International Hydrogen Ramp-up Programme – H2Uppp

In-Depth Analysis of Green Hydrogen Certification Processes in the EU

Advisory Report as Guidance for the Development of Digital Solutions (Extended version)

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The International Hydrogen Ramp-up Programme (H2Uppp) of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) promotes projects and market development for green hydrogen in selected developing and emerging countries as part of the National Hydrogen Strategy.

Brasilia, March 2024

Executive Summary

The H2Uppp programme of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) accompanies and supports the market ramp-up of green hydrogen (H2) and Power-to-X (PtX) applications in selected developing and emerging countries. Brazil is one of the partner countries and has great potentials to become a global player in green hydrogen production, domestic use, and export. Certification is crucial for the success of a sustainable hydrogen economy, as it can prove the sustainability of PtX products and create trust for national and cross-border trade. However, current certification processes have weaknesses and are not harmonized, making it difficult for producers to select a specific schemes. To address this, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and SAP are within the framework of H2Uppp jointly investigating the requirements of solutions that facilitate the exchange of relevant data between private companies, certifiers, public bodies, and other process participants. In this context, the report offers an in-depth analysis of specific primary certification schemes, as well as a concise overview of a selection of digital solutions for certifying green PtX products with the aim of combining theoretical knowledge and practical implications for the development of proposals and architectures for digital tools. The results of the report will be of importance to the whole hydrogen market, especially to interested stakeholders in Brazil and the European Union (EU).

The use of digital technologies, such as blockchain, Internet of Things devices, and smart contracts, can revolutionize the green hydrogen certification process. Digitalization can streamline the certification process, reduce paperwork, enhance traceability, and improve data exchange. However, challenges such as data integrity, security, and privacy must be addressed through robust security measures and data anonymization. Best practices from other sectors suggest an ecosystem approach involving producers, customers, partners, and government entities, and the establishment of centralized registries and databases to enhance transparency and traceability. With adequate measures in place and collaboration among stakeholders, digitalization can pave the way for a more modern global green hydrogen economy.

To highlight the different purposes of certification, it is necessary to distinguish between the markets for regulatory target compliance and the markets for voluntary reporting of PtX products. In this context, the legal anchoring of certification in the EU is particularly relevant, which distinguishes between Proof of Sustainability (PoS) and Proof of Origin (GoO) type certificates. While PoS are needed to access compliance/mandatory markets for Renewable Fuels of non-Biological Origin (RFNBOs), GoOs for hydrogen serve voluntary/reporting markets by disclosing the embedded share of renewable energy to customers. In addition, 'customized' schemes can be discerned, which are flexible, market-based certifications for voluntary/reporting markets that are not regulated and allow for tailor-made sustainability criteria and chain of custody models.

Three major certification schemes, namely CertifHy™ Scheme, TÜV Rheinland Standard H2.21 and ISCC PLUS with Greenhouse Gas (GHG) Emissions Add-On were selected for careful study to understand their background and essential PtX features as well as the involved steps, eligibility criteria and documentation requirements of the certification process. For the sake of completeness, the essential PtX features of the TÜV SÜD CMS 70 standard were also examined. To ensure comparability, the same characteristics were analyzed for all certification systems, which were assigned to the four groups 'availability', 'GHG emission savings', 'technologies' and 'monitoring and control system'.

Regarding the applicability all examined certification scheme can be assigned to the category of customized schemes and are therefore not suitable for demonstrating target compliance for RFNBOs. Except for the CertifHy™ Scheme, all schemes are globally applicable, which means that they could in principle also be used for domestic purposes by companies in Brazil. GHG emission savings criteria vary widely across the certification systems due to differing Product Carbon Footprint (PCF) calculation methodologies and associated life cycle coverage. Technological requirements of the different PtX certification schemes are not uniform. TÜV Rheinland Standard H2.21 mandates electrolysis for hydrogen production, while other schemes are less prescriptive, focusing on energy source requirements. Biomass is an accepted energy source in some schemes, and there is a general absence of stipulations on water source technology. Depending on the intended type and purpose of certification, the chain of custody models used differ. Both the book-and-claim model, which is typically used for GoO certificates, and the mass balancing model, which is prescribed for PoS certificates, are used. CertifHy™ Scheme and ISCC PLUS provide detailed guidance on how to deal with their chain of custody models as part of the certification process, while TÜV Rheinland Standard H2.21 is unclear in this regard. There is a variance in the availability and detail of guidance documents across certification schemes, affecting transparency and the ease of assessing a certification's suitability for a company's needs. The certification process for products varies in complexity and effort required from different companies, with all schemes involving an audit of the production facility. ISCC PLUS emerges as a promising template for digital certification solutions, given its alignment with ISCC EU, which is EC-recognized for biofuel sustainability under RED II, and its detailed mass balancing procedures that address the complexities of multi-stakeholder supply chains. This is where digital solutions can unleash their potential by significantly improving the integrity, efficiency, and safety of processes along the value chain and driving forward a modern, global green hydrogen economy.

