Article 8).

Demand for green electricity is therefore incentivised with plant characteristics (location and age) and generation characteristics (time of generation).

While the European regulation clearly defines that the RFNBOs themselves have to be accounted based on a mass-balance system, there are no clear requirements with a view to the underlying electricity supply (also taking into account that the defined requirements are supposed to be applicable on a global scale, also out of the scope of the general EU legislative framework). However, in case that a national GO-like system applies, these GOs have to be duly cancelled together with the PPA supply.

RFNBOs are a relevant case for energy conversion, so it is also worth noting that the related regulation clarifies that the accounting towards EU renewable energy targets of Article 3 is only done based on the RFNBO consumption, while the renewable electricity used to produce the RFNBOs is not counted towards this target. This avoids double counting of renewable attributes with respect to RES targets (Communication from the Commission – Guidance on the targets for the consumption of renewable fuels of non-biological origin in the industry and transport sectors laid down in Articles 22a, 22b and 25 of Directive (EU) 2018/2001 on the promotion of energy from renewable sources, as amended by Directive (EU) 2023/2413, 2025/27.05.2025).

Within the scope of this project, the assessment of RFNBOs as innovative approach particularly not only refers to the tracking requirements for the RFNBOs themselves, but also includes the key aspects on tracking and accounting of the electricity-specific criteria for RFNBOs in the sense of Art. 27 RES Directive and the related Delegated Regulation. It hereby includes as underlying criteria the eligibility and additionality criteria, including geographical and temporal correlation, for the supplied electricity as defined by the Delegated Regulation in order to consider the FNBOs as renewable. However, it should be noted that the description and evaluation of this approach in the standardised format as applied by this project does not fully reflect the complexity of describing both the aspects relating to accounting and disclosure of the RFNBOs themselves on the one hand, and to accounting and disclosure of the underlying electricity on the other.

The full description and assessment of an overall disclosure concept depends on the detailed implementation of all other aspects of a given disclosure concept, in which some RFNBO-specific rules, and particularly a distinction of disclosure information based on similar criteria, may be integrated. For that purpose, the rules would have to be adapted in order to work in a general disclosure environment (rather than only be applicable with a view to very specific individual offtaking installations).

Evaluation results:

The structured evaluation of the RFNBO-specific characteristics outlined above in the context of this project is related to high uncertainties, as most of the underlying criteria and related sub-criteria would depend on the detailed implementation of the more comprehensive disclosure system. Out of 38 assessed criteria in total, 24 have an uncertainty level of 50% or higher (meaning that for these criteria at least half of the respectively relevant sub-criteria can not be assessed based on the given design specifications). Still, the influence of the RFNBO specific design specifications result in an overall positive influence on the evaluation results for all stakeholder groups.

For **households**, the application of RFNBO criteria would positively contribute to the overall benefits by supporting the choice of supply based on geographical preferences, being predominantly geographical correlation, and by supporting a clear distinction according to the environmental performance based on additionality criteria. It also can contribute to the provision of information on relevant energy sources and environmental sub-criteria to consumers without easy options for resource shuffling, i.e. the mere re-allocation of existing capacities.

Organisations could also benefit by positive effects with a view to several criteria. This includes the enabling of 24/7 matching strategies and granular emissions accounting, as well as deductions about spatial and temporal correlation. Furthermore, such criteria could support the assessment of impactful procurement/additionality criteria.

For **plant operators**, positive effects would be related to the criteria on the definition of market boundaries and accounting periods preventing oversupply, and information on additionality characteristics of RES supply would be provided. Furthermore, with a view to RFNBO markets, relevant information would be provided on requirements for participation in compliance markets.

For **society as a whole** also positive effects are indicated by the applied evaluation criteria, while for most of these a high uncertainty factor applies. For example, the disclosure system could provide incentives for system-friendly energy consumption behaviour by an alignment with RES availability taking grid constraints into account, as tracking and disclosure of energy attributes would – to some extent – be linked to physical system restrictions for energy supply. Furthermore, consumers would be more empowered for a contribution to energy transition by a clear distinction according to the environmental performance based on additionality criteria, by the promotion of energy supply including "additionality" aspect., and by information being made available to consumers on energy-specific additionality indicators. Furthermore, a link to RFNBO rules could help in defining the scope and purpose of the respective disclosure system, and to coordinate it with other relevant tracking systems (particularly relating to target and support).

8.3.3 Innovative disclosure concepts

8.3.3.1 The Guarantees of Renewable Origin for cross-sectoral quota (GRO)

Description of the disclosure concept:

The Guarantees of Renewable Origin (GRO) mechanism, proposed by the Florence School of Regulation (FSR), presents a forward-looking and integrated approach to renewable energy disclosure and compliance in the EU (Pototschnig & Conti, 2021). It aims to transform the existing voluntary Guarantees of Origin (GOs) system into a **legally binding, market-based tool that aligns consumer disclosure with the enforcement of renewable energy obligations**. The primary goal is to achieve the EU's renewable energy targets at the lowest possible cost by enabling a flexible, cross-sectoral and cross-border trading mechanism for renewable energy certificates.

At its core, the GRO concept introduces a statutory **framework that applies uniformly across all energy carriers**—electricity, gas (including hydrogen), and heating and cooling—by issuing GROs for each verified unit of renewable energy. Consumers or their suppliers are then obliged to hold GROs corresponding to a certain share of their final energy consumption. This quota-based obligation ensures that all sectors contribute to renewable targets, while allowing differentiation based on sector or region if needed. Crucially, GROs would serve a dual function: as proof of renewable sourcing for consumers and as compliance instruments for meeting regulatory targets.

A central innovation of the GRO mechanism lies in its **cross-sector and cross-border flexibility.** GROs are fully tradable across jurisdictions and energy carriers, allowing actors in high-cost decarbonisation sectors to purchase GROs from lower-cost areas or vectors. For example, a hydrogen consumer may fulfil their obligation using GROs originating from solar power. This flexibility promotes cost-efficiency and helps equalise the marginal cost of decarbonisation across the energy system. The trading system is envisioned to be underpinned by a unified EU-wide registry to ensure transparency, eliminate double-counting, and facilitate enforcement.

Design considerations include the geographical and temporal scope of GRO obligations. While the long-term vision is an EU-wide mechanism, the system could initially scale through regional clusters, following a harmonised design. The timing of obligations could default to annual targets, with the potential to evolve towards more granular (e.g. quarterly or monthly) reporting and surrender cycles to better reflect real-time consumption-production matching and policy objectives.

Governance would rely on national or regional issuing bodies operating under common EU standards. Enforcement mechanisms would include non-compliance penalties, which also function as a price ceiling for GROs. Importantly, the GRO system is designed to be compatible with existing technology-specific support schemes, thus maintaining flexibility while enabling integration with market mechanisms.

It is argued that this concept of Guarantees of Renewable Origin should contribute to achieving renewable energy penetration targets at least cost. Consumers or their suppliers are then obliged to hold GROs corresponding to a certain share of their final energy consumption. This quota-based obligation ensures that all sectors contribute to renewable targets, while allowing differentiation based on sector or region if needed. Crucially, GROs would serve a **dual function**: as **proof of renewable sourcing for consumers** and as **compliance instruments for meeting regulatory targets**.

As the renewable energy penetration target is expressed in terms of final energy consumption, an obligation would be imposed on energy consumers, or, in the case of small consumers buying from suppliers, on the suppliers serving them, to procure an amount of GROs equal to a pre-defined share of their final energy consumption. In the following, this obligation will be referred to as the "GRO obligation".

Despite its advantages, the GRO concept faces **significant implementation challenges**.

Introducing GROs would require a legislative overhaul of the existing GOs system and revision of sector-specific targets such as those for hydrogen or biomethane under RED III.

While the FSR paper states that this pre-defined share of the GRO obligation might be the same or differentiate for different types of consumers and energy vectors, the differentiated approach is probably desirable, to integrate learnings from existing quota obligation systems with green certificates, even while those did not integrate disclosure purposes. Quota obligations have proven to work, yet differentiation for technologies and subsectors prevents windfall profits[39] for certain mature technologies and incentivises needed innovations. Past experiences with quota-based certificate systems in countries like Belgium, Italy, and Sweden show that without careful design, such systems can lead to windfall profits for mature technologies and fail to support emerging ones, prompting governments to revert to fixed-premium schemes or impose corrective adjustments.

While for suppliers, it may become more challenging to continue making up to historic 100% renewable energy supply promises if their portfolios include expensive renewable energy technologies, consumers may be additionally empowered to steer the production park to the renewable technologies of their choice because of the mechanism's cross-sector and cross-border flexibility. GROs are fully tradable across jurisdictions and energy carriers, allowing actors in high-cost decarbonisation sectors to purchase GROs from lower-cost areas or vectors.

[39] Windfall profits are unexpectedly large financial gains that a company or individual earns due to external factors (like favorable changes of regulations) rather than their own effort or investment decisions.

For example, a hydrogen consumer may fulfil their obligation using GROs originating from solar power.

However, cross-jurisdictional quota have been proven to only work if the parameters in quota systems in different national jurisdictions (penalty levels, eligible energy quantities, surrounding complementary support systems) are co-designed, to ensure a level playing field in terms of overall support for a certain type and quantity of renewable energy. This is both shown with the successful integration of the Swedish-Norwegian ElCert systems, and the challenges encountered within the Belgian regions in the attempt to develop a recognition framework for quota certificates from another region with different penalty levels or different represented quantities of energy per certificate.

To address these risks, robust safeguards must be embedded to prevent virtual greenwashing, ensure system integrity, and avoid double-counting. The GRO mechanism assumes that the existing European GO framework (as structured under EECS and EN 16325) remains in place, evolving rather than replacing it. If implemented with care, the GRO model holds the potential to transform Europe's renewable energy disclosure into a cost-effective, integrated, and scalable system aligned with long-term climate and energy goals.

Evaluation results:

The Guarantees of Renewable Origin (GRO) disclosure approach, as proposed in the academic literature, represents an innovative and integrated mechanism for tracking and attributing renewable energy consumption across sectors and borders. While its full impact depends heavily on the specifics of its eventual implementation, the conceptual design suggests substantial benefits, particularly for **organisations.** GRO ranks very highly in terms of its potential organisational advantages, meeting all the evaluation criteria, albeit with a considerable level of uncertainty. This uncertainty stems from the early-stage nature of the concept, which leaves several aspects either unspecified or insufficiently detailed. Nonetheless, two criteria stand out with both high benefit and high certainty, offering a clearer picture of GRO's value for organisational stakeholders.

The first of these criteria relates to the ability of energy disclosure to enable deductions about spatial correlations. GRO fulfills this requirement by necessitating that the geographic origin of renewable energy—at a minimum the country level—is tracked. This geographic tracking is essential for the functioning of cross-border trading and regional clustering within the GRO mechanism. As a result, the system supports multiple compliance objectives for organisations, including alignment with GHG accounting standards, adherence to low-carbon and green market initiatives, fulfillment of regulatory disclosure mandates, and the formulation of more impactful and location-sensitive decarbonisation strategies. Additionally, it facilitates compliance with emerging GHG accounting standards, ensuring that organisational reporting remains robust and credible in evolving policy contexts.

The second criterion with high certainty is the tracking and transfer of ownership of energy attributes. Within the GRO framework, renewable energy attributes are registered and tracked in a centralised EU-wide registry. GROs must be surrendered or cancelled in order to substantiate renewable energy claims, ensuring that attributes cannot be double-counted and that ownership is clearly defined. This provides organisations with a secure and transparent mechanism for demonstrating renewable sourcing, fulfilling compliance obligations, and participating confidently in energy attribute markets.

For **plant operators**, the GRO system also offers notable advantages, although the benefits are evaluated with slightly less certainty. One criterion is identified with a high level of confidence: 'consistency between disclosure and target accounting'. The GRO approach is designed not only to serve as an instrument for consumer disclosure but also as a means of accounting for national progress towards renewable energy targets. This dual function supports policy monitoring and enhances the credibility of renewable energy statistics. In turn, it can create additional revenue opportunities for plant operators in short-term markets through the sale of green attributes, as the accurate accounting and verification of renewable energy production become more valuable under regulatory and market-based mechanisms.

In contrast, the benefits of GRO for **households** and **society** are more limited and accompanied by greater uncertainty. However, two criteria are fulfilled with sufficient clarity to suggest meaningful societal advantages. Firstly, the GRO system provides centrally available information and statistics, which can be used for purposes beyond energy disclosure. This includes supporting policy development, target monitoring, and the design of renewable energy support schemes. Such transparency enables better-informed public debate and policy decisions, contributing to a more engaged and energy-literate society. Secondly, the GRO mechanism defines its scope and purpose in coordination with other relevant tracking systems, especially those used for target compliance and financial support schemes. This harmonisation reduces bureaucratic complexity and enhances the efficiency of administrative processes that benefits the society at large.

8.3.3.2 GO beyond targets

Description of the disclosure concept:

In the current policy framework, public renewable energy (RES) targets take into account all deployment of renewable energy, regardless of whether it is initiated by public support or voluntary consumer demand. At the same time, it can be assumed that policymakers will design public support schemes flexibly to meet the set targets at best, while the level of support is likely to be lowered if a large proportion of new investment is driven by voluntary demand. The most relevant effect which European consumers of renewable electricity can thereby achieve through their choice of electricity supply is to contribute to reaching the existing targets. This also means that less motivated actors, such as policymakers and grey consumers, will be less responsible and incur fewer costs. Based on this argumentation, Seebach and Timpe (2020b) have proposed a regulatory approach in order to give energy consumers the possibility for making a real difference by their choice of supply and to actually trigger an increased volume of renewable energy production. They refer to this level of additional benefit as 'hard additionality'. As key aspects, the discussion paper proposes the following regulatory and technical preconditions to be implemented:

- Market participants should be empowered to ensure that renewable electricity generated by new and unsupported plants and which potentially fulfils further eligibility criteria is not fully attributed to existing political renewables targets at EU and national levels, but only with a basic share of 20 %. The remaining 80 % of the eligible renewable production can be considered to be really additional.
- Monitoring and statistical attribution by public bodies should be done on the basis of existing systems for GOs, which are amended by two different features:
  1. In order to finance new and unsupported RES production through the demand for this electricity, eligible GOs should be established and marketed as 'GOplus'. For such GOplus, a premium market niche can emerge as a consequence of the demand of highly committed consumers.
  2. RES production which is new and (otherwise) unsupported and which benefits from private direct funding of the plant itself e.g. in the context of a 'fund model approach' by a green electricity supplier should be marked by a GO earmark. This earmark should also

specify the mechanism for the private funding. This could be private funding in the context of the Union Financing Mechanism according to Art. 33 of the Governance Regulation (FinMech target earmark), and/or a voluntary green energy label which applies appropriate criteria (private fund target earmark).

The authors state that while they consider this approach for hard additionality to be particularly relevant for the case of renewable electricity, it could analogously be applied to other forms of renewable energy.

The described aspects can be implemented in principle in a broad variety of GO-based disclosure systems, particularly in the electricity sector. For the context of this project and the applied standardised evaluation framework this means that many of the standardised disclosure specifications depend on the detailed implementation. Therefore, many of the standardised sub-criteria and the subsequent evaluation are depending on further aspect, while the automated evaluation focuses to the extent possible on the effects that are caused by the implementation of such 'GOs beyond targets', or 'GOplus' as they have been called by the authors of the quoted discussion paper.

Evaluation results:

The structured evaluation of proposal to introduce GOs beyond targets as outlined above in the context of this project is related to high uncertainties, as most of the underlying criteria and related sub-criteria would depend on the detailed implementation of the more comprehensive disclosure system. Out of 38 assessed criteria in total, 36 have an uncertainty level of 50% or higher (meaning that for these criteria at least half of the respectively relevant sub-criteria cannot be assessed based on the given design specifications). Still, the influence of design specifications for hourly matching indicates a positive influence on the evaluation results for all stakeholder groups, while the assessment results only apply to the rather detailed aspect of "GOs beyond targets".

Households benefit particularly by a stronger option to make an active choice supporting the energy transition, as is indicated by the relevant criteria that information on energy-specific additionality indicators is available to consumers. That the energy disclosure system includes clear distinction according to the environmental performance based on additionality criteria, and particularly by the option for consumers to increase public (RES) targets.

For **organisations**, particular benefits occur by a positive influence on enabling deductions about spatial correlations, and by the improved provision of information that enables to assess impactful procurement/additionality criteria.

For **plant operators**, a major benefit would result from the information provision on additionality characteristics of RES supply, and therefore (in case the respective plants are in line with the requirement) additional marketing options arise.

Society as a whole could benefit from this approach particularly by a strong option for contribution to the energy transition, which is indicated by various criteria.

8.3.3.3 Limiting geographical boundaries within the existing Guarantees of Origin (GO) system

Description of the disclosure concept:

The study titled 'Relevance of guarantees of origin for Europe's renewable energy targets' from Holzapfel et al. (2024) puts forward a significant evolution of the existing Guarantees of Origin (GO) system, specifically for electricity (Holzapfel et al., 2024). Developed by researchers at TU Berlin, the concept responds to growing concerns that the **current GO framework does not sufficiently support the EU's renewable energy and decarbonisation goals**. According to the authors, the disconnect between governmental target-setting methodologies and voluntary market-based instruments, such as GOs, results in **limited impact of the disclosure system on real-world energy transitions.**

To address these shortcomings, the study proposes the introduction of **geographical 'guard-rails' within the GO system**. These guardrails are intended to enhance the accuracy and credibility of renewable energy disclosure by ensuring that GOs more closely reflect the physical generation and consumption of electricity within national systems. By **limiting the cross-border transfer of GOs**, the proposed model aims to increase national responsibility for renewable energy development and make the disclosed renewable shares more representative of a country's actual system performance.

The authors outline several possible implementation models. One option is **conditional transfer, where GOs can only be exported if a country has already met its domestic renewable electricity targets**. Another model suggests a **full prohibition on GO exports**, keeping certificates entirely within national borders for accounting purposes. A third approach involves flow-based restrictions, in which **GOs may only be transferred between countries that share physical electricity interconnections**. These models are designed to align the disclosure mechanism with physical grid flows and renewable deployment realities, building on ideas echoed by ENTSO-E in their 2022 proposals (ENTSO-E, 2022).

Crucially, the study proposes a **multipurpose GO model that combines voluntary consumer choice with enforceable national obligations**. This would enable GOs to serve both as disclosure tools and as mechanisms for compliance with renewable targets, thus broadening their policy relevance. However, to effectively support such a transformation, further research and refinement of the GO system are needed. In particular, the authors stress the importance of **integrating additionality requirements**—ensuring that certificates represent new renewable generation—as well as improving the temporal and spatial granularity of market-based accounting practices.

The study's assessment is framed as a **reform of the current GO syste**m rather than a complete overhaul. It assumes that the broader EU disclosure framework remains intact and focuses specifically on electricity, not extending its conclusions to gas or other energy carriers. Nevertheless, the proposed reforms could have far-reaching implications for the future of energy attribute tracking and the credibility of consumer-facing renewable energy claims. By anchoring GO transfers more closely to physical and policy realities, the approach seeks to strengthen the GO system's contribution to the energy transition and better integrate it with national and European climate objectives.

Evaluation results:

The proposed innovative disclosure concept, which introduces a limitation of geographical boundaries within the existing GO system, appears to provide benefits across all stakeholder groups. While the concept demonstrates high potential, most of the evaluated criteria are fulfilled with a considerable degree of uncertainty. The greatest advantages are seen for **organisations** and **plant operators**, while **households** and **society** as a whole derive more indirect and less immediate benefits.

Plant operators benefit the most from the implementation of this disclosure concept. Nearly all assessment criteria are met, although only three of them are associated with a 0% uncertainty factor. The first of these is the criterion 'consistency between disclosure and target accounting'. This benefit arises from the concept's ability to align the disclosure of energy attributes and the trade of energy attribute certificates (EACs) with broader climate and energy policy targets. The disclosure framework allows for information on renewable energy source (RES) plants and their generation to be used for several purposes simultaneously—such as attribute tracking, administrative reporting, and statistical analysis. This multi-functionality enhances the practical value of disclosed data and strengthens its relevance in market-based instruments. Consequently, plant operators can benefit financially through increased opportunities for selling green attributes in short-term energy markets.

The second criterion fully met with no uncertainty is 'tracking and exclusion of double counting of green attributes across energy carriers'. This means that when energy is converted from one form to another—for example, from renewable electricity into green hydrogen—the system ensures that the environmental benefits are not claimed more than once. The disclosure concept ensures a single, traceable path for these attributes, preserving their environmental value through conversion processes. This supports the credible transfer of green attributes from inputs to outputs, enabling plant operators to derive value from renewable content not only in production but also in subsequent stages of energy use and transformation.

The third criterion fully met with no uncertainty factor would be the criterion 'unique claims on origin from RES'. This is because the concept would still be based on the principles of European GO system, which entails tracking and clear allocation of energy attributes as well as provides a residual mix calculation, both enabling unique claims on the origin of RES.

Organisations also benefit significantly from this disclosure framework. Almost all evaluated criteria show a positive fulfillment, though all of them carry a considerable level of uncertainty. The criterion with the lowest uncertainty concerns the prevention of double counting and double claiming. The proposed disclosure concept addresses this by innovatively limiting the geographical boundaries within the existing GO system.

For organisations, these improvements enable a range of strategic and compliance-related benefits. The system facilitates the implementation of renewable energy purchase agreements and supports compliance with GHG accounting standards and regulatory frameworks related to low-carbon initiatives. It also helps organisations to respond to growing stakeholder expectations, manage reputational risks, and position themselves as leaders in environmental sustainability. In simpler terms, the framework empowers companies to make credible and verifiable green claims about their energy usage and sustainability practices, which is increasingly important for maintaining investor confidence, brand integrity, and alignment with environmental goals.

Household consumers benefit to a lesser extent, with the most meaningful impact being psychological and motivational. The system helps individuals feel more involved in the energy transition process by offering a stronger sense of connection to renewable energy sources and more transparent insights into how their energy use aligns with broader sustainability goals. In essence, it enhances the emotional engagement of consumers by making the energy transition more tangible and accessible, even if they are not directly interacting with the GO system themselves.

For **society** at large, the innovative disclosure concept contributes to the reduction of administrative burdens and supports greater efficiency in policy implementation. By streamlining the geographical scope within the GO system, it simplifies governance structures and facilitates clearer, more accountable tracking of energy attributes. Additionally, the concept offers synergies beyond corporate disclosure, as the same tracking mechanisms can be leveraged for other purposes such as setting and monitoring policy targets or administering support mechanisms. In this way, the framework contributes to broader societal benefits by improving the overall transparency, coordination, and reliability of energy-related data, which is essential for effective climate governance and energy system planning.

8.3.3.4 System benefits of enhanced temporality in EACs (hourly matching)

Description of the disclosure concept:

This innovative concept describes the application of an hourly matching requirement in disclosure systems. Such a requirement is broadly discussed for various applications, including the further application in the context of the scope 2 accounting, the application of RFNBO requirements based on European legislation, and for common disclosure rules particularly in the electricity sector. For the purpose of description and evaluation of the concept in the context of this project, further key features besides the hourly matching as such are assumed. This includes any sort of geographical matching, in order to reflect the relevance of hourly matching only within the scope of a given common technical energy system, while temporal correlation is hardly relevant in case that the point of production and the point of consumption are located in non- or poorly connected energy systems. Furthermore, this approach assumes as a basic precondition that the related energy attributes can be allocated to a specific consumer as beneficiary and that there is an automated coordination of real time (hourly) data for consumption and production of the renewable fuel Furthermore, in order to allow for meaningful effects of such a matching requirement, it is assumed that the disclosure mechanism or any related mechanism provides real time or even advance information on the availability of energy from specific sources in order to allow for consumers to conduct demand side management measures on his side, thus striving for increasing the share of renewables of his energy consumption. This also includes a high level of digitalisation and automation of data provision and verification processes of disclosed information on the origin of energy, and the existence of automated systems for the collection and transfer of energy production data.

The described aspects are considered feasible to apply within a comprehensive disclosure system, while many of the standardised disclosure specifications in our project-specific analytical framework obviously depend on the detailed implementation. Therefore, many of the standardised sub-criteria and the subsequent evaluation are depending on further aspect, while the automated evaluation focuses to the extent possible on the effects that are caused by the implementation of the hourly correlation requirement.

Evaluation results:

The structured evaluation of the hourly matching as outlined above in the context of this project is related to high uncertainties, as most of the underlying criteria and related sub-criteria would depend on the detailed implementation of the more comprehensive disclosure system. Out of 38 assessed criteria in total, 34 have an uncertainty level of 50% or higher (meaning that for these criteria at least half of the respectively relevant sub-criteria cannot be assessed based on the given design specifications). Still, the influence of design specifications for hourly matching indicates a positive influence on the evaluation results for most stakeholder groups.

For **households**, none of the defined sub-criteria, criteria and benefits directly is influenced by the temporal matching criterion, so no significant influence is indicated.

For **organisations**, a positive influence with a relevant level of certainty is seen as energy disclosure enables 24/7 matching strategies and granular emissions accounting, and enables deductions about temporal correlation.

For **plant operators**, a particular positive influence is seen by the definition of market boundaries and an accounting period which prevents oversupply.

For **society as a whole**, with a considerably high level of uncertainty, a positive influence is indicated for the criteria of administrative efficiency due to the assumed features of automated data handling. Furthermore, the temporal correlation contributes to the provision of incentives for storage development. It also is considered beneficial for the provision of incentives for system-friendly energy consumption behavior (by the alignment with RES availability, taking grid constraints into account) and to a stronger link of the tracking and disclosure systems to physical system restrictions for energy supply.

8.3.3.5 Concept for a full disclosure obligation for heating and cooling suppliers in Germany

Description of the disclosure concept:

The concept of a full disclosure obligation for H&C grids in Germany was elaborated in the context of the research project 'IW3 – Integrierte WärmeWende Wilhelmsburg' supported by the German Federal Ministry for Economic Affairs and Climate Action (FKZ 03EWR006MB) and being part of the 'NextGenerationEU' programme.

In the context of green H&C products, disclosure requirements for H&C suppliers were analysed and the option of a full disclosure of H&C grids and the use of GOs as central reporting and verification instrument was analysed (Kemper, Styles, Schickling, & Werner, 2024; Styles & Claas-Reuther, 2023). The concept builds upon existing disclosure obligations for heating and cooling (H&C) suppliers in Germany, which currently require information on energy mix, GHG emissions and the PEF regarding the entire grid. However, the use of GOs is only mandatory for renewable energy amounts that are promised to customers. Hence, a full disclosure obligation would mean that GOs would need to be issued for all energy volumes that are fed into a H&C grid. GOs would need to be cancelled for each amount of energy delivered to a supplier accordingly (including grid and storage losses). If GO use is limited to interconnected grids, full disclosure could in principle also be opted for voluntarily on a grid-by-grid basis.

A full disclosure obligation, in combination with respectively harmonised legislation for the district H&C sector, would enable GOs to function as a unified and central reporting instrument for all disclosure or reporting obligations across the district H&C sector. Energy amounts fed into the grid would be verified through GOs, which would then provide a reliable data basis for calculating environmental performance metrics of H&C supply, such as GHG emissions or the PEF to support further reporting requirements. This approach would streamline enforcement, reporting, and verification processes by establishing GOs as the standard tool for transparency and monitoring in various regulatory and policy contexts (e.g. disclosure obligations towards customers or in the context of public support as well as in the context of monitoring policy targets). In this way, GOs could ensure consistency and efficiency in verification processed towards the several disclosure requirements H&C suppliers are facing.

By combining the full disclosure obligation with a highly digitalised and automated implementation approach, administrative efficiency can be further improved. This would require the GO registry to provide APIs, facilitating streamlined data verification and transmission—for example, by using certified smart meters that send valid and verified data directly to the GO registry. Allowing regulatory authorities to access the registry directly would further simplify the enforcement of relevant legislation.

Evaluation results:

The concept of a full disclosure obligation for H&C grids in Germany appears to offer **benefits for all stakeholder groups**. However, since this obligation currently exists only at a conceptual level and the GO registry for heating and cooling, which the concept heavily relies on, has not yet been implemented, the evaluation of related criteria is often associated with high levels of uncertainty.

Same as the current implementation of H&C disclosure in Germany, a full disclosure obligation for H&C grids would show benefits because disclosure is limited to the physical H&C system boundaries. This especially benefits **households and society as a whole**, as resource shuffling would not be possible and energy disclosure is based on a physical correlation of supply and consumption.

Households would additionally benefit from the fact that information on additionality criteria would be available. Furthermore, they would be enabled to make an active choice when procuring H&C products. As changing H&C grid connections is not possible for H&C consumers and product differentiation is not broadly offered by H&C suppliers, the active choice of households in terms of H&C products would still be quite limited due to the mainly monopolistic nature of the sector.

In terms of **society as a whole,** another benefitting aspect would be the integration of storage systems in disclosure obligations providing incentives for storage development. Additionally, as per evaluation results, system-friendly energy consumption behavior could be supported by a full disclosure obligation for H&C in Germany. It must be noted, that these results are associated with a relatively high uncertainty factor, as this would still depend on the actual implementation of the concept.
Although the criteria of administrative efficiency could not be assessed because the concept is highly dependent on the implementation of the GO registry for heating and cooling in Germany in terms of digitisation, automation and coherence, a full disclosure obligation for H&C in Germany would provide centrally available information and statistics benefitting society as a whole. Furthermore, by combining full disclosure with harmonised verification processes along regulatory requirements for the district H&C sector, this concept would be beneficial for society as a whole as it would be consistent and aligned with other policy instruments as well as coordinated with other tracking systems. This would however still depend on the implementation of the concept, which is why these criteria are associated with a relatively high uncertainty factor.
However, there is low benefit in allowing consumers to increase public (RES) targets which results from the fact that no 'GO beyond target' concept is incorporated by the full disclosure obligation for H&C grids and might additionally be limited by low purchasing power due to the monopolistic nature of the district H&C sector.

For **plant operators** a full disclosure obligation alongside with a harmonisation of verification processes in the context of different regulatory requirements would be beneficial, as consistency between disclosure and target accounting would be achieved and unique claims on the origin of renewable energy could be provided. Furthermore, administrative efficiency would be supported. However, this would depend on the implementation of the GO registry for H&C, which is why this criterion comes with a relatively high uncertainty factor. Same applies to the availability of additionality information and the definition of market boundaries that prevent oversupply.

Organisations would benefit from a full disclosure obligation for H&C grids, as spatial correlation being a criterion in the context of impactful procurement strategies would be ensured by the system boundaries of H&C disclosure being limited to one respective H&C

system. All other benefits for organisations come with high uncertainty factors and would in the end depend on the actual implementation of a GO registry and its information provision and accessibility for consumers. This would for example affect the administrative efficiency of energy disclosure for organisations. Criteria regarding energy disclosure serving as a proof for renewable energy procurement within different contexts and ensuring tracking and transfer of ownership of attributes also come with high uncertainty factors. However, this is primarily because no definitive assessment of their actual implementation can be made at this stage. Nevertheless, the concept of full disclosure is specifically designed to address these challenges by enhancing transparency and credibility.

8.3.3.6 Corporate disclosure following the proposal for a revised GHG Protocol Scope 2 Guidance

Description of the disclosure concept:

The GHGP's Corporate Suite of Standards and Guidance is currently undergoing a comprehensive revision process. This includes the Corporate Accounting and Reporting Standard (2004), the Corporate Value Chain (Scope 3) Standard (2011), the Scope 3 Calculation Guidance (2013), and Scope 2 Guidance (2015), and, in terms of accounting scopes, Scopes 1, 2 and 3 (Greenhouse Gas Protocol, World Resources Institute, & World Business Council for Sustainable Development, 2025a). The revision is carried out in a multi-stakeholder process. Between November 2022 and March 2023, a public survey was conducted to gather feedback on current standards and guidance as well as proposals for development perspectives (GHG Protocol et al., 2024; GHG Protocol, WRI, & WBCSD, 2023). Following a global application process, members of the Steering Committee, Independent Standards Board and Technical Working Groups were announced in September 2024, including experts from business, NGOs, academia, and governments (Greenhouse Gas Protocol, World Resources Institute, & World Business Council for Sustainable Development, 2025b). Broader feedback on revision proposals is gathered in public consultations, and meeting materials and minutes are available through a public governance repository to ensure transparency (Greenhouse Gas Protocol, World Resources Institute, & World Business Council for Sustainable Development, 2025e).

The integration of energy disclosure information into GHG accounting is particularly relevant in the revision of the Scope 2 Guidance, which covers indirect emissions from purchased and consumed electricity. A detailed proposal has been published in October 2025 (GHG Protocol et al., 2025b). Furthermore, insight on the direction of revisions is made available through regular GHGP secretariat progress updates e.g. (Greenhouse Gas Protocol, World Resources Institute, & World Business Council for Sustainable Development, 2025c) and the governance repository. To enhance the accuracy, comparability, and credibility of reported Scope 2 emissions, the revision proposal increases the stringency of geographical and temporal matching requirements when claims on carbon-free energy purchases are concerned, among other clarifications and revisions.

Under the current version of the guidance, it is possible to report on 100 % RES-based electricity purchases based on EAC cancellation from RES projects in regions which are not interconnected with an electricity consumer's location, and without reference to the availability of RES resources at the time of consumption (e.g. electricity consumption at night in Germany could be covered by attribute purchases from solar plants in Spain, without regard to whether storage systems are in place or whether electricity production was physically deliverable when taking e.g. interconnector capacities into account). In the current proposal, hourly matching is proposed as a requirement for claims on carbon free energy procurement (allowing for the use of standardised profile data where activity data is not available); exemptions are proposed for organisations with electricity consumption below a certain threshold within a market boundary. Moreover, regarding geographical matching, physical deliverability constraints are proposed which relate to market boundaries. Market boundaries are operationalised differently depending on electricity market organisation in different world regions but include zonal pricing boundaries where applicable (such as bidding zones in the European electricity market). Attribute transfers from adjacent and directly connected markets are permissible if excess transmission capacity can be demonstrated via electricity price differentials in respective markets. Transfers from any point in an interconnected system are permissible if exclusive rights regarding the provision of transmission capacity can be demonstrated on an hourly basis. Besides the market-based method for emissions accounting, higher locational and temporal granularity is also foreseen for the location-based method, if data is publicly and freely available.

In addition to dual reporting of results from market- and location-based approaches, the introduction of a third, new impact-based metric is under discussion, the Marginal Emissions Impact (GHG Protocol et al., 2025a). Besides other considerations, the metric includes different additionality tests to estimate how much fossil fuel emissions are displaced by carbon-free energy purchases. As an accounting method and reporting metric, it would be independent and separate from market- and location-based GHG inventory accounting methods. Discussions on this metric span several Technical Working Groups in the revision process, and it is yet unclear whether, if adopted, reporting on Marginal Emissions Impact would be an optional or binding requirement when implementing the GHGP standards and guidance.

Evaluation results:

As the GHG Protocol Scope 2 Guidance itself does not represent an energy disclosure concept but rather a corporate disclosure concept it must be noted that some design specification sub-criteria could not be assessed as they were not applicable. Furthermore, the GHG Protocol Scope 2 revisions are not yet final, so that some sub-criteria could not be assessed. This is why the results show relatively high uncertainty factors.

The currently proposed GHG Protocol Scope 2 Guidance revisions overall seem to be most beneficial for organisations, followed by plant operators and society as a whole. They are evaluated as being less beneficial for households. Most of the evaluation results remain the same as for the GHG Protocol scope 2 Guidance (see chapter 8.3.2.1). This is because the revisions do not affect the whole GHG Protocol Scope 2 Guidance but rather provide adjustments in certain aspects. However, some criteria score differently due to the changes proposed in the revision.

For instance, the proposed GHG Protocol Scope 2 Guidance revisions would better benefit **households**, due to the redefined market boundaries for energy accounting. These support the consumer's choice based on geographical preferences and resource shuffling is prevented.

In terms of **organisations**, by the proposed revisions within the GHG Protocol Scope 2 Guidance, the criterion 'energy disclosure serves as proof for renewable energy procurement' would score higher and as a result is rated as more beneficial. This is because the sub-criterion 'Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure' was assessed as having 'no conclusion' as there is a reporting requirement regarding this disclosure obligation under discussion.

Regarding **plant operators** most beneficial aspects of the GHG Protocol Scope 2 Guidance revisions would be the redefinition of market boundaries that would prevent oversupply and might lead to higher revenues when selling energy attributes in short-term markets. This is shown by a higher score of the respective criterion.

However, the revisions of the GHG Protocol Scope 2 Guidance seem to be **most beneficial for the society as a whole**. The redefinition of market boundaries also seem to be very beneficial for society as a whole. This is because, for example, resource shuffling is avoided. Furthermore, the revisions of the Scope 2 Guidance would affect incentives for storage development as well as system-friendly energy consumption behavior. In terms of system-friendly energy consumption the higher score and hence increased benefit for society as a whole also stems from the redefined market boundaries under the GHG Protocol Scope 2 Guidance revisions. The sub-criteria allocated to this criterion and were applicable to the GHG Protocol Scope 2 Guidance revisions mostly refer to physical deliverability that is taken into account when redefining the market boundaries. Same applies for the incentives for storage development. But, it has to be noted that these criteria are also accompanied by relatively high uncertainty factors.

8.3.3.7 Germany: Draft gas disclosure obligations

Description of the disclosure concept:

In Germany, the Guarantees of Origin and disclosure scheme for gas and hydrogen is still under implementation (as of January 2026, see UBA, 2026). The German draft gas disclosure obligations are therefore included in the analysis as an innovative rather than an existing disclosure concept. The RED II's requirements on the issuance of Gas GOs were implemented into national law by the Guarantees of Origin Registry Law (HkNRG)[40] of 4 January 2023, which provides the legal framework for issuing, transferring and cancelling GOs and creating GO registries for gas, heating or cooling from renewable energies. Detailed rules for issuing, transferring and cancelling GOs were implemented in the Gas Heating and Cooling Guarantees of Origin Registry Ordinance (GWKHV)[41] of 25 April 2024. The start of the gas GO registry is planned for 2026 (UBA, 2026).

The national legal implementation of gas disclosure obligations formulated in Annex 1 Nr. 5 of the Gas Directive (EU) 2024/1788 and Article 19 (8) of the RED III (EU) 2018/2001, last amended by Directive 2024/1711) is currently still at a drafting stage. A draft bill was published on November 4th 2025[42]. The analysis of the German gas disclosure system is based on this draft bill (BMWE, 2026) from November 2025 as well as on the established gas GO legislation provided by HkNRG and GWKHV.

As for electricity, gas disclosure obligations are to be legally implemented in the Energy Industry Law (Energiewirtschaftsgesetz, EnWG)[43]. Basic design principles are closely aligned with German electricity and H&C disclosure obligations. According to the draft law, gas and hydrogen suppliers will be obligated to publish a product-specific energy mix as part of their billing information for final consumers. Information on the supplier's total gas and hydrogen energy mix must be published either on the supplier's website or as part of the billing information. Differentiated information will have to be provided on the share of different gas types (distinguishing between gas from renewable sources, low carbon gas, gas from non-renewable and non-low carbon sources in a residual mix, hydrogen from renewable sources, low carbon hydrogen, hydrogen from non-renewable and non-low carbon sources in a residual mix). Disclosure rules differentiate between gas and hydrogen deliveries. If hydrogen is injected into gas grids, GO cancellation for hydrogen is limited to a share corresponding to the technical blending limit in the respective grid.

Moreover, with regard to the supplier's total energy mix, suppliers will need to provide information on their energy mix in Germany and, if the supplier is active in other countries as well, the overall energy mix. For both product and total energy mixes, environmental

[40] Herkunftsnachweisregistergesetz vom 4. Januar 2023 (BGBl. 2023 I Nr. 9), das durch Artikel 2 des Gesetzes vom 5. Februar 2024 (BGBl. 2024 I Nr. 32) geändert worden ist.

[41] Gas-Wärme-Kälte-Herkunftsnachweisregister-Verordnung vom 25. April 2024 (BGBl. 2024 I Nr. 139).

[42] Article 1, Nr. 63 (proposal for a new § 42c) of the draft bill 'Referentenentwurf des Bundesministeriums für Wirtschaft und Energie: Entwurf eines Gesetzes zur Änderung des Energiewirtschaftsgesetzes und weiterer energierechtlicher Vorschriften zur Umsetzung des Europäischen Gas- und Wasserstoff-Binnenmarktpakets', published 04.11.2025.

[43] Energiewirtschaftsgesetz vom 7. Juli 2005 (BGBl. I S. 1970, 3621), das zuletzt durch Artikel 1 des Gesetzes vom 21. Februar 2025 (BGBl. 2025 I Nr. 51) geändert worden ist.

information must be provided at least on carbon dioxide emissions. Disclosure information is to be published annually.

The draft law specifies GOs as the tracking instrument required to demonstrate renewable energy shares in gas and hydrogen supply. The same applies for low carbon gases. Conversion principles for producing electricity-based gases, in particular hydrogen from renewable energy sources, are included in the GWKHV. As a rule, electricity GOs must be cancelled for grid-based electricity inputs to exclude double claims on renewable attributes.

To qualify for policy target accounting and associated public support schemes, mass balancing remains the required tracking method (Art. 30 RED III). According to the energy disclosure draft bill from November 2025, disclosure statements will not include information on whether gases comply with sustainability criteria for RFNBOs according to 37th Federal Immission Control Ordinance (37. BImSchV) or for biomass-based gases according to the Biomass Electricity Sustainability Ordinance (BioSt-NachV). Respective Proofs of Sustainability are issued by separate registries based on certified mass-balancing-based documentation. However, the GWKHV specifies that when applying for gas GO issuance, plant operators need to provide information on the compliance with sustainability criteria for RFNBO or biomass.

Supervision of the veracity of disclosure statements is to be carried out by the German Environment Agency.

Evaluation results:

According to the defined evaluation criteria, the German gas disclosure concept performs reasonably well for organisations and plant operators, but scores comparatively low for households and society. This can be explained by the high relative importance of additionality criteria for the stakeholder groups households and society (e.g. information provision on plant age or support levels or sustainability), which are not covered by currently foreseen information provision requirements.

For many criteria, high uncertainty factors have to be taken into account, because the practical implementation of the gas GO system and the legal implementation of the disclosure implementation is still ongoing.

For **households**, the disclosure system reflects physical deliverability concerns by distinguishing between hydrogen and gas supply in disclosure information, and by limiting the cancellation of hydrogen GOs for gas supply to technical blending limits of gas grids. Information provision on production countries is not foreseen under the current draft, limiting the scope for expressing geographical preferences. A narrower definition of deliverability is also not supported (e.g. regional production information or information on direct connections), but these criteria are of limited applicability in the gas context: unlike in the electricity context, gas can easily be transported via vehicles, so establishing grid connections or regional correlation between producers and consumers is less relevant for assessing deliverability. Additionality information regarding plant age or subsidy levels is not covered by the disclosure information. The concept ranks highly in enabling consumers to make choices between differentiated offers, by mandating differentiated information provision on total energy and product mixes. Also, the concept performs reasonably well in ensuring that disclosed information is easily accessible and presented in a clear and user-friendly manner to ensure consumer understanding. However, this criterion is accompanied by a relatively high uncertainty factor, as the final rules for presenting gas disclosure information finally depend on its actual implementation.

For **organisations**, the concept may perform well in terms of administrative efficiency, albeit with a high uncertainty factor as disclosure legislation is not final and the gas GO system has not been implemented yet. Publication mandates for disclosure statements ensure that information is easily accessible to consumers, and REPAs are covered by the tracking tool and disclosure system. While the inclusion of information on sustainability criteria compliance in disclosure statements is not currently foreseen, this information will be included on GOs according to the GWKHV. As organisations can more easily gain access to detailed cancellation statements from the GO registry than households, this means that they could use it in the context of regulatory reporting requirements, or voluntary information disclosure to stakeholders. Also, the concept is assessed to be effective in preventing double counting and double claiming, by clearly specifying tracking tools for renewable and low carbon attributes and mandating residual mix use for untracked attributes. To assess the degree to which deductions about spatial or temporal correlation (beyond annual level) of consumption and supply are supported by the GO system, further implementation detail would be required. Impactful procurement is supported by the inclusion of information on compliance with sustainability criteria on GOs, but requirements on the depth of information provision are yet to be specified, leading to a high uncertainty factor for this criterion. With regard to environmental impacts, disclosure information requirements are limited to carbon dioxide emissions, while on GOs, plant operators may optionally include information on GHG emissions. In the context of GHG accounting, more comprehensive information on direct and indirect GHG emissions as part of gas disclosure requirements would be useful. However, compared to households, organisations can be assumed to be more likely to be able to request detailed sustainability information, including Proof of Sustainability and GHG emission documentation for their purchased gas quantities, from their suppliers. As proof for renewable energy procurement, the concept is assessed to be effective in organisational reporting contexts. This is supported by the legal anchoring of the concept, its consistency with EU principles, the existence of clear rules on tracking conversion between energy carriers and information provision on dissemination levels of energy which can prove relevant in differentiating scopes in GHG accounting. As the implementation of the GO system for gases is not completed yet, this criterion comes with a relatively high uncertainty factor

For **plant operators**, the concept may perform well for similar reasons as for organisations, i.e. high scores in administrative efficiency, the ability to transfer green attributes to off-takers in REPAs, tracking and exclusion of double counting of green attributes across energy carriers and enabling of unique claims on origin from RES. However, the fact that the gas disclosure and GO system has not yet been fully implemented in Germany, is also causing considerable uncertainty factors here. By recording information on compliance with RFNBO and biomass sustainability criteria on GOs, the value of green attribute supply might be increased (as part of bundled products including GOs, mass balancing tracking and Proofs of Sustainability, which would remain necessary for participation in compliance markets). The value of renewable energy offers could further be increased by disclosing further quality characteristics of RES supply, e.g. with regards to regionality, RES technology and sustainability (even outside of a compliance context). By including sustainability information in disclosure statements, rather than just on GOs, the visibility of quality characteristics of RES supply could be further improved. This is, however, not envisioned in the latest available analysed draft. Also, there is limited visibility of information on additionality indicators or suppliers' overall procurement strategies (e.g. with regard to a supplier's investments in RES plants or investments in fossil fuel production capacities), so the scope for quality differentiation in supplier competition is limited in this dimension.

For **society as a whole**, the lack of information provision on additionality indicators also is evident in the evaluation results. For RFNBOs, additionality information is indirectly supplied by indicating compliance with sustainability criteria on GOs, but this is not reflected in disclosure statements as per the current draft. Also, lack of integration of storage and RES availability aspects during the time of consumption impacts the assessment. However, these criteria are less relevant for gas than for electricity, as gas grids provide a temporary storage function, and storage as well as transport outside of grids is more easily available than in the case of electricity. The concept performs adequately in carrying out its societal role of providing transparency for consumers on the composition and environmental impacts of suppliers' offers, although more detailed information on energy sources used for gas production and GHG emissions (beyond CO_2) would improve the concept's rating. Improvement potential also remains in linking disclosure and information provision on the compliance with sustainability criteria more clearly, which would improve consistency between energy disclosure rules and other policy instruments. A significant uncertainty factor remains, as the interaction of disclosure rules with other policy instruments is not yet fully conceptualised.

8.3.3.8 Excursus: Reporting on additionality indicators

Description of the disclosure concept:

As discussed in chapters 3 and 6, addressing the aspect of 'additionality' is a key element in order to tap major potential benefits particularly for households and for society as a whole. However, there are several concepts either realised or proposed, which refer either to different sub-criteria as 'additionality indicators', and to the formal integration of such criteria, either being a mandatory precondition or an information item to be reported on in the context of fuel mix disclosure. Because of diversity of existing and proposed concepts, this dimension has – unlike the other approaches described in this chapter - not been analysed according to the standardised evaluation approach. Instead, it is described here as an excursus, offering a conceptual supplement to the main analytical framework.

When discussing 'additionality', it should be noted that there is a broad variety of what is exactly understood under this concept. One understanding stemming from scope 2 GHG accounting is largely relating to the relationship between cause and effect, meaning that the effect is considered as additional if it would not have occurred without the cause (see Schäfer et al. (2025)). However, besides this strict understanding there is also the understanding established in green power markets that additionality is considered as 'regulatory surplus' or 'incrementality'. This could include metrics such as the share of (long-term?) power purchase agreements (PPAs), the share of own (renewable) production, distinctions between supported and unsupported renewable electricity generation or constraints related to the age of generating plants. The intention to apply such criteria is to identify those power portfolios in the disclosure statement which actually reflect actual engagement and commitment by suppliers (--> share of own renewable production, PPAs) and an incremental further deployment of renewable energy production over and above the status quo (--> new plants) and over and above the regulatory baseline for what is financed by public support anyway (--> level of support).

Different tests for assessing the causality of specific approaches have been identified and discussed by Schäfer et al. (2025) with a view to the application for scope 2 accounting. However, many principles and conclusions can also be adapted for electricity disclosure. Identified tests include e.g.:

- Legal/regulatory/institutions tests: which project activities go beyond what is legally required (e.g. beyond a public quota obligation)?
- Investment tests: which project only become economically viable by generating additional revenues from green (EAC) markets?
- Timing tests: which projects have been only realised after or in close temporal proximity with an intervention.
- Positive list: which projects are included in a pre-defined list of specific activities which are considered to achieve additionality.

The authors point out that these tests could also be combined in order to make results more robust.

Irrespective of whether an approach of direct causality or of a regulatory surplus in a broader sense are pursued, there are different options on how this is reflected in the context of energy disclosure. In principle, this can cover the following range:

- Plain indication of the share of some features which are considered being a relevant indicator (e.g. share of new and unsupported plants, share of long-term PPAs)
- Results of more comprehensive tests or combinations of criteria are disclosed, including an overall 'level of additionality' of a given product.
- Products are granted a specific labelling or award to be shown with the disclosure statement in case they reach a pre-defined minimum threshold with respect to additionality indicators.

By considering such additionality aspects in the framework of energy disclosure, particularly households could benefit from being empowered to make meaningful energy supply decisions for contributing to energy transition and the increased deployment of renewables. Institutional consumers would also be supported in making impactful procurements decisions, and plant operators could benefit from further marketing options and increased revenues in case that their offer fulfills the defined additionality criteria. Finally, society as a whole could benefit as energy transition would be enhanced by more empowered consumers.

8.4 Assessment of the overall advantageousness of the disclosure concepts

As indicated in subchapter 2.5, the extent to which the individual pre-defined sub-criteria are reflected by the specific disclosure systems and concepts was assessed according to the following categories:

Table 12 Numerical and qualitative indicators for the fulfilment of different sub-criteria used for the evaluation of disclosure concepts in the study's analytical framework

Numerical indicator	Extent to which a sub-criterion is reflected by the studied disclosure concept
3	Yes
2	Yes with restrictions
1	No
0	Depending on other aspects (market framework, detailed implementation, etc.) Not applicable No conclusion

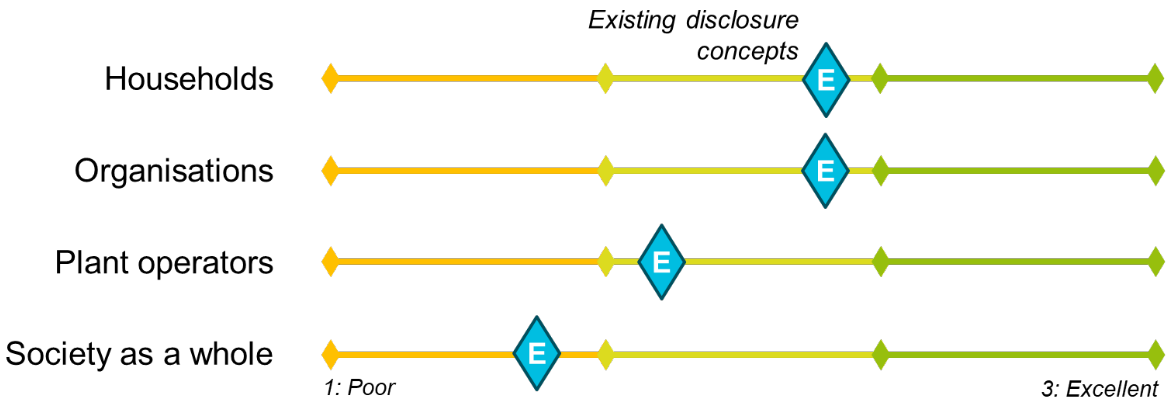
Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

By relating the sub-criteria to benefits, these numerical indicators help to draw a picture of how well the existing disclosure concepts provide benefits to the different stakeholder groups, and which sub-criteria are already well-reflected by the different disclosure concepts that underpin the well-provided benefits.

8.4.1 Stakeholder groups benefit, in general, moderately from the existing disclosure concepts

Calculating the average of the numerical indicators for all sub-criteria combined provides an overview of how well the existing disclosure concepts analysed in this study benefit the different stakeholder groups (see Figure 19).

Figure 19: Indication of how well the existing disclosure concepts (E) provide benefits to the different stakeholder groups



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

This figure reveals that the assessed existing disclosure concepts moderately provide benefits to the different stakeholder groups. It also indicates that organisations and households benefit the most, while plant operators and the society as a whole benefit the least.

A similar analysis of the average of the numerical indicators does not reveal significant differences between electricity, gas and heating and cooling.

8.4.2 Current benefits for households relate to disclosure of energy mix and easily accessible information

The numerical indicators help to identify the sub-criteria that are already fulfilled by the examined existing disclosure schemes. These are now discussed according to each stakeholder group to better relate the benefits to these stakeholder groups that arise from these well-reflected sub-criteria.

Table 13 presents the high-ranking sub-criteria that are relevant for households. These sub-criteria relate to the disclosure of the product mix and the supplier mix, and the fact that this information is easily accessible for private end-consumers. This empowers households to make a well-founded decision on the energy supply and, by doing so, to support the energy transition.

Table 13 List of well-reflected sub-criteria with relevance for households in the existing disclosure schemes examined

Criteria	Sub-criteria
Information available to consumers on energy-specific additionality indicators	The energy source mix of every product of a supplier is disclosed.
	The full energy source mix of the supplier is disclosed.
The disclosed information is easily accessible and presented in a clear and user-friendly manner to ensure consumer understanding	Disclosure information is easily accessible upon request (from a consumer's perspective).
	Disclosure information is mandatorily provided at key decision phases.
Product differentiation enables consumers to make a choice	The energy source mix of every product of a supplier is disclosed.
	The full energy source mix of the supplier is disclosed.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

8.4.3 Current benefits for organisations relate to reliable attribute tracking, energy disclosure and administrative efficiency

Table 14 presents the high-ranking sub-criteria that are relevant for organisations. They relate to attribute tracking allowing the allocation of energy attributes to specific customers in a way that double counting and double claiming are prevented. This allows organisations to make unique green claims with regard to their products and services, meet growing stakeholder expectations, mitigate reputational risks and demonstrate environmental leadership. Another benefit for organisations is the possibility of hedging against CO_2 prices.

Other sub-criteria relate to administrative efficiency stemming from the easy access to information, the ability to cancel GOs by themselves or by a third party acting on their behalf, and the facilitation of Renewable Energy Power Purchase Agreements (REPAs).

Table 14 List of well-reflected sub-criteria with relevance for organisations in the examined existing disclosure schemes

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	Tracking system differentiates energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed.
	The Disclosure Concept is anchored in legislation.
	The Disclosure method is based on principles consistent with those used at the EU level.
	Data sharing between relevant registries and public agencies in other countries or domains for coherent data use in the disclosure system.
In the context of energy disclosure, energy attributes are tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary.
	Energy attributes can be allocated to a specific product of a beneficiary.
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed.
Double counting/double claiming is prevented	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes.
Administrative efficiency	Information is digital and directly accessible for organisations.
	Disclosure information is easily accessible upon request (from a consumer's perspective).
	Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs).
	Ability to transfer EACs to individual consumers (with EAC cancellation by consumers).
	Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

8.4.4 Current benefits for plant operators relate to reliable attribute transfers allowing unique claims and facilitating REPAs and administrative efficiency

Table 15 presents the high-ranking sub-criteria that are relevant for plant operators. They are very similar to the ones ranking high for organisations.

Attribute tracking allows energy attributes to be allocated to specific customers in a way that double counting and double claiming are prevented. This allows plant operators to make unique green claims about their production and facilitates the transfer of renewable energy via Renewable Energy Power Purchase Agreements (REPAs).

Moreover, digitalisation, data sharing and harmonisation of requirements and procedures lead to administrative efficiency and consistency between disclosure and target accounting. This helps plant operators to fulfil the formal prerequisites and facilitates the transfer of green attributes in conversion processes.

Table 15: List of well-reflected sub-criteria with relevance for plant operators in the existing disclosure schemes examined

Criteria	Sub-criteria
Ability to transfer green attributes to off-takers in REPAs	Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)
	Ability to transfer EACs to individual consumers (with EAC cancellation by consumers)
	Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers
Unique claims on origin from RES	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
Tracking and exclusion of double counting of green attributes across energy carriers	Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
Administrative efficiency	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
	Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
	Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy
	Harmonisation of requirements and administrative procedures across energy carriers
	Disclosure information is easily accessible upon request (from a supplier's perspective)
Information provision on requirements for participation in compliance markets	Inclusion of information on GHG intensity of energy production (direct emissions)

Criteria	Sub-criteria
Consistency between disclosure and target accounting	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

8.4.5 Current benefits for the society relate to supporting the energy transition, harmonised rules and administrative efficiency

Table 16 presents the high-ranking sub-criteria that are relevant for the society as a whole.

On the one hand, they relate to supporting the energy transition by empowering the end-consumers via the disclosure of the product and supplier mix and by providing incentives for the development of storage.

On the other hand, they relate to the use of data for multiple purposes, consistent and harmonised rules and automation of processes leading to administrative efficiency and a reduction of bureaucracy.

Table 16: List of well-reflected sub-criteria with relevance for the society as a whole in the existing disclosure schemes examined

Criteria	Sub-criteria
Information available to consumers on energy-specific additionality indicators	The energy source mix of every product of a supplier is disclosed
	The full energy source mix of the supplier is disclosed
Disclosure system provides incentives for storage development	Tracking system prevents double counting of attributes of stored energy
	Harmonisation of requirements and administrative procedures across energy carriers
	Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
Energy disclosure system provides centrally available information and statistics	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments	Disclosure system is in line with EN 16325:2025 (using EECS Scheme Membership as a proxy)
	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
	Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
	Disclosure method is based on principles consistent with those used at the EU level
	Harmonisation of requirements and administrative procedures across energy carriers
	Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
Administrative efficiency	Automated provision of information to the beneficiary of disclosure

Criteria	Sub-criteria
	Automated provision of proof that tracking instruments are used
	Automation of national-level supervision processes
	Automation of verification processes
	Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy
	Existence of automated systems for the collection and transfer of energy production data

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

9 Takeaways regarding the improvement potentials

9.1 Methodology explanations

9.1.1 Combining well-performing elements in good practice and innovation scenarios

Based on the existing and innovative disclosure concepts, listed in chapters 8.1.2 and 8.2.2, three energy-type specific 'good practice scenarios' and three energy-type specific 'innovation scenarios' have been developed:

- the **'good practice scenarios'** combine well-performing elements from real-case disclosure examples;
- the **'innovation scenarios'** add innovations proposed in the literature to further improve the good practice scenarios;
- **Energy-type specific** means that a scenario was developed for electricity, gas and for heating and cooling.

The scenarios include good and innovative practices for each of the 76 sub-criteria used in the analysis. As an illustrative toolbox of the 76 sub-criteria for system designers, they are detailed in Annex B, while subchapter 9.3 depicts how a disclosure scheme can look when combining elements from good and innovative practices into a scenario for a good practice disclosure scheme and a scenario for an innovation disclosure scheme.

Within the report, the scenarios form the basis for identifying synergetic key lessons in chapter 10 and recommendations in chapter 11. The rationale behind formulating scenarios as a working step towards deriving lessons and recommendations is elaborated in more detail in the following.

Good practice scenarios

These scenarios are based exclusively on design specifications of energy disclosure which can be found in the real-life examples as listed in chapter 8.1. This has the advantage that disclosure elements are 'tried and tested,' and have more details on the specific way of implementation from the respective country implementations. To compile good practice scenarios, we assess which existing disclosure systems perform well with regard to each high-level criterion in our excel evaluation tool. Then, we assess which specific implementation of the related sub-criteria in the respective system drives its good evaluation performance. This analysis yields lessons on the specific ways in which the sub-criteria – underlying the successful evaluation criteria – have been implemented within the respective energy disclosure concepts. Their concrete implementation is what ultimately led to the respective positive evaluation outcomes. The 'good practice scenario' therefore is a combination of high-performing design features from different existing energy disclosure examples (for example, for H&C: combining successful features of Dutch, Finnish, Swedish and German H&C disclosure systems).

As part of documenting the analysis, we also indicate alternative options for design features, when there are several well-performing ones. Good practice scenarios will not represent 'the one optimal solution' (and are therefore not 'best practice'). When designing or further developing a disclosure system, care needs to be taken that different features combine to a consistent whole, and the specific national framework conditions need to be considered.

Also, the good practice analysis allows for the remaining weak points to be identified in the examples of implemented disclosure: the evaluation shows where none of the real-life examples analysed in chapter 8 perform well against the evaluation criteria. This will be further addressed by innovation scenarios.

Innovation scenarios

For the innovation scenarios, the three energy type-specific good practice scenarios are complemented by disclosure innovations proposed in the literature.

The innovative design features are selected based on the assessment of innovative concepts in chapter 8, focusing on aspects which promise to improve the performance of energy disclosure compared to even a ‘good practice’ status quo. Some examples are innovations which aim to address additionality, temporal or spatial correlation criteria while going beyond approaches that have been implemented in practice. However, compared to the good practice scenarios based on real-case examples, these proposals for additional elements may remain on a more general level.

Innovations regarding aspects such as additionality, temporal or spatial correlation have to be adjusted to fit the requirements of electricity, H&C and gas markets, because of differences in energy carriers’ market and distribution structures. Therefore, like the good practice scenarios on which they are based, innovation scenarios are developed by energy type.

9.1.2 Identifying recommendations and further work areas based on the established scenarios

As a final step, key lessons from good and innovative practices for enhancing the benefits of energy disclosure are derived from the analysis of the good practice and innovation scenarios. These are structured according to design specifications for disclosure schemes to provide practical guidance to authorities on how they can improve the disclosure schemes for which they are responsible.

9.2 Assessing the improvement potentials

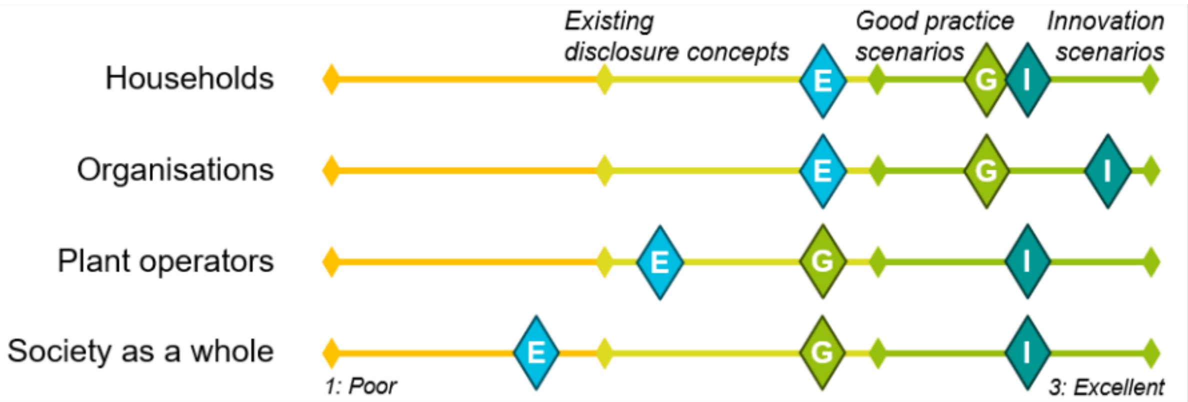
This chapter discusses how the existing disclosure schemes can be improved in case good practices from currently implemented exemplary cases would be generalised and in case innovative approaches from literature would be adopted as well.

The overall improvement potentials are indicated first, followed by the identification of the key (sub-)criteria that allow the disclosure concepts to be substantially improved.

9.2.1 Overall improvement potentials: each stakeholder group can benefit from implemented good practices and suggested innovative concepts

By taking the average of the numerical indicators for the three good practice scenarios and for the three innovation scenarios (electricity, gas and heating and cooling combined) and comparing these averages with the ones for the existing disclosure schemes (see Figure 19 in 8.4.1), an indication of the improvement potential can be obtained. Figure 20 shows the results of this.

Figure 20: Potential to improve the existing disclosure concepts (E) from currently implemented good practice examples (G) and from innovative concepts (I) described in literature



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

Figure 20 shows that each stakeholder group can benefit both from generalising good practices identified in the disclosure schemes studied (G: Good practice concepts) and from innovative concepts described in literature (I: Innovation concepts).

The improvement potential from generalising good practice examples is significant for each stakeholder group. This is an important finding as it indicates that existing disclosure schemes can substantially be improved by identifying the best practices already implemented by the various EU Member States and by exchanging knowledge on these best practices within the EU. Moreover, tapping this potential does not require any amendments to the current legislative and normative framework as each of these best practices has been developed within the current legislative and normative framework.

Embedding innovative approaches from literature allows the disclosure concepts to be improved further. However, tapping that potential might require amendments to the legislative and/or normative framework.

Figure 19 in chapter 8.4.1 indicates differences between the different stakeholder groups with a view to how they benefit from the existing disclosure schemes; this is copied by the 'E'-labelled diamonds in Figure 20. These differences between households and organisations on the one hand and plant operators and the society as a whole on the other hand seems to persist in the good practice scenarios, while it seems to be levelled out in the innovation scenarios. Organisations seem to benefit the most from the innovation disclosure concepts, but the differences in overall benefits with the other stakeholder groups might not be statistically significant.

To understand the improvement potentials better, the next sub-chapters discuss which (sub-)criteria allow the disclosure schemes to be significantly improved. A distinction is made between the following:

- (Sub-)criteria that are poorly reflected in the existing disclosure schemes analysed but excellent in the good practice scenarios;
- (Sub-)criteria that are poorly reflected in the existing disclosure schemes analysed but excellent in the innovation concepts;
- (Sub-)criteria that are poorly reflected in the existing disclosure schemes analysed, moderately in the good practice scenarios, and excellent in the innovation concepts.

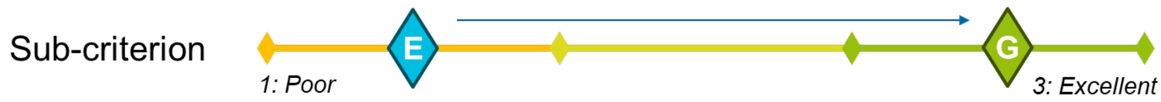
For each of these (sub-)criteria, good practices from the existing disclosure schemes or from the innovative disclosure concepts are provided.

Finally, there is also a – negative – list of (sub-)criteria for which no good practices examples can be identified in the existing disclosure schemes analysed or in the innovative disclosure concepts studied in this report, as described in the literature.

9.2.2 Good practice scenarios: improvement potentials from implemented good practices

The first list of sub-criteria are ones that are poorly reflected in the existing disclosure schemes but excellent in the good practice scenarios. They are identified by using the numerical indicator: sub-criteria have been added to this list if the average scores of good practice scenarios (electricity, gas and heating and cooling combined) are 1.33 points higher[44] than the average scores over all existing disclosure schemes studied.

Figure 21: Method for identifying the sub-criteria with an improvement potential drawn from implemented good practices



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

Generalising identified good practice examples based on individual existing disclosure schemes to elaborate good practice scenarios would lead to additional benefits for the different stakeholder groups. Table 17 lists these sub-criteria and indicates which stakeholder group would benefit from their wide-spread implementation. They relate to deliverability, geographical correlation and temporal correlation.

Table 17: Sub-criteria with a significant improvement potential from good practices including an indication of which stakeholder groups (households, organisations, plant operators, society) can benefit

Sub-criteria	HH	Org.	Pl. Op.	Soc.
Disclosure system limits the transfer and usage system boundaries of attributes to: - physical deliverability, in terms of a connection being present - physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone) - bundled sale of tracking instrument and energy commodity	X			X
Required geographical correlation of production and consumption of energy			X	X
Information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)		X	X	
Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)				X

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

[44] The value 1.33 is the distance between the average value of the lowest class (1.33 being the average of 1 and 1.66) and the average value of the highest class (2.66 being the average of 2.33 and 3).

Households can benefit from these sub-criteria as it would allow them to influence the geographical origin of their energy supply according to own preferences. Consumers would hence better understand where their energy comes from, which would increase their trust in the energy system and the energy transition.

The 'society as a whole' would also benefit from the widespread implementation of these sub-criteria as from providing real-time information on the availability of energy from (renewable) energy sources. This would provide incentives for a better alignment between supply and demand and for developing storage.

Providing information on nature or societal impacts enables organisations to assess the wider environmental and social impacts of their energy procurement strategies, while plant operators can demonstrate that they fulfil requirements in this field.

Finally, a tighter definition of market boundaries and accounting period might prevent oversupply of Energy Attribute Certificates, which both the society and plant operators benefit from.

These sub-criteria are based on the following good practice examples in which they have been well implemented. Inspiration can be gathered from these best practices to improve existing disclosure schemes.

- A best practice example of limiting the transfer and usage system boundaries based on geography is the French system of Guarantees of Origin (GOs) and Certificats de Production de Biogaz (CPBs). This system imposes a clear boundary on how certificates can be used. GOs and CPBs are tied to the physical delivery of biogas: once produced, the biogas is injected into the grid and mixed with natural gas, but the GO or CPB serves to trace its renewable attributes. Each MWh of injected biogas generates a GO or a CPB that indicates the place of production and source material. As a result, consumers can be confident that the gas attributed to them corresponds to a verified quantity of renewable biogas that has been produced and injected into the grid.

- Another best practice example of limiting the transfer and usage system boundaries are the Dutch and German GO schemes for heating and cooling. In the Netherlands, heating and cooling GOs cannot be transferred between grids that are not interconnected (as per the Regeling garanties van oorsprong en certificaten van oorsprong). Likewise, the German Ordinance on Guarantees of Origin for Heating, Cooling and Gases (GWKHV)[36] stipulates that GOs are restricted to the specific H&C system in which they were issued and cannot be traded or transferred across networks. This promotes harmonisation between disclosure and the monitoring of decarbonisation targets for heating and cooling grids. As a result, design sub-criteria like physical connection or geographical correlation are fulfilled by default due to the closed system structure. Within interconnected systems, GOs can be used for product differentiation (e.g. offering green heat products to industrial consumers).

- A best practice example of providing real-time information on the availability of energy from (renewable) energy sources is the Danish electricity GO scheme. This scheme supports increasing granularity in energy attribute tracking. While not required, the system allows for monthly and hourly GOs upon request by producers. This enables the granular matching of energy consumption with time-specific renewable generation.

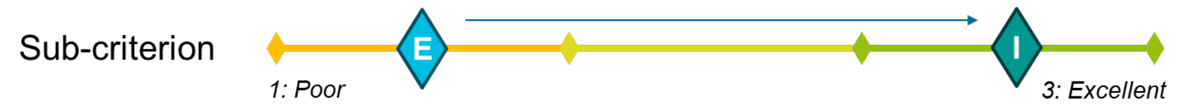
- Including information on broader nature or societal impacts of energy production (going beyond sustainability criteria for biogenic energy carriers according to RED II/III and the EU's RFNBO criteria) would improve the alignment of energy disclosure with CSRD-ESRS requirements (in particular, ESRS E1-E5 focusing on companies' impacts on nature, and

ESRS S1-S4 focusing on social impacts). For instance, information on voluntary sustainability labels could be provided as part of disclosure statements. According to EN 16325:2025, GO schemes may opt to include information on compliance with label schemes, which could be used as a basis for disclosing such extended sustainability information.

9.2.3 Innovation scenarios: improvement potential from innovative disclosure concepts

The second list of sub-criteria are ones that are poorly reflected in the examined existing disclosure schemes but are excellent in the innovation scenarios. They are identified by using the numerical indicator: sub-criteria have been added to this list if the average scores of the innovation scenarios (electricity, gas and heating and cooling combined) are 1.33 points[45] higher than the average scores over all existing disclosure schemes studied.

Figure 22: Method for identifying the sub-criteria with an improvement potential from innovative disclosure concepts



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

This list of sub-criteria is presented by Table 18 along with an indication of which stakeholder group can benefit.

Table 18: Sub-criteria with a significant improvement potential from innovative concepts including an indication of which stakeholder groups (households, organisations, plant operators, society) can benefit

Sub-criteria	HH	Org.	Pl.Op.	Soc.
Information on age of production device	X	X	X	X
Information on subsidy schemes that a plant profits from	X	X	X	X
Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure		X	X	
Monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame		X	X	X
Linking disclosure and EAC trade with policy target accounting to increase the value of green attributes			X	

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

All stakeholder groups can benefit from the disclosure of the age of the production device and subsidy schemes a production device profits from. This would empower end-consumers to support the energy transition by prioritising energy supply from recently built production devices and/or by selecting energy supply from unsupported production.

Furthermore, organisations benefit from information on the share of Renewable Energy Purchase Agreements in energy supply as it can contribute to the verification of "impactful" renewable energy procurement. Likewise, information on other environmental and social impacts helps to increase the impact of their energy procurement strategy. For plant operators,

[45] The value 1.33 is the distance between the average value of the lowest class (1.33 being the average of 1 and 1.66) and the average value of the highest class (2.66 being the average of 2.33 and 3).

this information may help create additional value for RES supply with additionality characteristics.

The provision of monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame, facilitates improving the temporal correlation between production and consumption and granular emissions accounting. Also, the society benefits from the disclosure of this information, besides plant operators and organisations. It stimulates energy consumers to align their demand with the supply and provides incentives for the development of storage and other flexibility means. In addition, a tighter definition of market boundaries and accounting period might prevent over-supply of Energy Attribute Certificates, which both the society and plant operators benefit from.

Finally, plant operators can benefit from linking disclosure and EAC trade with policy target accounting as this would increase the consistency between disclosure and target accounting, and potentially, the value of green attributes.

Inspiration on how to implement these sub-criteria in disclosure schemes can be taken from following innovative disclosure concepts.

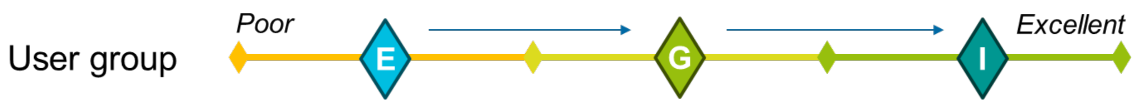
- Article 5 on 'Additionality' of **Delegated Regulation (EU) 2023/1184** detailing the rules for the production of RFNBOs sets **limits to the age** of the installation generating renewable electricity (not older than 36 months than the RFNBO production plant) and **limits the support** granted to the installation generating renewable electricity.
- Article 6 on 'Temporal correlation' of **Delegated Regulation (EU) 2023/1184** sets conditions to the **temporal correlation** between renewable electricity generation and renewable electricity consumption for the production of RNFBOs: monthly until end of 2029; hourly from start of 2030 on.
- The proposal to introduce **geographical 'guardrails' within the GO system** by **limiting the cross-border transfer of GOs** (Holzapfel et al. (2024)) aims at increasing national responsibility for renewable energy development and make the disclosed renewable shares more representative of a country's actual system performance. By doing so, **disclosure and EAC trade would be more closely linked with policy target accounting**.

9.2.4 Improvement potential from both the good practices and innovative concepts

The third list of sub-criteria are ones that are poorly reflected in the examined existing disclosure schemes, but which can be improved based on exemplary practices both in the good practice scenarios and the innovation scenarios. They are listed in Table 19.

Here as well, the numerical indicators were used to identify these: sub-criteria have been added to this list if the average scores of good practice scenarios (electricity, gas and heating and cooling combined) is 0.66 points higher than the average scores over all studied existing disclosure schemes and if the average scores of the Innovation scenarios is 0.66 points higher than the average scores of the good practice scenarios.

Figure 23: Method to identify the sub-criteria with an improvement potential of existing concepts (E) from both the implemented good practices (G) and innovative disclosure concepts (I)



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

Table 19: Sub-criteria with a significant improvement potential from both the good practice schemes and innovative concepts, including an indication of which stakeholder groups (households, organisations, plant operators, society) can benefit

Sub-criteria	HH	Org	Pl.Op.	Soc.
Information on the country of origin of the production device is specified	X	X		X
Information on the regional origin of the RES supply			X	
Required temporal correlation of production and consumption of energy			X	X
Information on GHG intensity of energy production (direct & indirect emissions)		X	X	
Transparency on the energy having been stored				X
The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets				X

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

All stakeholder groups can benefit from providing information on the location of the energy production device; it empowers energy consumers to select energy sources based on their location, it provides plant operators recognition for their production in the same area as consumption (country or region) and it provides incentives for better aligning consumption to production.

Facilitating a temporal correlation of production and consumption of energy allows organisations to fulfil requirements on that aspect, while plant operators could benefit from a reduced risk of oversupply of EACs.

Organisations can benefit from including information on GHG intensity of energy production, as it helps them to monitor their indirect emissions, including the upstream emissions, especially for biogenic energy carriers and hydrogen, while adding such information might provide proof that plant operators are fulfilling requirements in this field.

Transparency on the energy stored might give incentives for developing storage, while providing centrally available information and statistics allows for synergies with alternative purposes of energy tracking besides disclosure, like target accounting and granting support to renewable energy production. These are outcomes that the society can benefit from.

Examples on how to improve these sub-criteria can be taken from these good practices and innovative approaches.

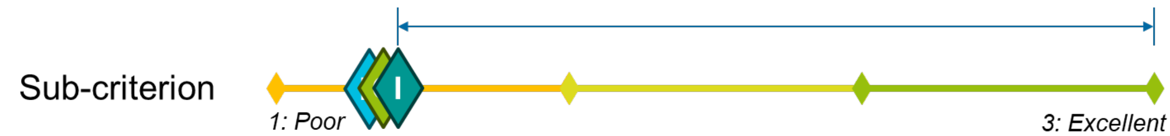
- The introduction of **geographical 'guardrails' within the GO system**, as proposed by Holzapfel et al. (2024) would enhance the accuracy and credibility of renewable energy disclosure by ensuring that GOs more closely reflect the physical generation and consumption of electricity within national systems. **Information on the country of origin** of the production device is a key component in this proposed approach.
- The **Guarantees of Renewable Origin (GRO)** mechanism, proposed by the Florence School of Regulation (FSR), includes the **geographical and temporal scope** of GRO obligations. While the long-term vision is an EU-wide mechanism, the system could initially scale through regional clusters, following a harmonised design. The timing of obligations could default to annual targets, with the potential to evolve towards more granular (e.g. quarterly or monthly) reporting and surrender cycles to better reflect real-time consumption-production matching and policy objectives.

- **France** applies **monthly matching** in its **electricity GO scheme**, requiring that the GOs used correspond to the same calendar month as the consumption. While more technically demanding, this matching mechanism contributes to greater temporal alignment between energy generation and consumption, strengthening the credibility of green claims.
- According to the guidelines provided by Värmemarkandskommittén (Heat Market Committee), **Swedish H&C companies** must **differentiate between CO_2-emissions** from direct combustion, from transport and from production of the fuels in their energy disclosure.
- The **Estonian gas disclosure scheme** is **well-integrated with other regulatory functions**: GOs serve not only for disclosure but also for national transport sector target accounting, sustainability compliance, and statistical reporting. These multifunctional uses of GO data reduce duplication and streamline energy governance. Additionally, the system supports supervision and verification by independent authorities such as the Competition Authority and certification bodies, particularly concerning sustainability compliance for biomethane.
- According to the **concept of a full disclosure obligation for H&C grids in Germany**, developed in the context of the 'IW3 – Integrierte WärmeWende Wilhelmsburg' project, GOs would need to be issued for all energy volumes that are fed into a H&C grid, including for heating and cooling fed into the grid from a storage device. This would provide transparency for the **energy that has been stored**. Moreover, the GO registry would function as a unified and central reporting instrument that allows to fulfil **other purposes than disclosure such as monitoring** the fulfilment of policy targets.

9.2.5 Sub-criteria lacking existing inspiration for realising their improvement potential

The fourth and final list of sub-criteria are ones that are poorly reflected in the existing disclosure schemes examined, but for which no improvement potential can be identified either in the existing disclosure schemes or in the innovative disclosure concepts.

Figure 24: Visualisation of sub-criteria without inspiration for realising their improvement potential



Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

Table 20 lists these sub-criteria. Two groups of sub-criteria can be distinguished.

One group of sub-criteria concerns the inclusion of information on the extent to which the supplier owns the energy generating devices. The inclusion of such information would allow plant operators/energy suppliers to acquire customers who are willing to pay for energy generation of particular sources.

The other group of sub-criteria concerns the inclusion of additionality information or easy access to such information. Such information would enable end-consumers to prioritise energy supply from newly built production installations and hence contribute to the energy transition. Households and the society as a whole would benefit from such information.

Table 20: Sub-criteria without inspiration for realising their improvement potential

Sub-criteria	HH	Org.	Pl.Op.	Soc.
Information on: - the share of supplier-owned fossil energy generation - the share of supplier-owned nuclear energy generation - the share of supplier-owned renewable energy generation			X	
Information provided in a ranking tool that evaluates performance based on additionality criteria	X			X
Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information	X			X
Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)	X			X
The degree of compliance with advanced additionality criteria is clearly indicated	X			X

Source: Authors' own illustration, Oeko-Institut, Hamburg Institut, Enunda.

9.3 Guidebook for disclosure system designers: Description of scenarios for good practice and innovation disclosure schemes

The previous subchapter explored which features of a disclosure scheme can be improved when integrating exemplary practices from the good practice disclosure schemes and innovative disclosure concepts described in subchapter 8.3.

This subchapter depicts how a disclosure scheme can look when, as a first step, the elements from the analysed good practice schemes are combined into a scenario for a good practice disclosure scheme and when, as a second step, also elements from the analysed innovative concepts are added into a scenario for an innovation disclosure scheme.

Within the description of the good practice and innovation scenarios, the good and innovative practices from the various energy carriers – electricity, gas and heating and cooling – are combined into one disclosure scheme as the disclosure schemes for the different energy carriers share key design features. This does not, however, imply that disclosure schemes should ideally be completely uniform across all energy carriers: Rather, they have the potential to build on a set of common key design features to which energy carrier-specific aspects can be added. Such energy-carrier specific aspects are likewise summarised in the scenario descriptions.

The description of the good practice and innovation disclosure scenarios builds on the different sub-criteria identified in Chapters 3 to 6: that is, on the design features of disclosure schemes which contribute to the realisation of disclosure benefits, based on the results of our initial literature review. Annex B provides a detailed list of the design features which make up the good practice and innovative scenarios. The following section provides a summarising description of the scenarios.

To better structure the overview, the 76 analysed sub-criteria were clustered into six overarching categories of disclosure systems design:

1. Clarity and consistency in energy disclosure purposes;
1. The institutional anchoring of disclosure;
2. The system boundaries of energy disclosure;
3. The type of information provided;
4. Information on additionality indicators; and
5. The format of information disclosure

The following Table 21 provides an overview over the sub-criteria which are related to each of these six categories:

Table 21 Overview over the relevant sub-criteria which are related to the six different overarching categories of disclosure systems design

1. Clarity and consistency in energy disclosure purposes:

	1 The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets 2 Disclosure instruments allow for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets 3 Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green attributes 4 Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)

2. Institutional anchoring of energy disclosure:

	5 Disclosure system is in line with EN 16325:2025 (EECS Membership as proxy) 6 Automated provision of information to the beneficiary of disclosure 7 Automated provision of proof that tracking instruments are used 8 Automation of national-level supervision processes 9 Automation of verification processes 10 Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy 11 Existence of automated systems for the collection and transfer of energy production data 12 The Disclosure Concept is anchored in legislation 13 Cancellation of certificates for the input energy and issuing of new certificates for the output energy 14 Clear rules are in place for tracking conversion between different energy carriers 15 Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking 16 Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system 17 Disclosure method is based on principles consistent with those used at the EU level. 18 Harmonisation of requirements and administrative procedures across energy carriers 19 Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production 20 Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure) 21 Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes 22 The residual mix is publicly available, enabling its usage for disclosure 23 Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)

3. System boundaries of energy disclosure:

	24 Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed 25 Energy attributes can be allocated to a specific consumer as beneficiary 26 Energy attributes can be allocated to a specific product of a beneficiary 27 Mandatory usage of the Residual Mix for untracked attributes 28 Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin. 29 Tracking system differentiates energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed

30 Tracking system accounts for energy losses over storage
31 Tracking system enables to record the time period of release from an energy storage system ("time shifting of attributes over storage")
32 Tracking system has clear and consistent rules for allocating attributes from the input to the output of an energy storage system
33 Tracking system is transparent on the energy having been stored
34 Tracking system prevents double counting of attributes of stored energy
35 Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)
36 Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
37 Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
38 Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers
39 Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)
40 Ability to transfer EACs to individual consumers (with EAC cancellation by consumers)
41 Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)
42 Mandatory restrictions apply for the application of explicit tracking instruments based on plant age
43 Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support
44 Required geographical correlation of production and consumption of energy
45 Required temporal correlation of production and consumption of energy

4. The type of information provided:

46 The energy source mix of every product of a supplier is disclosed
47 The full energy source mix of the supplier is disclosed
48 Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information
49 The degree of compliance with advanced additionality criteria is clearly indicated
50 Information on the country of origin of the production device is specified
51 Information on the specific region (state, province, city etc.) of a production device is specified
52 Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
53 Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
54 Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
55 Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).
56 Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
57 Inclusion of information on GHG intensity of energy production (direct emissions)
58 Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
59 Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
60 Disclosure statement includes information on the regional origin of the RES supply
61 Disclosure statement includes information on the sustainability characteristics of the RES supply

	62 Disclosure statement includes information on the technological origin of the RES supply 63 Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)

5. Information on additionality indicators:

	64 Information on the share of REPAs available to the beneficiary of disclosure 65 Information on the share of supplier-owned fossil generation available to the beneficiary of disclosure 66 Information on the share of supplier-owned nuclear generation available to the beneficiary of disclosure 67 Information on the share of supplier-owned RES generation available to the beneficiary of disclosure 68 Provide information on support 69 Provide information on plant age

6. Format of information disclosure:

	70 Disclosure information is easily accessible upon request (from a supplier's perspective) 71 Disclosure information is easily accessible upon request (from a consumer's perspective) 72 Disclosure information is mandatorily provided at key decision phases 73 Information is digital and directly accessible for organisations 74 Information provided in a ranking tool that evaluates performance based on additionality criteria 75 Information on non-renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table 76 Information on renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

For each category, characterising scenario elements are described based on a summary of the detailed description of good and innovative practices in Annex B. This includes:

- elements of a good practice scenario, consisting of sub-criteria which are either already fulfilled in many existing disclosure schemes or for which individual analysed disclosure schemes offer transferrable good practices;
- elements of an innovative scenario, where additional sub-criteria are fulfilled based on proposals from innovative disclosure concepts;
- Where applicable, some additional sub-criteria are highlighted for which no inspiration could be found from the analysed existing disclosure scheme or innovative disclosure concepts, indicating scope for further research (see chapter 12).