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List of Terms and Definitions

The following terms are used in this report:

Term	Definition
Account holder	Refers to a person in respect of whom an account is maintained on the CertifHy™ registry.
Additionality	A requirement that the hydrogen produced from electrolysis needs to have additional renewables-based electricity that would not have been built if not for the renewable hydrogen production.
Audit	A verification of the company's organizational processes, which is prepared by an entity accepted, accredited, or otherwise authorized by the certification body to conduct the assessment.
Auditor	Person working for a certification body conducting audits.
Batch	A specific amount of material with the same sustainability characteristics and GHG emissions savings.
Bidding zone	Largest area within which market players (private/public entities) can submit their bids and offers for electricity without technical restrictions.
Blockchain technology	A decentralized and distributed digital ledger system that records transactions across multiple computers in such a way that the registered transactions cannot be altered retroactively.
Book and claim	A model that allows clean energy/fuel/materials producers to 'book' the emissions reductions, in which the corporate customers can 'claim' the emissions benefit by buying certificates, complete separation between the certified product and the certificate.
Certificate	Issue of a statement (a certificate) to demonstrate that specified requirements are fulfilled.
Certification body	Performs an assessment of a product, process, or service to demonstrate that requirements specified in the certification scheme have been fulfilled and issues a certification if the assessment is satisfactory; when the certification body and scheme owner are the same organization, they may rely on external auditors to provide audit and review services.
Certification scheme	Set of governance, assessment, and verification processes used to ensure that the product meets a given set of requirements or criteria.
Chain of custody	General term for the process of transferring, monitoring, and controlling inputs and outputs and related specific information through the supply chain.
Controlled blending	Planned blending regime, which means mixing without a chemical or biological reaction, resulting in constant and verifiable content of bio, circular and renewable feedstock in the final product.
Cradle	Term for the starting point in the life cycle of a product, usually the extraction of raw materials; synonymous term to cradle is 'well'.
Cradle-to-gate	Assessment of a partial product life cycle from raw material extraction (cradle) to the transfer point at the exit of the production plant before logistics of the product (fuel, energy carrier, feedstock) to the consumer begins (gate).
Cradle-to-tank	Assessment of a partial product life cycle from raw material extraction (cradle) to the point at which the product (fuel, energy carrier, feedstock) is ready for use (tank).
Cradle-to-wheel	Assessment of the product life cycle from the extraction of raw materials (cradle) to the use of the product (wheel). In the case of fuels, energy sources and chemical feedstocks that are completely consumed during use, the terms cradle-to-wheel and cradle-to-grave both correspond to a complete product life cycle.

Cradle-to-X	Assessment of a complete or partial product life cycle from raw material extraction (cradle) to a variable point X in the life cycle of a product (fuel, energy carrier, feedstock) between cradle and wheel
Designated competent bodies	Refers to the entities that shall be appointed by the Member States to supervise the issuance, transfer, and cancellation of guarantees of origin (GoO) by putting in place appropriate mechanisms to ensure that the issuance, transfer, and cancellation of GoO is accurate, reliable, and fraud-resistant.
Dedicated CO_2 sources	CO_2 origin in combination with the corresponding carbon capture technology to produce the CO_2 that is then combined with the hydrogen to produce derivative
Dedicated energy sources	Energy input into the production device that leads to the formation of the hydrogen molecule
Double counting	Describes a situation in which certifications are counted or used more than once towards achieving climate change mitigation targets or pledges, for regulatory or voluntary purposes.
Economic operator	Refers to a wide variety of business entities such as a producer of raw material, a collector of waste and residues, an operator of installations processing raw material into final fuels or intermediate products, an operator of installations producing energy (electricity, heating or cooling) or any other operator, including of storage facilities or traders that are in physical possession of raw material or fuels, provided that they process information on the sustainability and greenhouse gas emissions saving characteristics of those raw materials or fuels. In particular, ISCC uses this term to describe the elements of the supply chain relevant for certification.
Energy Attribute Certificate (EAC)	Provides information about the origin of the energy, its renewable source and other information such as the date and location of generation; GoO can be classified as an EAC.
Fossil fuel comparator value	Defined value of the Product Carbon Footprint (PCF) of a fossil benchmark process, which is used for comparison purposes regarding the achievable greenhouse gas (GHG) emission savings
Greenhous gas (GHG)	According to the United Nations Framework Convention on Climate Change (UNFCCC) any gas that absorbs infrared radiation in the atmosphere. GHG include, but are not limited to, water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrochlorofluorocarbons (HCFCs), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).
Green hydrogen	Hydrogen produced by electrolysis with electricity from renewable energy sources.
Guarantee of origin	Synonymous term to energy attribute certificate which is used within the EU.
Holistic approach	All-inclusive and comprehensive method of approach encompassing a holistic view.
H_2 production technology	Range of industrial methods and processes used to generate gaseous hydrogen.
Issuing body	Receives information from the certification body and ensures that the information evidenced by the certificate is correct and complies with the requirements of the scheme.
Label	Signals that certain defined requirements are fulfilled. Synonymous term is certification mark.
Life cycle	A multi-stage concept that includes all the stages of a product or service's life from the extraction of raw materials, through production and use, to disposal or recycling.
Life cycle coverage	Refers to the coverage along the value chain for which all relevant GHG emissions associated with each phase of the product life cycle are examined, evaluated, or covered in a particular analysis.