For each sub-criterion, further and more detailed examples for good and innovative practices are provided in Annex B.

9.3.1 Clarity and consistency in energy disclosure purposes

9.3.1.1 Good practice includes the provision of data for other administrative uses, including the monitoring of policy target achievement

In the good practice scenario, the disclosure scheme **make information on RES plants and generation available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)**. This is common standard in analysed existing disclosure schemes. However, the degree to which synergies are used can vary considerably between schemes. Examples can be found in – amongst others – the

French and Flemish disclosure schemes for electricity, the Austrian or Estonian disclosure schemes for gas and the Dutch disclosure scheme for heating and cooling where information on RES plants and generation is also used to support administration.

Further synergies are tapped as **the accounting instrument for disclosure can be also used for national monitoring of the fulfilment of policy targets**. This is illustrated in the Estonian disclosure scheme for gas where biomethane consumption reporting for national transport sector target accounting is based on GOs.

9.3.1.2 The Innovation scenario further links disclosure to policy target accounting

In the innovation scenario, there can be market-driven extension of public targets and a single instrument for both disclosure and policy target accounting.

- **Disclosure instruments can allow for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets.** This would allow to make a real difference in terms of additionality over and above existing targets, which would have to be achieved particularly with the backing of appropriate public support systems. It follows from the proposal of Seebach and Timpe (2020b) on the implementation of a specific type of tradable RES-E GOs which have the specific characteristic that those volumes are not counted towards public RES targets, which addresses highly motivated consumers.
- **The tracking instrument for disclosure is linked with policy target accounting to increase the value of green attributes (incl. international transfers)**, they would get a higher financial value in the market if the disclosure purpose gets combined with a compliance trigger. At least with a view to gases where regulation requires the streamlining of target accounting and of GO trade anyway, this could enhance efficiency.
  - This is pursued in the concept of Guarantees of Renewable Origin (GROs) as proposed by the Florence School of Regulation (Pototschnig & Conti, 2021), where the same GROs would serve a dual function: as proof of renewable sourcing for consumers and as compliance instruments for meeting regulatory targets, the respective consumer or supplier group are envisaged to pay for the green attributes.
    The concept of Guarantees of Renewable Origin (GROs) however proposes a GO scheme for all energy carriers combined, which needs a careful consideration of prices in the underlying markets and impacts on sector-specific decarbonisation incentives before a recommendation for adopting such a scheme could be made.
  - Incorporating cross-border GO trade in the calculation of country-specific RES shares would impact renewable policy target compliance. Holzapfel et al. (2024) shows for the case of electricity that this would change the 2020 renewable electricity target achievement of 13 European countries.
    Considering the implementation of this aspect would require substantial further research and political discussion.

9.3.2 The institutional anchoring of disclosure

9.3.2.1 Good practice disclosure schemes have automated and harmonised processes in line with international rules

In the good practice scenario, disclosure schemes are designed to have automated and harmonised processes in line with international rules. As a regulatory requirement formulated by the RED II, good practice disclosure schemes implement the EN 16325. To support administrative efficiency, they also automate the processes for information flows to the beneficiary, for backing claims with proof, for third party verification, for data collection internally in a country and with foreign authorities. They anchor disclosure obligations in legislation, where the single instrument for making renewable energy consumption claims (the guarantee of origin) is specified, and the framework for calculating and using the residual mix is described. They harmonise system rules with jurisdictions that operate in the same international market.

- All analysed countries are EECS scheme members for electricity and most are members of the EECS scheme members for gas, which supports the **implementation of the requirements imposed by EN 16325:2025.** It should be noted that the implementation of EN16325 also has positive effects on other sub-criteria (e.g. storage, conversion, …).
- It is established practice to provide **information on energy sources to the beneficiary of disclosure**, with energy bills and/or on supplier websites. Beyond that, some good practice examples **automatically provide proof that tracking instruments are used**. Examples are the Flemish interactive web-tool GreenCheck allowing individual consumers to check the renewable electricity supply using their individual EAN identifier; or disclosure statements built into the Austrian GO registry for gas available to consumers who create a log-in..
- Good practice disclosure schemes have **automated processes in place for national-level supervision and verification**. In Flanders for instance, both the Supplier Disclosure Dashboard and the Green check are based on intensive reporting procedures, anchored in law, of grid operators and suppliers uploading extensive lists of all impacted consumers to the supervision database of the regulatory authority, on a monthly basis. Behind both webtools, there are regulated extensive Green Reporting processes.
- Good practice disclosure schemes **digitalise and automate the data provision and verification processes of disclosed information on the origin of energy**. In the Estonia gas GO scheme, data is collected from smart meters to the data hub, where it is digitally stored and from where the gas GO registry automatically retrieves production and consumption data. After data transfer the GOs are automatically issued to the producer´s account. In the Netherlands, the Issuing Body VertiCer has automated and digitalised processes in place for issuing, transferring and cancelling GOs for electricity, gas and heating and cooling.
- Most of the existing disclosure schemes have **automated systems** in place **for the collection and transfer of energy production data**. In all analysed countries, the EECS Domain Protocols describe the metering and provision of energy production data with a high level of automation of processes and data handling. Usually, there are only exemptions for very small plants from automated meter readings and transfer of data.
- In all analysed countries, the **disclosure concept is anchored** in principle **in legislation**. The level of detail can vary, so that detailed regulations are to some extent defined in non-legislative formats. For heating and cooling, the analysed case studies of Finland, the Netherlands and Germany provide examples of legislation on the establishment of H&C GOs as tracking instrument, while the inclusion of H&C in the legal framework for GOs is currently being prepared in Sweden.
- All analysed existing disclosure schemes **share data between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system**. International transfer of data is provided in all analysed countries by the joint EECS Scheme Membership, cooperation within AIB and the use of the AIB hub. However, this

particularly includes EECS GO, which might only cover renewable energy, but not fossil or nuclear energy. So far, no cross-country or cross-domain data sharing has been established for H&C in view of the local nature of H&C networks and the restriction of GO transfer and/or use in disclosure to network boundaries (in the Netherlands and Germany) or national boundaries (in Finland) in the analysed case studies.

- In all analysed existing disclosure scheme, the **disclosure method is based on principles consistent with those used at the EU level**. This is particularly supported by the joint operation under the EECS Scheme Rules, and the implementation of the requirements imposed by RED II and the IEM Directive 2019/944.
- The analysed countries generally **harmonise the requirements and administrative procedures across energy carriers.** In all H&C case studies, the legal framework for GOs applies either jointly to electricity, gases and H&C, or to the new GO systems for gases and H&C with close alignment to existing regulations on electricity GOs. Moreover, in the Netherlands, Sweden and Germany, the same Issuing Body is responsible for GO systems for electricity, gases and H&C and in Finland, the Energy Authority acts as Competent Body for Disclosure for all three energy carriers.
- In the analysed existing disclosure schemes, **rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production**. In Sweden and the Netherlands, the alignment of legal framework conditions across energy carriers and the responsibility of one Issuing Body for all energy carriers ensures the coordination of rules and procedures for tracking different energy carriers. In Finland, the Energy Authority acts as Competent Body for Disclosure for all three energy carriers (even though they act as Issuing Body only for H&C), enabling coordination across energy carriers as part of a supervisory role.
- All analysed existing disclosure schemes **specify the tracking tool(s) that enable market-based claims on renewable energy attributes**. For electricity and gas, the specification of guarantees of origin as the tracking tool that enables market-based claims on renewable energy attributes is stipulated by EU Directives and generally implemented across the analysed countries. For heating and cooling, GOs are legally implemented as the tracking tool as proof of renewable H&C supply in Finland and the Netherlands, while such legislation is in preparation in Sweden. In Germany, GOs are legally implemented as the tracking tool when a supplier commits to supplying a certain share of H&C from renewable or waste heat sources.
- For electricity, **the residual mix is publicly available, enabling its usage for disclosure**. For gas, at the time of writing this report, in many countries no such residual mix is available yet, since the related EU legislation is still under implementation; the ReGaDISS study [46]suggests assuming natural gas (for methane-type gas) or steam-methane reforming-based hydrogen (for hydrogen) as energy source for the gas for which no GOs are cancelled. For H&C, applicability of the residual mix concept depends on whether attributes can be traded across network boundaries.

9.3.2.2 Good practices accommodate conversion issuance

In the good practice scenario, disclosure schemes accommodate tracking of energy attributes when converting one form of energy into another (for instance biomethane into renewable heating or renewable electricity into renewable hydrogen) by ensuring that certificates are cancelled when consuming the input energy and issue new certificates when producing the

[46] https://www.aib-net.org/news-events/aib-projects-and-other-news/regadiss

output energy and by aligning the tracking systems and disclosure schemes of the input and output energies.

- **Clear rules are in place for tracking conversion between different energy carriers** and the **cancellation of certificates for the input energy and subsequent issuing of new certificates for the output energy is required**. Among the case studies analysed, this is described by the respective EECS Domain Protocols for electricity of the Netherlands, Belgium-Flanders, Denmark or Austria, the EECS Domain Protocol for gas of Austria or the legal framework for H&C GOs in Finland and H&C and gas GOs in Germany. This approach is also supported by the implementation of EN16325, and context for Conversion Issuance rules is given in REGATRACE Deliverable 4.3 (Verwimp et al., 2021).
- **Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking** takes place in various of the analysed countries. The Netherlands for instance has merged the formerly separated issuing bodies for electricity and gas GOs into one single GO issuing body for electricity, gas including hydrogen and heat, which unlocks efficiencies for energy carrier conversion, which is particularly relevant for hydrogen GOs. Also, in Belgium-Flanders and in Austria, the electricity and gas GO registrations are embedded in the same software, operated by a single body namely the regulatory authority for electricity and gas.

9.3.2.3 Good practices support full disclosure

Austria and the Netherlands implemented the **full disclosure model for electricity and specify the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources**. Moreover, GOs for renewable gas, natural gas, hydrogen, syngas and other gas are cancelled and used for disclosure in Austria.

9.3.2.4 The innovation scenario complements good practices with using a residual mix for gas

Improvement potentials regarding the benefits of energy disclosure, which relate to its institutional anchoring, can largely be unlocked by a wider implementation of good practices already adopted at least in individual cases. Some of these good practices are even widely adopted already. As for innovations not yet implemented, the innovation scenario includes an institutional anchoring of the **publication of residual mix for gas**. In the Draft German and Danish gas disclosure framework, this is planned for the implementation period of disclosure rules. Potentially, transition measures may apply (in Denmark, fossil natural gas may be used as default for the residual mix for gases, while in the Draft German gas disclosure obligation, gas or hydrogen quantities for which no GOs are issued may be disclosed as “gas or hydrogen from non-renewable and non-low carbon sources” until mid-2027. After this, the residual mix has to be used).

9.3.2.5 The innovation scenario integrates energy disclosure into the Digital Product Passport framework

As a more far-reaching innovation, energy disclosure information could be integrated into the Digital Product Passport framework, including the development of a European standard for machine-readable disclosure statements. Especially for gases, this could provide a harmonised framework for disclosing and tracking green attributes across energy and non-energy purposes and along international value chains.

9.3.2.6 The innovation scenario integrates real-time production and consumption information

Although no clear example has been identified as show case in the analysed innovative disclosure concepts, the Danish Data Hub is worth mentioning as an enabler of a **disclosure mechanism (or related mechanism) providing real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)**.

9.3.3 The system boundaries of energy disclosure

9.3.3.1 Good practice disclosure schemes robustly track attributes to end-consumers and prevent double counting

In the good practice scenario, disclosure schemes rely on GOs for tracked energy and require the use of the residual mix for untracked energy (only in place for electricity for the time being). This allows to track energy attributes, such as GHG intensity of energy, from production to the end-consumer. This allows end-consumers to opt for Renewable Energy Power Purchase Agreements (REPAs) while excluding double-counting of associated renewable energy attributes. In their scope of choice, end-consumers are furthermore empowered if they themselves or third parties (contractor, service provider) can cancel EACs on behalf of specific consumers.

- For renewable electricity, all analysed countries require the **tracking of energy attributes via the issuing and cancellation of GOs,** while some countries like Austria or the Netherlands have implemented a full disclosure system which includes this requirement also for other energy sources. For gas, energy attributes are tracked through GOs in Austria, Estonia, and France, which must be cancelled before claims on renewable energy can be made. For heating and cooling, the Finnish, Dutch and Swedish (if implemented) GO and disclosure regulations impose clear rules that renewable H&C supply needs to be backed by H&C GOs. In Germany, the use of GOs is only legally required when a supplier commits to supplying a certain share of H&C from renewable or waste heat sources.
- The **mandatory use of the residual mix for untracked attributes** is already well established for electricity and included in the disclosure scheme of Sweden, Belgium, Norway, France, Germany and Denmark amongst others. At the time of writing this report, in the analysed countries, no residual mix is calculated for gas or for heating and cooling, though Denmark applies fossil natural gas as its residual mix for gases.
- **Energy attributes can be allocated to a specific consumer as beneficiary** in most analysed countries, which should inspire other European countries. Whereas in Denmark and many other countries, all consumers are able to cancel GOs for their own consumption, Germany as well as Austria restrict GO cancellation to licensed suppliers but enable suppliers to cancel GOs for a specific consumer. While for most analysed countries this option only applies to RES, e.g. in Austria such a consumer-specific cancellation is possible also for non-RES, as fossil and nuclear sources are also covered by the GO system. Energy attributes of gas can be allocated to a specific consumer as beneficiary in the gas GO schemes of Estonia & France. In Austria this can be done through the supplier who cancels the GOs then on behalf of a specific consumer.
- It is also established good practice to allow for the **allocation of energy attributes to a specific product of the beneficiary**, if the beneficiary is an energy supplier. The according option to make such an allocation when cancelling GOs and to have this documented by a cancellation statement is given e.g. in Germany, Norway and Austria. In Belgium-Flanders, such a product-specific allocation is a key part of the webtools allowing end-consumers to

verify their renewable supply. In individual cases, such as Norway, it is also possible to specify the product of an electricity consumer (e.g. an industrial company using renewable electricity to produce a certain product) as beneficiary, further improving the resolution of attribute allocation.

- **Information on GHG intensity of energy production (direct emissions)** must be provided for at least CO_2 in the energy disclosure based on IEMD and Gas Directive requirements in all analysed countries (and for electricity also on radioactive waste). In Denmark, also methane has to be disclosed (besides SO_2 and N_2O). Direct GHG emission publication requirements are also observed in all analysed H&C cases.
- Most analysed countries have a **tracking system in place differentiating energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed**, as they apply GO systems based on EECS. The EECS Rules require the indication of the "dissemination level" on the GOs. Also, the Finnish, German and Dutch legal frameworks for H&C GOs explicitly differentiate between energy amounts that were fed into the grid and supplied by a direct line/by an on-site generation facility. This helps ensure the consistency between the various data flows used in the calculation of the residual mix (e.g. if consumption figures in the residual mix calculation formula are determined based on offtake from the grid, production figures in that formula should relate only to grid-injected energy (and exclude onsite consumption)).
- Good practice **tracking systems prevent double counting of attributes of stored energy**. In Austria for instance, GOs are issued for production devices with electricity storage capacity on net production and only based on natural inflow (minus any nett electricity consumed by pumping). The electricity supply for pumping is multiplied with an efficiency of 75 percent (or verified plant specific percentage) and the result must be deducted from the total amount of electricity that will be injected into the grid. For the compensation of the efficiency losses in the pumps the respective amount of GOs is cancelled. Austria also has copied the technical process for handling GOs related to gas storage from the technical process for electricity storage. Moreover, in all analysed cases, the H&C GO system is based on the established GO system for renewable electricity, where double counting of attributes of stored energy is prevented.
- In all analysed countries, it is possible to **apply for GOs/energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)** and to use GOs together with a REPA for those energy sources which are covered by the respective national GO scheme. While this is limited to RES-E in some countries, this option also applies for fossil and nuclear electricity production in countries which have GO systems for these sources.
- In several of the analysed countries, it is allowed that any party can open an account in the GO registry and cancel GOs, like in the Netherlands, Norway, France and Denmark. This **allows a third party (contractor, service provider) to cancel EACs on behalf of specific consumers**.
- In several of the analysed countries, it is allowed that **any party** can open an account in the GO registry and acquire and **transfer GO/EACs to individual consumers (with EAC cancellation by consumers)**, like in the Netherlands, Norway, France and Denmark for electricity, Estonia and France for gas, while in the Netherlands, this option is open to commercial end-consumers. This is an inspiration to countries where currently only licensed suppliers are entitled to do so, since the CSRD and REPA-stimulating regulations would

benefit from an implementation of green claim proofs that is consistent with the GO framework.

9.3.3.2 Good practices better correlate production and consumption

The good practice scenario supports improvements in correlating the production of energy and the consumption of energy. It can build on good practices which include on-site production and consumption into the disclosure scheme, correct for energy losses over storage or allow time-shifting through storage. Some other examples tie the use of GOs for disclosure to deliverability requirements of associated energy flows or temporal correlation.

- In the Netherlands, the full disclosure scheme requires all supply to be covered by cancelled GOs, which is an example of **disclosure rules that oblige suppliers respectively consumers (on-site production) to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin**. In the context of conversion of electricity to H&C, the use of GOs for electricity supplied through a direct line to a conversion plant may facilitate conversion tracking and the exclusion of double counting (alternatively, this may be achieved by auditing metering data). For instance, the electricity GO system in the Netherlands supports GO issuance for electricity supplied through a direct line, as the Dutch full disclosure system requires all supply to be covered with GOs.

- In Austria, the **tracking system accounts for energy losses over storage**. For electricity, E-control issues GOs for production devices with electricity storage capacity on net production and only based on natural inflow (minus any nett electricity consumed by pumping) and the technical process for handling GOs related to gas storage is copied from the technical process for electricity storage

- Austria is the first country where "Storage issuance" is implemented – for electricity only – and where the *tracking system* **enables to record the time period of release from an energy storage system ("time shifting of attributes over storage")**, has **clear and consistent rules for allocating attributes from the input to the output of an energy storage system** and **is transparent on the energy having been stored**.
  GOs are cancelled for the energy input flowing into a storage system (historically pumped hydro stations), and new GOs are issued for the measured output flowing out of the storage system. This method systematically takes storage energy losses into account. The output is based on the GOs of the input. The attributes of the output stay the same after storage, except for the unique ID of the certificates, the production period, the country of issue, and if changed the dissemination level of the output.
  Germany and most other countries have a restricted implementation: no storage issuance for the time being, but where storage is on the site of the RES production, GOs are only issued for energy made available to the market (after storage, and injection into the grid).

- Examples of **disclosure systems limiting the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)** can be found for heating and cooling.
  In Germany, the use of H&C GOs for disclosure is restricted to interconnected district H&C systems; GOs may only be cancelled within the same system in which they were issued. Likewise, in the Netherlands H&C GOs cannot be transferred in between grids that are not interconnected.

- Examples for **disclosure systems limiting the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity** and **to physical deliverability, in terms of a connection being present** can be found for gas and for heating and cooling.
  Estonia and France both ensure that renewable gas attributes are bundled with the physical energy commodity, limiting the transfer and use of tracking instruments to actual gas supplied and consumed. Estonia requires a mass balance system. France ties the tracking instruments to the associated energy sold.
  In the German and Dutch disclosure schemes for heating and cooling, GO use and/or transfer is limited to interconnected H&C systems; as a result, they are provided bundled with H&C sales within that system.
- The Estonian gas GO scheme is an example **requiring geographical correlation of production and consumption of energy** as consumption of biomethane in Estonia can only be proven with gas GOs issued in Estonia for the time being. Other examples are H&C GO schemes that limit the transfer and usage system boundaries to physical deliverability, such as German and the Dutch schemes.
- France applies monthly matching, requiring that the GOs used correspond to the same calendar month as the consumption. This is an example of a disclosure scheme **requiring temporal correlation of production and consumption of energy**. While more technically demanding, this matching mechanism contributes to greater temporal alignment between energy generation and consumption, strengthening the credibility of green claims.

9.3.3.3 The innovation scenario combines storage with granular information of production time to supports time shifting of attributes over storage

The revised EN 16325:2025 includes an optional provision on GO issuance for energy flowing out of storage devices. Implementing this provision would **enable tracking systems to record the time period of release from an energy storage system ("time shifting of attributes over storage").** In combination with the equally optional inclusion of information on the start time and end time of energy production in production devices and energy release from storage devices, time shifting of attributes through storage is supported.

9.3.3.4 For an innovation scenario, adjustments of system boundaries of disclosure to better reflect deliverability and additionality require further research

For the innovation scenario, the good practices outlined above can be complemented with proposals from innovative concepts, which adjust the system boundaries of disclosure and tracking instruments to better ensure deliverability and additionality compared to the good practice examples. However, if these aspects are addressed in disclosure as adjustments of system boundaries (including tighter restrictions on when market-based claims based on tracking instruments can be made), impacts on GO and renewable energy markets can be significant. Therefore, further research would be necessary before arriving at recommendations (meanwhile, a no-regret option is the inclusion of these aspects as additional information, improving transparency and the scope for consumer choices, see 9.3.4).

- Concerning **limitations to the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)**, physical deliverability constraints relating to market boundaries are proposed within the discussed GHGP Scope 2 revisions. The RFNBO rules impose a limitation of transfer and accounting of attributes to an area which includes connectivity and the location of electricity producer and consumer within the same bidding zone, or adjacent bidding zone from time periods without congestion.

- RE100 imposes **mandatory restrictions on the use of tracking instruments based on plant age**, with a 15-year commissioning or repowering limit as a core eligibility criterion. Also, the RFNBO rules (European Commission 2023a) impose a limitation of transfer and accounting of attributes to an area which includes connectivity and the location of electricity producer and consumer within the same bidding zone, or adjacent bidding zone from time periods without congestion.

9.3.4 The type of information provided

9.3.4.1 Good practice schemes disclose the energy mix of both suppliers and their various products

This widely established practice forms part of the good practice scenario. Examples include:

- In several of the analysed countries, like Belgium-Flanders and Germany for electricity, Austria for gas, and Sweden for heating and cooling the **energy source mix of the relevant supplied product of a supplier must be disclosed**.
- According to the clear requirements by Annex I 5. of the IEMD, all analysed countries have implemented the requirement that the **full energy source mix of the supplier is disclosed**. Disclosure of the full energy source mix of H&C suppliers is also provided in all four H&C case studies.

9.3.4.2 Good practices provide detailed information on origin, production time and generation technology

In the good practice scenario, disclosure schemes provide additional information compared to what is required by European regulation. Examples include schemes requiring the disclosure of country of origin or even allowing to opt for energy from a particular region. Further examples include details on the sustainability or generating technology of the renewable energy supply.

- In German electricity disclosure, the **country-specific shares of origin for renewable energy consumption must be indicated** for RES and this is based on cancelled GOs. Note that in heating and cooling case studies where GOs cannot be transferred and/or used beyond the boundaries of interconnected grids (the Netherlands, Germany), the country and region of origin will equal the country and region of consumption in the vast majority of cases, because of the local character of H&C grids to which both producer and consumer are connected.
- Germany is also an example of an electricity disclosure scheme allowing **disclosure statements to include information on the regional origin of the RES supply.** Germany has implemented the option to indicate the share of "regional RES-E" based on so-called "Regionalnachweise" ("regional GOs"), but only within the share of national supported RES in the disclosure statement of a supplier. This share of national supported RES is clearly distinguished from other RES shares which have to be disclosed based on cancelled GOs. Regionalnachweise can be used if the respective supported power plant is located not more than 50km from the respective consumer. For other RES-E which is disclosed based on cancelled GOs, no such option for the documentation and disclosure of the specific region is implemented.

- The French disclosure scheme for electricity not only **provides monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame**. France also applies monthly matching, requiring that the GOs used correspond to the same calendar month as the consumption.

- Denmark supports increasing granularity in energy attribute tracking and **allows to provide sub-hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame** (15 minutes). While not required, the system allows for monthly and hourly GOs upon request by producers. This enables the granular matching of energy consumption with time-specific renewable generation.

- All countries that adopt EECS, have a requirement on electricity suppliers to disclose the origin of supplied energy on their bills to consumers in at least the categories: renewable, fossil, nuclear. EECS compliant **GO systems include information on the technological origin of the RES supply and provide more detailed information on the energy source** used to produce a unit of energy (e.g. information according to level 1, level 2 and level 3 of annex A of EN 16325), which can be made visible in GO cancellation statements made available to consumers on request. In addition, in Belgium-Flanders, the distinction of specific types of energy used, is provided by the regulatory authority, Vlaamse Nutsregulator, in the individual online Green check (GroenCheck) and in the online Origin Comparator per electricity supply product. In Austria, the split between detailed energy sources is provided on the automated disclosure statement produced by E-Control and to be used by suppliers in their disclosure to their customers. In Sweden, the Netherlands, and Germany, information on H&C technologies is included in disclosure obligations and guidelines. Yet, the level of detail provided depends on individual energy suppliers. In the Netherlands, providing detailed information appears to be the established practice of energy suppliers.

9.3.4.3 Good practices provide additional information on GHG emissions and sustainability

Good practice disclosure schemes provide additional information than currently required by EU regulation by including more detailed GHG intensity or sustainability information as attributes.

- EECS gas GOs may contain optional information on the **sustainability characteristics of the** RES supply, including information on certification body, scheme, audit report and additional information. Though sustainability characteristics are not mandatory in disclosure towards consumers, suppliers may choose to inform consumers of the sustainable character of their gas supply.
  Some H&C suppliers in analysed case studies voluntarily publish sustainability characteristics of biomass inputs.

- In the case of Sweden, H&C suppliers must report on **GHG intensity of energy production including both direct and indirect GHG emissions,** in line with the reporting guidelines developed by Värmemarknadskommittén.

- In Estonia, biomethane is eligible for GOs only if it complies with sustainability criteria. This ensures that all biomethane covered by GOs in Estonia is verifiably produced in a sustainable manner. However, the extent to which inclusion of **information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)** is passed on to end consumers depends on the disclosure practices of individual suppliers.

9.3.4.4 The innovation scenario adds more information on nature or societal impacts

For the innovative scenario, the information content of disclosure can be extended by providing **enhanced information on nature or societal impacts** of energy production**.** Disclosure requirements under ESRS S1-S4 are focusing on how a company affects people and requirements under ESRS E1-E5 are focusing on how a company impacts nature. This puts pressure on the disclosure schemes to provide more information on nature or societal impacts. For example, disclosure schemes could provide information on compliance with sustainability criteria for biomass or RFNBO criteria. This could also improve harmonisation between disclosure and target accounting.

9.3.4.5 The innovation scenario supports granular matching of production and consumption at a finer scale

For the innovative scenario, enhancing the granularity of information provision is another important aspect, particularly in the context of electricity. Innovative concepts **provide sub-monthly – hourly – information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame**: temporal granularity is a key aspect of the described approach for hourly matching. It is also a key element of the RFNBO rules for electricity taken from the grid, with a shift from *monthly matching* during a transitional period to *hourly matching* in the long-term. As part of the innovation scenario, innovative disclosure schemes could support hourly matching by integrating hourly production time information into electricity GO systems and including information on the share of hourly matched electricity supply into disclosure information.

Meanwhile, hourly matching is predominantly a concept applying to electricity markets, whereas H&C supply and gas supply are characterised by greater temporal inertia. However, hourly data on energy production could be relevant in the case of electricity-based H&C or gas production, if suppliers wish to demonstrate an hourly matching of H&C or gas production to renewable electricity availability.

9.3.5 Information on additionality indicators

9.3.5.1 Good practices disclose share of Renewable Energy Purchase Agreements

In a good practice scenario, **information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure** is provided. To some extent, this is the case in the German and Austrian electricity GO schemes, which could be used as starting points for a more comprehensive implementation.

- The German electricity GO registry at least allows for the tracking and cancellation of so-called "bundled GOs", where the contractual delivery of electricity in consistency with the traded GOs is verified and confirmed. Although the disclosure system does not foresee this information to be explicitly included in the disclosure statement towards the beneficiary of disclosure (i.e. the end-consumer), such an element of the underlying tracking system could be used to implement "share of PPAs" as information parameter of the final disclosure.
- In Austria, suppliers are required to report the percentage of electricity and GOs purchased together—referred to as ‘coupling’—on disclosure statements. This offers a partial insight into the degree of alignment between physical supply and attribute claims.

9.3.5.2 Good practices disclose information on domestic subsidies

Energy disclosure schemes in the good practice scenario **provide information on subsidy schemes that a plant profits from**, at least relating to domestic subsidy schemes. Examples for such a basic implementation of according provisions can be found in Germany and France.

- In Germany, domestically supported RES-E is allocated on a statistical pro-rata basis towards all end-consumers as part of their fuel mix. This share is clearly distinguished from other renewable shares, which allows for a distinction at least between German supported RES-E and other RES-E. However, it should be pointed out that this regulation on distinguished disclosure in Germany is linked to the specific allocation mechanism for supported RES shares but does not allow for information on the level of support relating to cancelled GOs. This also means that no information on the level of support is provided for imported RES-E (which might include GOs for supported RES-E).
- In France, there must be a specific indication of the share of renewable energy disclosed through GOs, particularly those originating from production devices supported under the French feed-in tariff system and procured via auctions organised by EEX. This adds a layer of transparency regarding public support mechanisms embedded in the disclosed energy. Note that the GOs contain this information on the level of support of a production plant.

9.3.5.3 Innovative concepts disclose the share of energy covered with REPAs specifically distinguishing REPAs that meet consumption target compliance conditions

In the innovation scenario, energy disclosure concepts make **information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure**, including a distinction for further characteristics like the compliance with consumption target requirements. One example is the EU's RFNBO set of criteria necessitating the verification of PPA existence as part of the check whether electricity taken from the grid can be accounted as fully renewable when producing RFNBOs. As another starting point for such an implementation, one can refer to the Guarantees of Renewable Origin (GRO) mechanism as proposed by the Florence School of Regulation (FSR). This proposed instrument obliges consumers or their suppliers to hold GROs corresponding to a certain share of their final energy consumption. Such an obligation would stimulate Renewable Energy Purchase Agreements and the disclosure of such REPAs in the energy supply.

9.3.5.4 Innovative concepts disclose specific and comparable subsidy information also for imported volumes

In the innovation scenario, **information on subsidy schemes that a plant profits from** has to be mandatorily provided also for imported GOs. Such an implementation can build, amongst other things, on the mandatory subsidy-related information as contained on GOs in accordance with EN 16325. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from supported or unsupported plants).

9.3.5.5 Innovative concepts disclose plant age

In the innovation scenario, energy disclosure schemes include the **provision of information on the age of a production plant** to end consumers. This can build on the mandatory information parameters of GOs according to EN 16325, namely the information on the date when a production device first became operational. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from plants newer than a certain age threshold).

Elements of such an approach could also be drawn from the Delegated Regulation (EU) 2023/1184 detailing the rules for the production of RFNBOs. Article 5 on 'Additionality' sets limits to the age of the installation generating renewable electricity (not older than 36 months than the RFNBO production plant).

9.3.5.6 Specific additionality indicators could be considered

No application of sub-criteria related to disclosure of information on additionality indicators could be observed in the analysed disclosure schemes, yet they could be considered where the consumer-incentivising impact of the existing disclosure scheme would be deemed insufficient.

9.3.5.7 Share of supplier-owned generation could be provided

No inspiration from the analysed existing disclosure scheme or innovative disclosure concepts could be found for following evaluation criteria that are recommended by some NGOs:

- **Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure**.
- **Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure**.
- **Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure**.

Accordingly, these aspects are not covered in neither the good practice not the innovation scenario.

9.3.6 The format of information disclosure

9.3.6.1 The good practice scenario ensures that information of existing disclosure schemes is easily accessible and available at key decision phases

The good practice scenario ensures that **disclosure information is easily accessible upon request**, both **from a supplier's perspective** and **from a consumer's perspective**. **Disclosure information is** also **mandatorily provided at key decision phases** and **is digital and directly accessible for organisations**.

Some of these aspects are already common standard in analysed energy disclosure schemes. Examples include:

- EU regulation ensures that disclosure of electricity is based on cancelled Guarantees of Origin, and GO registries issue cancellation statements to suppliers. Therefore, the data required for disclosure is digital, centrally recorded and readily accessible. Besides that, suppliers need to disclose information on the supply on a bill and promotional material.
- Moreover, disclosure information is mandatorily available on website of the supplier, on marketing materials and on or attached to invoices in all analysed countries in line with requirements by EU legislation.

More advanced aspects can be implemented based on good practice examples from individual show cases:

- Some jurisdictions, such as Flanders and Estonia, have in addition developed webtools via which end-consumers can verify the renewable share in their electricity (Flanders) or gas (Estonia) supply.

- In the Finnish and Dutch GO schemes, end-consumers can open accounts in the GO registry and monitor exactly what GOs have been cancelled on their behalf and access the detailed information included on the GOs. Finnish and Dutch H&C disclosure concepts are examples where information has to be made available electronically by default.

9.3.6.2 Good practices clearly present information and cover the full mix

In the good practice scenario, the energy disclosure schemes ensure that **information on energy sources is presented in a clear and accessible format using visuals like a chart, graph or table** and that **this information covers both renewable and non-renewable sources**.

Inspiration can be taken from these examples for the different energy types:

- In Denmark, for instance, the full fuel composition of the electricity supply is indicated in text and by a graphical overview as shown in the standard form provided by the TSO. In the case of electronic distribution of invoices to consumers, the composition of fuels may be stated in text only if the declaration is accompanied by information that the graphic overview has been published on the company's website. Also in Austria, Germany and Sweden, there is legal regulation about the format and content of the graphical illustration of the disclosure information.

- Austria is a good practice example of requiring gas suppliers to use graphs for disclosure indicating the share of biomethane in the supply. The remainder part is indicated as ‘gas of an unknown origin’.

- In Finland, Sweden, and the Netherlands, where H&C disclosure is already practically implemented, suppliers use charts and tables to present disclosure information on their websites. Also, the H&C suppliers in these countries usually provide information on the full fuel mix.

9.3.6.3 Ranking tools can be considered but are hard to adopt in governmental context

No inspiration from the analysed existing disclosure scheme or innovative disclosure concepts could be found for following sub-criterion, which is therefore not included in either of the scenarios. However, the implementation of such a design feature could be considered:

- **Information provided in a ranking tool that evaluates performance based on additionality criteria**.
  Note: Governments may not be able to rank (as qualification may be subject to subjective criteria) but that they may facilitate COMPARISON tools based on transparent information. This is in line with the CEER advise on Trustworthy green offers from 2023.
  Some NGOs (Greenpeace in Belgium Flanders, based on the supplier’s investment profile) and WISE in the Netherlands (based on production location)) organise for such ranking but do not all update this every year.

10 Key lessons from good and innovative practices for enhancing the benefits of energy disclosure

Building on the description and analysis of different scenarios based on the identified good practice and innovative approaches as outlined in chapter 9, the following chapter elaborates key lessons of the analysis relating to the different sub-criteria within both the good practice scenario and the innovation scenario. As in the description of the scenarios (see 9.3), the different sub-criteria are clustered within the following pillars:

1. Clarity and consistency in energy disclosure purposes;
2. The institutional anchoring of disclosure;
3. The system boundaries of energy disclosure;
4. The type of information provided;
5. Information on additionality indicators; and
6. The format of information disclosure

This clustering should allow policy makers to have a condensed overview of relevant aspects (i.e. sub-criteria) which relate to these design elements when discussing potential improvements of disclosure systems on a more general level.

10.1 Clarity and consistency in energy disclosure purposes

Relevant sub-criteria	
1	The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets
2	Disclosure instruments allow for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets
3	Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green attributes
4	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)

The purpose of disclosure needs to be clearly defined

The purpose of disclosure in its underlying accounting instruments need to be clearly defined by law and in practice. EU disclosure legislation points at GOs as the instrument for disclosure, and accordingly, the current legislation on GOs clearly specifies that their purpose is restricted to disclosure and that they should be distinguished from support certificates. The mechanisms of policy target accounting historically do not build on GOs but on production statistics reported to the European Commission. However, striving for synergies between the purpose of GOs and other purposes like target accounting and support administration could, to some extent, increase the potential benefits of energy disclosure.

Enhanced consistency between target and disclosure accounting could increase benefits particularly for gas

This becomes more an issue now that renewable energy targets have spread over all energy carriers and now that disclosure obligations on the origin of electricity is extending to other energy types. For example, EU legislation historically counted national policy targets at the country of production but counts new sectoral targets for renewable and low-carbon gases at the point of consumption. For doing so, the gases are tracked between their production and consumption point through the mass-balance accounting mechanism. If the consumption is considered renewable for target accounting (and related claims in a quota system as in the transport sector) but not for disclosure, which could lead to confused customers. This is why the Union Database for sustainable biofuels requires GOs to be cancelled at the same point of consumption as where the renewable gas is counted for targets. This illustrates how EU policy makers maintain the credibility of the GO as instrument for disclosure by bringing it together with the consumption while counting the policy targets. Turning it around and designing the tracking instrument from the outset in a way that it can serve both purposes of disclosure and target accounting, would prevent confusion and yield operational efficiency. It requires taking a closer look at the legally defined tracking mechanisms for disclosure and target accounting. GOs are allowed to be used in a book-and-claim manner but have the possibility of being used in a bundled sale (energy and GOs traded together). For gases, the targets are legally counted following mass-balancing. Whereas the Renewable Energy Directive defines the interconnected gas network as one single logistical system, for the purpose of mass-balancing, this overlaps with the use of a book-and-claim instrument like the GO in a restricted geography.

This provides an opportunity to enhance the efficiency of system management and the credibility of tracking in the eyes of critics of the GO system. Indeed, allowing the disclosure instrument of the GO and the tracking of targets in the Union Database to become interacting systems creates a highly complex situation for all related administrations and IT systems. This has led to years of practical IT design discussions between Member States and the EU. Integrating them in one overall tracking system from the outset would overcome many practical issues and remove the need for discussions about the division of responsibility between Member States and the centralised EU level.

For heating and cooling, the physical transport of energy is practically limited to restricted areas of district heating grids rather than a pan-European network. In that framework, the identified examples are largely innovative approaches taken from literature, and good practice examples from the country case-studies for gases and heating and cooling can be used as starting points for further recommendations, and potential considerations for electricity.

Administrative synergies are a 'no-regret' option

Firstly, administrative synergies can be tapped in various respects. Both good practice examples and innovative approaches are show-cases for the use of joint standing data in registries and for the use of GO data for different administrative uses. Such administrative uses can include attribute tracking, the administration of support schemes, and the compilation of statistics. For example, this could mean that plant operators only have to register their plants in one registry both for participation in the GO system and for the participation in the respective support scheme. In the context of a full disclosure obligation, GOs can also be used as a statistical instrument, which is also suitable for monitoring the fulfilment of national renewable or decarbonisation targets.

Direct linkage between tracking for the target and disclosure purposes requires cautious considerations

As a more fundamental system upgrade, an integration of tracking systems or direct linkage between tracking for the target purpose and the disclosure purpose (e.g. via GOs) is suggested by the literature. Such innovative system adaptations are suggested particularly for electricity and gas, while for H&C the assumption prevails that cross-border trade of attributes for any purpose would have major inconsistencies with the limited geographical boundaries of district heating systems. Therefore, it is assumed and recommended that heating and cooling attributes are claimed for consumption in the same country as the country of production. In this framework, the identified approaches described in detail in Annex B.1 can provide inspiration for further considerations and development in the relation between different energy disclosure purposes.

Given the longstanding (>2 decades) segregation of purposes in electricity tracking in EU, it should be pointed out that such fundamental changes to the existing system for electricity may have complex implications with overall RES and energy policy. This means that the details of their applicability and their potential implications should be thoroughly assessed before taking decisions about implementation. This should include the following considerations:

- Voluntary markets may not include sufficient willingness to pay to stimulate a sufficient level of new RES supply unless being combined with appropriate legal obligations.
- Consumer-driven financial support which is not clearly guided towards specific technologies and new capacities may result in a large amount of windfall profits for plant operators and for traders rather than in stimulation of increased RES capacities.
- Voluntary markets may not provide comparable security on long-term financial stability, which is needed for bankability of new RES projects. Lessons could be taken from compliance markets in, for example, the US.
- It is harder to finance technology development in voluntary, market-driven schemes, for which innovation may still need separate/additional government-driven financial support frameworks.
- From a broader perspective, grid and pipeline infrastructure needs to be developed in line with increased RES capacities, which is harder to coordinate in voluntary (and potentially pan-European) markets than in systems consistently managed in the framework of national targets.
- With national targets defined across EU Member States, the responsibility for meeting these targets is more clearly allocated to the respective governments, thus increasing the probability of these targets being met. This also means that these governments need to have control over the natural and technical capacity potentials in a given country or region.
- There are complex and unclear implications with regard to public acceptance if RES plants are built in regions without contributing to national targets.
- Member States have an interest in tapping benefits by EU-wide system management and related synergies in order to increase flexibility and tapping least-cost production opportunities. But they also have the interest that sub-sets of the overall energy system increase their RES shares in order to increase system resilience and overall decarbonisation in the long term.

While stronger coherence between the support, target and disclosure systems would increase the relevance of energy disclosure and its potential benefits, further analysis should focus on designing such coherence to avoid the above-outlined potential drawbacks. It should also consider whether the benefits (particularly from society's perspective) could be achieved more efficiently and effectively by other instruments.

Relevance for benefits and stakeholder groups:

Society could benefit from contributions to the reduction of bureaucracy if administrative synergies are tapped, while a positive contribution to the energy transition would depend on added value of a shift of 'responsibility' from existing support systems to markets, and a high level of motivation/willingness to pay by consumers.

Plant operators could strongly benefit from the outlined measures in terms of reduced bureaucracy, fulfilling formal requirements for market participation or reporting, and particularly additional revenues from green attribute sales.

10.2 Institutional anchoring of energy disclosure

Lessons can be derived for the following categories of energy disclosure information, as distinguished by the different sub-chapters:

10.2.1 Legal clarity of tracking principles and data availability

Relevant sub-criteria	
5	Disclosure system is in line with EN 16325:2025 (EECS Membership as proxy)
12	The Disclosure Concept is anchored in legislation
20	Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)
21	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
22	The residual mix is publicly available, enabling its usage for disclosure
23	Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)

A robust legal definition of tracking principles for energy disclosure has the highest relevance for electricity due to the advanced market development and differentiation, and the related complexity which needs to be handled. For gas, there is a particular relevance due to different regulatory regimes which are applicable for gas due to the strong interaction with the transport and heating sector). For heating and cooling, there appears to be a reduced relevance as market differentiation and competition in such rather local systems are limited, thus also reducing the relevance of disclosure to some extent. Nevertheless, when H&C suppliers offer product differentiation within H&C grids, a legal definition of tracking principles and disclosure rules is required to ensure the uniqueness of claims and prevent double counting of attributes.

Disclosure should be mandatory

The disclosure concept should be anchored in legislation, which is common practice in the analysed countries. The level of detail can be addressed at different regulatory levels. This has the benefit of aiming at an appropriate level of binding nature in high-level legislation (voted by a national parliament), while also ensuring clarity and consistency of disclosure systems in more practical regulations (like decisions issued by a regulatory authority). At the same time, it maintains flexibility for adapting the system in detail where needed.

Ensure consistency with the standard of the tracking instrument - EN 16325

A crucial baseline for the implementation of disclosure system is consistency with EN 16325:2025 as mandated by the Renewable Directive 2018/2001(EU). This standard particularly defines the instrument of the GOs as a major underlying tracking instrument with a view to implementing its purpose given by law, being disclosure. Consistency with this common standard is also crucial in order to address many of the more technical sub-criteria related to tracking instruments for disclosure systems.

Appointing a unique instrument for disclosure through law consistently for all disclosing actors prevents double claims

In order to prevent double claims, it must be clear what tracking mechanism is used for each claim. Legal clarity should be ensured by specifying the applicable tracking instruments for the disclosure system. The use of GO systems in line with EU Directives is the common approach for renewables. But also for non-renewable energy, clarity on eligible instruments for tracking and documentation is helpful – for example, for organisations that need to comply with specific reporting standards and to substantiate a claim in public. While the application of fully GO-based 'full disclosure' systems seem to be straight forward, further inspiration for defining applicable tracking instruments besides GOs can also be drawn from the GHG Protocol Scope 2 Guidance (Sotos, 2015). The latter formulates quality criteria that contractual instruments have to meet, including tracking tools used under the market-based approach.

For preventing inconsistent or double claims, it is important that corporate renewable consumption claims are based on the same tracking instrument as the claims made by suppliers, and all disclosing parties consistently using the GOs for their claims of consumption or supply of energy from renewable sources.

Install supervision on claims of temporally-matched renewable energy supply for safeguarding credibility and reliability

A more advanced element of information aims to provide real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources). The aim is to facilitate not only the disclosure of a more time-granular fuel mix, but also to allow consumers to influence their fuel mix – not only by choice of supply, but by responsive demand-side management and flexibility, thus potentially increasing their real-time RES shares in energy consumption. With a view to electricity, there are examples of data hubs in Denmark and in Germany[47] that provide such information. Once the volume of claims on temporally-matched supply grows high, in order to prevent erroneous and fraudulent claims, attention must be paid to this issue in the supervision exercise of the disclosure supervisors.

Relevance for benefits and stakeholder groups:

The legal clarity of tracking principles and sufficient data availability ensure that the provided data is reliable and that related claims are commonly acknowledged. Therefore, this aspect is crucial, particularly for organisations which depend on clear and commonly agreed principles, e.g. in order to make justified claims for marketing products or services, to comply with carbon accounting standards, to meet growing stakeholder expectations, mitigate reputational risks and to demonstrate environmental leadership.
But also society as a whole can benefit from reduced bureaucracy and the efficiency of administrative action, and – if consumers have information available to adapt their consumption patterns to the availability of RES in energy systems – also in terms of reduced GHG emissions and incentives for a consistent development of system infrastructure.

[47] See https://greengrid-compass.eu/

10.2.2 Automatisation of processes

Relevant sub-criteria	
6	Automated provision of information to the beneficiary of disclosure
7	Automated provision of proof that tracking instruments are used
8	Automation of national-level supervision processes
9	Automation of verification processes
10	Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy
11	Existence of automated systems for the collection and transfer of energy production data

Enhanced automated digital processes can build on good practice examples

Automatisation of processes includes more specifically aspects like

- the automated provision of information;
- automated provision of proof that tracking instruments are used;
- Automation of national-level supervision processes;
- Automation of verification processes;
- Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy; and
- the existence of automated systems for the collection and transfer of energy production data.

For electricity, there are manifold established approaches which can be considered as good practice for automation of processes, and – according to the less developed markets - some fewer for gas, where the automation is in many countries still on the design table. With respect to heating and cooling, there are only limited examples, while also the relevance in this case might be smaller due to the limited complexity of restricted heating and cooling systems.

The provision of verified and digital information to end consumers as implemented in the GreenCheck of Belgium-Flanders, Brussels and Estonia is a specific showcase, as well as the provision of cancellation statement information to end-consumers (particularly to institutional consumers) based on direct access to GO registry data from Austria and Estonia. In both cases, the integrated processes and high level of automation are supported by underlying legal requirements, activating the relevant actors to contribute.

Besides EECS and EN 16325, general technical developments can support digitalisation

In general terms, the further technical developments in digitalisation and those relating to the application of smart meters open up a broad range of options for automatising data flows from the plant operators to end consumers, including the role of auditors and national bodies for verification and the national-level supervision of these processes. The implementation of EN 16325 based on EECS allows for a good governance framework to ensure a harmonised approach for such activities relating to GOs as underlying tracking instruments. This is particularly relevant with a view to the technical interfaces between registries for different energy carriers.

Ensuring DPP builds on the GO and its processes

From an innovative perspective, it seems promising to further develop the Digital Product Passport and include features in its design to support automated verification and supervision, which could greatly increase efficiency. This should build on the existing tracking instrument (the GO) to prevent double counting and to use the existing strengths.

Relevance for benefits and stakeholder groups:

Automatising processes is key to reducing bureaucracy and to the efficiency of administrative action. This is particularly beneficial for society as a whole (and its administrative agencies) and for plant operators as market participants. For households, accessible online tools like origin comparators and GreenCheck consumption verification empower consumers to make an informed choice of supplier and to positively influence the energy transition.

10.2.3 Coordination of different energy carriers and of conversion processes

Relevant sub-criteria	
13	Cancellation of certificates for the input energy and issuing of new certificates for the output energy
14	Clear rules are in place for tracking conversion between different energy carriers
15	Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking
18	Harmonisation of requirements and administrative procedures across energy carriers
19	Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production

Sector coupling increases the need for coordinating the rules for different energy carriers and of conversion processes to maintain the integrity of overall accounting systems.

Use EN 16325 as guidance for the handling of conversion processes

Clear rules for tracking the conversion between energy carriers have to be implemented, including cancelling certificates for the input energy and subsequently issuing new certificates for the output energy. This is required to avoid the double counting of green attributes (or other explicit attributes as represented by GOs). Implementation examples are provided in the analysed country cases for the different energy types. As a standardised framework, EN 16325:2025 contains rules on conversion issuance which can be used as a general guidance.

Tap synergies between registries by data sharing and harmonised rules

Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking are highly recommended to maintain data integrity and to increase efficiency of processes. While some countries have separate GO-issuing bodies and registries for electricity, many more will have the GOs for gas and electricity in a single registry. Of the analysed countries, Austria, for example, manages GOs for all energy carriers in a single registry, thus allowing for seamless tracking of conversion.

In general, it is advisable that requirements, administrative procedures across energy carriers are harmonised in order to facilitate (cost-)efficient processes and to avoid double counting, particularly with a view to the applicable tracking procedures. While it is complex to describe this on a detailed level, the consistent application of EECS rules, the allocation of responsibilities for different energy carriers to a single authority and the handling of data in a joint GO registry for the different energy carriers are basic measures which strongly support a consistent operation of disclosure and tracking rules for the different energy carriers. This allows for an in-depth consideration of differences which need to be considered for the different energy carriers. It also allows potential energy-carrier specific implementation approaches to be evaluated in terms of potential draw-backs and appropriate mitigation measures.

Relevance for benefits and stakeholder groups:

The clear coordination of different energy carriers and of conversion processes is particularly relevant for plant operators which need to document their internal processes and fuels, also as a prerequisite for their market participation. However, organisations also benefit as this contributes to their interest in providing unique green claims for marketing products or services. Finally, society as a whole can gain benefits, as these coordination processes are expected to contribute to the reduction of bureaucracy and efficiency of administrative action, and to support incentives for a consistent development of overall system infrastructure.

10.2.4 International coordination and consistency

Relevant sub-criteria	
16	Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
17	Disclosure method is based on principles consistent with those used at the EU level.

Ensuring the international coordination and consistency of energy disclosure systems and underlying tracking instruments facilitates international trade and increases practical feasibility by building on established principles and procedures.

Data-sharing facilitates international trade of energy attributes

Data sharing on tracked attributes between relevant registries and public agencies in other countries or domains for a coherent data use in the disclosure system is largely facilitated by membership of the EECS Scheme, cooperation within AIB and the use of the AIB hub for international transactions of GOs. This covers renewable energy, but not always fossil or nuclear energy. Either way, international trade of attributes has to be thoroughly supervised. Data sharing is also a prerequisite for calculating a comprehensive residual mix, taking international market activities into account. For gases, the Union Database aims to include an additional trust layer for traceability monitoring, yet inconsistencies and challenges are to be overcome in the interaction with the separately and nationally legislated GO system. For heating and cooling, data sharing obviously is only relevant to the extent that such international trade activities take place, while the delivery of heating and cooling energy (unless in exceptional cases) is restricted to smaller regions withing individual countries.

In order to ensure that the disclosure methods applied are consistent with those used at the EU level, the RED, the IEMD and the recast Directive on the Common Rules for Gas and Hydrogen (EU) 2024/1788 (Directive (EU) 2024/1788 of the European Parliament and of the Council of 13 June 2024 on common rules for the internal markets for renewable gas, natural gas and hydrogen, amending Directive (EU) 2023/1791 and repealing Directive 2009/73/EC (recast) (Text with EEA relevance), 2024) provide a common ground for disclosure obligations for suppliers for electricity and for gas, with renewables substantiated via GOs. For corporate energy source disclosure, the CSRD-ESRS (Corporate Sustainability Reporting Directive (CSRD), 2022) requirements provide common guidance.

Relevance for benefits and stakeholder groups:

International coordination is particularly relevant for market participants active in international markets. For plant operators, this allows them to fulfill the formal prerequisites for market participation. The relevance is substantial for organisations acting as institutional consumers, providing unique green claims for marketing products or services. By applying a coordinated approach on an international level, society as a whole can benefit from a reduced level of bureaucracy and increased efficiency of administrative action.

10.3 System boundaries of energy disclosure

System boundaries of the disclosure system define which tracking instruments may be used to make claims on green energy supply and consumption in the context of disclosure while ensuring the uniqueness of claims. On a fundamental level, the analysed case studies provide recommendations for rules regarding the clear and robust allocation of attributes, residual mix calculation and the prevention of double counting. The inclusion of energy storage and losses can further improve the attribute allocation system, while rules regarding system access can have implications for market participation and administrative efficiency. More significant impacts can be expected from changes in system boundaries which refer to geographical and temporal boundaries of disclosure systems and restrictions based on additionality criteria. Here, individual concepts provide starting points for consideration. More in-depth research would be required to develop recommendations for adjusting the system boundaries of disclosure.

In summary, lessons can be derived for the following categories of energy disclosure information, as distinguished by the different sub-chapters:

10.3.1 Clear and robust attribute allocation

Relevant sub-criteria	
24	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
25	Energy attributes can be allocated to a specific consumer as beneficiary
26	Energy attributes can be allocated to a specific product of a beneficiary

Energy disclosure systems must ensure that energy attributes are accurately tracked and allocated to specific energy consumption to ensure the uniqueness of claims and prevent double counting. Within the boundaries of an energy disclosure system, it is necessary to specify clearly and in a legally binding manner the tracking instruments based on which claims can be made. Using GO cancellation as the exclusive basis for renewable attribute allocation is a widely adopted good practice, because it ensures that each unit of energy is only claimed once. Some countries among the case studies, such as Austria and the Netherlands, have implemented a full disclosure system in which the unequivocal attribute allocation is also extended to non-renewable energy sources.

Attributes can be explicitly allocated to specific energy consumption by cancelling GOs on behalf of a supplier's energy product (or the suppliers' mix if no differentiated products are offered), aggregating all individual consumers who have contracted said product. Alternatively, GOs can be cancelled on behalf of a specific energy consumer. While the Internal Electricity and Gas Market Directives mandate product level disclosure (Annex I section 1.3 lit. c Nr. 5 Directive (EU) 2019/944 for electricity; Annex I section 5 Directive (EU) 2024/1788 for gases), the EN

16325 and EECS rules specify that GO registries must also enable consumers to be named as the beneficiary of cancellation. Product- and beneficiary-specific attribute allocation can therefore be considered standard good practice.

Beyond this, individual case studies also allow for the allocation of attributes to a specific product of an energy consumer as the beneficiary of GO cancellation (e.g. a particular product line of an industrial company). For organisations, this facilitates the use of energy disclosure information as part of consumption disclosure statements for their stakeholders as part of corporate sustainability reporting.

For H&C, disclosure obligations in the recast Renewable Energy Directive (EU) 2018/2001 and recast Energy Efficiency Directive (EU) 2023/179 do not yet provide a clear link between H&C GOs and disclosure. On a national level, the Finnish, Dutch and Swedish (if implemented) GO and disclosure regulations impose clear rules that renewable (and waste heat-based, where covered) H&C supply needs to be backed by H&C GOs. In Germany, the use of GOs is only legally required when a supplier commits to supplying a certain share of H&C from renewable or waste heat sources. To prevent double counting, mandating the use of GOs is recommended, at least if suppliers offer product differentiation in grids (if GOs can be used across non-interconnected grids, comprehensive disclosure rules tying all renewable energy supply claims to GO cancellation is necessary to ensure the uniqueness of claims).

Relevance for benefits and stakeholder groups:

Clear and robust attribute allocation ensuring the uniqueness of claims is a fundamental precondition for a transparent and credible energy tracking and disclosure system (see Table 1 in chapter 2.4.3). As far as the specific interests of stakeholder groups are concerned, it is particularly relevant for organisations. Here, the verifiable uniqueness of claims on renewable and low carbon attributes is a prerequisite for applying the market-based approach when complying with requirements on energy procurement set by carbon accounting standards, low carbon initiatives or regulation. Similarly, it is vital for meeting growing stakeholder expectations, mitigating reputational risks and demonstrating environmental leadership through credible renewable energy procurement. This is mirrored by benefits for plant operators: here, the value of attributes in green attribute markets results from their verified uniqueness. As contract partners in REPAs, an alignment with organisations' demands on attribute allocation is likewise important for plant operators.

10.3.2 Residual mix and prevention of double counting

Relevant sub-criteria	
27	Mandatory usage of the Residual Mix for untracked attributes
28	Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin.
29	Tracking system differentiates energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed.

To complement the clear and robust allocation of attributes, disclosure rules should also specify what attributes are assigned to energy supply and consumption if no legally recognised tracking instruments are used. In such cases, mandating the use of the residual mix from which explicitly tracked attributes have been excluded is recommended by the literature (Seebach et al., 2015; Verwimp et al., 2025) and a widely adopted good practice in electricity disclosure systems. If energy consumers with a supply contract that is not backed by tracking instruments such as GO cancellation use grid averages instead of the residual mix when making claims on renewable attributes of energy consumption, it would result in double counting. As a result, complementing explicit energy attribute tracking with a residual mix for untracked attributes is essential for ensuring the integrity of the disclosure system. Exceptions apply for full disclosure systems when calculation of a residual mix is not necessary if there are no untracked attributes of energy production, supply and consumption.

In the case of electricity, an established residual mix calculation methodology is available and annual residual mixes are publicly available, at least for EECS member states (AIB, 2025). The RED III requires all Member States to annually publish data on their residual energy mixes for electricity as well as for gases (Article 19 section 4 RED III), but the implementation of gas disclosure systems is still ongoing. As an intermediate measure, mandating that consumption for which no GOs are cancelled must be declared as fossil natural gas, as in the Austrian example, can be considered a good practice (see also EC Directorate-General for Energy und AIB Association of Issuing Bodies aisbl 2025).

For H&C, if the use of GOs is limited to interconnected H&C networks, residual mixes are calculated on a network level and become part of the information published by suppliers regarding the characteristics of their H&C supply. If disclosure rules permit the trading of attributes across grids, it should be accompanied by the publication of a national and – if cross-border transfer is enabled – European residual mix, to prevent double counting. Alternatively, adopting a fossil fuel 'default' for H&C supply without GO cancellation could be an intermediate solution (see Verwimp et al., 2022).

Furthermore, residual mix calculation requires clear system boundaries, including a clarification on which distribution systems are covered by explicit tracking instruments. In the electricity case studies in particular, it is established good practice to differentiate between energy amounts fed into the grid or another distribution system and energy amounts that were self-consumed. Self-consumed energy amounts tend to be outside the disclosure system and residual mix calculation. If GO issuance is offered for self-consumed energy amounts, it is recommended for GO cancellation to be tied to such self-consumption to ensure that no double counting of energy attributes occurs. That said, GO issuance for self-consumption can improve the clarity of attribute allocation particularly if production devices partly feed energy into the grid and are partly used for self-consumption. The introduction of a 'dissemination level' tag by the revised EN 16325:2025 as part of the required information on GOs facilitates differentiation between distribution systems and self-consumption.

Relevance for benefits and stakeholder groups:

The mandatory use of the residual mix for non-tracked offers complements the clear and robust allocation of attributes. It is a necessary component of ensuring the uniqueness of claims on renewable and low carbon attributes. For the reasons outlined above, this is particularly relevant to the organisations' benefits from energy disclosure – and indirectly, as contract partners supplying organisations – the plant operators' benefits.

10.3.3 Inclusion of energy storage and losses

Relevant sub-criteria	
30	Tracking system accounts for energy losses over storage
31	Tracking system enables to record the time period of release from an energy storage system ("time shifting of attributes over storage")

32	Tracking system has clear and consistent rules for allocating attributes from the input to the output of an energy storage system
33	Tracking system is transparent on the energy having been stored
34	Tracking system prevents double counting of attributes of stored energy

To date, most studied countries consider storage systems in energy tracking in a restricted manner only: where storage devices are located on the site of the RES production device, GOs are only issued for energy made available to the market (after storage and injection into the grid). This follows the rules provided by EN 16325 prior to its 2025 revision.

With temporal matching strategies gaining in importance, it becomes advisable to explicitly integrate storage into energy tracking and disclosure systems. Storage systems allow for the time of energy production and consumption to uncouple to a degree (with the length of storage time depending on storage technology). Reflecting this when tracking energy attributes allows storage operators to realise a market value for temporal shifts in the availability of green attributes, in particular. However, when including storage devices in attribute tracking, provisions need to be taken to allocate attributes from the energy input to the output of storage systems, take storage losses into account and prevent a double counting of the attributes of stored energy. The revised EN 16325:2025 includes provisions on GO issuance for energy flowing out of storage devices which tackle these issues, as in the current EECS rules. In both cases, GO issuance for storage systems can be adopted by domain schemes on an optional basis.

According to the revised EN 16325:2025, attributes from the energy input into storage systems are allocated to outputs by GO cancellation for input energy (unless the energy has been produced on the site of the storage device and its attributes can readily be determined). This principle has been adopted in Austria: GOs are cancelled for the energy input flowing into a storage system, and new GOs are issued for the measured output flowing out of the storage system. In this way, energy losses during storage are systematically taken into account. Attributes of GOs cancelled for input are inherited to GOs issued to output, except for the unique ID of the certificates, the production period, the country of issue, and if changed the dissemination level of the output. If GOs for the output of storage devices are issued only after GOs for inflows have been cancelled, double counting of green attributes is prevented. Moreover, the principle of issuing GOs for net energy production is taken into account (particularly in the case of pumped hydro stations, where GO issuance is only based on natural inflow, minus any net electricity consumed by pumping).

In the case of multiple inputs into storage, rules are needed for allocating specific attributes to storage outputs. Austria allows storage operators to choose the allocation method, or alternatively applies a ‘first in–first out’ principle by default.

For the sake of transparency, EN 16325 and EECS rules provide that GOs issued following a release of energy from a storage device need to be marked accordingly with a ‘storage tag’. This is important to prevent double counting of green attributes when compiling statistics based on GO issuance. To support a ‘time shifting’ of attributes through storage, GO issuance for storage devices should be combined with the inclusion of information on the start time and end time of energy production in production devices and energy release from storage devices (which is equally optional according to EN 16325:2025 and EECS rules).

Relevance for benefits and stakeholder groups:

The explicit integration of storage systems into tracking and disclosure systems primarily benefits society as a whole, by supporting incentives for a consistent development of system infrastructure. Also, storage device operators (which were not a focus of this study) would benefit from a valorisation of temporal shifts in the availability of green attributes.

10.3.4 System access and market participation

Relevant sub-criteria	
38	Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers
39	Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)
40	Ability to transfer EACs to individual consumers (with EAC cancellation by consumers)

GO registry access and cancellation rules determine which actors can apply for accounts in GO registries and which specific rights are associated with accounts, in particular with regard to GO cancellation. These practices differ between analysed case studies. In case of electricity, gas and H&C GO systems, there are several cases where any party can open an account in the GO registry and cancel GOs. This offers third parties such as service providers or contractors the ability to conduct GO transactions and cancellations on behalf of specific consumers, but also consumers themselves may participate and cancel GOs on their own behalf. In individual cases, like the Netherlands, specific monitoring accounts for consumers are offered in addition.

Where system access for producers is concerned, the issuance of GOs to renewable energy plants under Renewable Energy Purchase Agreements is established good practice in all analysed schemes (insofar as energy sources and dissemination levels are covered by the GO system). This is an important precondition for the clear allocation of attributes in case of REPAs – in markets where GO systems or other explicit tracking instruments exist, the existence of a REPA alone should not be considered proof of transfer of green attributes. To prevent double counting, the cancellation of associated GOs (and PoS, in the case of gases) on behalf of the beneficiary of the REPA is required.

Relevance for benefits and stakeholder groups:

In general, broadening system access can potentially increase participation in green attribute markets and allows particularly organisational consumers to optimise energy attribute procurement strategies from an administrative efficiency perspective. Therefore, benefits centre on plant operators and organisations. Further research would be needed to assess the costs and benefits of system changes in individual cases, and possible adjustment needs in legal disclosure frameworks. Covering REPAs in energy tracking and disclosure systems is a precondition for providing unique green claims for marketing products or services, which is likewise particularly important for plant operators and organisations.

10.3.5 Geographical and temporal boundaries

Relevant sub-criteria	
35	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)
36	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
37	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
44	Required geographical correlation of production and consumption of energy
45	Required temporal correlation of production and consumption of energy

Geographical and temporal boundaries of the disclosure system have a major impact on the balance of supply and demand for green attributes, and as a consequence, for their prices and the potential incentive effects of green energy attribute markets. The literature review in chapter 5 clearly indicates that the European GO market with its EU internal market boundary and annual matching of electricity supply and consumption is characterised by oversupply and low prices for green attributes. Furthermore, since the introduction of energy disclosure mandates and GOs as tracking instruments, the role of RES in electricity systems in particular has changed from niche market to becoming the dominant energy source in many electricity systems, with an increasing importance also for H&C, transport and industry sectors through power-to-X applications. As a result, the actual temporal availability and geographical deliverability (taking grid constraints into account) of RES to cover a certain demand become increasingly important prerequisites for claims on renewable energy supply and consumption which are both credible and meaningful from a systemic perspective. Aligning time and location matching of green electricity supply and demand more closely with the granularity of the energy products in European markets would allow for the creation of market signals incentivising grid-friendly consumption from RES, taking their temporal and spatial availability into account, as well as demand- and supply-side flexibility and a grid-friendly use of storage capacity.

As for temporal boundaries, individual electricity case studies such as France and the EU`s RFNBO rules impose monthly instead of annual matching requirements of supply and demand. The RFNBO rules foresee a move to hourly matching from 2030, and hourly matching is also the proposed requirement for green electricity claims in the revised GHGP Scope 2 guidance (including the option to use production and load profiles). Given the innovative character of such rules, impacts of more granular temporal matching have been modelled, but not comprehensively studied in practice yet. Thus, it would be premature to recommend a general shift in temporal boundaries in energy disclosure – beyond annual matching as established good practice. However, good and innovative practice examples indicate that it would be advantageous to further develop tracking instruments such as GOs to enable more granular matching strategies on a voluntary basis or in the contexts of specific regulatory requirements, such as the RFNBO rules. For example, information on the share of hourly matched electricity supply could be integrated as part of the type of disclosure information provided (see 10.4).

Examples of formulating geographical boundaries while taking physical deliverability constraints into account can be found in innovative concepts such as the EU's RFNBO rules and the proposed GHGP Scope 2 revisions. Both refer to bidding zones as relevant electricity market boundaries in a European context, while formulating conditions under which transfers beyond bidding zones, but within interconnected systems also remain permissible if the absence of transmission constraints can be demonstrated. Beyond the context of RFNBO rules and GHG accounting rules, changing the system boundaries of electricity disclosure from the EU internal market to bidding zones would be a major change that would require significantly more research than feasible or foreseen in this project. Similarly to temporal boundaries, however, the transparency of energy disclosure systems could be improved by making the share of geographically matched electricity supply visible as part of the type of disclosure information provided (see 10.4).

For H&C and gases, geographical and temporal boundaries need to be adjusted to the respective market and physical delivery conditions. For both energy carriers, grids provide a limited storage function, leading to a greater temporal uncoupling of supply and demand than in the case of electricity; at the same time, providing incentives for building up or maintaining appropriate storage capacities is an important component of RES integration. Analysing the impact of different temporal matching strategies is an open research question, given that the implementation of annual H&C and gas disclosure is still an ongoing process.

For H&C, the boundaries of interconnected grids form a natural deliverability boundary, which is already considered in several of the analysed H&C case studies (in particular, the Netherlands and Germany). For gases, deliverability is more complex because road and marine transport are viable options besides grid-based transport, while also conversion routes such as hydrogen transport in the form of ammonia have to be considered. In the context of target accounting, mass balancing and requirements on the bundled transfer of Proofs of Sustainability and energy commodity are established as a form of deliverability constraint. In individual case studies such as Estonia and France mass balance logic is also integrated into gas GO and energy disclosure systems, by tracking grid injections and withdrawals (including the use of virtual grids in Estonia) and ensuring that renewable gas attributes are bundled with the physical energy commodity.

In this regard, requirements on a bundled sale of tracking instrument and energy commodity can likewise be interpreted as a form of geographical and temporal boundary setting, taking physical deliverability and temporal availability into account. Thus far, this is mainly relevant in the context of target accounting (for gases, in the context of the RFNBO rules, and indirectly also in the case of H&C when policy targets refer to interconnected grids). Some cases, such as Austrian electricity disclosure, include information about bundled attribute and energy sales in disclosure statements. Excluding unbundled attribute sales from the system boundaries of energy disclosure does not appear recommendable. This is because flexibility in usable contract and market forms would be lost, with participation in unbundled short-term markets and bundled long-term (e.g. PPA) markets offering different, but complementary benefits. However, including the bundled sale of tracking instrument and energy commodity in information recorded on a tracking instrument (e.g. whether a PPA exists) could increase transparency for consumers and improve the usability of disclosure tracking tools for target accounting purposes.

Relevance for benefits and stakeholder groups:

For consumers, the geographical boundaries of energy disclosure systems in particular can have an impact on the awareness of the environmental effects of their own energy consumption (see chapter 3.4). Supplying information on geographical origins can enable consumers to better match energy supply choices to their own preferences and make active choices in support of the energy transition (see 10.4). For society, improving the availability of market incentives for aligning green electricity supply and demand could support the energy transition, contribute to GHG emission reductions of energy production and facilitate a consistent development of system infrastructure, which in turn might lead to a reduction of public costs of the energy transition. For plant operators, changes in geographical and temporal system boundaries could increase revenues from green attribute sales in short-term markets, if the scarcity and the value of the specific attributes offered increases. However, plant operators whose production devices are located in market zones with low green energy demand may be disadvantaged. If narrower geographical matching requirements are implemented, it is therefore important to take the possibility of energy transfers between market zones into account, so as not to curtail RES development in remote but still interconnected parts of the European electricity system, and set incentives for extending interconnections.

Thus far, a narrower definition of the system boundaries of energy disclosure has not been widely adopted, except for specific contexts (such as monthly matching requirements in individual electricity disclosure cases, RFNBO rules or the proposed revised GHGP Scope 2 guidance, which is however a voluntary standard). Therefore, it is important to point out that expectations on these causal links are so far mostly based on modelling studies (see chapter 4.3), and broader changes in system boundaries would require much more in-depth assessments that are out of scope of this project. Meanwhile, more detailed information provision on geographical and temporal origin would make it possible for consumers to adopt narrower system boundaries for their own supply choices (see 10.4). This can be a particularly relevant option for organisations in the light of changing GHG accounting requirements.

10.3.6 Integration of additionality criteria into system boundaries

Relevant sub-criteria	
41	Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)
42	Mandatory restrictions apply for the application of explicit tracking instruments based on plant age
43	Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support

Beyond a narrowing of geographical and temporal boundaries, there are also literature proposals for mandatory restrictions for applying explicit tracking instruments in energy disclosure based on additionality criteria such as plant age or the level of support (see chapters 3 and 6). In individual cases such as the German electricity disclosure, no GOs are issued for RES-E which have received support under the domestic support system. This is because these volumes are allocated on a statistical pro-rata basis to consumers (assuming that they have equally contributed to the funding of the support system and hereby have paid for the value of the greenness of the production and the respective attributes). However, no such restrictions apply for import and use of non-domestic GOs, resulting in different system boundaries for domestic RES production and attribute imports.

The EU's RFNBO rules are an example of an innovative concept in which mandatory additionality criteria are formulated in a specific context (target accounting of RFNBOs). At least for specific supply cases and national grid situations, only non-supported RES-E are permitted for criteria-compliant RFNBO production. Moreover, electricity must originate from a production device no older than 36 months (compared to the start of hydrogen production). As an example of a voluntary corporate disclosure initiative, RE100 imposes mandatory restrictions on the use of tracking instruments based on plant age, with a 15-year commissioning or repowering limit as a core eligibility criterion.

According to EN 16325, GOs must include information on the date when a production device first became operational, as well as information on whether production devices have received investment and/or production support, and the type of such support. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from plants newer than a certain age threshold, and informing consumers on the share of renewable energy supply originating from supported or unsupported plants). Based on this, consumers could set their own restrictions on plant age and support when choosing energy products (see 10.5).

However, imposing age-based mandatory restrictions on the use of tracking instruments altogether raises the challenge of how to carry out accounting for attributes of older and/or supported plants, requiring pro rata allocations such as in the case of German RES-E. In the H&C context specifically, excluding older or supported plants from explicit tracking instruments would prevent synergies from using tracking instruments for monitoring the decarbonisation progress of grids, where all connected plants would have to be included. Similarly, imposing mandatory restrictions on the use of explicit tracking instruments is mutually exclusive with the concept of full disclosure.

Relevance for benefits and stakeholder groups:

While trade-offs with the clarity of attribute allocation and benefits such as market-driven revenues for plant operators have to be considered, a focus of disclosure and green energy claims on new and unsupported energy production could enhance consumers' role in making active choices supporting the energy transition and contributing to the energy transition. These benefits are relevant for households and society as a whole. A corresponding narrowing of the system boundary of disclosure would, however, significantly narrow the scope of voluntary green energy markets. In this regard, the benefits of more impactful procurement would have to be weighed against a decrease in market size. Moreover, the continued operation of older plants falling out of support schemes might depend on revenues from green attributes, whereas for supported plants, co-financing from market revenues and support becomes increasingly important, given that support schemes are increasingly designed in a market-orientated and competitive manner, or as Contracts for Differences with uncertain implications for net support over the duration of the contract. Potential impacts of a change in disclosure system boundaries based on additionality criteria would thus have to be studied in greater detail.

10.4 The type of information provided

Good practices in the analysed case studies and innovative approaches in the literature provide lessons for the type of information to be provided by energy disclosure systems. With a view to maximising benefits to households, organisations, plant operators and society at large, providing information with both greater width and depth than currently established seems beneficial. However, there are trade-offs with the accessibility of information for households in particular, and with the costs of information provision. The latter particularly applies to cases in which further development of tracking instruments is required to record information (e.g. with regard to granular information on production time). In many cases, however, information is already recorded by underlying tracking instruments (e.g. information on plant age and existence of public support on GOs) or could be made available by linking existing tracking instruments which currently tend to be separate (especially with regard to sustainability information). Also, good practice examples already exist for increasing the informativeness of tracking instruments e.g. with regard to temporal granularity.

In terms of costs of information provision and accessibility, great potential lies in increasing the digitalisation and automation of energy tracking instruments and energy disclosure. For instance, sustainability information in registries issuing Proofs of Sustainability for biomass or RFNBOs could be automatically exchanged with GO registries via interfaces. On the user side, digital provision of energy disclosure information could enable stakeholders to select the information relevant to them. To enhance accessibility, stakeholder group profiles with pre-selected information types could be defined (e.g. simplified information for households and detailed information for organisations), with the option of additionally selecting or deselecting information based on individual preferences.

Specifically, lessons can be derived for the following categories of energy disclosure information, as distinguished by the different sub-chapters:

10.4.1 Comprehensive disclosure of energy source mix (supplier's mix and product mix)

Relevant sub-criteria	
46	The energy source mix of every product of a supplier is disclosed
47	The full energy source mix of the supplier is disclosed
63	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)

For electricity and gas, the European legal framework for disclosure mandates that suppliers must provide customers with information on their overall energy source mix and the energy source mix of the product purchased by the consumer (Annex I section 1.3 lit. c Nr. 5 Directive (EU) 2019/944 for electricity; Annex I section 5 Directive (EU) 2024/1788 for gases; for gases, the disclosure obligation refers not to the overall energy source mix, but to the share of renewable and separately low-carbon gas, specifically). Information must be provided in bills. This level of energy source mix information can be considered the smallest common denominator of national disclosure obligations, which may contain more extensive requirements.

For H&C, Article 24 section 1 of the recast Renewable Energy Directive (EU) 2018/2001 only requires Member States to 'ensure that information on the energy performance and the share of renewable energy in their district heating and cooling systems is provided to final consumers in an easily accessible manner, such as on bills or on the suppliers' websites and on request.' Moreover, the recast Energy Efficiency Directive (EU) 2023/1791 requires Member States to ensure that final H&C users are provided 'in or with their bills' information on the fuel mix used. Product level disclosure requirements do not yet exist. Countries such as the case studies analysed (the Netherlands, Sweden, Finland and Germany) provide examples of national disclosure rules for H&C which build on electricity and gas disclosure rules, and could provide a basis for more detailed, harmonised provisions on energy source mix disclosure.

From good practices in case studies and innovative approaches, two key recommendations on energy source mix disclosure can be derived, which apply to all energy carriers:

- Require energy suppliers to disclose the product mix of every product offered, not only the product supplied to a specific consumer. This can be disclosed on websites or in annual disclosure reports, for instance. Providing this information can increase transparency and help empower consumers when choosing energy products. For data protection reasons, it seems useful to limit such an information requirement to products available to a range of consumers rather than bilateral contracts such as individual REPAs.

- Beyond standardised, broad energy source categories such as the share of renewable, fossil and nuclear energy sources, it is recommended that consumers are offered detailed information on the energy sources employed in the supplier and product mix (e.g. regarding the type of RES used in energy production). This can be achieved most efficiently in a digital manner (e.g. via online portals for consumers, publication of detailed disclosure statements on suppliers websites, or consumer access to GO registries). To improve comparability and transparency, guidance on the detailed categories to be used should be provided at least on a national level.

Relevance for benefits and stakeholder groups:

The provision of comprehensive energy source mix information is important for households and society as a whole to improve the involvement and help empower consumers in supporting the energy transition and enable active choices and the expression of individual preferences. The provision of detailed energy source information can also be particularly relevant for organisations to enable procurement strategies which are in line with impactful decarbonisation strategies, the requirements of carbon accounting standards or low carbon initiatives, or product-specific requirements imposed by regulations or green lead markets (e.g. in the case of RFNBO production). The ability to differentiate between individual RES or, for instance, biomass types according to sustainability characteristics can be important when navigating stakeholder expectations, mitigating reputational risks and demonstrating environmental leadership. For plant operators, the provision of comprehensive information on the energy source mix can provide competitive advantages or enable additional value realisation for green attributes deemed particularly desirable by consumers.

10.4.2 Technological origin of energy supply

Relevant sub-criteria	
62	Disclosure statement includes information on the technological origin of the RES supply

Beyond energy source mix disclosure obligations, several of the analysed case studies also require suppliers to provide information on the technologies employed. EN 16325 and the EECS rules offer standardised guidance on detailed energy source and technology categories, and permissible combinations of the two (for H&C, this is provided only by the revised EN 16325:2025). For example, combining energy source and technology codes allows for differentiation between onshore and offshore wind, or the information that heating production from a heat pump is based on wind or solar power.

Relevance for benefits and stakeholder groups:

Information on the technological origin of energy supply allows for an even finer distinction of RES supply options in particular, as well as low carbon gas supply options. This can be particularly relevant for plant operators competing for shares in renewable and low carbon energy markets. To a lesser extent, the same benefits apply as for the comprehensive disclosure of the energy source mix.

10.4.3 Geographical origin of energy supply

Relevant sub-criteria	
50	Information on the country of origin of the production device is specified
51	Information on the specific region (state, province, city etc.) of a production device is specified
60	Disclosure statement includes information on the regional origin of the RES supply

In European disclosure regulation for electricity and gases, there are no requirements regarding the distinction of geographical origin. In the case of H&C, Article 24 section 1 of the recast Renewable Energy Directive (EU) 2018/2001 specifies that consumers must receive information on 'the share of renewable energy in their district heating and cooling systems,' but does not link to GOs as a tracking instrument and therefore leaves the matter of GO use from non-interconnected grids for disclosure purposes open to national interpretation. Practically, several but not all, of the analysed case studies have opted to restrict the use and/or transfer of GOs to interconnected grids.

For electricity and gas, including information on the country of origin of the energy supply enhances transparency for consumers. In the electricity context, information on the bidding zone in which a production device is located is relevant in the context of regulatory matching requirements set by the EU's RFNBO criteria (Commission Delegated Regulation (EU) 2023/1184) and potentially in the context of future requirements by carbon accounting standards, as indicated by the proposal for a revised GHG Protocol. More granular information on production device location can be relevant in the context of individual consumers geographical preferences or procurement strategies. In principle, detailed information on production device location is already recorded on GOs (as per EECS rules and EN 16325) and can therefore be accessed by GO registry users. As with the detailed energy source mix and technology information, digital disclosure information tools could be used to make the geographical origin of energy supply more visible to a wider range of consumers.

For H&C, information on the country of origin is only relevant if a transfer of H&C GOs across the boundaries of H&C grids is enabled. Even within a national context, deliverability constraints refer to individual, interconnected grids. The most relevant information on geographical origin in the H&C context thus indicates whether energy supply and its attributes originate from the same grid system (including interconnected grid systems, where relevant) that a consumer is connected to. For more detailed information, this could be accompanied by providing a map of H&C grids on suppliers' websites.

Relevance for benefits and stakeholder groups:

Providing information about the country and more specific regions (e.g. bidding zone, province, city) of energy production enables households and organisations to align their energy procurement with geographical preferences or procurement strategies that are tailored to organisations' decarbonisation strategies or stakeholder demands. For households, this enables more active choices of energy supply and contributions to the energy transition in a specific geographical context. For electricity supply in particular, geographical matching requirements are increasingly being introduced by regulation (particularly in the context of RFNBO production) and potentially more stringent future geographical matching requirements of carbon accounting standards. The rationale is to take the – at least theoretical – deliverability of electricity into account. This aims to set incentives for a consistent development of system infrastructure and ensure actual GHG emission reductions through an increase in renewable electricity demand (see chapters 3, 4 and 6). These aspects can also be relevant for households and organisations when making choices regarding the energy supply and when seeking to impactfully support the energy transition. For plant operators, increasing the visibility of geographical origin information can improve the value of green attributes, if they share a geographical context with energy consumers with an increased willingness to pay for geographically matched energy supply. For energy suppliers geographically matched products could enhance customer acquisition and loyalty.

10.4.4 Temporal information as a basis for temporal matching of energy production and consumption

Relevant sub-criteria	
52	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
53	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame

Gas and Electricity Market Directives specify that disclosure information must be provided for the preceding year. The usability of GOs for energy disclosure is limited by the lifetime of GOs according to Art. 19 section 3 RED II (12 months limit on the validity of GOs for transactions after production of the underlying energy unit, expiration of uncancelled GOs at the latest 18 months after energy production). Additionally, to support residual mix calculation and prevent double counting, it is recommended that all GOs are cancelled which are to be counted in the disclosure period of a given calendar year before the disclosure deadline in the following year (see Seebach et al., 2015).

In this regard, the revised EN 16325:2025 specifies some time-related limitations to cancellation, e.g. 'a GO shall only be cancelled for the purpose of Disclosure, and to demonstrate the origin of energy consumed: (…) ii. before the date of cancellation of the GO, or in the consumption period during which the Cancellation takes place. Maximum length of a consumption period being one calendar year' (EN 16325:2025, section 4.9.2.1.4 Limitations for Cancellation).

Referring to a harmonised consumption period of one calendar year (i.e**. annual matching of energy production and consumption**) can be considered basic good practice that has been implemented by many national disclosure systems.

Beyond this, issuing GOs for production periods at the level of the month or even the hour of energy production in energy disclosure information further increases transparency. Providing such information enables consumers to implement more granular matching strategies between RES supply and demand.

GO issuance for monthly or daily production periods is already included in existing GO registries, and the size of the energy unit for which GOs are issued, is generally one MWh. EN 16325 allows for **GOs to be registered for (sub-)hourly production periods**, and for production periods of Wh. Indeed, a more granular issuance of GOs requires doing so in units sized in Whs to enable small production devices to participate. While this is enabled optionally by RED III, it has not yet been widely implemented; however, there are good practice examples among the case studies. While individual countries like France have implemented monthly matching strategies, the issuance of GOs for (sub-)hourly production periods has tended to be optional to date. For example, Denmark[48] allows for 15-minute certificate issuance upon request by producers, enabling a voluntary sub-hourly matching of renewable energy production and consumption on a quarter-hour basis. Hourly matching strategies and residual mix calculation can be facilitated by data hubs providing disaggregated real-time or even advance data on grid mixes, as implemented e.g. in Denmark[49] and Germany[50]. However, it is important that in the context of disclosure, claims on temporally granular green energy supply and consumption cannot be based on grid mixes. Instead, they need to be based exclusively on GOs as the legally defined tracking instrument to prevent double counting. (Where no GOs are used, the disclosed origin of consumed energy should refer to the residual mix which excludes the attributes that are already allocated to specific consumers through GOs or alternative tracking mechanisms.)

Hourly information provision requires access to detailed digital disclosure information; leading for disclosure at aggregated level to a metric such as the share of consumption matched with RES supply on an hourly basis. This could be added to the established formats (on bills or on suppliers' websites).

Meanwhile, **hourly matching is predominantly relevant for electricity** markets, where demand and supply are balanced on an hourly or sub-hourly basis. Demand has not yet shown itself for hourly matching of production and consumption for renewable gases or heating and cooling. H&C distribution via grids is characterised by greater temporal inertia and subject to a more central planning of capacity allocation to meet the demand of consumers connected to the

[48] See https://energytrackandtrace.dk/en.

[49] See Energi Data Service, https://www.energidataservice.dk.

[50] See Green Grid Compass: https://greengrid-compass.eu/.

grid. Gas grids also provide a degree of infrastructural storage function. However, hourly data on energy production is relevant in the case of electricity-based H&C or gas production, if suppliers wish to demonstrate an hourly matching of H&C or gas production to renewable electricity availability.

While RNFBO-compliant hydrogen will depend on the hourly matched electricity input, an efficient sector-integration could be. As a result, rather than issuing hourly hydrogen GOs, monthly hydrogen GOs could be issued with a RFNBO tag that confirms that the electricity input was hourly matched to the hydrogen production profile.

Relevance for benefits and stakeholder groups:

As energy users, the provision of monthly and especially hourly information is most relevant for organisations, focusing on especially credible, impactful procurement strategies and alignment with evolving carbon accounting standards. Moreover, in the context of proving compliance with the EU's RFNBO criteria, monthly and, from 2030, hourly matching of renewable electricity production and RFNBO production becomes relevant. This makes granular temporal information provision also increasingly relevant for plant operators. If the relevance of temporal matching in green electricity marketing increases, revenues from green attribute sales in short-term markets might increase in hours in which electricity from RES is comparatively scarce. For society as a whole, research indicates that hourly matching can provide enhanced contributions to GHG emission reductions of electricity production and incentives for consistent development of system infrastructure (see chapter 6). Facilitating disclosure of a more time-granular fuel mix, could allow consumers to influence their fuel mix, not only by choice of supply, but by responsive demand-side management and flexibility, thus potentially increasing their real-time RES shares in energy consumption.

For gases and H&C, the implementation of energy disclosure systems is still ongoing. Annual matching and information provision on the production year is recommended to ensure comparability of disclosure information across suppliers, reliability and timely availability of residual mixes, and coherence with national target accounting periods. Benefits and challenges of more granular matching strategies, e.g. in terms of GHG emission impacts and storage incentives, require further research.

10.4.5 Information on sustainability characteristics of energy supply

Relevant sub-criteria	
54	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
55	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).
56	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
57	Inclusion of information on GHG intensity of energy production (direct emissions)
58	Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
59	Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)

61 Disclosure statement includes information on the sustainability characteristics of the RES supply

In the context of target accounting, **proof of compliance with sustainability and GHG mitigation criteria** is an integral part of tracking and verification mechanisms for biogenic energy carriers and RFNBOs. In the context of disclosure, information on whether sustainability criteria are met and how energy supply performs with regard to GHG emissions has only been integrated by disclosure systems to a limited degree. The analysed case studies offer various good practices and innovative approaches on how the integration of sustainability information into disclosure systems could be improved.

With a view to environmental impacts, European disclosure obligations of the Electricity and Gas Market Directives require information provision on CO_2 emissions resulting from energy supply, and additionally radioactive waste in the case of electricity disclosure. As such, this is generally established good practice in the analysed case studies for electricity and gases. In Danish electricity disclosure, methane, SO_2 and N_2O have to be disclosed in addition to the CO_2 emissions. For H&C, the recast Energy Efficiency Directive (EU) 2023/1791 requires Member States to ensure that final H&C users are provided with information on the annual GHG emissions related to the fuel mix used. In contrast, Art. 24 section 1 RED II requires that information on the energy performance of district heating and cooling systems must be provided to consumers ‘in an easily accessible manner’. Accordingly, all analysed case studies for H&C disclosure require suppliers to report on direct GHG emissions associated with their H&C supply.

In Sweden, H&C suppliers must also report on both direct and indirect GHG emissions, in line with the reporting guidelines developed by the Värmemarknadskommittén (the ‘Heating Market Committee,’ which develops market rules on district heating supply in a collaborative process between suppliers and customers (Lundqvist, 2026)). If more widely adopted, including information both on direct and indirect GHG emissions (including upstream emissions relevant to biogenic fuels and hydrogen) would improve the alignment of energy disclosure with CSRD-ESRS requirements as an innovative concept (in particular, ESRS E1-4).

In the case of RFNBOs, tracking instruments could include information on the **compliance with the EU's RFNBO requirements** along two dimensions:

- Information provision on whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and from a production device no older than 36 months (as compared to the start of hydrogen production).
- When electricity is obtained from the grid, information provision on bidding zone location (Art. 4), additionality condition in terms of commissioning date and subsidies (Art. 5), temporal correlation (Art. 6), geographical correlation (Art. 7).

Both are particularly relevant for electricity GO schemes covering energy input to RFNBO production and gas GO schemes covering energy output (for H&C, the inclusion of such information becomes relevant only in cases in which RFNBOs are used for H&C production). To date, none of the studied case studies has integrated information yet on the compliance with the EU's RFNBO requirements into GOs, but future integration in several national GO systems is being considered. For example, according to the German legal framework for gas GOs, information will be included on GOs whether RFNBOs comply with the EU’s RFNBO criteria. The EECS rules include optional provisions for a standardised recording of the relevant data on GOs, which can be used as a guideline by domain schemes in support of a harmonised evolution of GO systems.

For biomethane and biobased electricity and H&C, information on compliance with sustainability requirements (with links to Proofs of Sustainability as verification) can be integrated into energy disclosure. While this has not yet been widely adopted, examples are available in individual case studies. In Estonia, biomethane is eligible for GO issuance only if it complies with sustainability criteria. Here, sustainability information becomes a defining characteristic of the system boundary. However, the degree to which **consumers receive this sustainability information** is largely determined by each supplier's disclosure practices. In the case of analysed electricity and H&C case studies, no disclosure obligations on sustainability characteristics for biobased energy carriers could be identified. However, suppliers may decide to optionally disclose such information. As a basis for such optional disclosures, the German legal framework for H&C and gas GOs requires that specific sustainability information must be provided when applying for a GO for H&C generated from biomass or biomass-based energy. Compliance with sustainability requirements is not a requirement for GO issuance; however, information on compliance is recorded on GOs.

Moreover, there are cases in which suppliers include certification-based information also on broader sustainability aspects on a voluntary basis (e.g. existence of fish ladders for migratory species in case of hydropower).

Including sustainability information in energy disclosure information would provide relevant information to consumers and can be recommended for all energy carriers. As tracking instruments for sustainability criteria already exist (Proofs of Sustainability for biomass) or are under implementation (proof of compliance with the EU's RFNBO criteria for RFNBOs), relevant information could be integrated into GO and disclosure systems with limited effort. Including information on sustainability characteristics would furthermore improve the alignment of energy disclosure with CSRD-ESRS requirements (in particular, ESRS E1-E5 focusing on companies' impacts on nature, and ESRS S1-S4 focusing on social impacts where broader sustainability criteria going beyond sustainability criteria for biogenic energy carriers according to RED II/III and the EU's RFNBO criteria are concerned). Also, information on voluntary sustainability labels could be provided as part of disclosure statements. According to EN 16325:2025, GO schemes may opt to include information on compliance with label schemes, which could be used as a basis for disclosing such extended sustainability information.

In principle, sustainability and GHG information criteria could also be used to define the boundaries of energy disclosure (see 10.3) – in this case, only energy carriers conforming with set criteria (or exempted) would be eligible to be allocated to consumers using explicit tracking instruments. Thus far, this is established in target accounting, but not yet in disclosure. In the latter, the focus has been on the information provision to consumers to date. One noteworthy exception is GO issuance for biomethane in Estonia, which is only offered for biomethane meeting sustainability criteria. In this case, the system boundary of disclosure is aligned with target accounting.

Relevance for benefits and stakeholder groups:

For households, the inclusion of sustainability information in energy disclosure enhances transparency and supports active choices about energy supply. For organisations, improved accessibility and visibility of the sustainability information can help meet stakeholder expectations and mitigate reputational risks. Moreover, it facilitates the implementation of impactful energy supply decarbonisation strategies and compliance with carbon accounting standards, low carbon initiatives and green lead markets, as well as regulatory sustainability reporting requirements on organisations. The increased integration of sustainability concerns when making green energy demand decisions could also benefit society as a whole, in contributing to a successful energy transition. For plant operators and suppliers whose energy offers meet sustainability characteristics, increased visibility of this could increase the value of products offered or lead to non-financial benefits for customer acquisition and loyalty.

10.4.6 Information on additionality criteria

Relevant sub-criteria	
48	Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information
49	The degree of compliance with advanced additionality criteria is clearly indicated

Lessons for **integrating additionality indicators into tracking instruments and disclosure** are the focus of section 10.5. In the following, implications for the display of additionality information as part of disclosure statements are summarised. Neither in the analysed case studies, nor in the innovative concepts can examples of integrating additionality information in disclosure statements be found. In principle, relevant information elements such as whether production devices benefit from public support or their start of operation are recorded on GOs. In cases in which consumers can access GO registries and monitor the detailed information contained in GOs cancelled on their behalf, they can access this information. Beyond this, including information on the **share of supported or unsupported energy production** in RES supply and the share of **plants below a certain age limit** in detailed disclosure statements would enhance transparency for consumers. Another relevant information element could be the **existence of PPAs** offering long-term planning security to RES producers, but this is not currently included on GOs. On its own, such types of information are not sufficient to establish a causal link between renewable energy procurement and the realisation of RES plants (see, for example, comprehensive additionality tests proposed by Schäfer et al. (2025). However, they can make relevant information elements more visible and enable consumers to better align energy product choice with individual preferences (in case of households) or decarbonisation strategies (in the case of organisations).

Relevance for benefits and stakeholder groups:

Increasing the visibility of information on public support, plant age or the existence of PPAs could better enable household consumers to make active choices supporting the energy transition when choosing between energy supply options. For organisations, access to such information can be relevant in the context of low carbon initiatives and implementation of impactful procurement strategies, with associated benefits for meeting growing stakeholder expectations. For plant operators and suppliers, increasing the visibility of such information could potentially set incentives to offer premium products based on energy from new, unsupported plants. However, more research would be needed on the conditions under which green energy demand provides a relevant incentive for investments in unsupported plants, alongside other factors influencing investment decisions.

10.5 Information on additionality indicators

Lessons can be derived for the following categories of energy disclosure information, as distinguished by the different sub-chapters (besides the aspects and sub-criteria as covered in this section, it should be noted that regulation on the system boundaries of energy disclosure also affects the role of additionality aspects for disclosure, see chapter 10.3):

10.5.1 Information on the contractual relation of energy production with the energy

Relevant sub-criteria	
64	Information on the share of REPAs available to the beneficiary of disclosure
65	Information on the share of supplier-owned fossil generation available to the beneficiary of disclosure
66	Information on the share of supplier-owned nuclear generation available to the beneficiary of disclosure
67	Information on the share of supplier-owned RES generation available to the beneficiary of disclosure

Information on the existence of REPAs can be provided

Information on the contractual relation of energy production with the energy supplier is of interest with regard to assessing additionality. To some extent, it can indicate the level of commitment of a given supplier to specific energy supply options, particularly with a view to renewable electricity. Information on the share of renewable energy purchase agreements (REPAs) can be tracked in combination with the use of the respective GOs, as the examples of Austria shows. Austria is also a 'showcase' example of such information on the 'bundled' or 'coupled' use of GOs disclosed to end-consumers. The relevance for additionality could be further increased with additional information on the period of REPAs and on age and the level of support of the respective plants (see below). Such information on the share of REPAs in the supply mix is to be understood as an additional information item of the disclosure system. However, it cannot replace the positive functionalities of technically robust accounting instruments like a GO, particularly with a view to avoiding double counting and statistical overview.

When RFNBOs are used for the production of gases or in H&C production, providing consumers with information on whether RFNBO criteria were met would increase transparency. Indirectly, this would provide information on the existence of REPAs between renewable electricity producers and RFNBO producers or operators of heat pumps or power-to-heat technologies (in case electricity from the grid was used). Such information would ideally be directly conveyed by the GO system for the electricity used for the production of, for example, hydrogen. For now, it is unclear when and to what extent RFNBO shares gain a relevant share of gas supply to standard consumers, thereby justifying the increased complexity.
For H&C supply itself, the provision of information on the share of REPAs in H&C supply is less relevant. This is because grid-bound H&C supply decisions have a long-term character by default, given the costs of changing between grid-bound and decentralised supply options and the common monopoly structure of supply (i.e. one supplier per grid).

From a more formal perspective, information on the share of REPAs is also relevant for large commercial consumers to fulfill reporting requirements, e.g. regarding the energy transition impacts of procurement. Besides direct corporate PPAs, electricity suppliers may act as intermediaries contracting renewable energy plants on behalf of organisational consumers. As with corporate PPAs, plant operators benefit from long-term revenue streams in supplier PPAs. Thus, the share of energy and bundled GOs a supplier sources via long-term PPAs as opposed to short-term markets (e.g. electricity exchange plus unbundled GOs) can be relevant to consumers.

Information on the share of supplier-owned generation is difficult to include in disclosure

As a second specific contractual situation besides REPAs, information on the share of supplier owned generation from different energy sources also provides an increased level of transparency on the deeper commitment of individual suppliers, particularly in electricity markets. However, this is only partly applicable as many suppliers in EU unbundled markets do not act as producers at all, but rather simply focus on the role as suppliers. Besides this, it should be noted that it is not straight-forward for regulatory authorities to keep track and supervise the production plants' ownership trail for every supplier. This may include several institutional hierarchies, vary over time and may be complex especially in case of partial ownerships. Therefore, the effort may outbalance the benefit while still risking incomplete representations as a result. An approach for addressing this aspect may build on non-governmental private initiatives from NGOs (like Greenpeace in Belgium Flanders), may bring this information on an irregular campaign-related basis (see also chapter 10.6).

Relevance for benefits and stakeholder groups:

Providing such information on the contractual situation in energy disclosure would be beneficial, particularly for those plant operators in a position to market their energy according to 'premium' options as preferred by markets. More specifically, this taps benefits like added revenues from REPAs and green attribute sales, customer acquisition and loyalty. From the perspective of organisations, a clear documentation of the share of REPAs would allow for more impactful supply decarbonisation strategies (e.g. if electricity suppliers act as intermediary parties in PPAs, contracting renewable energy plants on behalf of organisational consumers), formal compliance with revised GHG standards (if companies have to report on energy transition impacts of energy procurement), compliance with regulatory requirements on organisations, and allow for hedging against CO_2 prices.

10.5.2 Information on plant-specific additionality indicators

Relevant sub-criteria	
68	Provide information on support
69	Provide information on plant age

Information on age and support is essential as additionality indicator, and available based on GOs

Essential indicators for plant-specific attributes like the age of the plant or the level of support of the plant and the supplied energy are relevant in order to distinguish the supply from renewable plants which are newly build and/or operated without the use of public support. They thereby contribute to the further increase of renewable energy production compared to the existing status quo over driven by market demand, especially in the electricity sector. While such information on the level of support is currently disclosed with a view to domestically supported volumes in France and Germany, there is no 'show-case' example for the general disclosure of this attribute, also in the case of non-domestic production.

However, both information items are information parameters included in GOs based on the Renewable Directive and on EN 16325, so that this information is available for all RES production for suppliers, and could also be incorporated in disclosure information.

GOs contain information on the type of support in the categories 'production support,' 'investment support,' 'both,' and 'none'. However, with a view to disclosure towards end-consumers a simple distinction between 'supported' and 'non-supported,' indicated as a percentage of renewable shares, would reduce complexity without losing the core of the information.

Disclosure of the ages of all plants supplying energy is apparently more complex due to the non-binary parametrisation of that parameter. This could be addressed by introducing thresholds or categories to be disclosed on disclosure statements.

Disclosure of such additionality indicators can be implemented as a second-layer information

In order to provide in-depth information without overloading the standard disclosure statement, the respective information on support and on plant age could also be made available to consumers as second layer information on the website of suppliers, or by allowing for direct access of consumers to the cancellation statements for their respective energy supply.

Relevance for benefits and stakeholder groups:

The provision of additionality indicators is of high relevance for households and for society as a whole to empower consumers to make an active choice that supports the energy transition. It also allows organisations as institutional consumers to implement impactful supply decarbonisation strategies, and, from a formal perspective, comply with the expected revised GHG standards. Plant operators who are in the position to market their energy with attributes preferred by consumers can also profit through increased revenues, and increased customer acquisition and loyalty.

10.6 Format of information disclosure

The format of information disclosure determines the extent to which the respective information is available to consumers. It also determines how this information is perceived and understood with respect to its relevance, so that the information can be duly taken into account when choosing a specific energy product. Furthermore, it also contributes to a better understanding of the implication of the existing energy supply, both in terms of awareness-raising (particularly for the case of household consumers) and in terms of reporting and monitoring (for the case of organisations as institutional consumers). For the case of electricity, ANNEX I point 5 of the Internal Electricity Markets Directive requires Member States '*to ensure that the information provided by suppliers to final customers pursuant to this point is reliable and is provided at a national level in a clearly comparable manner*.' Likewise, the Gas Directive Annex I point 5 requires the following: '*The regulatory authority or another competent national authority shall take the necessary steps to ensure that the information provided by suppliers to final customers [pursuant to this point] is reliable and is provided at a national level in a clearly comparable manner.'* As in the RE-DISS outcome for electricity, Section 8.2.6 of the REGADISS report provides a proposal for such a format of a comparable clear disclosure statement. For H&C, Article 24 section 1 RED II requires Member States to 'ensure that information on the energy performance and the share of renewable energy in their district heating and cooling systems is provided to final consumers in an easily accessible manner, such as on bills or on the suppliers' websites and on request.' The recast Energy Efficiency Directive (EU) 2023/1791 requires Member States to ensure that final H&C users are provided 'in or with their bills' information on the fuel mix used.

Lessons can be derived for the following categories of energy disclosure information, as distinguished by the different sub-chapters

10.6.1 Accessibility from a supplier's perspective

Relevant sub-criteria
70 Disclosure information is easily accessible upon request (from a supplier's perspective)

Combining GOs with a residual mix is a robust approach

It is important that suppliers themselves have good access to relevant information, at least on their request, so that they are in a position to design specific products. This mainly requires their access to information which is included in and represented by the respective tracking instruments. In electricity markets, the GO systems established in the analysed countries allow for a well-structured access to this information, both within the GO registries where suppliers usually have their own accounts with respective access to GO data, and by the cancellation statements which are usually issued by the registries. However, this information only covers the energy sources for which the GO system is established. As a consequence, this source of information is restricted to RES in many cases, while in 'full-disclosure' countries like Austria such GO-based information is accessible for all energy types. For energy sources not covered by GOs, the use of a residual mix is considered good practice. While this approach reduces differentiation amongst suppliers, it should also be pointed out that information on non-RES can be considered less relevant compared to information on RES shares, which is an argument in favour of this pragmatic approach.

For H&C data availability is locally organised

In H&C markets, suppliers often operate H&C networks themselves. As such, they usually have access to detailed information on the energy sources connected to their H&C network. Where disclosure for H&C limits itself to the boundaries of the same H&C network, this aspect is thus more or less automatically given and does not depend on the design of the disclosure system. In countries that allow wider geographic boundaries for H&C disclosure, dedicated collection systems and oversight are needed in order to prevent incomplete or inconsistent data and double claims.

10.6.2 Accessibility from a consumer's perspective

Relevant sub-criteria
71 Disclosure information is easily accessible upon request (from a consumer's perspective)
72 Disclosure information is mandatorily provided at key decision phases
73 Information is digital and directly accessible for organisations

Access to digital information based on GO cancellations can complement the basic summary from standard disclosure statements

For consumers, the format of disclosure is crucial to identify relevant information and to be aware of relevant characteristics and attributes of energy supply options. This builds on the available tracking instruments (first and foremost GOs) while aiming at the disclosure statements themselves as a key element. For household consumers, it is particularly important to have a good selection of information accessible both on request and mandatorily provided at key decisions phases, but at least for high-interested customers and for organisations with reporting obligations access on detailed information on request in a digital format is also relevant (see also chapter 10.4 for more detailed analyses of the type of information provided). Disclosure information is provided in all analysed countries for electricity in line with EU legislation, where information is mandatorily available on the website of the supplier, on marketing materials or attached to invoices, while more detailed information is accessible to customers (e.g. in Austria and Estonia) by making the disclosure statements electronically available to end consumers. In Belgium-Flanders, digital platforms provide additional comparable and verified information on the disclosure of different suppliers.[51]

[51] For the Disclosure Dashboard, see https://www.vreg.be/nl/controleren-hoe-groenuw-stroom-groencheck; https://dashboard.vreg.be/report/DMR_Brandstofmix.html. For Green Check, see .

Good practice examples show that this general recommendation also can be applied to gas and H&C

For the case of gas, Austria and Estonia also allow for consumer-level access to disclosure information and cancellation statements in GO registries increasing transparency for end-consumers.
All analysed H&C concepts cover the annual publication of disclosure information (on suppliers' websites and/or as part of the billing information). In Germany, for example, H&C suppliers are legally obliged to make selected disclosure information (such as energy sources and technology mix, renewable energy share, primary energy factors, GHG emissions) publicly available on their websites and as part of the billing information. Therefore, this information is available to consumers when comparing district H&C supply with other supply options, or when comparing different H&C products (supplier choice, however, tends to be limited, because grids are most typically owned and operated by individual suppliers). With respect to more detailed information available on request, the Finnish and Dutch cases perform best where ease and depth of information access is concerned. In both cases, end consumers have the option of opening accounts in the GO registry (commercial consumers in the Dutch case). As such, consumers can monitor exactly what GOs have been cancelled on their behalf and access the detailed information contained on the GOs.

Further development of DPP might enhance automatisation and standardisation

With a view to digital accessibility of disclosure information, it is notable that there is no European standard for machine-readable disclosure statements. However, such a standard could be developed by integrating energy disclosure into the Digital Product Passport framework.

10.6.3 Understandability of disclosure information

Relevant sub-criteria
74 Information provided in a ranking tool that evaluates performance based on additionality criteria
75 Information on non-renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table
76 Information on renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table

Understandability should be enhanced by ensuring an intuitive and comparable presentation of disclosure information

In order to enhance the understandability of disclosed information, information should be presented in a clear and accessible format, which should be ensured by legal provisions. It is common practice in the analysed electricity disclosure schemes that there is a legal regulation on the format and content of disclosure, including provisions for the graphic. Also for gas disclosure, Austria requires suppliers to use graphs for gas disclosure, which is also referred to as good practice by the REGADISS project (Verwimp et al., 2023). In Finland, Sweden, and the Netherlands, where H&C disclosure has already been implemented in practice, suppliers use charts and tables to present disclosure information on their websites.

Providing clearer guidance to households could be enhanced by ranking tools, although those are difficult to establish in governmental frameworks

From the perspective of household consumers in particular, the format of energy disclosure also determines the extent to which the meaning of the provided information is easily understandable. This is particularly aimed at understanding the complex relevance of different parameters and as guidance for the selection of beneficial products. In this respect, ranking tools are considered an attractive instrument. However, it is also acknowledged that ranking is often not appropriate for inclusion in governmental frameworks given the need to adhere to objective criteria. Therefore, no examples were identified with such ranking tools as ‘official’ instruments. Rather than ranking, authorities can provide comparison tools based on transparent information, which is in line with the CEER guidelines on trustworthy green offers in 2023 (CEER, 2023). Outside the governmental setting, ranking instruments published by NGOs in Belgium and in the Netherlands are a ‘show-case’ example of how ranking could be implemented in an NGO setting.

Relevance for benefits and stakeholder groups:

The format of information disclosure primarily addresses the interests of both household consumers and organisations as institutional consumers. Depending on the fulfillment of the related sub-criteria, households may particularly benefit by being empowered to make an active choice supporting the energy transition, while organisations are put in the position to make procurement decisions based on disclosure information, to provide unique green claims, to meet growing stakeholder expectations, to mitigate reputational risks and to demonstrate environmental leadership.

Plant operators can also benefit to the extent to which the provision of this disclosure information allows them to fulfill formal prerequisites for market participation. Society as a whole would benefit if the provision and perception of disclosure information leads to conscious and well-informed consumer choices, thereby ultimately also contributing to the energy transition as a major public interest.

11 Recommendations for further developing disclosure

Based on the analysis of good practice and innovative scenarios and on the description of key lessons outlined in chapters 9 and 10, this chapter 11 summarises the condensed recommendations stemming from the project work for further improving energy disclosure systems in Europe. While the two earlier more detailed chapters particularly address system designers for disclosure and tracking systems, chapter 11 in its condensed form aims at high-level policy makers.

11.1 Bottom-up harmonisation of detailed practices

Examining the construction of good practice scenarios which combine the well-performing elements of a sample of existing disclosure schemes reveals a significant improvement potential if these well-performing elements, as implemented by various EU Member States, were to be generalised across the EU (see chapters 9.2 and Annex B (Annex II)).

This improvement potential can already be tapped. The identified good practices have been developed in the current legislative and normative framework. Therefore, these good practices can provide inspiration in the same legislative and normative framework. This also applies to other work (like chapter 8 and 10.2 of REGADISS final report (Verwimp et al., 2023).

Tapping the improvement potential shown by the innovation scenarios might require modifications to the legislative and normative framework. Several of the outlined options for improvements would benefit from further refining legislation at EU level, and/or consistent usage of the disclosure rules in various areas of regulation.

Some aspects that have clear regulation at EU level may risk diverse implementation in national frameworks. It would be beneficial for there to be a dialogue between national disclosure system designers and supervisors, seeking voluntary synchronisation of disclosure methodologies for a stronger realisation of the potential benefits of disclosure. Such a dialogue can also be used to identify challenges that national disclosure system implementers encounter and to facilitate a collective conversation on how to overcome these so as to meet the needs in the different Member States.

A dialogue will also be needed with the respective stakeholder groups on potential barriers and on how to further realise the potential benefits of energy disclosure.

Anchoring such a dialogue in a platform that enables disclosure supervisors from all relevant countries in a joint market to align practices and take inspiration from each other would support a harmonised roll-out that can benefit multiple stakeholders all over Europe.

11.2 Tackling the main challenges in today's disclosure context

The analysis of good and innovative practices shows that there is potential for a tiered approach to further developing energy disclosure systems:

11.2.1 Further digitalise and automate data flows

Use the potential of digitalisation to provide consumers with more detailed disclosure information, based on information recorded on GOs today

By providing detailed information digitally (e.g. specific renewable energy sources used, geographical origin, production month, existence of public support, age structure of production devices), consumers could filter information according to their preferences, avoiding information overload. At the same time, household consumers would be empowered to make more impactful supply decisions, and organisations would receive the detailed information increasingly required to meet stakeholder demands and comply with updated GHG accounting standards.

For plant operators, the increased visibility of information on energy attributes that are valued by markets (e.g. origin from unsupported plants within a geographic context) could help improve revenues from green attribute sales. For society, empowering both household and organisational consumers to pursue a more impactful procurement could enhance the impacts of voluntary energy markets on the energy transition and GHG mitigation. At the same time, an increased use of digital solutions for information supply could contribute to the reduction of bureaucracy and increased efficiency of administrative action. As a result, this measure can be regarded as a ‘no regret' option to unlock additional benefits of energy disclosure.

11.2.2 Transparency: Ensure easy access to tracked data

Transparency: ensure actors have access to the information that empowers them to influence the energy transition

Consumers who have a choice may change their purchasing behaviour on a voluntary basis, based on the information provided to them regarding the origin of their energy.

1. The existing obligation of suppliers to disclose the energy source has promoted the popularity of green offers. Ensuring consumer access to details tracked on the GO can allow them to differentiate their selected energy purchase (e.g. with regard to geographical proximity or temporal correlation) on a voluntary basis. This can benefit household consumers and organisations.
2. To enable consumers particularly from the household sector to drive additionality and to meet their expectations on regional sourcing, they should be provided with easily comprehensible information on relevant key parameters like plant age and level of support as well as on the regional origin, at least for electricity. It is also recommended that they are provided with insights on any labels related to the GOs cancelled for their consumption. Furthermore, enhancing public ranking tools (by public initiatives or by cooperation with NGO-driven programmes) helps to empower consumers to make conscious decisions.
3. Organisations who manage larger portfolios of GOs in multiple countries benefit from application programming interfaces (APIs) to support their corporate GO portfolio management.

11.2.3 Mandate use of the same tracking instrument for all disclosing parties

To prevent inconsistent or double claims, it is important that **corporate** market-based renewable consumption claims are based on the **same tracking instrument** as the regulated claims made by **suppliers**, and that all disclosing parties consistently use GOs for their claims of consumption or supply of energy from renewable sources. EU regulation currently requires suppliers to use GOs for renewable energy supply claims, while leaving room for corporates to base their claims on more general contractual instruments. Where corporates would back their claims with PPAs, these PPAs still need to be backed with GOs to prevent any GOs issued for PPA production from being sold elsewhere, which would cause double counting.

11.2.4 Analyse in more detail the impact of mandatory changes in geographical and temporal boundaries

A more in-depth analysis is needed on the impact of reforms to energy disclosure like regulated restrictions on geographical and temporal boundaries (e.g. a shift to bidding zones as relevant system boundaries for disclosure while allowing for transmissions between bidding zones under conditions of deliverability, such as in the EU's RFNBO rules), or requiring monthly or hourly matching as a basis for green energy claims. Here, it seems recommendable to first study practical impacts of cases where system boundaries are narrowed compared to the European status quo, such as the EU's RFNBO criteria, voluntary initiatives like the revised GHGP Scope 2 guidance (if adopted), or national disclosure rules such as monthly matching requirements in France.

It is worth considering how this compares with the potential impact of voluntary behaviour resulting from mandatory transparency, as mentioned in the above section.

11.2.5 Evaluate the existing accounting mechanisms for disclosure and policy targets.

EU legislation has been strengthened over time to prevent double counting in the supplier disclosure framework and in the system for Guarantees of Origin. Furthermore, recent EU **regulatory developments in the gas sector have brought together the accounting for both disclosure purposes and policy targets at the same point of consumption**. In the heating and cooling sector as well, target accounting and disclosure are closely aligned under existing practices, if H&C grid boundaries are taken into account in disclosure rules or as long as **H&C GOs are not traded across borders**. This deviates from the longstanding practices in the electricity sector, where EU legislation clearly regulates that **international GO trade does not affect governmental target accounting** for renewables. At the same time, some studied innovative concepts consider counting the disclosure and the policy targets at the same point of consumption for electricity, too.

Especially for **electricity, impacts of a potential linkage** between target setting and disclosure would have to be studied in more detail. Changes need to be analysed in combination **with considerations of changes to geographical boundaries of energy disclosure**. Otherwise, national RES target achievement would become dependent on attribute imports and exports on voluntary green energy markets, with problematic implications for governmental incentivising initiatives. While several accounting methods omit the market-based method in disclosure (like embedded emissions in the framework of the Ecodesign Directive) in favour of location-based accounting, the omission of market-based methods takes away the incentive for consumers to impact the energy transition by their purchasing and sourcing choices. This deserves a more in-depth study of the impacts.

11.2.6 Institutionalise exchange and cooperation between disclosure authorities

Harmonisation between disclosure practices benefits both consistency, efficiency of disclosure and prevents double counting. In order to enhance mutual learning and to support convergence, a structured platform for dialogue and cooperation among policy makers, national disclosure public authorities, system designers, supervisors, and stakeholders is recommended, enabling voluntary harmonisation and shared learning.

11.3 Tackling the main challenges for tracking systems – to support consistent disclosure

The tracking mechanisms based on which the origin of energy is disclosed, are essential. Many strengths have been built into the European Guarantee of Origin system over the years. The main challenges to be addressed are provided in the following.

11.3.1 Integrate additional information in GOs as the established unique tracking instrument for European energy disclosure

The ambition to include additional data in the GOs is supported by standards such as the revised EN 16325:2025 and the EECS rules on an optional basis. There are examples of implementation (or of development) among European GO and energy disclosure schemes, providing potential blueprints for a wider roll-out. Relevant information includes details of compliance with sustainability criteria and RFNBO criteria, the existence of PPAs/REPAs, direct and indirect GHG emissions, and (sub-)hourly production time periods (the latter requires a shift to a more granular GO issuance than 1 MWh).

By integrating such additional information, the value of energy disclosure information is increased, ensuring relevance in energy markets with an increasing share of RES and increasing interlinkages between different energy and industry sectors.

11.3.2 Where multi-purpose accounting takes place, synchronise tracking frameworks

For gases, an urgent critical success factor for gas disclosure lies with solving the coordination between the instruments for target accounting and disclosure. This is because the co-existence of different tracking instruments for the same energy quantity (i.e. GOs and PoS) requires increased administrative efforts to prevent double counting and inconsistent claims.

Gas GO registries are becoming operational in a context in which PoS have a longstanding history of being tradable documents in the private sector, on which the prevention of double counting has historically been partly based on self-declarations. The European Union Database, which aims to consolidate the monitoring of sustainable gas consignments' PoS along the value chain, is in a developmental stage. Developments relating to the interaction between the national GO systems and the centralised European Union Database, and the plausibility of mutual governmental agreements related to potential EU recognition of CEN compliant GOs from outside the EU/EEA, lie outside the scope of this project.

However, for disclosure, the operation and use of different registries (national GO and PoS registries or national GO registries and the Union Database) increases administrative costs both on the side of state agencies and of market actors. From an **administrative efficiency** perspective, developing integrated solutions for attribute tracking for gases which service the needs of target accounting and disclosure therefore ranks among the priorities of further development of European energy disclosure.

11.3.3 Empower corporates to cancel GOs for their own consumption for increasing the benefits for organisations

In several countries in the EU, only licensed suppliers can cancel GOs. According to market feedback, this leads to some suppliers charging high surplus prices to their corporate customers for backing their energy supply with GOs, which the corporates could acquire themselves at better price conditions. For consistency, corporates who make their own claims should also be enabled to cancel GOs.

Moreover, the clarity and consistency of attribute allocation would be improved. Currently, the absence of GO cancellation options for corporate consumers in some domains bears the real risk that GOs are cancelled in other countries than where the consumption takes place, despite this practice being against the rules of the European GO standards EECS and EN16325 (so-called 'Hidden Ex Domain Cancellations'). This may lead to misrepresentations of renewable shares in the residual mix.

Especially corporates in a PPA without intervention of a supplier (e.g. virtual PPAs) need access to a GO account enabling them to cancel for their own consumption, to unlock the respective benefits of corporate disclosure. Besides this, corporates who cancel GOs by themselves often would use the GO-based disclosure attributes over and above the disclosure information which is provided by their respective suppliers, which results in an inconsistency of the overall disclosure accounting statistics. GO registries could address this issue by enabling the corporate's GO cancellation to be linked to his supplier's cancellation portfolio, as facilitated in the Flemish GO registry.

12 Considerations for further research

This chapter provides an overview of issues which need further research and analysis for assessing and implementing specific policy options in the field of energy disclosure systems. Like chapter 11, this chapter 12 builds on the detailed elaborations from chapters 9 and 10. However, its content particularly aims at research organisation and funding institutions.

The findings of this project underline that existing disclosure frameworks were largely designed for an era in which renewable energy supply plays a marginal role. As renewable energy sources (RES) become dominant in electricity generation and expand into the gas, heating, cooling, and hydrogen sectors, stakeholders are demanding greater detail, comparability, and credibility from energy disclosure systems. This shift introduces new requirements for interoperability across energy carriers, time-correlated data, and transparent communication of additionality.

The developed analytical framework demonstrates how well-designed disclosure systems can generate multi-dimensional benefits for households, organisations, plant operators, and society. However, the analysis also highlights gaps in both regulatory design and empirical understanding that call for further research and policy experimentation.

National implementation of recent EU legislation needs to be analysed to establish the effectiveness of the rules and their implementation. While it needs to be clarified what can be accomplished within existing legislative frameworks and what needs further legislation, the following aspects have been identified as needing further research.

12.1 Methodological advancements for the evaluation tool

Future work should focus on refining the **evaluation methodology** developed in this project. While the Excel-based tool enables structured indicative assessment of disclosure concepts, its current reliance on expert judgment introduces subjectivity. To strengthen robustness and policy relevance, future versions should integrate **quantitative indicators** and normalised weighting methods that can reflect **societal priorities or consumer preferences**. However, it needs to be highlighted that there is no single truth regarding a 'correct' development of parameters, but rather different perspectives, reflecting different priorities of stakeholder groups and policy makers within distinct national frameworks. To reflect this, the following steps would be beneficial:

- The tool should better facilitate the tailored development of parameters and priorities.
- Discussions (in stakeholder platforms, research projects, platforms for authorities etc.) should be conducted to move towards agreed societal agreements for the further development of energy disclosure.

Moreover, applied research should evaluate how design elements interact – particularly, how new approaches such as hourly energy matching, integration of Guarantees of Origin (GOs) with emission accounting, or PPA-based additionality claims – affect the transparency and functionality of disclosure frameworks.

12.2 Consistency between energy tracking instruments that lead to consumer claims

How PPA-based tracking can prevent double counting with mandatory GO based tracking needs to be elaborated. Likewise, imported energy from outside Europe that is claimed to have a renewable origin, should not leave behind the same origin claim, e.g. in the form of an energy attribute certificate, in the country of origin or elsewhere. An international framework for preventing double claims needs to be further elaborated and strengthened.

12.3 Organising for temporal and geographical granularity

With regard to enhancing the temporal and geographical granularity of disclosure systems, the following aspects were identified as benefitting from further study:

- To date, energy system modelling studies on temporal and geographical granularity tend to focus on GHG emission impacts, partly with a focus on electricity use for hydrogen production (see chapter 6.4). If changes to the system boundaries of energy disclosure are considered, it should be accompanied by more comprehensive modelling studies that analyse the joint impact of geographical and temporal changes on electricity GO markets, electricity markets and investment incentives for RES plants – for individual countries and on the EU level.
- In-depth empirical analysis of experiences with pilot schemes offering granular GOs on a voluntary basis is needed. If feasible, a pilot case could be implemented with mandatory hourly tracking and accompanying research.
- In order for hourly tracking systems to work, temporal granularity would have to be introduced in the tracking instrument (GOs), and other preconditions would have to be met. For example, including the relevance and provision of real time details as part of disclosure information, and clarifying feasible geographical correlation are essential for meaningful temporal correlation of renewable energy production with consumption.
- For the technical implementation, some stakeholders consider a tiered introduction from annual to monthly to hourly matching. Others believe that each system update in the electricity tracking framework takes such a large amount of time that the resources for any significant upgrade are better used for the most granular option possible. This needs further analysis and both roadmaps need to be compared.
- Before installing any mandatory matching at sub-hourly level, experiences gathered with such matching on a voluntary basis need to be studied. For gases and H&C, the benefits and challenges of sub-annual (e.g. quarterly, monthly or hourly) matching strategies, e.g. in terms of GHG emission impacts and storage incentives, require further research.

12.4 Methodology for energy mix data compilation

12.4.1 Accommodate efficient implementation of voluntary corporate standards

The impact of updates in the GHGP and ISO GHG standards, implementation challenges and consistent disclosure across various stakeholders need to be analysed and addressed with regard to the way in which tracking instruments and regulated disclosure frameworks are organised. This should lead to an improved applicability and eligibility of energy mix data as compiled for disclosure systems with the framework of voluntary corporate standards.

12.4.2 Enhanced transparency on own production park

Transparency about the share of own production in the disclosed fuel mix could solve a criticism voiced by some NGOs. The investment profile of a supplier may impact consumers' purchasing choice. Work is needed to clarify what exactly to disclose and how to structure such information.

12.4.3 Cross border cooperation mechanism for establishing the fuel mix of international suppliers and consumers

While EU legislative frameworks (Annex 1§5 of the Electricity Market Directive and the Gas and Hydrogen Directive) require displaying the international energy source mix at supplier level, disclosure supervisors indicate challenges with the practical application of this regulation. Specifically, they struggle to retrieve the relevant data from neighbouring countries and interacting markets. A particular challenge lies in the collection timelines for disclosure information as countries all need the data at the same time (e.g. 31 March of the year following the disclosure year). For this, they cannot provide each other with the processed data from their own country in time for the other country to process it in their disclosure supervision exercise. A pan-European collection framework with harmonised timelines could be beneficial here.

12.5 Impact assessment of interacting purposes of energy tracking

Another area of further research is the impact of stronger linkages between disclosure and the allocation of underlying tracking instruments with other purposes. While stronger interactions between the support, target and disclosure systems would increase the relevance of energy disclosure and its potential benefits, further analysis should focus on designing such interactions to avoid potential drawbacks as outlined below. It should also consider whether the benefits (particularly from society's perspective) could be achieved more efficiently and effectively by other instruments. Potential drawbacks to be studied and mitigated include the following:

- Voluntary markets may include a lower willingness to pay for stimulating a sufficient level of new RES supply unless combined with appropriate legal obligations.
- Consumer-driven support may result in a large amount of windfall profits for plant operators and for traders rather than in stimulation of increased RES capacities.
- Voluntary markets may not provide comparable security on long-term financial stability, which is needed for the bankability of new RES projects.
- It is harder to finance technology innovation development in voluntary, market-driven schemes.
- From a broader perspective, infrastructure needs to be developed in line with increased RES capacities, which is harder to coordinate in voluntary (and potentially pan-European) markets than in the framework of national support systems.
- With national targets being defined across EU Member States, the responsibility for reaching these targets is more clearly allocated to the respective governments, thus increasing the probability for reaching these targets. This also means that these governments need to have control over the natural and technical capacity potentials in a given country or region.
- There are complex and unclear implications on public acceptance if RES plants are built in regions without contributing to national targets.
- Member States have an interest in tapping benefits by EU-wide system management and related synergies to increase flexibility and tap least-cost production opportunities. They also have an interest in sub-sets of the overall energy system increasing their RES shares in order to increase system resilience and overall decarbonisation in the long term.

12.6 Harmonising enhanced digitalisation

Several of the recommended developments for disclosure systems build on sophisticated digital processes. For the aspects listed below, it should be ensured that the respective digital solutions are developed and applied in a consistent and coordinated way to ensure interoperability and efficiency:

- Machine-readable consumer access to GO information/cancellation statement/integration of DPP instrument
- Digital system set-up for using GOs in mass balancing tracking frameworks, at least for gas
- A greater differentiation between energy carriers is needed. Gas and hydrogen disclosure must be aligned with mass-balance tracking and the Union Database, while heating and cooling disclosure requires solutions compatible with closed-network systems. For electricity, attention should shift to the integration of temporal and spatial correlation and to the treatment of storage and flexibility services. Comparative analysis of these sectoral dynamics for clearly defining both similarities and specifics of the different energy carriers will improve the precision of future guidance.

12.7 Further research on how to present information

While the analysis provides a clear recommendation for more detailed presentation of disclosure information, applied research is required on how best to present detailed energy disclosure information to consumers. The following options were identified in this project:

- Online consumer portals such as the 'GroenCheck' in Flanders-
- Consumer access to GO registries to monitor detailed information on GOs cancelled by them and/or on their behalf (among the analysed case studies, this is established practice in Sweden, Netherlands, Belgium-Flanders, Norway, France, Denmark, Estonia, France and Finland). Given the specialised effort and potentially the cost of registry use involved, this option is more relevant for organisations (particularly large energy consumers) rather than household consumers.
- Publication of detailed disclosure reports on suppliers' websites (voluntary practice adopted by individual suppliers)
- Suppliers providing existing or prospective customers with detailed digital disclosure information through interactive displays on websites or through apps.

To reach conclusions on the format of information provision, empirical consumer research testing the impact of these and potential further options on the benefits of different stakeholder groups would be beneficial.

Moreover, the question of how to structure combined information on energy sources and energy technologies in a manner which is both easy to understand and comprehensive would benefit from further research. The EECS rules and EN 16325 provide guidance on energy source and technology codes with varying levels of detail. However, the level of information detail implemented in GO systems across domain schemes differs. How combinations of energy sources and technologies are presented in disclosure statements differs not only between countries, but frequently also between suppliers. A more detailed study of best practices and categorisations demanded by different European regulations could prove insightful.

Furthermore, the specific integration of information related to additionality assessments in energy disclosure information appears almost to be a blind spot in the analysed case studies and innovative concepts. Here, more research is necessary on what kind of information is perceived as meaningful by consumers, and what kind of impacts follow from the publication of relevant information. From a transparency and consumer empowerment perspective, including information on public support and plant age in detailed disclosure statements seems a ‘no regret’ option, as this information is already recorded on GOs. The integration of information on PPA existence merits further research due to the relevance of verifying contractual arrangements. Potentially, including this option on GOs on an optional, voluntary basis with verification by auditors seems possible, following a similar approach as verifying compliance with RFNBO criteria.

12.8 Expanding the policy dialogue

Further work should embed the methodological outcomes into European and national policy dialogues. Key areas include:

- **Harmonisation** of disclosure principles under the RED III, Gas and Hydrogen Package, and CSRD/ESRS.
- Integration of **additionality and temporal matching** requirements into official disclosure regimes.
- Exploration of **cross-border data exchange** to ensure the compatibility of national GO registries and digital product passports.

Finally, the framework developed in this study can inform the policy dialogue towards a **European blueprint** for a comprehensive disclosure system for electricity, gases as well as for heating and cooling – one that supports consumers’ informed choices, organisations’ decarbonisation goals, and the EU’s climate neutrality objectives.

13 Stakeholder feedback

On 7 November 2025, the project results were discussed at a CEER-hosted event in Brussels, attended by around 60 participants both on-site and online. Stakeholders praised the project's in-depth analytical approach, and expressed strong interest in remaining engaged as the discussion on the future of energy disclosure continues.

The event highlighted three overarching insights that emerged across the discussions.

- Firstly, participants confirmed that transparency, consistency and trustworthiness are essential foundations of effective energy disclosure. Although consumer engagement with disclosure information remains limited in quantitative terms, transparency still has a strong indirect effect: suppliers adjust their behaviour to avoid negative public attention. Regulators emphasised that the trustworthiness of the system is crucial for consumer protection and legitimacy. Europe's fragmented disclosure landscape therefore requires greater harmonisation to ensure coherent and credible information for all stakeholders.
- Secondly, there is broad agreement that further regulation on system boundaries must evolve, but considerable disagreement on how far granularity and spatial constraints should go without harming market liquidity, costs, or usability. While annual matching is considered good practice today, concerns were raised about the administrative burden, consumer comprehensibility, and potential market distortions associated with moving to monthly or hourly granularity. At the same time, emerging standards such as the proposal for a revised GHG Protocol Scope 2 guidance push for a more granular correlation between production and consumption. This reflects a fundamental tension in the debate: how can accuracy be improved without undermining the feasibility and usability of the GO system?
- Thirdly, the event opened a strategic conversation about the future role of GOs in a decarbonised energy system by 2040. While some stakeholders emphasise GOs as a voluntary market tool that enables consumer choice, policymakers question whether disclosure can meaningfully influence behaviour or support climate objectives at scale. To remain relevant and effective as energy systems evolve, GOs must demonstrate clear added value, whether as a market instrument, a traceability tool or a complementary policy mechanism.

14 General conclusion

The project developed and applied a **structured methodology** for evaluating energy origin disclosure concepts across multiple energy carriers. By systematically linking potential benefits for stakeholder groups to measurable evaluation criteria and recommendations for the design of disclosure systems, this study demonstrates how disclosure systems can play a role, not only as reporting instruments, but also as enablers of transparency, consumer empowerment, and decarbonisation.

The comparative evaluation of established and innovative disclosure systems revealed that **current frameworks predominantly serve informational purposes** for consumers but **insufficiently support impact-oriented benefits** such as additionality, temporal correlation, and societal transparency. The methodological approach developed here – combining literature review, expert evaluation, and structured criteria mapping – proved effective in identifying strengths, weaknesses, and development pathways for disclosure systems.

Overall, the study concludes that:

- **Modernisation of disclosure rules** is essential to reflect the transition from a niche renewable market to a predominantly renewable energy system.
- **Major improvements are possible based on mutual learning from good practice examples** as implemented in European countries.
- **Harmonised European guidance** is necessary to ensure consistency across energy carriers and jurisdictions.
- **Integration with broader policy instruments** (CSRD, RED III, RFNBO, ESPR, CBAM) will enhance the systemic role of disclosure in achieving EU climate targets.

The proposed analytical framework and derived findings provide a **foundation for a reform** of disclosure systems reflecting the current challenges of regulation and market framework. It facilitates a common transparency and discussion on **addressed benefits**, and enables policymakers and stakeholders to assess, benchmark, and improve disclosure systems with a view to maximising their environmental and societal value, therefore fulfilling its expected purpose.

In this regard, the project results highlight that disclosure is not a purpose in itself. While disclosure is a purpose of energy tracking systems, like 'target accounting' and 'support administration,' the purpose of disclosure needs to relate to wider benefits. Policy designers, authorities and market participants should always reflect on the underlying objectives for implementing and applying such systems. The project results contribute to this by providing in-depth information and analysis on which benefits can be addressed and how this can be accomplished.

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A Annex I: Relation between sub-criteria, criteria and benefits

The high-level criteria elaborated in chapters 3-6 are elaborated in further detail in sub-criteria as explained in chapters 2.4.4 and 7. These sub-criteria may relate to more than one criterion and may lead to multiple benefits for the stakeholder groups. The below table details the correlations between the high-level criteria and sub-criteria per stakeholder group and per benefit.

A.1 Households

A.1.1 Benefit: Consumer can make an active choice supporting the energy transition

Criteria	Sub-criteria
Information available to consumers on energy-specific additionality indicators	The energy source mix of every product of a supplier is disclosed
	The full energy source mix of the supplier is disclosed
	Provide information on subsidy schemes that a plant profits from
	Provide information on the age of a production plant
	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
Energy disclosure system includes clear distinction according to the environmental performance based on additionality criteria, either as indication of the level of additionality or by limiting the scope of the disclosure system to "additional" energy	Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information
	The degree of compliance with advanced additionality criteria is clearly indicated
	Information provided in a ranking tool that evaluates performance based on additionality criteria
	Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)
	Mandatory restrictions apply for the application of explicit tracking instruments based on plant age
	Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support
Disclosure system allows consumers to increase public (RES) targets	Disclosure instruments allow for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets

Criteria	Sub-criteria
The disclosed information is easily accessible and presented in a clear and user-friendly manner to ensure consumer understanding	Disclosure information is easily accessible upon request (from a consumer's perspective)
	Disclosure information is mandatorily provided at key descision phases
	Information on non-renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table
	Information on renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table
	Information provided in a ranking tool that evaluates performance based on additionality criteria

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.1.2 Benefit: Consumers get emotionally involved and feel empowered in the context of energy transition

Criteria	Sub-criteria
Product differentiation enables consumers to make a choice	The energy source mix of every product of a supplier is disclosed
	The full energy source mix of the supplier is disclosed

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.1.3 Benefit: Consumers become aware of environmental effects of own energy consumption

Criteria	Sub-criteria
Information on relevant energy sources and environmental parameters is transparently disclosed to consumers without easy options for resource shuffling, i.e. the mere re-allocation of existing capacities	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.1.4 Benefit: Consumers can influence the geographical origin of their energy supply according to own preferences

Criteria	Sub-criteria
Energy disclosure supports the choice of supply based on	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified

Criteria	Sub-criteria
geographical preferences being predominantly geographical correlation	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.1.5 Benefit: Consumers can make a statement on individual preferences by choice of energy supply

Criteria	Sub-criteria
Product differentiation enables consumers to make a choice	The energy source mix of every product of a supplier is disclosed
	The full energy source mix of the supplier is disclosed

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2 Organisations

A.2.1 Benefit: Make procurement decisions based on information contained in energy disclosure

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
Administrative efficiency	Information is digital and directly accessible for organisations
	Disclosure information is easily accessible upon request (from a consumer's perspective)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.2 Benefit: Allow for impactful energy supply decarbonisation strategies

Criteria	Sub-criteria
Energy disclosure provides information that enables to assess impactful procurement/additionality criteria	Provide information on the age of a production plant
	Provide information on subsidy schemes that a plant profits from
	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)

Criteria	Sub-criteria
	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
	Inclusion of information on GHG intensity of energy production (direct emissions)
	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
	Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
Energy disclosure serves as proof for renewable energy procurement	Tracking system differentiates energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed
Energy disclosure enables deductions about temporal correlation	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Energy disclosure enables deductions about spatial correlation	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
Energy disclosure enables 24/7 matching strategies in electricity procurement	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.3 Benefit: Facilitate Renewable Energy Purchase Agreements

Criteria	Sub-criteria
In the context of energy disclosure, energy attributes tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary
	Energy attributes can be allocated to a specific product of a beneficiary
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
Double counting/double claiming is prevented	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
	Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)
	The residual mix is publicly available, enabling its usage for disclosure
	Mandatory usage of the residual mix for untracked attributes

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.4 Benefit: Compliance with carbon accounting standards

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
Energy disclosure enables deductions about temporal correlation	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Energy disclosure enables deductions about spatial correlation	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
In the context of energy disclosure, energy attributes tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary
	Energy attributes can be allocated to a specific product of a beneficiary
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
	Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin
Double counting/double claiming is prevented	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
	Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)
	The residual mix is publicly available, enabling its usage for disclosure
	Mandatory usage of the residual mix for untracked attributes

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.5 Benefit: Compliance with carbon accounting standards

Criteria	Sub-criteria
Administrative efficiency	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.6 Benefit: Compliance with revised GHG accounting standards

Criteria	Sub-criteria
Energy disclosure provides information that enables	Provide information on the age of a production plant
	Provide information on subsidy schemes that a plant profits from

Criteria	Sub-criteria
to assess impactful procurement/additionality criteria	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
Energy disclosure enables deductions about temporal correlation	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Energy disclosure enables deductions about spatial correlation	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
Energy disclosure enables 24/7 matching strategies and granular emissions accounting	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.7 Benefit: Compliance with low carbon initiatives and green lead markets

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
Energy disclosure enables deductions about temporal correlation	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Energy disclosure enables deductions about spatial correlation	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
In the context of energy disclosure, energy attributes tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary
	Energy attributes can be allocated to a specific product of a beneficiary
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
	Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin
Double counting/double claiming is prevented	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes

Criteria	Sub-criteria
	Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)
	The residual mix is publicly available, enabling its usage for disclosure
	Mandatory usage of the residual mix for untracked attributes
Administrative efficiency	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.8 Benefit: Compliance with regulatory requirements on organisations

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
Energy disclosure enables deductions about temporal correlation	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Energy disclosure enables deductions about spatial correlation	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
In the context of energy disclosure, energy attributes tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary
	Energy attributes can be allocated to a specific product of a beneficiary
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
	Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin
Administrative efficiency	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.9 Benefit: Hedge against CO_2 prices

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
In the context of energy disclosure, energy attributes tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary
	Energy attributes can be allocated to a specific product of a beneficiary
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.10 Benefit: Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
In the context of energy disclosure, energy attributes tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary
	Energy attributes can be allocated to a specific product of a beneficiary
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
Double counting/double claiming is prevented	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
	Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)
	The residual mix is publicly available, enabling its usage for disclosure
	Mandatory usage of the residual mix for untracked attributes
Administrative efficiency	Information is digital and directly accessible for organisations
	Disclosure information is easily accessible upon request (from a consumer's perspective)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.2.11 Benefit: Provide unique green claims for marketing products or services

Criteria	Sub-criteria
Energy disclosure serves as proof for renewable energy procurement	The Disclosure Concept is anchored in legislation
	Disclosure method is based on principles consistent with those used at the EU level
	Clear rules are in place for tracking conversion between different energy carriers
	Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
In the context of energy disclosure, energy attributes tracked and ownership is transferred	Energy attributes can be allocated to a specific consumer as beneficiary
	Energy attributes can be allocated to a specific product of a beneficiary
	Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed
Double counting/double claiming is prevented	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
	Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)
	The residual mix is publicly available, enabling its usage for disclosure
	Mandatory usage of the residual mix for untracked attributes
Administrative efficiency	Information is digital and directly accessible for organisations
	Disclosure information is easily accessible upon request (from a consumer's perspective)
	Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)
	Ability to transfer EACs to individual consumers (with EAC cancellation by consumers)
	Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.3 Plant operators

A.3.1 Benefit: Fulfilling the formal prerequisites for market participation

Criteria	Sub-criteria
Unique claims on origin from RES	Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes
	The residual mix is publicly available, enabling its usage for disclosure

Criteria	Sub-criteria
Administrative efficiency	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
	Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
	Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking
	Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy
	Harmonisation of requirements and administrative procedures across energy carriers
	Disclosure information is easily accessible upon request (from a supplier's perspective)
Information provision on requirements for participation in compliance markets	Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
	Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
	Inclusion of information on GHG intensity of energy production (direct emissions)
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.3.2 Benefit: Enabling revenues and planning security from long-term REPAs

Criteria	Sub-criteria
Ability to transfer green attributes to off-takers in REPAs	Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)
	Ability to transfer EACs to individual consumers (with EAC cancellation by consumers)
	Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers
Information provision on additionality	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure

Criteria	Sub-criteria
characteristics of RES supply	Provide information on subsidy schemes that a plant profits from
	Provide information on the age of a production plant
	Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure
	Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure
	Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure
Information provision on requirements for participation in compliance markets	Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
	Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
	Inclusion of information on GHG intensity of energy production (direct emissions)
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.3.3 Benefit: Revenues from green attribute sales in short-term markets

Criteria	Sub-criteria
Definition of market boundaries and accounting period prevents oversupply	Required temporal correlation of production and consumption of energy
	Required geographical correlation of production and consumption of energy
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Information provision on additionality characteristics of RES supply	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure
	Provide information on subsidy schemes that a plant profits from
	Provide information on the age of a production plant

Criteria	Sub-criteria
	Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure
	Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure
	Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure
Disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
	Disclosure statement includes information on the regional origin of the RES supply
	Disclosure statement includes information on the technological origin of the RES supply
	Disclosure statement includes information on the sustainability characteristics of the RES supply
Consistency between disclosure and target accounting	Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green Attributes
	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
Information provision on requirements for participation in compliance markets	Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
	Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
	Inclusion of information on GHG intensity of energy production (direct emissions)
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.3.4 Benefit: Customer acquisition and loyalty

Criteria	Sub-criteria
Information provision on additionality	Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure

Criteria	Sub-criteria
characteristics of RES supply	Provide information on subsidy schemes that a plant profits from
	Provide information on the age of a production plant
	Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure
	Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure
	Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure
Disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
	Disclosure statement includes information on the regional origin of the RES supply
	Disclosure statement includes information on the technological origin of the RES supply
	Disclosure statement includes information on the sustainability characteristics of the RES supply
Disclosure of information on energy suppliers' overall procurement	Information on the share of supplier-owned renewable energy generation in energy supply available to the beneficiary of disclosure
	Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure
	Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.3.5 Benefit: Additional value through regional renewable energy

Criteria	Sub-criteria
Disclosure of further quality characteristics of RES supply, e.g. with regard to regionality, RES technology, sustainability	Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)
	Disclosure statement includes information on the regional origin of the RES supply
	Disclosure statement includes information on the technological origin of the RES supply
	Disclosure statement includes information on the sustainability characteristics of the RES supply

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.3.6 Benefit: Transfer of green attributes from energy inputs to energy outputs in conversion processes

Criteria	Sub-criteria
Information provision on requirements for participation in compliance markets	Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
	Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
	Inclusion of information on GHG intensity of energy production (direct emissions)
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).
Tracking and exclusion of double counting of green attributes across energy carriers	Cancellation of certificates for the input energy and issuing of new certificates for the output energy
	Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.3.7 Benefit: Fulfilling reporting requirements placed on plant operators

Criteria	Sub-criteria
Consistency between disclosure and target accounting	Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green Attributes
	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
Information provision on requirements for participation in compliance markets	Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)
	Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)
	Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)
	Inclusion of information on GHG intensity of energy production (direct emissions)

Criteria	Sub-criteria
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.
	Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.4 Society as a whole

A.4.1 Benefit: Contribution to the energy transition

Criteria	Sub-criteria
Information available to consumers on energy-specific additionality indicators	The energy source mix of every product of a supplier is disclosed
	The energy source mix of every product of a supplier is disclosed
	Provide information on subsidy schemes that a plant profits from
	Provide information on the age of a production plant
	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
Energy disclosure system includes clear distinction according to the environmental performance based on additionality criteria, either as indication of the level of additionality or by limiting the scope of the disclosure system to "additional" energy	Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information
	The degree of compliance with advanced additionality criteria is clearly indicated
	Information provided in a ranking tool that evaluates performance based on additionality criteria
	Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)
	Mandatory restrictions apply for the application of explicit tracking instruments based on plant age

Criteria	Sub-criteria
	Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support
Disclosure system allows consumers to increase public (RES) targets	Disclosure instruments allows for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets
Information on relevant fuels and environmental parameters is transparently disclosed to consumers without easy options for resource shuffling, i.e. the mere reallocation of attributes from existing capacities	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
Energy disclosure system promotes energy supply including "additionality" aspect (e.g. RFNBO tracking. or tradable GO only for “new and unsupported’)	Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information
	Information provided in a ranking tool that evaluates performance based on additionality criteria
	The degree of compliance with advanced additionality criteria is clearly indicated
	Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)
	Mandatory restrictions apply for the application of explicit tracking instruments based on plant age
	Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.4.2 Benefit: Contributing to reduction of public cost of energy transition

Criteria	Sub-criteria
Definition of market boundaries and accounting period prevents oversupply	Required temporal correlation of production and consumption of energy
	Required geographical correlation of production and consumption of energy
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame

A.4.3 Benefit: Contribution to GHG emission reductions of energy production

Criteria	Sub-criteria
Disclosure provides incentives for system-	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing

Criteria	Sub-criteria
friendly energy consumption behaviour (alignment with RES availability taking grid constraints into account)	mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
	Required temporal correlation of production and consumption of energy
	Required geographical correlation of production and consumption of energy
	Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.4.4 Benefit: Contribution to the reduction of bureaucracy and efficiency of administrative action

Criteria	Sub-criteria
Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments	Disclosure system is in line with EN 16325:2025 (using EECS Scheme Membership as a proxy)
	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
	Cancellation of certificates for the input energy and issuing of new certificates for the output energy
	Clear rules are in place for tracking conversion between different energy carriers
Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments	Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking
	Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system
	Disclosure method is based on principles consistent with those used at the EU level
	Harmonisation of requirements and administrative procedures across energy carriers

Criteria	Sub-criteria
	Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
Administrative efficiency	Automated provision of information to the beneficiary of disclosure
	Automated provision of proof that tracking instruments are used
	Automation of national-level supervision processes
	Automation of verification processes
	Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy
	Existence of automated systems for the collection and transfer of energy production data
Energy disclosure system provides centrally available information and statistics	Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)
	The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.4.5 Benefit: Incentive for a consistent development of system infrastructure

Criteria	Sub-criteria
Tracking and Disclosure of energy attributes is linked to physical system restrictions for energy supply	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
Disclosure system provides incentives for storage development	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present

Criteria	Sub-criteria
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Tracking system accounts for energy losses over storage
	Tracking system enables to record the time period of release from an energy storage system ("time shifting of attributes over storage")
	Tracking system has clear and consistent rules for allocating attributes from the input to the output of an energy storage system
	Tracking system is transparent on the energy having been stored
	Tracking system prevents double counting of attributes of stored energy
	Cancellation of certificates for the input energy and issuing of new certificates for the output energy
	Clear rules are in place for tracking conversion between different energy carriers
	Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking
	Harmonisation of requirements and administrative procedures across energy carriers
	Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production
Disclosure system provides incentives for system-friendly energy consumption behaviour (alignment with RES availability taking grid constraints into account)	Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)"
	Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity
	Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present
	Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame
	Information on the country of origin of the production device is specified
	Information on the specific region (state, province, city etc.) of a production device is specified
	Required geographical correlation of production and consumption of energy
	Required temporal correlation of production and consumption of energy
	Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

A.4.6 Benefit: Synergies with alternative purposes of energy tracking besides disclosure, like target and support

Criteria	Sub-criteria
Scope and purpose of the respective disclosure system is clearly defined and coordinated with other relevant tracking systems (particularly relating to target and support)	The accounting instrument for disclosure also is used for national monitoring of the fulfilment of policy targets

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

B Annex II: Showcasing the proposals for improving energy disclosure based on good practice and on innovative concepts

This chapter identifies good practices in disclosure for electricity, gases as well as for heating and cooling which demonstrate what works in reality, highlight potential pitfalls, and provide practical lessons for designing effective energy disclosure systems. It presents examples drawn from the countries that were analysed and which serve as the real-world evidence base for the recommendations that follow. These are supplemented with inspiration from studies that describe innovative disclosure concepts.

B.1 Clarity and consistency in energy disclosure purposes

Sub-criterion 1: The accounting instrument for disclosure is also used for national monitoring of the fulfilment of policy targets

Stakeholder group	Benefit
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
	Synergies with alternative purposes of energy tracking besides disclosure, like target and support
Improvement potential	Significant potential from both the good practices and the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	In Estonia, biomethane consumption reporting in the transport sector is directly linked to national target accounting. The system is based on GOs, which serve both for disclosure purposes and for monitoring the fulfilment of policy targets, with reporting carried out through a central Registry. Data is automatically transmitted to the Environmental Board's database, ensuring accurate accounting of consumption against national transport targets. A prerequisite for this GO-based solution is the inclusion of sustainability criteria compliance on the respective certificates, further strengthening the credibility of the system. This example demonstrates how a disclosure instrument can simultaneously inform consumers and provide a robust basis for monitoring policy targets.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity Gas Heating and cooling	The Guarantees of Renewable Origin (GRO) concept, proposed by the Florence School of Regulation (FSR), proposes to transform the existing voluntary Guarantees of Origin (GOs) system into a legally binding, market-based tool that aligns consumer disclosure with the enforcement of renewable energy obligations applied uniformly across all energy carriers—electricity, gas (including hydrogen), and heating and cooling (Pototschnig und Conti 2021). It is argued that this concept of Guarantees of Renewable Origin should contribute to achieving renewable energy penetration targets at least cost. However, the GRO concept faces significant implementation challenges. Introducing GROs would require a legislative overhaul of the existing GOs system and revision of sector-specific targets such as those for hydrogen or biomethane under RED III. Past experiences with quota-based certificate systems in countries like Belgium, Italy, and Sweden

Stakeholder group	Benefit
	show that without careful design, such systems can lead to windfall profits for mature technologies and fail to support emerging ones, prompting governments to revert to fixed-premium schemes or impose corrective adjustments. Balancing cross-border benefits and costs may face resistance, especially if national interests diverge. Additionally, merging independently developed quota systems post hoc has historically led to compatibility and fairness issues—Sweden and Norway remain the only successful example of a multi-jurisdictional quota system. Finally, while the FSR paper states that this predefined share of the GRO obligation might be the same or differentiate for different types of consumers and energy vectors, the latter is likely desirable, given the renewable gases and hydrogen generally need higher support levels than renewable electricity. The Estonian transport sector obligation proves how sectoral quotas for gases work, and how they can indeed integrate disclosure purposes.
Electricity	As innovative approach, the study Holzapfel et al. (2024) proposes a multipurpose GO model that combines voluntary consumer choice with enforceable national obligations. This would enable GOs to serve both as disclosure tools and as mechanisms for compliance with renewable targets, thus broadening their policy relevance. However, to effectively support such a transformation, further research and refinement of the GO system are needed. In particular, the authors stress the importance of integrating additionality requirements—ensuring that certificates represent new renewable generation—as well as improving the temporal and spatial granularity of market-based accounting practices
Heating and cooling	In the context of a full disclosure obligation for heating and cooling suppliers, H&C GOs could also be used for monitoring the fulfilment of national decarbonisation targets for H&C grids. To have comprehensive data for target monitoring, however, this requires a) that suppliers submit data on all renewable and waste H&C production to the GO registry, not just data on selected quantities which are marketed as green H&C products. Moreover, b) data on H&C production from non-renewable and non-waste H&C sources would also have to be submitted, in order to calculate the share of renewable and waste H&C in the overall thermal energy quantities supplied. In a full disclosure context, the data submitted to the GO registry to apply for GO issuance could be used for an automated calculation of renewable and waste H&C shares in H&C grids, enabling decarbonisation progress to be monitored in a central registry.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 2: Disclosure instruments allow for disclosure of RES attributes which are not accounted to public targets, thus leading to a market-driven extension of public targets

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Society as a whole	Contribution to the energy transition
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NOT APPLICABLE

Stakeholder group	Benefit
Innovation	
Electricity	Seebach and Timpe (2020b) propose the implementation of a specific type of tradable GOs which have the specific characteristic that those volumes are not counted towards public RES targets. For highly motivated consumers, this would allow to make a real difference in terms of additionality over and above existing targets, which would have to be achieved particularly with the backing of appropriate public support systems.
Gas	The disclosure of RES which are not accounted to public targets is the core aspect of the innovative “GOs beyond targets" concept. Per definition, the "GOs beyond targets” are explicitly considered in order NOT to be taken into account for existing policy targets, but to extent those.
Heating and cooling	NOT APPLICABLE. Policy targets for grid-based H&C supply usually aim for a complete decarbonisation of grids in the long term. As closed systems, H&C suppliers require to be able to account the attributes they disclose to their consumers towards their decarbonisation targets.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 3: Linking the tracking instrument for disclosure (incl. international trade) with policy target accounting, to increase the value of green attributes

Stakeholder group	Benefit
Plant Operators	Consistency between disclosure and target accounting
Improvement potential	Significant potential from innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity Gas Heating and cooling	While the concept of Guarantees of Renewable Origin (GROs) as proposed by the Florence School of Regulation (Pototschnig und Conti 2021) aims to achieve renewable energy policy targets at least cost, it acknowledges that it partially shifts the burden from subsidy systems to market-based systems. If the same GOs, possibly renamed to GROs, would serve a dual function: as proof of renewable sourcing for consumers and as compliance instruments for meeting regulatory targets, the respective consumer or supplier group are envisaged to pay for the green attributes. The GOs/GROs would get a higher financial value in the market if the disclosure purpose gets combined with a compliance trigger.
Electricity	The TU Berlin study (ref Holzapfel, 2024) calls it „aligning target setting methodologies for RES and decarbonisation on a governmental and organisational level“. Their results show that including cross-border GO trade in the calculation of country-specific RES shares would change the 2020 renewable electricity target achievement of 13 European countries.
Heating and cooling	In H&C disclosure systems with physical connectivity constraints, where GO use for disclosure purposes is limited to interconnected grids, there is hardly any incentive for GO trade (with the rare exception of H&C grids with multiple suppliers). GOs

Stakeholder group	Benefit
	have mainly a documentation and verification function, allowing the marketing of different H&C products within an interconnected H&C system while preventing double counting of green attributes. In such a context, the sub-criterion is not applicable. In systems that allow GO trade across grid boundaries, GOs could accrue an additional value if linked to a tradeable renewable (or waste) H&C quota. This would be the case if all H&C suppliers had to meet e. g. a specific renewable energy quota in each year and could fulfil this by purchasing GOs from other grids. The Guarantees of Renewable Origin for cross-sectoral quota (GRO), proposed by the Florence School of Regulation (FSR), extends this concept to the trade of GOs across sectors. In a cross-sectoral scheme, it is uncertain to what extend suppliers could achieve additional revenues by marketing H&C GOs, as prices would most likely be determined by the cheapest available options to meet cross-sectoral quota targets, such as GOs for wind- or solar-based electricity production.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 4: Information on RES plants and generation is available for different administrative uses to increase administrative efficiency (e.g. attribute tracking, support administration, statistics)

Note: attribute tracking refers to attribute tracking for disclosure.

Stakeholder group	Benefit
Plant Operators	Administrative efficiency
	Consistency between disclosure and target accounting
Society as a whole	Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments
	Energy disclosure system provides centrally available information and statistics
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In most of the analysed countries (e.g. France, Netherlands, BE-Flanders), information on RES plants and generation based on Guarantees of Origin is used for attribute tracking, disclosure and support administration.
Gas	In Estonia, information on RES plants and generation is integrated across multiple uses, including statistics, support administration, national target accounting, and disclosure. This shared infrastructure reduces administrative burdens while ensuring consistent and reliable data across functions. In France, data on RES plants and generation, managed through Guarantees of Origin, is used for attribute tracking and disclosure purposes, avoiding the need for parallel systems and streamlining reporting processes. Similarly, in Austria, information based on Guarantees of Origin serves multiple purposes, including attribute tracking and disclosure, demonstrating how a single tracking system can support different stakeholders and uses. Together, these examples illustrate how countries can design tracking systems that are cost-efficient, interoperable, and capable of serving multiple functions thereby maximising efficiency and reducing administrative burden.
Heating and cooling	In the Netherlands, information on RES plants and generation which is included in the GO registry is not only used for attribute tracking and disclosure purposes, but also for support administration (for subsidies under the scheme "Stimulation of sustainable energy production and climate transition – SDE++). This established

Stakeholder group	Benefit
	good practice from the Dutch electricity GO scheme has been also implemented to facilitate the administration of subsidies for low-carbon heat.
Innovation	
Electricity	The multipurpose GO model (Holzapfel et al. 2024) that combines disclosure instruments with a compliance mechanism, implicitly builds on the application of the same information sources in multiple usages, thereby gaining efficiency and reducing administrative overhead.
Gas	NO EXAMPLES
Heating and cooling	In a full disclosure context, the data submitted to the GO registry to apply for GO issuance for all energy sources could be used for an automated calculation of renewable and waste H&C shares in H&C grids, enabling decarbonisation progress to be monitored in a central registry. Moreover, such data could be used as a comprehensive base for energy statistics on grid-based H&C supply, as well as for the administration of public support programmes for low-carbon H&C technologies. To facilitate data access, agencies responsible for statistics, support administration or target monitoring could be provided with monitoring accounts in the GO registry.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

B.2 Institutional anchoring of energy disclosure

Sub-criterion 5: Disclosure system is in line with EN 16325:2025 (using EECS Scheme Membership as a proxy)

Stakeholder group	Benefit
Society as a whole	Rules and regulations of energy disclosure system are consistent and harmonised/aligned with other policy instruments
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	All analysed countries are EECS scheme members for electricity, which supports the implementation of the requirements imposed by EN 16325:2025. It should be noted that the implementation of EN16325 also has positive effects on other sub-criteria (e.g. storage, conversion, …).
Gas	Estonia and Austria are both members of the EECS (European Energy Certificate System) gas scheme. This membership demonstrates their alignment with EN 16325:2025, ensuring that their disclosure systems operate according to common rules and technical protocols. Such alignment is particularly valuable because it allows GOs to be reliably tracked and exchanged across borders, giving consumers and market participants confidence in the credibility of claims about renewable gas. France is in the process of applying to become a member of the EECS Gas Scheme, at the time of drafting this report. Similar is the case in Latvia, Finland, Italy, Czech Republic, Spain, Belgium (Brussels, Flanders, Wallonia), Lithuania, Portugal, Netherlands, and several others, through their existing and upcoming membership of the EECS Gas Scheme Group. It is expected that all EU countries will eventually comply with the legally binding CEN EN16325:2025 GO standard, but some are in delay.

Stakeholder group	Benefit
Heating and cooling	Alignment with the EN 16325 standard is mandated by the RED II, making it a binding constraint for H&C GO systems in the EU. However, the EN 16325 does not cover disclosure rules, but rather the tracking system supporting energy disclosure. Beyond the EN 16325, all case study countries are members of the EECS with their electricity GO schemes. While there are currently no specific EECS rules on H&C yet, this makes an alignment with future EECS scheme rules on H&C likely.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 6: Automated provision of information to the beneficiary of disclosure

Stakeholder group	Benefit
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In Belgium-Flanders, an interactive web-tool GreenCheck allows individual consumers to check whether their own consumption was proven to be sourced from RES-E by GOs, using their individual EAN identifier. Austria has implemented a disclosure system which fully builds on GOs for all energy sources, and has built-in a disclosure statement viewer into the GO registry, which is available to consumers who create a log-in.
Gas	In Austria, the disclosure statement is built into the GO registry, available to consumers who create a log-in. In Estonia, through the platform biometaan.elering.ee, consumers can automatically access information on the origin of the biomethane consumed at their metering point, as well as the share of their consumption covered or uncovered by guarantees of origin. Since biomethane in Estonia is currently used exclusively in the transport sector, the 'consumers' are fuel stations purchasing biomethane for vehicle use. Innovations: Implementation of the Digital Product Passport, which may be rolled out mainly for hydrogen, would most meaningfully be designed for automated reliable provision of info to the beneficiary of disclosure.
Heating and cooling	In Finland, information on the H&C sources must be included in the energy bill, which has to be provided electronically by the district H&C supplier (unless agreed otherwise).
Innovation	
Electricity Gas Heating and cooling	Implementation of the Digital Product Passport would most meaningfully be designed for automated reliable provision of info to the beneficiary of disclosure. As part of the Digital Product Passport framework, a European standard could be developed for machine-readable disclosure statements (see sub-criterion "Information is digital and directly accessible for organisations").

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 7: Automated provision of proof that tracking instruments are used

Stakeholder group	Benefit
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	The Austrian Registry provides an automated proof (cancellation statement) that the GO as a tracking instrument was used (while Austria has implemented a fully GO-based disclosure accounting system). Such cancellation statements are also generated by the GO registries in the other analysed countries. In Belgium-Flanders, both the Supplier Disclosure Dashboard and the interactive web-tool Green Check allow individual consumers to check whether their own consumption was proven to be sourced from RES-E by GOs, using their individual EAN identifier.[52]
Gas	The Austrian and Estonian GO registries provide automated proof (cancellation statement) that tracking instrument was used.
Heating and cooling	The electronic provision of information as part of the energy bill in the Finnish disclosure system also extends to information on renewable energy supply. In the Finnish system, there is a clear obligation to cancel H&C GOs as proof for the supply of renewable H&C, creating a clear link to the tracking instrument. Moreover, consumers have the option of opening an account in the GO registry, in which case they gain direct access to proof that GOs have been cancelled on their behalf. This option is also available for commercial energy consumers in the Netherlands.
Innovation	
Electricity	When elaborating the concept of the Digital Product Passport, it would make sense to include this as a prerequisite. A DPP which wouldn't include this, would risk under mining the security levels that the DPP could bring in.
Gas	When elaborating the concept of the Digital Product Passport, which may be rolled out mainly for hydrogen, would most meaningfully be designed for integrating automatic proof that tracking systems are used. A DPP which wouldn't include this, would risk under mining the security levels that the DPP could bring in.
Heating and cooling	As part of the Digital Product Passport framework, a European standard could be developed for machine-readable disclosure statements (see sub-criterion "Information is digital and directly accessible for organisations"). This could also extend to more detailed GO cancellation statements.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 8: Automation of national-level supervision processes

Stakeholder group	Benefit
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes

52 See https://www.vreg.be/nl/controleren-hoe-groenuw-stroom-groencheck and https://dashboard.vreg.be/report/DMR_Brandstofmix.html.

Stakeholder group	Benefit
Good Practice	
Electricity	Both the Supplier Disclosure Dashboard and the Green check in Flanders are based on intensive reporting procedures, anchored in law, of grid operators and suppliers uploading extensive lists of all impacted consumers to the supervision database of the regulatory authority, on a monthly basis. This enables the monthly publication to all (including household) consumers in an interactive web-tool, to check whether their individual own consumption was proven to be sourced from RES-E by GOs, using their individual EAN identifier.[53]
Gas	Austria in its GO registry creates the numbers on supplied energy for the disclosure statements that suppliers need to display to their customers, based on the cancelled GOs per supplier. Note: This sub-criterion is challenging to assess primarily due to the lack of publicly available information regarding the degree of integration and automation of these processes and systems at the supervisory authorities. These processes are typically internal to issuing bodies, regulatory authorities, or market participants, and are seldom documented publicly in sufficient detail to enable a consistent assessment and comparison.
Heating and cooling	Both in Finland and the Netherlands, national-level authorities are appointed to supervise H&C disclosure. No information is available on the degree of automation in handling the data this involves.
Innovation	
Electricity	When elaborating the concept of the Digital Product Passport as a more advanced concept than the current GO, it would make sense to include this as a prerequisite. It has the potential of gaining much efficiency (or losing much efficiency if disregarded).
Gas	When elaborating the concept of the Digital Product Passport as a more advanced concept than the current GO, it would make sense to include this as a prerequisite. It has the potential of gaining much efficiency (or losing much if disregarded).
Heating and cooling	Automation of supervision processes could be facilitated by the development of a standard for machine-readable disclosure statements, as envisioned under the Digital Product Passport framework. For instance, this would facilitate automated checks of disclosure information published by suppliers against data on cancelled GOs in GO registries.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 9: Automation of verification processes

Stakeholder group	Benefit
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	

53 See https://www.vreg.be/nl/controleren-hoe-groenuw-stroom-groencheck, https://dashboard.vreg.be/report/DMR_Brandstofmix.html.

Stakeholder group	Benefit
Electricity	Behind the webtools of both the Supplier Disclosure Dashboard and the Green check in Belgium Flanders,54 there are regulated extensive GreenReporting processes, as elaborated in Annex 1 of Decisions 2011/7 of the Flemish Utility Regulator. This decision requires that 1. **Green reporting procedure for suppliers**: Suppliers submit on a monthly basis the list of their consumers to the regulator, with an indication of the percentage of renewable energy supply promise to each individual consumer in the list (note: consumers are identified by their EAN codes). 2. **Green reporting procedure part for grid operators**: The regulator's automated system subsequently makes this list of green consumers available to the grid operator, who is asked to fill in, per individually listed consumer, the total consumption in the preceding month. 3. **Automated calculation of GOs to cancel for meeting the promise**: Subsequently, the regulator's tool calculates per supplier and per product, the number of GOs to be cancelled for that month. This number (the GO cancellation quota) is uploaded to the GHO registry as a 'GO cancellation quota' per supplier. The GO registry displays to each suppliers their GO cancellation quotum for the respective month, the supplier cancels the GOs, and 'closes' the month. 4. **Automated overview of "cancelled GOs compared to green promise" for the regulator:** The result is available in a dashboard for the regulator, who can supervise the status of GO cancellations compared to the promises. 5. **Result in GreenCheck Webtool involves individual consumers in the check of the promise**: The GreenCheck involves individual consumers (including households) to the verification exercise. The consumer, through their individual consumer's EAN code, on the GreenCheck webtool can check whether their supplied energy conforms to the percentage, energy sources and and country of origin of their contract. An easy complaint procedure enables them to notify the regulator upon incompliance of their supplier. 6. **Agility of the regulator upon incompliant suppliers**: when a supplier would not meet their promise with cancellation of GOs, law enables the regulator to take measures against that supplier.
Gas	NO EXAMPLES Note: No specifications for automation have been observed so far for the process of verification of bills that energy suppliers send out to their customers, to verify whether these contain the correct disclosure information. The Sub-criterion is challenging to assess primarily due to the lack of publicly available information regarding the degree of integration and automation of these processes and systems. These processes are typically internal to issuing bodies, regulatory authorities, or market participants, and are seldom documented or disclosed in sufficient detail to enable a consistent assessment and comparison.
Heating and cooling	In the Netherlands, district H&C companies need to draft a monthly or annual metering report as a basis for H&C GO issuance, with requirements on this report detailed as part of the legal framework conditions (in "Regeling garanties van oorsprong en certificaten van oorsprong, geraadpleegd op 23-09-2025"). In Finland, the Act on Guarantees of Origin for Energy Production details verification requirements: prior to GO issuance for a production device, an assessment body has to verify the production method and energy sources used by the device.

54 See https://www.vreg.be/nl/controleren-hoe-groenuw-stroom-groencheck, https://dashboard.vreg.be/report/DMR_Brandstofmix.html.

Stakeholder group	Benefit
	Verification certificates have to be renewed periodically. In both cases, no information is available on the degree of automation in handling the data involved.
Innovation	
Electricity	Whereas GO issuing bodies currently have manual work to update the information in the GO registry with inspection results, there is an opportunity for the concept of the Digital Product Passport to include in its design automation features for verifications. IT systems can program access for certain roles to provide certain blockers or enablers or proportionalisations of GO issuing in relation with an inspection of a production device.
Gas	Whereas certification bodies and GO issuing bodies currently have manual work to update the information in the GO registry with inspection and sustainability/RFNBO criteria certification results, there is an opportunity for the concept of the Digital Product Passport to include in its design automation features for verifications. IT systems can program access for certain roles to provide certain blockers or enablers or interfacing with GO cancellation in relation with a certification that moves along in the supply chain.
Heating and cooling	Automation of verification processes can be facilitated by technical registry design, e.g. the creation of technical interfaces between registries for input and output energy carriers in case of conversion processes. For instance, using an interface or other form of technical integration between a domain's electricity GO registry and H&C GO registry, attributes of cancelled electricity GOs could be automatically transferred to corresponding H&C GOs for electricity-based H&C production. Furthermore, there is a large potential for automating production data verification in the H&C case, as H&C production data usually cannot be verified by independent grid operators (if grid operators act as H&C suppliers). Here, the transmission of metering data via certified smart meter gateway could significantly simplify verification processes.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 10: Digitalisation and automation of data provision and verification processes of disclosed information on origin of energy

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	Belgium: See above elaboration of the Green Reporting procedure and monthly GO quota and forth-flowing GreenCheck, for both Belgium Flanders as for Belgium Brussels.
Gas	In Estonia, smart meters feed data directly into the Gas Data Hub, where it is digitally stored. The gas GO registry automatically retrieves production and consumption data from the hub. Once transferred to the GO registry operated by Estonian TSO, Elering, GOs are automatically issued to the producer´s account, minimizing manual handling and ensuring a fully automated, verifiable process.

Stakeholder group	Benefit
Heating and cooling	In the Netherlands, the Issuing Body VertiCer has automated and digitalised processes in place for issuing, transferring and cancelling GOs.
Innovation	
Electricity	Automation is a highly beneficial design element of hourly matching concepts.
Gas	There is an opportunity for the concept of the Digital Product Passport to include in its design automation features for verifications. IT systems can program access for certain roles to provide certain blockers or enablers or interfacing with GO cancellation in relation with a certification that moves along in the supply chain, especially where emissions of final energy consumption are embedded in the emissions of a product.
Heating and cooling	See sub-criterion “Automation of national-level supervision processes” – data provision and verification of disclosure information could be further facilitated by the development of a standard for machine-readable disclosure statements, as envisioned under the Digital Product Passport framework.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 11: Existence of automated systems for the collection and transfer of energy production data

Stakeholder group	Benefit
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In all analysed countries, the EECS Domain Protocols describe the metering and provision of energy production data with a high level of automation of processes and data handling. Usually, there are only exemptions for very small plants from automated meter readings and transfer of data. However, it should be noted that these EECS rules only apply for those volumes which are covered by the GO system and may not hold true for the tracking of other fuels in these countries.
Gas	In Estonia, production data is measured with smart meters that transfer data automatically to the Gas Data Hub on a regular basis. From the hub, data is again transferred to the gas GO registry for issuance of GOs.
Heating and cooling	The Dutch H&C disclosure system stipulates that metering equipment needs to be remotely readable, unless this would be cost inefficient. In electricity GO systems, it is established good practice that independent grid operators submit metering data electronically to GO registries, so that energy production data is verified. In the case of vertically integrated H&C grids, grid operators own production devices and also act as suppliers, making alternative verification methods for production data necessary. This can be significantly facilitated by the use of remotely readable metering equipment and the creation of interfaces between GO registries and certified smart meter gateways.
Innovation	
Electricity	Hourly matching: Descriptions of hourly matching concepts are not explicit, but automated data collection is a default practice for such systems, and this constitutes a highly beneficial element of this specific approach

Stakeholder group	Benefit
	For the roll-out of Digital Product Passports, there is an opportunity to include in its design automation features for receiving energy production data. IT systems can program access for certain roles to provide certain input for DPP/GO issuing.
Gas	NO EXAMPLES in the studied literature with emphasis on this.
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 12: The Disclosure Concept is anchored in legislation

Stakeholder group	Benefit
Organisations	Provide unique green claims for marketing products or services
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In all analysed countries, the Disclosure concept is anchored in principle in legislation. However, the level of detail can vary, so that detailed regulations are to some extent defined in non-legislative formats.
Gas	In Austria, the disclosure of energy origin is formally established and regulated by law, ensuring a clear legislative basis. In Estonia, every consumer has the right to access information on Guarantees of Origin cancellation for their metering point, as stipulated in the Energy Sector Organisation Act, embedding disclosure rights in legislation. In France, suppliers are legally obliged to use GOs to certify the renewable origin of energy sold for all their green offers ensuring that disclosure requirements are mandated by law.
Heating and cooling	In Finland, the Netherlands and Germany, legislation exists firstly on the establishment of H&C GOs as tracking instrument; secondly, disclosure obligations on suppliers to provide information on the source of the supplied heating and cooling are clearly defined in law. Importantly, disclosure obligations link back to the use of GOs as tracking instrument for the energy sources covered by the GO scheme (e.g. renewable energy and waste heat sources). In Sweden, the inclusion of H&C in the legal framework for GOs is currently being prepared.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 13: Cancellation of certificates for the input energy and issuing of new certificates for the output energy

Stakeholder group	Benefit
Plant Operator	Transfer of green attributes from energy inputs to energy outputs in conversion processes

Stakeholder group	Benefit
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	
Electricity	The cancellation of certificates for the input energy and subsequent issuing of new certificates for the output energy is required and described by the respective EECS Domain Protocols in various countries like the Netherlands, Belgium-Flanders, Denmark and Austria. This approach is also supported by the implementation of EN16325.
Gas	In Austria, the GOs are converted by cancelling the GOs used for the input into conversion and issuing new GOs for the measured output of conversion. Potential environmental aspects stay unchanged on the certificate. Also in Germany, the legal frameworks for GOs (GWKHV) contains rules for energy conversion, detailing that certificates issued for the input energy need to be cancelled as proof of the renewable character of input energy, to avoid double counting of green attributes. As a standarised framework, EN 16325:2025 contains rules on conversion issuance.
Heating and cooling	Both in Finland and Germany, the legal frameworks for GOs (Act on Guarantees of Origin for Energy (1050/2021) in case of Finland, GWKHV in case of Germany) contain rules for energy conversion, detailing that certificates issued for the input energy need to be cancelled as proof of the renewable character of input energy, to avoid double counting of green attributes.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 14: Clear rules are in place for tracking conversion between different energy carriers

Stakeholder group	Benefit
Organisations	Provide unique green claims for marketing products or services
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	
Electricity	Clear rules are in place for tracking conversion between different energy carriers and are described by the respective EECS Domain Protocols in various of the analysed countries, like the Netherlands, Belgium-Flanders, Denmark and Austria. This approach is also supported by the implementation of EN16325.

Stakeholder group	Benefit
Gas	According to the Domain Protocol, there are clear, defined rules for tracking energy when it is converted from one carrier to another in Austria. During the conversion process, GOs are transferred to a conversion account and immediately cancelled with the tag "Cancelled for Conversion" and the start and end date of the conversion. Based on meter readings for the converted energy, new GOs are issued with unchanged primary information, except for the production date (set to the injection date) and the source, which changes to reflect the conversion (including country of origin if foreign GOs are converted in Austria). The certificate number of the input GO and the conversion date are added as additional information. Label information remains unchanged and is either visible on the new GO or stored in the history for reconversion. A new certificate number is assigned to the output GO. The output must equal the input plus conversion losses, with the required input calculated ex-post and verified by an accredited auditor. If not enough GOs are available on the account, the output after conversion is of unknown origin.
Heating and cooling	Both in Finland and Germany, the legal frameworks for GOs (Act on Guarantees of Origin for Energy (1050/2021) in case of Finland, GWKHV in case of Germany, also applying to gases) contain rules for energy conversion. They apply to energy amounts that are marketed as renewable energy, as in these cases Guarantees of Origin following EN 16325 need to be used as an accounting instrument. As a standardised framework, EN 16325:2025 contains rules on conversion issuance.
Innovation	
Electricity Gas Heating and cooling	NO EXAMPLES from entire disclosure concepts as subjected to the evaluation. Example from a dedicated study on efficient operational handling of energy carrier conversion: • REGATRACE reports D4.3 and D4.4 describe proposals for efficient handling of energy carrier conversion through integration of GO systems for multiple energy carriers (Verwimp & Aalto, 2022; Verwimp et al., 2021)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 15: Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	
Electricity	Data sharing and interfaces between energy carrier-specific EAC registries for conversion tracking takes place in various of the analysed countries, like the Netherlands, Belgium-Flanders, Denmark and Austria. The Netherlands has merged the formerly separated issuing bodies for electricity and gas GOs into VertiCer, a single GO issuing body for electricity, gas including hydrogen and heat. From July 2025 onwards, new gas GOs are issued in the same registry as for electricity. This unlocks efficiencies for energy carrier conversion, which is particularly relevant for hydrogen GOs.

Stakeholder group	Benefit
	Also in Belgium-Flanders and in Austria, the electricity and gas GO registrations are embedded in the same software, operated by a single body namely the regulatory authority for electricity and gas. Austria already issued hydrogen GOs. Flanders included the energy conversion rules in the GO legislation, while the other countries include this rather in their operational procedures (Domain Protocols).
Gas	In Austria, all energy carriers are managed within a single registry, allowing seamless tracking of conversions between different energy carriers.
Heating and cooling	For H&C registries already in operation, this could not be assessed as part of the study, as the technical details of registry interfaces are usually only available to system users.
Innovation	
Electricity Gas Heating and Cooling	For conversion tracking, data sharing and the establishment of technical interfaces between energy carrier-specific EAC registries is an important technical innovation in registry design (see also sub-criterion "Automation of verification processes"). For instance, using an interface or other form of technical integration between a domain's electricity GO registry and H&C GO registry, attributes of cancelled electricity GOs could be automatically transferred to corresponding H&C GOs for electricity-based H&C production. This improves administrative efficiency and acts as a safeguard against double counting of green attributes. An automation of data sharing processes is particularly needed if conversion tracking is to reflect an hourly matching of energy inputs and output energy production, as envisioned under the EU's RFNBO criteria from 2030. Example from a dedicated study on efficient operational handling of energy carrier conversion: REGATRACE report D4.4 describes proposals for efficient handling of energy carrier conversion through process flows for, integration of and collaboration between GO systems for multiple energy carriers(Verwimp & Aalto, 2022)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 16: Data sharing between relevant registries and public agencies in other countries/domains for coherent data use in the disclosure system

Stakeholder group	Benefit
Organisations	Provide unique green claims for marketing products or services
Plant Operator	Fulfilling the formal prerequisites for market participation
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	International transfer of data is provided in all analysed countries by the joint EECS Scheme Membership, cooperation within AIB and the use of the AIB hub. However, this particularly includes EECS GO, which might only cover renewable energy, but not fossil or nuclear energy.
Gas	In Austria and Estonia, data sharing between relevant registries and public agencies ensures coherent and consistent use of energy disclosure information across domains and borders. For example, under the EECS gas scheme, registries

Stakeholder group	Benefit
	coordinate to track GOs and related data accurately, ensuring interoperability and reliability.
Heating and cooling	So far, no cross-country or cross-domain data sharing has been established for H&C. Given the local nature of H&C networks and the restriction of GO transfer and/or use in disclosure to network boundaries in many (but not all) of the case studies, this aspect is of lower relevance for H&C. In case of cross-border networks, bilateral agreements could be implemented on what registry to use.
Innovation	
Electricity Gas Heating and cooling	If GOs were to be integrated into a European, cross-sectoral renewable energy quota such as foreseen by the “Guarantees of Renewable Origin (GRO)” concept, the establishment of data sharing between relevant registries and public agencies in different countries would become necessary in the context of target accounting.
Heating and cooling	In the context of energy disclosure, cross-domain data sharing would only be necessary in cases where deliverability constraints are not reflected in disclosure rules and cross-domain transfer of H&C GOs is enabled, and in the limited use case of cross-border H&C grids. In the latter case, bilateral agreements on which domain’s registry to use could be made, limiting the need for technical data sharing solutions such as interfaces.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 17: Disclosure method is based on principles consistent with those used at the EU level

Stakeholder group	Benefit
Organisations	Provide unique green claims for marketing products or services
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	The application of a disclosure method which is consistent with the principles used at the EU level in all analysed countries is particularly supported by the joint operation under the EECS Scheme Rules, and the implementation of the requirements imposed by RED II and the IEM Directive 2019/944.
Gas	In Austria, the recast Directive on the Common Rules for Gas and Hydrogen (EU) 2024/1788 establishes the first gas disclosure obligation for suppliers, requiring the renewable and low-carbon origin of supplied gas to be stated on bills, with renewable gas substantiated via GOs. Austria has already started implementing these principles in national law: the revision of the Gas Act 2011 in 2022 introduced a gas disclosure system covering all gas types from 2023 for the year 2022, and the Gas Acts incorporate the 2009/73/EC disclosure regulations (§§ 129b, c, 130 GWG for Gas). Additional rules on disclosure display and GOs are specified in the disclosure secondary laws for gas. In Estonia, the same EU Directive is guiding the introduction of gas disclosure in national law, requiring suppliers to state the renewable and low-carbon origin of gas on bills, with renewable gas substantiated via GOs, and Estonia has already begun implementing these principles.

Stakeholder group	Benefit
Heating and cooling	In all H&C case studies, legal frameworks for GOs and disclosure implement requirements by the RED II/III (or will implement them once adopted, in the case of Sweden).
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 18: Harmonisation of requirements and administrative procedures across energy carriers

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
	Incentive for a consistent development of system infrastructure
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	NO EXAMPLES Note: For almost all assessed countries, the assessment resulted in no clear conclusion.
Gas	Austria integrates Conversion Issuance in the GO registry.
Heating and cooling	In all H&C case studies, the legal framework for GOs applies either jointly to electricity, gases and H&C, or to the new GO systems for gases and H&C with close alignment to existing regulations on electricity GOs. Moreover, in the Netherlands, Sweden and Germany, the same Issuing Body is responsible for GO systems for electricity, gases and H&C. While detailed administrative procedures are still under development in some cases, this leads to harmonisation benefits. In Finland, the Energy Authority acts as Competent Body for Disclosure for all three energy carriers, even though they act as Issuing Body only for H&C, whereas electricity and gas transmission system operators act as Issuing Bodies for electricity and gas/hydrogen, respectively.
Innovation	
Electricity Gas Heating and cooling	Input from a dedicated study on efficient operational handling of energy carrier conversion: REGATRACE reports D4.3 and D4.4 describe proposals for efficient handling of energy carrier conversion through integration of GO systems for multiple energy carriers (Verwimp & Aalto, 2022; Verwimp et al., 2021)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 19: Rules and procedures for tracking different energy carriers are coordinated to prevent double claims of attributes of the same energy production

Stakeholder group	Benefit
Plant Operator	Transfer of green attributes from energy inputs to energy outputs in conversion processes
Society as a whole	Contribution to the reduction of bureaucracy and efficiency of administrative action
	Incentive for a consistent development of system infrastructure
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity Gas Heating and cooling	In the case of Sweden and the Netherlands, the alignment of legal framework conditions across energy carriers and the responsibility of one Issuing Body for all energy carriers ensures the coordination of rules and procedures for tracking different energy carriers. In Finland, the Energy Authority acts as Competent Body for Disclosure for all three energy carriers (even though they act as Issuing Body only for H&C), enabling coordination across energy carriers as part of a supervisory role. In the case of Germany, separate registries and responsible agencies exist for GOs and mass balancing certificates for renewable gases, which imposes the need for added coordination efforts to prevent double counting.
Innovation	
Electricity Gas Heating and Cooling	NO EXAMPLES from entire disclosure concepts as subjected to the evaluation. Example from a dedicated study on efficient operational handling of energy carrier conversion: REGATRACE reports D4.3 and D4.4 describe proposals for efficient handling of energy carrier conversion through integration of GO systems for multiple energy carriers (Verwimp & Aalto, 2022; Verwimp et al., 2021)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 20: Specification of the tracking tool(s) that enable market-based claims on energy attributes from all fuel types, including renewable and non-renewable sources (full disclosure)

Stakeholder group	Benefit
Organisations	Facilitate Renewable Energy Purchase Agreements
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Improvement potential	Inspiration from the good practice disclosure disclosure concepts
Good Practice	
Electricity	Austria has implemented full disclosure. National GOs are tracked in Austrian registry for use in Austria only while EECS GOs are transferred via the AIB Hub to other countries. The Netherlands too has implemented the full disclosure concept for electricity.

Stakeholder group	Benefit
Gas	Austria facilitates that GOs for renewable gas, natural gas, hydrogen, syngas and other gas are cancelled and used for disclosure. But it acknowledges that there is also gas consumption for which no GO exists, given imported natural gas. The regulations provide that the amount of gas consumption for which no GO is cancelled, needs to be disclosed as natural gas.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	In the case of Full Disclosure for district H&C grids, GOs would be issued for all energy sources including renewable and non-renewable sources. This would enable an explicit allocation of energy source attributes and associated emission factors to each customer connected to a H&C grid. In the H&C context, implementation costs of full disclosure as compared to GO tracking only of renewable and waste H&C quantities are likely to be limited, as grid operators frequently own most if not all production devices connected to the grid. This ensures that data on all energy generation is already available to the grid operator/supplier. Besides increasing the transparency of market-based claims, the main benefit of full disclosure in a H&C context lies in synergies with decarbonisation progress monitoring, as GO registries could be used as a central information tool to fulfil various reporting requirements that H&C suppliers may face (depending on national legal frameworks for grid-based H&C supply.)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 21: Specification of the tracking tool(s) that enable market-based claims on renewable energy attributes

Stakeholder group	Benefit
Organisations	Facilitate Renewable Energy Purchase Agreements
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Plant Operator	Fulfilling the formal prerequisites for market participation
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	The specification of guarantees of origin as the tracking tool that enables market-based claims on renewable energy attributes is stipulated by EU Directives and generally implemented across the analysed countries.
Gas	In Austria and Estonia, Guarantees of Origin GOs are specified in legislation as the tracking tool that enables market-based claims on renewable energy attributes.

Stakeholder group	Benefit
	In France, the legal framework specifies a dual system of GOs and CPBs as the recognised tracking instruments, ensuring that market-based claims on renewable gas are consistent and regulated.
Heating and cooling	In Finland and the Netherlands, GOs are legally implemented as the tracking tool to be used as proof of supply of renewable heating and cooling. In Sweden, such legislation is in the process of being implemented. In Germany, the use of GOs is only legally required when a supplier commits to supplying a certain share of H&C from renewable or waste heat sources, leaving a degree of legal uncertainty as what counts as such commitment.
Innovation	
Electricity	Further inspiration can also be drawn from the GHG Protocol Scope 2 Guidance, which formulates quality criteria that contractual instruments incl. tracking tools used under the market-based approach have to meet (e.g. exclusion of double counting) and which refers to certain tracking schemes.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 22: The residual mix is publicly available, enabling its usage for disclosure

Stakeholder group	Benefit
Organisations	Facilitate Renewable Energy Purchase Agreements
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Plant Operator	Fulfilling the formal prerequisites for market participation
Improvement potential	Already well established in the existing disclosure schemes for electricity Inspiration from the good practice and innovative disclosure concepts for gas and heating and cooling
Good Practice	
Electricity	A calculation of a residual mix and its use for covering electricity volumes of "unknown origin" is common practice in the analysed countries.
Gas	Several countries' regulations specify that the residual mix for gas is fossil natural gas. (e.g. Denmark).
Heating and cooling	For H&C, no general residual mix calculation methodology has been established yet. In cases where the use of GOs is limited to interconnected H&C networks, residual mixes are calculated on a network level and become part of the information published by suppliers regarding the characteristics of their H&C supply (e.g., the energy mix in a "base product" where customers have not contracted deliveries with specific renewable energy characteristics). If H&C suppliers offer differentiated products in their grids, it is recommendable that the renewable and waste H&C shares in all such products must be backed by GO

Stakeholder group	Benefit
	cancellation, to avoid a potential double counting of green attributes. This appears to be the case in the disclosure rules of Finland, the Netherlands and perspectively Sweden, where GOs are legally implemented as the general tracking tool to be used as proof of supply of renewable heating and cooling. In Germany, where the use of GOs is only legally required when a supplier commits to supplying a certain share of H&C from renewable or waste heat sources, the question remains whether GOs also need to be used in case of a "base product" based on a residual mix containing renewable or waste H&C attributes, which are however not explicitly promised as part of an offer. In this case, it would need to be verified separately that the supplier did not also apply for GOs for underlying energy quantities. This can be avoided if the disclosure of all renewable and waste energy shares has to be backed by GO cancellation.
Innovation	
Electricity	NO EXAMPLES
Gas	In the German draft gas disclosure obligations, publication of residual mix is planned for the implementation period of disclosure rules, following a transition period where gas or hydrogen quantities for which no GOs are issued can be disclosed as "gas or hydrogen from non-renewable and non-low carbon sources". The REGADISS report provides a proposal for the set up of the residual mix for gases.
Heating and cooling	If disclosure rules permit the trading of attributes across grids, as in the case of Finland, calculating a national and – if cross-border transfer is enabled – European residual mx becomes a necessity. Here, such a residual mix is needed to determine what attributes replace attributes which are "exported" from a grid. If no sufficient data and harmonised residual mix calculation methodology is available, using a fossil-only energy mix for H&C can be an intermediate solution (Verwimp et al. 2022). In case of Full Disclosure for district H&C grids, it is not necessary to calculate residual mixes because all attributes are explicitly tracked based on information provided to the GO registries and GO cancellation.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 23: Disclosure mechanism (or related mechanism) provides real-time or advance information on the availability of energy from specific sources (particularly renewable energy sources)

Stakeholder group	Benefit
Society as a whole	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Significant potential from the good practice disclosure concepts for electricity Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts for gas and heating and cooling
Good Practice	
Electricity	The Data Hub in Denmark enables this public information provision.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	

Stakeholder group	Benefit
Electricity	No clear example has been identified as show case. But the provision of a real-time or advance information on the availability of energy from specific sources is a highly beneficial design element of hourly matching concepts.
Gas	NO EXAMPLES
Heating and cooling	If H&C GOs are issued on an hourly basis based on automatically transmitted production data, the real-time profile of H&C sources could be made visible to consumers in principle. However, compared to the electricity system, H&C supply via grids has a higher temporal inertia due to the storage function of grids; moreover, H&C storage solutions tend not to be implemented individually by consumers but centrally by the grid operator/H&C supplier as part of the overall grid optimisation. With the possible exception of process heat, flexibilization potentials for H&C are also more limited than in the case of electricity applications. While in principle possible, the use case of providing real-time or advance information on the availability of energy from specific sources seems therefore limited in the H&C context and has to be weighed against implementation costs involved.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

B.3 System boundaries of energy disclosure

Sub-criterion 24: Energy attributes are tracked and have to be cancelled (or similarly marked) in order to be claimed

Stakeholder group	Benefit
Organisations	Facilitate Renewable Energy Purchase Agreements
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
	Hedge against CO2 prices
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	For renewables, all analysed countries have require the cancellation of GOs for RES-E, while some countries like Austria have implemented a full disclosure system which includes this requirement also for other energy sources.
Gas	In Austria, Estonia, and France, energy attributes are tracked through GOs, which must be cancelled before claims on renewable energy can be made. This procedure ensures that each unit of energy is only claimed once.
Heating and cooling	The Finnish, Dutch and Swedish (if implemented) GO and disclosure regulations impose clear rules that renewable (and waste heat-based, where covered) H&C supply needs to be backed by H&C GOs. In Germany, the use of GOs is only legally

Stakeholder group	Benefit
	required when a supplier commits to supplying a certain share of H&C from renewable or waste heat sources.
Innovation	
Electricity	RE100 Technical Criteria require that energy claims be backed by attributes that are accurately and transparently tracked from the point of generation to the end user.
Electricity Gas Heating and cooling	Both the Guarantees of Renewable Origin (GRO) and the ‘GO beyond targets’ concepts rely on Guarantees of Origin (GO) and require GOs to be cancelled to claim renewable energy consumption.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 25: Energy attributes can be allocated to a specific consumer as beneficiary

Stakeholder group	Benefit
Organisations	Facilitate Renewable Energy Purchase Agreements
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
	Hedge against CO2 prices
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	Whereas in Denmark and many other countries, all consumers are able to cancel GOs for their own consumption. Germany as well as Austria restricts GO cancellation to licensed suppliers but enables suppliers to cancel GOs for a specific consumer. While for most analysed countries this option only applies to RES, e.g. in Austria such a consumer-specific cancellation is possible also for non-RES, as these sources are also covered by the GO system.
Gas	Energy attributes can be allocated to a specific consumer as beneficiary in the gas GO schemes of Estonia, France. In Austria this could be done but only through the supplier who cancels the GOs then on behalf of a specific consumer.
Heating and cooling	For existing H&C disclosure systems, this level of implementation detail could not be assessed; however, EN 16325:2025 mandates that cancellation requests shall include information on beneficiaries of the cancellation, including final customers or end users of a corresponding quantity of energy and their identity as an option. As RED II/III require H&C GO schemes to be aligned with EN 16325, it can be assumed that enabling energy attributes to be allocated to specific consumers will be a widely supported good practice.
Innovation	
Electricity	NO EXAMPLES

Stakeholder group	Benefit
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 26: Energy attributes can be allocated to a specific product as beneficiary

Stakeholder group	Benefit
Organisations	Facilitate Renewable Energy Purchase Agreements
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
	Hedge against CO2 prices
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	Several of the analysed countries allow for the allocation of energy attributes to a specific product of the beneficiary, if the beneficiary is an energy supplier. The according option to make such an allocation when cancelling GOs and to have this documented by a cancellation statement is given e.g. in Germany, Norway and Austria. In Belgium-Flanders, such a product-specific allocation is a key part of the Greencheck concept and the underlying Green Reporting Procedure (Groenrapportering), that GOs are cancelled on a monthly basis per specific product per supplier, with a link to all individual consumers under that product for that month, and their measured consumption data provided by the grid operators. In individual cases, such as Norway, it is also possible to specify the product of an electricity consumer (e.g. an industrial company using renewable electricity to produce a certain product) as beneficiary.
Gas	Energy attributes can be allocated to a specific product as beneficiary in the gas GO schemes of Austria, Estonia.
Heating and cooling	The Internal Electricity and Gas Market Directives mandate product level disclosure for electricity and gas suppliers, respectively (Annex I section 1.3 lit. c Nr. 5 Directive (EU) 2019/944 for electricity; Annex I section 5 Directive (EU) 2024/1788 for gases). To facilitate this, several of the analysed countries allow for the allocation of energy attributes to a specific product of the beneficiary, if the beneficiary is an energy supplier. In individual cases, such as in the Norwegian electricity GO registry, the product of a beneficiary can be specified as part of cancellation statements even if the beneficiary is not an energy supplier but an energy consumer (e.g. an industrial company using renewable electricity to produce a certain product). These good practices can be carried over to heating and cooling.
Innovation	
Electricity	NO EXAMPLES

Stakeholder group	Benefit
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 27: Mandatory usage of the residual mix for untracked attributes

Stakeholder group	Benefit
Organisations	Facilitate Renewable Energy Purchase Agreements
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Improvement potential	Already well established in the existing disclosure schemes for electricity Inspiration from the innovative disclosure concepts for gas and heating and cooling
Good Practice	
Electricity	The mandatory use of the residual mix for untracked attributes is included in several of the analysed countries, including Sweden, Belgium, Norway, France and Denmark.
Gas	In Austria, consumption for which no GOs are cancelled, must be declared as fossil natural gas.
Heating and cooling	See sub-criterion "The residual mix is publicly available, enabling its usage for disclosure". For H&C, no general residual mix calculation methodology has been established yet. In cases where the use of GOs is limited to interconnected H&C networks, residual mixes are calculated on a network level and become part of the information published by suppliers regarding the characteristics of their H&C supply (e.g., the energy mix in a "base product" where customers have not contracted deliveries with specific renewable energy characteristics).
Innovation	
Electricity	Analysis GHG Protocol Scope 2: To ensure unique claims by all electricity users, an adjusted, residual mix characterising the GHG intensity of unclaimed or publicly shared electricity is necessary. This residual mix should be based on combining national or subnational energy and emissions production data with contractual instrument claims. If a residual mix is not currently available, companies shall disclose that an adjusted emissions factor is not available or has not been estimated to account for voluntary purchases and this may result in double counting between electricity consumers (see chapter 8.3.3.6).
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 28: Disclosure rules oblige suppliers to report electricity supplied through a direct line to consumers (without passing through the public grid), and to substantiate this claim with Guarantees of Origin

Stakeholder group	Benefit
Organisations	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
Improvement potential	Inspiration from the good practice disclosure concepts for electricity Not relevant for gas and for heating and cooling
Good Practice	
Electricity	In the Netherlands, the full disclosure scheme requires all supply to be covered by cancelled GOs.
Gas	NOT APPLICABLE
Heating and cooling	In the context of conversion of electricity to H&C, the use of GOs for electricity supplied through a direct line to a conversion plant may facilitate conversion tracking and the exclusion of double counting (alternatively, this may be achieved by auditing metering data). For instance, the electricity GO system in the Netherlands supports GO issuance for electricity supplied through a direct line, as the Dutch full disclosure system requires all supply to be covered with GOs.
Innovation	
Electricity	NO EXAMPLES
Gas	NOT APPLICABLE
Heating and cooling	NOT APPLICABLE

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 29: Tracking system differentiates energy amounts that were fed into the grid or another distribution system and energy amounts that were self-consumed

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	All analysed countries apply GO systems based on EECS, while the EECS Rules require the indication of the "dissemination level" on the GOs.
Gas	In Austria, GOs are issued exclusively for energy that has been fed into the grid, ensuring that only traceable amounts are certified, while self-consumed production remains outside the GO system.
Heating and cooling	Both the Finnish, German and Dutch legal frameworks for H&C GOs explicitly differentiate between energy amounts that were fed into the grid and supplied by a direct line/by an on-site generation facility. In the case of Germany and the Netherlands, GOs are offered for grid-based supply and for non-grid-based supply

Stakeholder group	Benefit
	(supply on site). As rules on disclosure and GO use are tied to network boundaries in both cases, GOs for non-grid-based supply can only be cancelled on behalf of the consumer supplied by such a direct connection. More detailed legal analysis, however, would be required to assess under what instances the use of GOs for on-site supply is mandatory. In Germany, it is also explicitly possible to apply for specifically marked GOs for self-supply on a voluntary basis, to exclude double counting in the case of "prosumers" who are supplied by H&C from a grid but also operate H&C production devices themselves and feed H&C into the grid. In Finland, the Act on GOs (1050/2021) clarifies that it is not necessary to cancel GOs for the proof a supply of renewable H&C in case of a direct connection and in case all H&C sources feeding the H&C grid are renewable.
Innovation	
Electricity Gas Heating and cooling	NO EXAMPLES, though EECS and CEN16325:2025 require such transparency to be integrated in the GOs. (These rules have been clarified only after the here performed evaluation exercise, and will be implemented in the national GO systems in the period after publication of this report)

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 30: Tracking system accounts for energy losses over storage

Stakeholder group	Benefit
Society as a whole	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	
Electricity	In Austria, E-control issues GOs for production devices with electricity storage capacity on net production and only based on natural inflow (minus any nett electricity consumed by pumping).
Gas	In Austria, GOs are cancelled for storage losses. Note, gas can only be stored for up to one year, as the lifetime of GOs expires after this period. The technical process used in the registry to manage stored GOs follows the same procedures applied for electricity storage.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity Gas Heating and cooling	The revised EN 16325:2025 includes optional provisions on GO issuance for energy flowing out of storage devices which take energy losses into account.
Heating and cooling	Furthermore, in the context of a full disclosure obligation for H&C grids, the whole H&C production and consumption in a grid would be accounted for and tracked by using GOs. This means that storage losses as well as grid losses would receive an explicit attribute allocation by means of GO cancellation.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 31: Tracking system enables to record the time period of release from an energy storage system ("time shifting of attributes over storage")

Stakeholder group	Benefit
Society as a whole	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	Austria: Austria is the first country where “Storage issuance” is implemented: GOs are cancelled for the energy input flowing into a storage system (historically pumped hydro stations), and new GOs are issued for the measured output flowing out of the storage system. This method systematically takes storage energy losses into account. The output is based on the GOs of the input. The attributes of the output stay the same after storage, except for the unique ID of the certificates, the production period, the country of issue, and if changed the dissemination level of the output. Germany and most other countries have a restricted implementation: No Storage Issuance for the time being, but where storage is on the site of the RES production, GOs are only issued for energy made available to the market (after storage, and injection into the grid).
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity Gas Heating and cooling	The revised EN 16325:2025 include optional provisions on GO issuance for energy flowing out of storage devices. In combination with the equally optional inclusion of information on the start time and end time of energy production in production devices and energy release from storage devices, time shifting of attributes through storage is supported.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 32: Tracking system has clear and consistent rules for allocating attributes from the input to the output of an energy storage system

Stakeholder group	Benefit
Society as a whole	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	Austria is the first country where “Storage issuance” is implemented: GOs are cancelled for the energy input flowing into a storage system (historically pumped hydro stations), and new GOs are issued for the measured output flowing out of the storage system The storage operator can decide its allocation method of input attributes to attributes on the GOs issued for the output from storage. If the operator doesn’t decide, the default FIFO (First In – First Out) system applies as allocation method
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	

Stakeholder group	Benefit
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	The revised EN 16325:2025 include optional provisions on GO issuance for energy flowing out of storage devices, where attributes from the input is allocated transparently to the output of an energy storage system (by GO cancellation for input energy, unless the energy has been produced on the site of the storage device and its attributes can readily be determined).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 33: Tracking system is transparent on the energy having been stored

Stakeholder group	Benefit
Society as a whole	Incentive for a consistent development of system infrastructure
Improvement potential	Significant potential from both the good practices and the innovative disclosure concepts
Good Practice	
Electricity	In Austria, GOs are issued for production devices with electricity storage capacity on net production and only based on natural inflow (minus any nett electricity consumed by pumping). GOs for the output is based on the cancelled GOs of the input. The attributes of the output are copied from the input, except for the unique ID of the certificates, the production period, the country of issue, and if changed the dissemination level of the output.
Gas	In Austria, following storage the GOs receive a storage tag in accordance with the EECS Rules
Heating and cooling	NO EXAMPLES
Innovation	
Electricity Gas Heating and cooling	The revised EN 16325:2025 include optional provisions on GO issuance for energy flowing out of storage devices. For transparency, GOs issued following a release of energy from a storage device need to be marked accordingly.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 34: Tracking system prevents double counting of attributes of stored energy

Stakeholder group	Benefit
Society as a whole	Incentive for a consistent development of system infrastructure
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In Austria, GOs are issued for production devices with electricity storage capacity on net production and only based on natural inflow (minus any nett electricity consumed by pumping). The electricity supply for pumping is multiplied with an efficiency of 75 percent (or verified plant specific percentage) and the result must be deducted from the total amount of electricity that will be injected into the grid.

Stakeholder group	Benefit
	For the compensation of the efficiency losses in the pumps the respective amount of GOs is cancelled.
Gas	In Austria, the technical process used in the registry to manage stored GOs follows the same procedures applied for electricity storage.
Heating and cooling	In all analysed cases, the H&C GO system is based on the established GO system for renewable electricity, where double counting of attributes of stored energy is prevented. Following the electricity GO rules set in EN 16325 prior to its revision, issuance of GOs for stored energy is not supported, unless the production device feeds directly into the storage device before energy is fed into the grid, and no GOs have been issued for the production device's energy generation.
Innovation	
Electricity	Double counting of attributes of stored energy would be prevented in the concept proposed in study 'Relevance of guarantees of origin for Europe's renewable energy targets' from Holzapfel et al. (2024) assuming EECS and/or EN16325 are implemented in the basic GO system upon which this innovative concept.
Electricity Gas Heating and cooling	The revised EN 16325:2025 includes rules on GO issuance for energy flowing out of storage devices including measures preventing double counting (such as GO cancellation for attributes of energy flowing into the storage device).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 35: Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
	Consumers become aware of environmental effects of own energy consumption
	Consumers can influence the geographical origin of their energy supply according to own preferences
Society as a whole	Contribution to the energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Already well established in the existing disclosure schemes for gas and heating and cooling Significant potential from the good practice disclosure concepts for electricity
Good Practice	
Electricity	NO EXAMPLES
Gas	The disclosure systems in Estonia and France ensure that renewable gas attributes are linked to physical deliverability and respect the boundaries of the distribution system. In Estonia, a mass balance system is applied: physical biomethane must first be injected into the grid before GOs are issued, and GOs can only be cancelled once the gas is actually withdrawn from the network. Where the production or

Stakeholder group	Benefit
	consumption site is too far from the grid, the system allows for the use of a virtual grid, ensuring that GOs still represent physically deliverable gas within the system. Similarly, in France, biogas injected into the gas network is traced through GOs and CPBs, with each certificate representing a specific megawatt-hour of injected biogas associated with a defined location and feedstock.
Heating and cooling	In Germany, the use of H&C GOs for disclosure is restricted to interconnected district H&C systems. Disclosure obligations from the FFVAV refer to one H&C system/grid, and as per the GWKHV, GOs may only be cancelled within the same system in which they were issued. Likewise, in the Netherlands GOs cannot be transferred in between grids that are not interconnected (as per the Regeling garanties van oorsprong en certificaten van oorsprong). As H&C networks are closed systems without exchange of energy between non-interconnected grids, reflecting connectivity in disclosure rules is associated with a higher amount of credibility of green energy products to consumers.
Innovation	
Electricity	Within the discussed GHGP Scope 2 revisions, physical deliverability constraints are proposed relating to market boundaries, incl. zonal pricing boundaries where applicable. Attribute transfers from adjacent and directly connected markets are permissible if excess transmission capacity can be demonstrated via electricity price differentials in respective markets. Transfers from any point in an interconnected system are permissible if exclusive rights regarding provision of transmission capacity can be demonstrated on a hourly basis. Also the RFNBO rules impose a limitation of transfer and accounting of attributes to an area which includes connectivity and the location of electricity producer and consumer within the same bidding zone, or adjacent bidding zone from time periods without congestion.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 36: Disclosure system limits the transfer and usage system boundaries to bundled sale of tracking instrument and energy commodity

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
	Consumers become aware of environmental effects of own energy consumption.
	Consumers can influence the geographical origin of their energy supply according to own preferences
Society as a whole	Contribution to the energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Already well established in the existing disclosure schemes for gas and heating and cooling Significant potential from the good practice disclosure concepts for electricity
Good Practice	

Stakeholder group	Benefit
Electricity	NO EXAMPLES
Gas	Estonia and France both ensure that renewable gas attributes are bundled with the physical energy commodity, limiting the transfer and use of tracking instruments to actual gas supplied and consumed. In Estonia, a mass balance system requires that biomethane is first injected into the grid before GOs are issued, and GOs can only be cancelled once the gas is withdrawn from the network. Where the production or consumption site is too far from the grid, a virtual grid is allowed, but the GOs remain linked to the corresponding physically deliverable gas. In France, biogas injected into the network generates GOs or CPBs that are tied to each specific megawatt-hour of injected gas and its location and feedstock, ensuring that the tracking instrument is used only in conjunction with the associated energy sold.
Heating and cooling	In the German and Dutch cases, GO use and/or transfer is limited to interconnected H&C grids; as a result, they are provided bundled with H&C sales within that grid (even if within the interconnected grid, a Book & Claim logic is applied, and the allocation of attributes is independent of thermodynamic energy flows).
Innovation	
Electricity	The discussed GHGP Scope 2 revisions include this aspect to some extent. Within a market boundary, the bundled sale of tracking instrument and energy commodity is not required. Also, it is not required in case of transfers from adjacent and directly connected markets where excess transmission capacity can be demonstrated via electricity price differentials. However, in case of an attribute transfer from markets within an interconnected system (need not be adjacent or directly connected), the bundled sale of tracking instrument and energy commodity is required. Also, the RFNBO rules impose such a requirement for bundled sales based on the PPA-related requirements for RFNBO electricity supply, while for specific grid situations this might not be required.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 37: Disclosure system limits the transfer and usage system boundaries to physical deliverability, in terms of a connection being present

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
	Consumers become aware of environmental effects of own energy consumption
	Consumers can influence the geographical origin of their energy supply according to own preferences
Society as a whole	Contribution to the energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure

Stakeholder group	Benefit
Improvement potential	Already well established in the existing disclosure schemes for gas and heating and cooling Significant potential from the good practice disclosure concepts for electricity
Good Practice	
Electricity	NO EXAMPLES
Gas	Estonia and France both ensure that renewable gas attributes are bundled with the physical energy commodity, limiting the transfer and use of tracking instruments to actual gas supplied and consumed. In Estonia, a mass balance system requires that biomethane is first injected into the grid before GOs are issued, and GOs can only be cancelled once the gas is withdrawn from the network. Where the production or consumption site is too far from the grid, a virtual grid is allowed, but the GOs remain linked to the corresponding physically deliverable gas. In France, biogas injected into the network generates GOs or CPBs that are tied to each specific megawatt-hour of injected gas and its location and feedstock, ensuring that the tracking instrument is used only in conjunction with the associated energy sold.
Heating and cooling	See “Disclosure system limits the transfer and usage system boundaries of attributes to physical deliverability including connectivity and within a common balancing mechanism (same bidding zone or adjacent bidding zone from time periods without congestion)”; as the bidding zone concept does not apply to H&C markets, there is no difference between the two sub-criteria for H&C.
Innovation	
Electricity	Within the discussed GHGP Scope 2 revisions, physical deliverability constraints are proposed relating to market boundaries, see line 77; within these boundaries, the existence of connections does not need to be demonstrated, but given a narrow definition of market boundaries the existence of connections can generally be assumed. In case of transfers from other market boundaries (adjacent and/or interconnected), connections and transmission capacity would need to be demonstrated. Also the RFNBO rules (European Commission 2023a) impose a limitation of transfer and accounting of attributes to an area which includes connectivity and the location of electricity producer and consumer within the same bidding zone, or adjacent bidding zone from time periods without congestion. This implies the requirement for a connection to be present." The RE100 Technical Criteria limit the transfer and usage boundaries to markets for renewable electricity. Individual countries are defined as distinct markets for renewable electricity. However, the European market as well as the market between the US and Canada are recognised as single markets. Countries that do not have a grid connection are excluded from these single markets.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 38: Ability for a third party (contractor, service provider) to cancel EACs on behalf of specific consumers

Stakeholder group	Benefit
Organisations	Provide unique green claims for marketing products or services

Stakeholder group	Benefit
Plant Operator	Enabling revenues and planning security from long-term REPAs
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In several of the analysed countries, it is allowed that any party can open an account in the GO registry and cancel GOs, like in the Netherlands, Norway, France and Denmark.
Gas	Both Estonia and France allow third parties, such as contractors or service providers, to cancel Energy Attribute Certificates (EACs) on behalf of specific consumers.
Heating and cooling	In Finland, there are no restrictions in the law on who can apply to be an account holder; this allows contractors or service providers to apply for an account with cancellation rights and cancel GOs on behalf of specific consumers.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 39: Ability to apply for energy attribute certificates (EACs) for renewable energy plants under Renewable Energy Power Purchase Agreements (REPAs)

Stakeholder group	Benefit
Organisations	Provide unique green claims for marketing products or services
Plant Operator	Enabling revenues and planning security from long-term REPAs
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In all analysed countries, it is possible to use GOs together with a REPA for those energy sources which are covered by the respective national GO scheme. While this is limited to RES-E in some countries, this option also applies for fossil and nuclear electricity production in countries which have GO systems for these sources.
Gas	In Austria, Estonia, and France, renewable energy plants operating under Renewable Energy Power Purchase Agreements (REPAs) are eligible to apply for EACs, such as GOs or CPBs (in France).
Heating and cooling	In the context of H&C supply, REPAs are not an established contract form yet. However, as a form of long-term supply contract, there is no reason to assume that production devices with a H&C REPA could not apply for H&C GOs, as far as other constraints on the use of GOs for disclosure (such as physical deliverability in the case of the Netherlands and Germany) are taken into account.
Innovation	
Electricity	NO EXAMPLES

Stakeholder group	Benefit
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 40: Ability to transfer EACs to individual consumers (with EAC cancellation by consumers)

Stakeholder group	Benefit
Organisations	Provide unique green claims for marketing products or services
Plant Operator	Enabling revenues and planning security from long-term REPAs
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In several of the analysed countries, it is allowed that any party can open an account in the GO registry and cancel GOs, like in the Netherlands, Norway, France and Denmark.
Gas	Consumers can apply for an account in the gas GO registry of France and Estonia and have the ability to cancel GOs themselves.
Heating and cooling	In the Netherlands, this option is open to commercial end-consumers. In Finland, there are no restrictions in the law on who can apply to be an account holder, so individual consumers can cancel GOs on their own behalf.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 41: Mandatory restrictions apply for the application of explicit tracking instruments based on other additionality criteria (besides age and support)

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition.
Society as a whole	Contribution to the energy transition
Improvement potential	Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts.
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES

Stakeholder group	Benefit
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 42: Mandatory restrictions apply for the application of explicit tracking instruments based on plant age

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Society as a whole	Contribution to the energy transition
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	RE100 imposes mandatory restrictions on the use of tracking instruments based on plant age, with a 15-year commissioning or repowering limit as a core eligibility criterion. Also the RFNBO rules (European Commission 2023a) impose a limitation of transfer and accounting of attributes to an area which includes connectivity and the location of electricity producer and consumer within the same bidding zone, or adjacent bidding zone from time periods without congestion.
Gas	NO EXAMPLES
Heating and cooling	According to EN 16325, GOs must include information on the date when a production device first became operational. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from plants newer than a certain age threshold). Based on this, consumers could set their own restrictions on plant age when choosing energy products. For instance, the RE100 initiative uses a 15-year commissioning or repowering limit on plant age as a core eligibility criterion for renewable energy purchases. On the other hand, imposing age-based mandatory restrictions on the use of tracking instruments altogether raises the challenge of how to carry out accounting for attributes of older plants. In the H&C context, excluding older plants from explicit tracking instruments would prevent synergies from using tracking instruments for monitoring the decarbonisation progress of grids, where all connected plants would have to be included. Similarly, imposing mandatory restrictions on the use of explicit tracking instruments is mutually exclusive with the concept of full disclosure.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 43: Mandatory restrictions apply for the application of explicit tracking instruments based on the level of support

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Society as a whole	Contribution to the energy transition
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	In Germany, no RES-E GOs are issued for RES-E which has received support under the domestic support system, as these volumes are allocated on a statistical pro-rata basis to consumers (assuming that those have equally contributed to the funding of the support system and hereby have paid for the value of the greenness of the production and the respective attributes. However, no such restrictions apply for import and use of non-domestic GOs.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	The RFNBO rules only allow (at least for specific supply cases and national grid situations) only for the supply and accounting of non-supported RES-E.
Gas	NO EXAMPLES
Heating and cooling	According to EN 16325, GOs must include information on whether production devices have received investment and/or production support, and the type of such support. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from supported or unsupported plants). Based on this, consumers could set their own restrictions on support when choosing energy products. For instance, as part of proving compliance with RFNBO criteria, hydrogen producers must demonstrate that contracted renewable electricity plants did not receive support in the form of operating aid or investment aid (with exceptions). On the other hand, imposing support-based mandatory restrictions on the use of tracking instruments altogether raises the challenge of how to carry out accounting for attributes of supported plants. In the H&C context, excluding supported plants from explicit tracking instruments would prevent synergies from using tracking instruments for monitoring the decarbonisation progress of grids, where all connected plants would have to be included. Similarly, imposing mandatory restrictions on the use of explicit tracking instruments is mutually exclusive with the concept of full disclosure.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 44: Required geographical correlation of production and consumption of energy

Stakeholder group	Benefit
Plant Operator	Revenues from green attribute sales in short-term markets
Society as a whole	Contributing to reduction of public cost of energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Significant potential from the good practice disclosure concepts

Stakeholder group	Benefit
Good Practice	
Electricity	NO EXAMPLES
Gas	In Estonia, production and consumption proven with gas GOs issued in Estonia is only possible in Estonia at this moment.
Heating and cooling	See sub-criterion "Disclosure system limits the transfer and usage system boundaries to physical deliverability".
Innovation	
Electricity	The RFNBO rules require geographical correlation of electricity production and consumption, referring to the same bidding zone, or adjacent bidding zones from time periods without congestion. The study 'Relevance of guarantees of origin for Europe's renewable energy targets' from Holzapfel et al. (2024) proposes to limit the cross-border transfer of GOs. The authors outline several possible implementation models. One option is conditional transfer, where GOs can only be exported if a country has already met its domestic renewable electricity targets. Another model suggests a full prohibition on GO exports, keeping certificates entirely within national borders for accounting purposes. A third approach involves flow-based restrictions, in which GOs may only be transferred between countries that share physical electricity interconnections. In the GHG Protocol revisions, a much narrower definition of market boundaries is being proposed than currently implemented in the standard.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 45: Required temporal correlation of production and consumption of energy

Stakeholder group	Benefit
Plant Operator	Revenues from green attribute sales in short-term markets
Society as a whole	Contributing to reduction of public cost of energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Significant potential from both the good practices and the innovative disclosure concepts
Good Practice	
Electricity	France applies monthly matching, requiring that the GOs used correspond to the same calendar month as the consumption. While more technically demanding, this matching mechanism contributes to greater temporal alignment between energy generation and consumption, strengthening the credibility of green claims. Germany at least requires a matching on a calendar yearly basis.
Gas	NO EXAMPLES
Heating and cooling	In electricity disclosure, annual matching of production and consumption of energy is a widely established practice. The French electricity disclosure system provides an example where monthly matching is established. For the H&C context,

Stakeholder group	Benefit
	specifying annual matching would enhance transparency for consumers. No practical experience exists on the impacts of a monthly matching requirement. Especially in disclosure contexts where GO use is limited to interconnected H&C systems, unplanned outages in individual renewable or waste H&C production devices might lead to deviations from supply contracts, if the basis for temporal correlation is set too narrow.
Innovation	
Electricity	The RFNBO rules (European Commission 2023a) require temporal correlation of production and consumption of the supplied electricity. This includes a monthly period for an initial transitional phase, and an hourly period as of 2030. In the GHG Protocol Revisions, hourly matching is proposed as a requirement for claims on carbon free energy procurement (allowing for use of standardised profile data where activity data is not available); exemptions are proposed for organisations with electricity consumption below a certain threshold within a market boundary.
Gas	NO EXAMPLES
Heating and cooling	Individual H&C suppliers might offer contracts with a monthly matching component on a voluntary basis. Given the relevance of seasonal storage in H&C systems, this could only be meaningfully implemented in GO systems which explicitly track stored energy in a way that enables time shifting of attributes through storage (see sub-criterion “Tracking system enables to record the time period of release from an energy storage system”).

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

B.4 The type of information provided

Sub-criterion 46: The energy source mix of every product of a supplier is disclosed

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
	Consumers get emotionally involved and feel empowered in the context of energy transition
	Consumers can make a statement on individual preferences by choice of energy supply
Society as a whole	Contribution to the energy transition
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In several of the analysed countries, like Belgium-Flanders and Germany, the energy source mix of every product of a supplier has to be disclosed.
Gas	In Austria, gas suppliers must provide the product mix of their products in the beginning of April of the year following the year of supply. A product can be dedicated to only one customer or a group of customers.
Heating and cooling	In most cases, H&C sales still follow the principle of “one grid, one product” in the analysed case studies, meaning that only a single, uniform H&C product is offered within each district H&C system. Following disclosure regulations, the energy mix

Stakeholder group	Benefit
	of that uniform product is made publicly available. However, in future the introduction of product diversification might become more common, as H&C GO systems become a more established part of H&C market processes. First good practice examples for product disclosure exist in Sweden, where some suppliers offer a range of products and disclose their energy source mix following the guidelines provided by the Värmemarknadskommittén.
Innovation	
Electricity	NO EXAMPLES
Gas	According to the German draft gas disclosure obligations, gas and hydrogen suppliers will be obligated to publish the product mix of the supplied product as an attachment to their invoices to final consumers. Information on gas and hydrogen suppliers' total energy mix must be supplied either with bills or on suppliers' websites.
Heating and cooling	If suppliers offer product differentiation, the energy source mix of every product could be disclosed on suppliers' websites in order to ensure transparency for consumers when making choices on H&C supply.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 47: The full energy source mix of the supplier is disclosed

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
	Consumers get emotionally involved and feel empowered in the context of energy transition
	Consumers can make a statement on individual preferences by choice of energy supply
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	According to the clear requirements by Annex I 5. of the IEMD, all analysed countries have implemented the requirement that the full energy source mix of the supplier is disclosed.
Gas	In Austria, gas suppliers must provide the product mix of their products in the beginning of April of the year following the year of supply. A product can be dedicated to only one customer or a group of customers.
Heating and cooling	Disclosure of the full energy source mix of H&C suppliers is provided for in all four H&C case studies.
Innovation	
Electricity	NO EXAMPLES
Gas	According to the German draft gas disclosure obligations, gas and hydrogen suppliers will be obligated to publish a total energy mix either as part of their billing information for final consumers or on their websites. Suppliers will need to provide information on their energy mix in Germany and, if the supplier is active in other countries as well, the overall energy mix.
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 48: Compliance with a set of advanced additionality criteria is clearly disclosed as distinct information

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Society as a whole	Contribution to the energy transition
Improvement potential	Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 49: The degree of compliance with advanced additionality criteria is clearly indicated

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Society as a whole	Contribution to the energy transition
Improvement potential	Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 50: Information on the country of origin of the production device is specified

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition

Stakeholder group	Benefit
	Consumers can influence the geographical origin of their energy supply according to own preferences
Organisations	Allow for impactful energy supply decarbonisation strategies
	Compliance with carbon accounting standards
	Compliance with revised GHG accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
Society as a whole	Contribution to the energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Significant potential from both the good practices and the innovative disclosure concepts
Good Practice	
Electricity	In Germany, the share of origin from individual countries has to be indicated for RES, being based on GOs.
Gas	NO EXAMPLES in the obliged information to disclose to consumers in the observed countries, though GOs have to include the location of the production device
Heating and cooling	As mandated by EN 16325:2025, GOs have to include information on the location of the production device. In case studies where GOs cannot be transferred and/or used beyond the boundaries of interconnected grids (the Netherlands, Germany), the country of origin will be the country of consumption in the vast majority of cases (with the exception of cross-border grids).
Innovation	
Electricity	The study ‘Relevance of guarantees of origin for Europe's renewable energy targets’ from Holzapfel et al. (2024) proposes to limit the cross-border transfer of GOs. That requires information on the country of origin of the production device. One of the key features of the Digital Product Passport (DPP) is the system’s ability to support geographically informed choices about energy supply. The DPP framework includes information about the country of origin of the energy-producing device, empowering consumers to align their energy choices with personal or regional preferences.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 51: Information on the specific region (state, province, city etc.) of a production device is specified

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
	Consumers can influence the geographical origin of their energy supply according to own preferences

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies
	Compliance with carbon accounting standards
	Compliance with revised GHG accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
Society as a whole	Contribution to the energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	Information on the location of the production plant is provided on all GOs, and therefore available to system users which have access to the primary GO information within the GO registries or as indicated on a cancellation statement. However, this specific information is not included in standard disclosure information towards the consumers. Besides this, Germany has implemented the option to indicate the share of "regional RES-E" based on so-called "Regionalnachweise" ("regional GOs"), but only within the share of national supported RES in the disclosure statement of a supplier. This share of national supported RES is clearly distinguished from other RES shares which have to be disclosed based on cancelled GOs. Regionalnachweise can be used if the respective supported power plant is located not more than 50km from the respective consumer. For other RES-E which is disclosed based on cancelled GOs, no such option for the documentation and disclosure of the specific region is implemented.
Gas	NO EXAMPLES
Heating and cooling	As mandated by EN 16325:2025, GOs have to include information on the location of the production device. In case studies where GOs cannot be transferred and/or used beyond the boundaries of interconnected grids (the Netherlands, Germany), the region of origin will be the region of consumption in the vast majority of cases, because of the local character of H&C grids.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 52: Provide monthly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies
	Allow for impactful energy supply decarbonisation strategies

Stakeholder group	Benefit
	Compliance with carbon accounting standards
	Compliance with revised GHG accounting standards
	Compliance with revised GHG accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
Plant Operator	Revenues from green attribute sales in short-term markets
Society as a whole	Contributing to reduction of public cost of energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Significant potential from the innovative disclosure concepts
Good Practice	
Electricity	Monthly information on the time of production is available on GOs in most GO systems with issuing on the basis of months or shorter time periods. However, this is mostly not disclosed towards end consumers, but there are some positive examples. France applies monthly matching, requiring that the GOs used correspond to the same calendar month as the consumption. While more technically demanding, this matching mechanism contributes to greater temporal alignment between energy generation and consumption, strengthening the credibility of green claims. Denmark also supports increasing granularity in energy attribute tracking. While not required, the system allows for monthly and hourly GOs upon request by producers. This enables the granular matching of energy consumption with time-specific renewable generation
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	The provision of temporal granularity is a key aspect of the described approach for hourly matching. It is also a key element of the RFNBO rules for electricity taken from the grid, with a shift from monthly matching during a transitional period to hourly matching in the long-term.
Gas	NO EXAMPLES
Heating and cooling	See sub-criterion “Required temporal correlation of production and consumption of Energy”. No practical experience exists on the impacts of a monthly matching requirement in the H&C context. Especially in disclosure contexts where GO use is limited to interconnected H&C systems, unplanned outages in individual renewable or waste H&C production devices might lead to deviations from supply contracts, if the basis for temporal correlation is set too narrow. To gather such experiences, individual H&C suppliers might offer contracts with a monthly matching component on a voluntary basis.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 53: Provide hourly information on time of energy production, to enable granular matching with time of energy consumption within a specified time frame

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies
	Compliance with carbon accounting standards
	Compliance with revised GHG accounting standards
	Compliance with revised GHG accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
Plant Operator	Revenues from green attribute sales in short-term markets
Society as a whole	Contributing to reduction of public cost of energy transition
	Contribution to GHG emission reductions of energy production
	Incentive for a consistent development of system infrastructure
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	Denmark supports increasing granularity in energy attribute tracking. While not required, the system allows for monthly and hourly GOs upon request by producers. This enables the granular matching of energy consumption with time-specific renewable generation.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	The provision of temporal granularity is a key aspect of the described approach for hourly matching. It is also a key element of the RFNBO rules for electricity taken from the grid, with a shift from monthly matching during a transitional period to hourly matching in the long-term.
Gas	NO EXAMPLES
Heating and cooling	Hourly matching is predominantly a concept applying to electricity markets, whereas H&C distribution via grids is characterised by greater temporal inertia. However, hourly data on energy production could be relevant in the case of electricity-based H&C production, if suppliers wish to demonstrate an hourly matching of H&C production to renewable electricity availability.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 54: Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: Information provision whether electricity is obtained from a direct line (Art. 3 Delegated Regulation 2023/1184) without grid connection and no older than 36 months.

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
	Enabling revenues and planning security from long-term REPAs

Stakeholder group	Benefit
	Revenues from green attribute sales in short-term markets
	Transfer of green attributes from energy inputs to energy outputs in conversion processes
	Fulfilling reporting requirements placed on plant operators
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	NOT APPLICABLE
Gas	NO EXAMPLES yet, but several national GO systems are studying this possible future integration.
Heating and cooling	NOT APPLICABLE
Innovation	
Electricity	NOT APPLICABLE
Gas	NO EXAMPLES
Heating and cooling	NOT APPLICABLE

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 55: Inclusion of information on compliance with RFNBO requirements in the case of green hydrogen: When electricity is obtained from the grid, information provision on Bidding zone location (Art. 4), Additionality condition in terms of commissioning date and subsidies (Art. 5), Temporal correlation (Art. 6), Geographical correlation (Art. 7).

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Transfer of green attributes from energy inputs to energy outputs in conversion processes
	Fulfilling reporting requirements placed on plant operators
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	NOT APPLICABLE
Gas	NO EXAMPLES yet, but several national GO systems are studying this possible future integration. Note that the EECS GO standard enables recording the relevant data on GOs, which gives room for harmonised evolution.
Heating and cooling	NOT APPLICABLE
Innovation	

Stakeholder group	Benefit
Electricity	NOT APPLICABLE
Gas	NO EXAMPLES
Heating and cooling	NOT APPLICABLE

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 56: Inclusion of information on GHG intensity of energy production (direct & indirect emissions --> incl. upstream emissions, especially for biogenic energy carriers and hydrogen)

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies
	Compliance with carbon accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
Plant Operator	Fulfilling the formal prerequisites for market participation
	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Transfer of green attributes from energy inputs to energy outputs in conversion processes
	Fulfilling reporting requirements placed on plant operators
Improvement potential	Significant potential from both the good practices and the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	In the case of Sweden, suppliers must report on both direct and indirect GHG emissions, in line with the reporting guidelines developed by Värmemarknadskommittén.
Innovation	
Electricity	Including information both on direct and indirect GHG emissions (including upstream emissions relevant to biogenic fuels and hydrogen) would improve the alignment of energy disclosure with CSRD-ESRS requirements (in particular, ESRS E1-4).
Gas	
Heating and cooling	

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 57: Inclusion of information on GHG intensity of energy production (direct emissions)

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Transfer of green attributes from energy inputs to energy outputs in conversion processes
	Fulfilling reporting requirements placed on plant operators
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	Such information relating to CO2 emissions has to be provided based on IEMD requirements in all analysed countries. In Denmark, also methane has to be disclosed (besides SO2 and N2O). According to the GHG Protocol, direct emissions of energy production within the organisations boundaries are not part of the Scope 2 emissions reporting but fall under Scope 1. In contrast, GHG emissions of energy production purchased from suppliers (suppliers' direct emissions) fall under consumers' Scope 2 emissions and are reported on.
Gas	In Austria and Estonia, the environmental effects associated with the disclosed energy sources is displayed by obligatory supplier disclosure of CO2 emissions and radioactive waste.
Heating and cooling	In all H&C case studies, suppliers must report on direct GHG emissions associated with their H&C supply.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 58: Inclusion of information related to sustainability characteristics (especially for biogenic energy carriers and hydrogen)

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Transfer of green attributes from energy inputs to energy outputs in conversion processes
	Fulfilling reporting requirements placed on plant operators
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	

Stakeholder group	Benefit
Electricity	NO EXAMPLES
Gas	In Estonia, biomethane is eligible for GOs only if it complies with sustainability criteria. This ensures that all biomethane covered by GOs in Estonia is verifiably produced in a sustainable manner. However, the extent to which this sustainability information is passed on to end consumers depends on the disclosure practices of individual suppliers. ESRS Disclosure Requirements E1-6 – Gross Scopes 1, 2, 3 and Total GHG emissions requires information on sustainability characteristics of the consumed energy.
Heating and cooling	In none of the H&C case studies, there are disclosure obligations on sustainability characteristics beyond direct GHG emissions. Suppliers may decide to optionally disclose such information. As a basis for such optional disclosures, the German legal framework for H&C and gas GOs (GWKHV) requires that specific sustainability information be provided when applying for a GO for H&C generated from biomass or biomass-based energy. For H&C generated from RFNBO, information is included on GOs whether RFNBO comply with the EU's RFNBO criteria. In both cases, compliance with sustainability requirements is not a requirement for GO issuance, but information on compliance is recorded on GOs.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	Including information on sustainability characteristics (especially for biogenic energy carriers and hydrogen) would improve the alignment of energy disclosure with CSRD-ESRS requirements (in particular, ESRS E1-E5 focusing on companies' impacts on nature). For instance, disclosure statements could specify the existence of Proofs of Sustainability for biomass-based energy provision, and whether RFNBO meet the EU's RFNBO criteria.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 59: Provides information on nature or societal impacts (other than biomass and RFNBO criteria, e.g. fish ladders for migratory species)

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies
Plant Operator	Fulfilling the formal prerequisites for market participation
	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Transfer of green attributes from energy inputs to energy outputs in conversion processes
	Fulfilling reporting requirements placed on plant operators
Improvement potential	Significant potential from the good practice disclosure concepts
Good Practice	
Electricity	

Stakeholder group	Benefit
Gas	Disclosure requirements under ESRS S1-S4 is focusing on how company affects people and requirements under ESRS E1-E5 is focusing on how company impacts nature.
Heating and cooling	
Innovation	
Electricity	Including information on broader nature or societal impacts of energy production (going beyond sustainability criteria for biogenic energy carriers according to RED II/III and the EU's RFNBO criteria) would improve the alignment of energy disclosure with CSRD-ESRS requirements (in particular, ESRS E1-E5 focusing on companies' impacts on nature, and ESRS S1-S4 focusing on social impacts). For instance, information on voluntary sustainability labels could be provided as part of disclosure statements. According to EN 16325:2025, GO schemes may opt to include information on compliance with label schemes, which could be used as a basis for disclosing such extended sustainability information.
Gas	
Heating and cooling	

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 60: Disclosure statement includes information on the regional origin of the RES supply

Stakeholder group	Benefit
Plant Operator	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
	Additional value through regional renewable energy
Improvement potential	Significant potential from the good practices disclosure concepts
Good Practice	
Electricity	Information on the location of the production plant is provided on all EECS GOs, and therefore available to system users which have access to the primary GO information within the GO registries or as indicated on a cancellation statement. However, this specific information is not included in standard disclosure information towards the consumers. Besides this, Germany requires the indication of the countries of origin (in percentage) for all RES-E which are disclosed based on the GO information. Furthermore, Germany has implemented the option to indicate the share of "regional RES-E" based on so-called "Regionalnachweise" ("regional GOs"), but only within the share of national supported RES in the disclosure statement of a supplier. This share of national supported RES is clearly distinguished from other RES shares which have to be disclosed based on cancelled GOs. Regionalnachweise can be used if the respective supported power plant is located not more than 50km from the respective consumer. For other RES-E which is disclosed based on cancelled GOs, no such option for the documentation and disclosure of the specific region is implemented.
Gas	NO EXAMPLES
Heating and cooling	In case studies where GOs cannot be transferred and/or used beyond the boundaries of interconnected grids (the Netherlands, Germany), the region of origin will be the region of consumption in the vast majority of cases, because of the local character of H&C grids
Innovation	

Stakeholder group	Benefit
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 61: Disclosure statement includes information on the sustainability characteristics of the RES supply

Stakeholder group	Benefit
Plant Operator	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
	Additional value through regional renewable energy
Improvement potential	Inspiration from the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	In all analysed cases, mandatory disclosure obligations only cover GHG emissions, in some cases accompanied by other indicators such as GHG emissions savings or Primary Energy Factors. In some cases, H&C suppliers opt voluntarily to publish sustainability characteristics beyond this, e.g. on the sustainability of biomass inputs.
Innovation	
Electricity	Including information on sustainability characteristics would improve the alignment of energy disclosure with CSRD-ESRS requirements. For instance, disclosure statements could specify the existence of Proofs of Sustainability for biomass-based energy provision, and whether RFNBO meets the EU's RFNBO criteria. Also, Information on the existence of voluntary sustainability labels could be included.
Gas	See Electricity.
Heating and cooling	See Electricity

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 62: Disclosure statement includes information on the technological origin of the RES supply

Stakeholder group	Benefit
Plant Operator	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
	Additional value through regional renewable energy
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	

Stakeholder group	Benefit
Electricity	All EU countries, and all EECS Countries, have a requirement on electricity suppliers to disclosure the origin of supplied energy on their bills to consumers in at least the categories: renewable, fossil, nuclear. In addition, 'In Belgium-Flanders, the distinction of specific types of energy used is made by the regulatory authority, Vlaamse Nutsregulator, in the individual online Green check (GroenCheck) and in the online Origin Comparator per electricity supply product. In Austria, the split between detailed energy sources is made on the automated disclosure statement produced by E-Control and to be used by suppliers in their disclosure to their customers.
Gas	NO EXAMPLES
Heating and cooling	In Sweden, the Netherlands, and Germany, information on H&C technologies is included in disclosure obligations and guidelines
Innovation	
Electricity	According to the GHG Protocol, companies shall disclose the category or categories of instruments from which the emission factors were derived, where possible specifying the energy generation technologies.
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 63: Provides detailed information on the energy source used to produce a unit of energy (e.g. information according to level 1, level 2, level 3 of annex A of EN 16325 are provided)

Stakeholder group	Benefit
Organisations	Make procurement decisions based on information contained in energy disclosure
	Allow for impactful energy supply decarbonisation strategies
	Compliance with carbon accounting standards
	Compliance with revised GHG accounting standards
	Compliance with low carbon initiatives and green lead markets
	Compliance with regulatory requirements on organisations
	Hedge against CO2 prices
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
Plant Operator	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
	Additional value through regional renewable energy
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	
Electricity	All EU countries, and all EECS Countries, have a requirement on electricity suppliers to disclose the origin of supplied energy on their bills to consumers in at least the categories: renewable, fossil, nuclear. In addition, in Belgium-Flanders,

Stakeholder group	Benefit
	the distinction of specific types of energy used is made by the regulatory authority, Vlaamse Nutsregulator, in the individual online Green check (GroenCheck) and in the online Origin Comparator per electricity supply product. In Austria, the split between detailed energy sources is made on the automated disclosure statement produced by E-Control and to be used by suppliers in their disclosure to their customers: secondary disclosure statements (which may be only available in digital format) also include detailed information on the technology (solid biomass, liquid biomass, biogas, landfill and sewage gas, geothermal energy, wind, solar, hydropower, natural gas, oil and oil products, coal, nuclear).
Gas	NO EXAMPLES
Heating and cooling	In the Netherlands, this appears to be the established practice of energy suppliers; in other H&C case studies, the level of detail provided depends on individual energy suppliers and can vary accordingly.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	Providing guidance on what energy source categories to use in disclosure statements improves comparability and transparency for consumers.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

B.5 Information on additionality indicators

Sub-criterion 64: Information on the share of Renewable Energy Purchase Agreements in energy supply available to the beneficiary of disclosure

Stakeholder group	Benefit
Organisations	Allow for impactful energy supply decarbonisation strategies
	Compliance with revised GHG accounting standards
	Compliance with regulatory requirements on organisations
	Hedge against CO2 prices
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
Plant Operator	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
Improvement potential	Significant potential from the innovative disclosure concepts
Good Practice	
Electricity	The German GO registry at least allows for the tracking and cancellation of so-called "bundled GOs", where the contractual delivery of electricity in consistency with the traded GOs is verified and confirmed. Although the disclosure system does not foresee this information to be explicitly included in the disclosure

Stakeholder group	Benefit
	statement towards the beneficiary of disclosure (i.e. the end-consumer), such an element of the underlying tracking system could be used to implement "share of PPAs" as information parameter of the final disclosure. While Austria also does not impose mass-balancing as a chain of custody tracking method, suppliers are required to report the percentage of electricity and GOs purchased together—referred to as 'coupling'—on disclosure statements. This offers a partial insight into the degree of alignment between physical supply and attribute claims.
Gas	NO EXAMPLES Note: is hard for regulatory authorities to keep track of PPAs especially when economic operators are not obliged to inform on this. EU legislation on this can help.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	In the compliance-based systems, this is an implicitly included element.
Electricity Gas Heating and cooling	According to the Guarantees of Renewable Origin (GRO) mechanism, proposed by the Florence School of Regulation (FSR), consumers or their suppliers are obliged to hold GROs corresponding to a certain share of their final energy consumption. This obligation would stimulate Renewable Energy Purchase Agreements and the disclosure of such REPAs in the energy supply.
Heating and cooling	The EU's RFNBO criteria necessitate the verification of PPA existence as part of the check whether electricity taken from the grid can be accounted as fully renewable when producing RFNBOs. When RFNBOs are used in H&C production, providing consumers with information on whether RFNBO criteria were met would increase transparency. Indirectly, this would provide information on the existence of PPAs between renewable electricity producers and RFNBO producers (in case electricity from the grid was used). Transferring RFNBO criteria to the context of electricity-based H&C production, H&C producers could indicate whether RFNBO criteria for the renewable character of electricity inputs were fulfilled for electricity used in heat pumps and other Power-to-Heat technologies. For H&C supply itself, the provision of information on the share of REPAs in H&C supply is less relevant, as grid-bound H&C supply decisions have a long-term character by default, given the costs of changing between grid-bound and decentralised supply options and the common monopoly structure of supply (i.e., one supplier per grid). In practice, contracts on green H&C products therefore have REPA characteristics. As a result, this information would be covered as long as suppliers inform on their product portfolio.

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 65: Information on the share of supplier-owned fossil energy generation available to the beneficiary of disclosure

Stakeholder group	Benefit
Plant Operator	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
Improvement potential	Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts

Stakeholder group	Benefit
Good Practice	
Electricity	NO EXAMPLES in governmentally operated disclosure frameworks. (NGOs (like Greenpeace in Belgium Flanders) may bring this information on an irregular campaign-related basis).
Gas	NO EXAMPLES Note: is not straight-forward for regulatory authorities to keep track and supervise the production plants' ownership trail for every supplier as this may vary over time; especially in case of partial ownerships it would need refined rules if this criterion would be seen important. The effort may outbalance the benefit while still risking resulting in incomplete representations.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 66: Information on the share of supplier-owned nuclear energy generation available to the beneficiary of disclosure

Stakeholder group	Benefit
Plant Operator	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
Improvement potential	Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES Note: is not straight-forward for regulatory authorities to keep track and supervise the production plants' ownership trail for every supplier as this may vary over time; especially in case of partial ownerships it would need refined rules if this criterion would be seen important. The effort may outbalance the benefit while still risking resulting in incomplete representations.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES

Stakeholder group	Benefit
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 67: Information on the share of supplier-owned renewable energy generation available to the beneficiary of disclosure

Stakeholder group	Benefit
Plant Operator	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
Improvement potential	Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts
Good Practice	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES Note: is not straight-forward for regulatory authorities to keep track and supervise the production plants' ownership trail for every supplier as this may vary over time; especially in case of partial ownerships it would need refined rules if this criterion would be seen important. The effort may outbalance the benefit while still risking resulting in incomplete representations.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 68: Provide information on subsidy schemes that a plant profits from

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Organisations	Allow for impactful energy supply decarbonisation strategies
	Compliance with revised GHG accounting standards
Plant Operator	Enabling revenues and planning security from long-term REPAs
	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
Society as a whole	Contribution to the energy transition
Improvement potential	Significant potential from the innovative disclosure concepts

Stakeholder group	Benefit
Good Practice	
Electricity	In Germany, domestically supported RES-E is allocated on a statistical pro-rata basis towards all end-consumers as part of their fuel mix. This share is clearly distinguished from other renewable shares, which allows for a distinction at least between German supported RES-E and other RES-E. However, it should be pointed out that this regulation on distinguished disclosure in Germany is linked to the specific allocation mechanism for supported RES shares, but does not allow for information on the level of support relating to cancelled GOs. This also means that no information on the level of support is provided for imported RES-E (which might include GOs for supported RES-E). In France, there must be a specific indication of the share of renewable energy disclosed through GOs, particularly those originating from production devices supported under the French feed-in tariff system and procured via auctions organised by EEX. This adds a layer of transparency regarding public support mechanisms embedded in the disclosed energy. Besides that, it should be pointed out that the GOs contain this information on the level of support of a production plant.
Gas	NO EXAMPLES Note: Not a mandatory information for disclosure towards beneficiary in the analysed countries.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	A blueprint for such an approach could also be drawn from the RFNBO regulation (see Article 5 European Commission 2023a), which requires that the level of support (at least with a clear distinction between supported and non-supported electricity) is mandatorily provided and disclosed within the tracking schemes used. Note: According to EN 16325, GOs must include information on whether production devices have received investment and/or production support, and the type of such support. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from supported or unsupported plants).
Gas	Article 5 on ‘Additionality’ of Delegated Regulation (EU) 2023/1184 detailing the rules for the production of RFNBOs sets limits to support granted to the installation generating renewable electricity. In the “GO beyond targets” concept, proposed by Seebach und Timpe (2020a), a GO earmark should mark whether new and (otherwise) unsupported RES production benefits from private direct funding of the plant itself e.g. in the context of a ‘fund model approach’ by a green electricity supplier. This earmark should also specify the mechanism for the private funding.
Heating and cooling	According to EN 16325, GOs must include information on whether production devices have received investment and/or production support, and the type of such support. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from supported or unsupported plants).

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 69: Provide information on the age of a production plant

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Organisations	Allow for impactful energy supply decarbonisation strategies
	Compliance with revised GHG accounting standards
	Enabling revenues and planning security from long-term REPAs
Plant Operator	Revenues from green attribute sales in short-term markets
	Customer acquisition and loyalty
Society as a whole	Contribution to the energy transition
Improvement potential	Significant potential from the innovative disclosure concepts
Good Practice	
Electricity Gas	NO EXAMPLES in the studied supplier national disclosure obligations: The plant age is not a mandatory information for disclosure towards beneficiary in the analysed countries. However, the GOs contain this information on the age of a production plant.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	A blueprint for such an approach could also be drawn from the Delegated Regulation (EU) 2023/1184 detailing the rules for the production of RFNBOs. Article 5 on 'Additionality' sets limits to the age of the installation generating renewable electricity (not older than 36 months than the RFNBO production plant).
Gas	NO EXAMPLES
Heating and cooling	According to EN 16325, GOs must include information on the date when a production device first became operational. On an aggregated level, such information could be made available to consumers as part of disclosure statements (e.g. informing consumers on the share of renewable energy supply originating from plants newer than a certain age threshold).

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

B.6 Format of information disclosure

Sub-criterion 70: Disclosure information is easily accessible upon request (from a supplier's perspective)

Stakeholder group	Benefit
Plant Operator	Fulfilling the formal prerequisites for market participation
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	

Stakeholder group	Benefit
Electricity	Since electricity disclosure is based on cancelled Guarantees of Origin, and GO registry issues cancellation statements to suppliers, the data required for disclosure is digital, centrally recorded and readily accessible. In all EU countries GOs are cancelled for renewable electricity supply, in several countries (Austria, Netherlands, France, Switzerland) also for non-renewable supply. Almost all other countries in EU require the use of the residual mix, which is calculated by member states, following RED art. 19.
Gas	In Austria and Estonia, disclosure is based on cancelled Guarantees of Origin, with the GO registries issuing cancellation statements directly to suppliers. This ensures that all data required for disclosure is digital, centrally recorded and readily accessible, providing a reliable and transparent basis for reporting.
Heating and cooling	In H&C markets, suppliers often operate H&C networks themselves. As such, they usually have access to detailed information on the energy sources connected to their H&C network. Moreover, as participants in the H&C GO registry, suppliers can easily access tracking information themselves, so this good practice is covered "by default" in all analysed case studies
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 71: Disclosure information is easily accessible upon request (from a consumer's perspective)

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Organisations	Make procurement decisions based on information contained in energy disclosure
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In addition to the information required for disclosure on a bill and promotional material, both the Supplier Disclosure Dashboard and the Green check- an interactive web-tools- individual consumers can check whether their own consumption was proven to be sourced from RES-E by GOs, using their individual EAN identifier. Also, disclosure information of different suppliers is made centrally available by VREG. For instance, the Origin Comparator displays the results of the fuel mix reporting of the electricity suppliers, after check by VREG and this is at the disposal for consumers in an easily accessible web tool they can use while considering a choice of an electricity supplier.[55]

[55] See chapter 8.3.1.3 (Belgium-Flanders).

Stakeholder group	Benefit
Gas	Austria and Estonia, both countries ensure direct, consumer-level access to disclosure information upon request. In Austria, the disclosure statement is integrated into the national GO registry and can be accessed by consumers through a secure login, providing transparent information on products and suppliers. In Estonia, consumers can access GO cancellation information for their metering points, with biomethane consumers additionally able to view the origin and volume of gas covered by GOs via a dedicated online platform. At present, this applies mainly to the transport sector, where fuel stations act as the direct consumers of biomethane.
Heating and cooling	Whereas all analysed H&C concepts cover the annual publication of disclosure information (on suppliers' websites and/or as part of the billing information), the Finnish and Dutch cases perform best where ease and depth of information access is concerned. In both cases, end consumers have the option of opening accounts in the GO registry (commercial consumers in the Dutch case). As such, consumers can monitor exactly what GOs have been cancelled on their behalf and access the detailed information included on the GOs. This does not necessitate active GO cancellation rights on the part of consumers. In the Dutch case, consumer accounts are explicitly designed as monitoring accounts, giving commercial consumers the option of downloading PDF reports indicating the number of certificates cancelled, their ID, expiry date, kind of renewable H&C source and production device. Organisations can use these, for instance, to facilitate audits of their sustainability reporting.
Innovation	
Electricity Gas Heating and cooling	FRS’s ‘Guarantees of Renewable Origin’ concept builds on implementation of this design specification.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 72: Disclosure information is mandatorily provided at key decision phases

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	In line with requirements by EU legislation, disclosure information is mandatorily available on website of the supplier, on marketing materials and on or attached to invoices in all analysed countries.
Gas	In Austria and Estonia, consumers can access detailed, product-specific information for their own consumption metering point through secure national GO registries or equivalent platforms. In all three countries, suppliers also provide disclosure statements at important moments such as contract sign-up, billing, and in marketing materials. Together, these measures ensure that all consumers—particularly households—can easily access reliable information, understand their energy mix, and make informed choices.
Heating and cooling	In Germany, H&C suppliers are legally obliged to make selected disclosure information (such as energy sources and technology mix, renewable energy share, primary energy factors, GHG emissions) publicly available on their websites and as

Stakeholder group	Benefit
	part of billing information. Therefore, this information is available to consumers when comparing district H&C supply with other supply options, or when comparing different H&C products (supplier choice, on the other hand, tends to be limited, because grids are most typically owned and operated by individual suppliers). Whether suppliers opt to offer differentiated H&C products is up to individual suppliers.
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 73: Information is digital and directly accessible for organisations

Stakeholder group	Benefit
Organisations	Make procurement decisions based on information contained in energy disclosure
	Meet growing stakeholder expectations, mitigate reputational risks & demonstrate environmental leadership
	Provide unique green claims for marketing products or services
Improvement potential	Already well established in the existing disclosure schemes
Good Practice	
Electricity	NO EXAMPLES
Gas	In Estonia, every consumer has the right to access information on the cancellation of Guarantees of Origin for their metering point. At present, “consumers” primarily refers to fuel stations, as this disclosure mechanism is applied only in the transport sector. Biomethane consumers can view the origin of the methane consumed at their metering point, including the share covered and not covered by biomethane Guarantees of Origin, through the dedicated platform biometaan.elering.ee.
Heating and cooling	In the analysed case studies, the Finnish and Dutch H&C disclosure concepts require the most information to be made available electronically by default. In Finland, energy retailers have to provide consumption and billing information for district heating and district cooling electronically, unless agreed otherwise. In the Netherlands, heat suppliers need to publish on their websites an annual report - the so-called 'Warmte-etiket' / 'heat label' – detailing the sources of the heat they have supplied to end-consumers, alongside further information (e.g. primary energy factors, CO2-emissions and -savings and network losses). Innovations: So far, there is no European standard for machine-readable disclosure statements. Such a standard could be developed by integrating energy disclosure into the Digital Product Passport framework. For organisations, this would facilitate the integration of energy disclosure information when tracking the environmental impacts of products and production processes along value chains. Also, the administrative efficiency of verification procedures of such information might be improved.
Innovation	
Electricity Gas Heating and cooling	The GRO concept also builds on directly accessible information to organisations.

Source: Authors’ own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 74: Information provided in a ranking tool that evaluates performance based on additionality criteria

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Society as a whole	Contribution to the energy transition
Improvement potential	Lacking inspiration for improvement from the good practices and from the innovative disclosure concepts

Stakeholder group	Benefit
Good Practice	
Electricity	NO EXAMPLES from governmentally organised systems because ranking is often based on subjective criteria. Some NGOs (Greenpeace in Belgium Flanders, based on the supplier's investment profile) and WISE in the Netherlands (based on production location)) organise for such ranking but don't all update this every year.
Gas	NO EXAMPLES Note: Governments may not be able to RANK (as qualification may be subject to subjective criteria) but that they may facilitate COMPARISON tools based on transparent information. This is in line with the CEER advise on Trustworthy green offers from 2023.
Heating and cooling	NO EXAMPLES
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

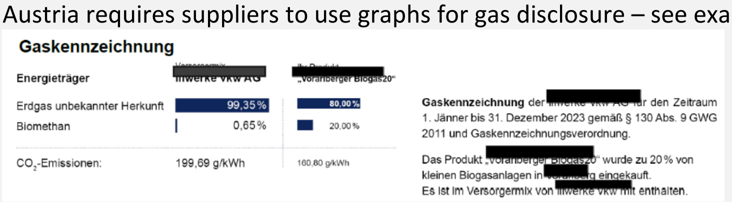
Sub-criterion 75: Information on non-renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	
Electricity	In Denmark, the fuel composition is indicated in text and by a graphical overview as shown in the standard form provided by the TSO. In the case of electronic distribution of invoices to consumers, the composition of fuels may be stated in text only if the declaration is accompanied by information that the graphic overview has been published on the company's website. Also in Austria, Germany and Sweden, there is legal regulation about the format and content of the graphical illustration of the disclosure information.
Gas	Austria requires suppliers to use graphs for gas disclosure – see example below. 

Stakeholder group	Benefit
Heating and cooling	In Finland, Sweden, and the Netherlands, where H&C disclosure is already practically implemented, suppliers use charts and tables to present disclosure information on their websites. [56]
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.

Sub-criterion 76: Information on renewable energy sources is presented in a clear and accessible format using visuals like a chart, graph or table

Stakeholder group	Benefit
Households	Consumer can make an active choice supporting the energy transition
Improvement potential	Inspiration from the good practice disclosure concepts
Good Practice	
Electricity	In Denmark, the fuel composition is indicated in text and by a graphical overview as shown in the standard form provided by the TSO. In the case of electronic distribution of invoices to consumers, the composition of fuels may be stated in text only if the declaration is accompanied by information that the graphic overview has been published on the company's website. Also in Germany and Sweden, there is legal regulation about the format and content of the graphical illustration of the disclosure information.
Gas	Austria requires suppliers to use graphs for gas disclosure – see example below. 
Heating and cooling	In Finland, Sweden, and the Netherlands, where H&C disclosure is already practically implemented, suppliers use charts and tables to present disclosure information on their websites.53F57
Innovation	
Electricity	NO EXAMPLES
Gas	NO EXAMPLES
Heating and cooling	NO EXAMPLES

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda

[56] See, for example, The Netherlands: Warmte-etiquette Vattenfall 2024 (in Dutch), The Netherlands: Warmte-etiquette Eneco 2024 (in Dutch), Sweden: Vattenfall (in Swedish), Sweden: Göteborg Energi (in Swedish), Finland: Vase Elektriska (in Swedish), Finland: Helen - Helsinki (in Swedish).

[57] See for example: The Netherlands: Warmte-etiquette Vattenfall 2024 (in Dutch), The Netherlands: Warmte-etiquette Eneco 2024 (in Dutch), Sweden: Vattenfall (in Swedish), Sweden: Göteborg Energi (in Swedish), Finland: Vase Elektriska (in Swedish), Finland: Helen - Helsinki (in Swedish)

C Annex III: Set of search strings for literature review

Category	German search string	English search string
Energy Disclosure in General	(*Kennzeichnung OR Zertifi* OR Nachverfolg* OR *Nachweis* OR PoS OR 'book and claim' OR Massenbilanz* OR 'chain of custody') AND (Energie OR Strom OR *gas OR Elektrizität OR Strom OR Wasserstoff* OR Biomethan OR Wärme OR Kälte)	(disclosure OR certificat* OR tracking OR traceability OR guarantee OR 'Proof of sustainability' OR PoS OR claims OR 'book and claim' OR 'mass balanc*' OR 'chain of custody') AND (full OR energy OR *gas OR electricity OR power OR hydrogen OR biomethane OR heat* OR cooling))(electricity OR *gas OR hydrogen OR biomethane OR heat* OR cooling) AND (disclosure OR Tracking OR Traceability) AND (certificate* OR 'proof of sustainability' OR 'label') ('Union Database') AND (concept OR development OR implementation) AND (electricity OR *gas OR hydrogen OR biomethane OR heat* OR cooling) AND (disclosure OR Tracking OR Traceability OR certificate* OR 'proof of sustainability' OR 'label')
Requirements regarding energy procurement / quality of energy	(erneuerbar* OR grün* OR *wirkung*) AND (Energie OR Strom OR *gas OR Elektrizität OR Wasserstoff* OR Biomethan OR Wärme OR Kälte) AND/OR (*Beschaffung OR *Lieferung OR *vertrag OR *einkauf) (Herkunftsnachweis* OR HKN OR Direktvertrag) AND (*reduktion OR erneuerbar* OR grün* OR *wirkung* OR *markt) (Klimastrategie OR Klimaschutzstrategie OR Umweltmanagement OR Nachhaltigkeitsstrategie) AND (Herkunftsnachweis* OR HKN OR Direktvertrag OR 'Guarantee of Origin' OR 'PPA' OR 'Proof of Sustainability')	(green OR impact* OR renewable*) AND (energy OR electricity OR power OR hydrogen OR biomethane OR heat* OR cooling) AND/OR (procurement OR purchase*) AND (disclosure OR criteria OR requirement*) ('renewable energy procurement') AND (disclosure) ('impact procurement') AND (requirement* OR criteria) AND (energy) (Guarantee* of Origin OR GO OR Energy Attribute Certificate OR EAC OR PPA) AND ('emission reduction' OR renewable* OR green OR impact* OR market) ('climate strategy' OR 'environmental management' OR 'sustainability strategy') AND ('Guarantee of Origin' OR 'Power Purchase Agreement' OR 'Proof of Sustainability' OR 'renewable energy certificate' OR 'energy attribute certificate')
Requirements on climate disclosure	(Energie OR Strom OR *gas OR Elektrizität OR Wasserstoff* OR Biomethan OR Wärme OR Kälte) AND (*bilanz* OR *Emission* OR *Fußabdruck OR THG OR CO2)	('emissions accounting' OR 'carbon footprint' OR 'GHG accounting' OR 'carbon accounting') AND (energy OR *gas OR electricity OR power OR hydrogen OR

Category	German search string	English search string
	(marktbasiert OR ortsbasiert) AND (Energie OR Strom OR Elektrizität OR *bilanz* OR THG OR CO2) (Kriterien OR Anforderung* OR Datenqualität*) AND (marktbasiert) AND Energie	biomethane OR heat* OR cooling) AND 'energy attributes' ('market-based approach' OR 'market-based accounting' OR 'location-based approach' OR 'location-based accounting') AND (energy OR electricity OR GHG OR CO2) ('data requirement' OR 'criteria' OR 'data quality') AND ('market-based approach' OR 'market-based method' OR 'market-based accounting') AND electricity 'scope 2 reporting' AND ('guarantee of origin' OR 'renwable energy certificate' OR 'energy attribute certificate') ('guarantee of origin' OR 'renwable energy certificate' OR 'energy attribute certificate') AND industry
Further development of energy disclosure	(granular*) AND (HKN OR Herkunftsnachweis OR *Zertifi*)	Granular*AND ('energy attribute certificate' OR 'guarantee of origin' OR 'renewable energy certificate') ('24/7') AND ('carbon free' OR 'carbon-free' OR CFE) (energy OR *gas OR electricity OR power OR hydrogen OR biomethane OR heat* OR cooling OR renewable) AND (additionality OR 'hourly-matching' OR 'avoided emissions' OR offset* OR 'emissions first') ('green hydrogen' OR biomethane OR 'renewable gas') AND ('energy attribute certificate' OR 'guarantee of origin' OR 'renewable energy certificate' OR certification OR standard) 'hydrogen investment' AND 'certification'

Source: Authors' own compilation, Oeko-Institut, Hamburg Institut, Enunda.