Mass balancing	Chain of custody model that allows tracking and tracing sustainability attributes from production to consumption.
Off-taker	Company that purchases the product (e.g. hydrogen) based on an off-take agreement.
Production batch	Hydrogen output produced by a specific production device within a specific period.
Production device	Separately measured device or group of devices that produces a hydrogen output.
Product Carbon Footprint (PCF)	Total amount of GHG emissions caused directly by a product associated with the life cycle (full PCF) or life cycle stage of a product (partial PCF).
PCF approach	Methodical approach used to calculate the PCF within the life cycle coverage. A distinction is made here between the two categories 'single' and 'cumulative'. Single means that the PCF calculation of the product to be certified is only carried once within the certification process for the selected life cycle coverage. In contrast to this cumulative refers to an approach in which the PCF of a product is calculated cumulatively within the system boundaries of the respective certified supply chain elements along the supply chain until the targeted life cycle coverage is reached. Accordingly, certain elements of the supply chain are responsible for calculating partial PCFs, which finally cumulate to a full PCF.
Proof of sustainability	Term used in the EU for a sustainability certificate by a competent body with the purpose of demonstration target compliance.
Power-to-X (PtX)	Technological processes in which electrical energy is converted into other forms of energy or materials with the aim of creating a sustainable and carbon-neutral energy system.
PtX products	A range of substances and energy carriers comprising electrolytic hydrogen and its derivatives, e.g. ammonia, methane, methanol, and fuels.
RED II	Recast of the 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. [1]
RED II GHG methodology	Methodology for determining GHG emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels described in Commission Delegated Regulation (EU) 2023/1185(delegated act adopted pursuant to on RED II Article 28(5)). [2]
Regulatory framework	Legal mechanism with a set of rules that are valid in a given industry/sector at national and/or international level that can be mandatory, coercive or voluntary.
Renewable energy (RED II Art. 2(1))	Energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas.
RFNBO	Abbreviation used in RED II for Renewable Fuel of Non-Biological Origin; refers to liquid or gaseous fuels which are used in the transport sector other than biofuels or biogas, the energy content of which is derived from renewable sources other than biomass.
Scheme owner	Public or private entities that develop and maintain a specific certification scheme.
Sustainability declaration	Delivery document containing relevant information about the sustainable material that must be issued by the supplier for each delivery of sustainable material within the ISCC framework.
System element boundaries	Reference framework for the determination of GHG emissions within a calculation to be applied for the respective system element.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1185

System user	Economic operators who have successfully registered with ISCC, providing their specific data and the name of the certification body in charge of the audit.
Turnover based	Based on the total annual turnover of the registered legal entity.
Union Database	Database, which should be put in place by the European Commission, to ensure transparency and traceability of renewable fuels by storing and tracking the proof of sustainability (PoS) at the EU level.
Voluntary disclosure	Voluntary reporting made by companies for their sustainability claims, e.g. environmental, social, and governance (ESG) reporting.
Well	Synonymous term to cradle.

List of Abbreviations

The following abbreviations are used in this report:

Abbreviations	Full name
AIB	Association of Issuing Bodies
ASU	Air Separation Unit
APS	Audit Procedure System (relevant for ISCC certification scheme)
BMWK	Bundesministerium für Wirtschaft und Klimaschutz (engl. Federal Ministry for Economic Affairs and Climate Action)
CCS/CCU	Carbon Capture Storage / Carbon Capture Use
CEA	Commissariat à l'énergie atomique et aux énergies alternatives
CH_3OH	Methanol
CO_2	Carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EAC	Energy Attribute Certificate
EC	European Commission
EECS	European Energy Certificate System
ESG	Environmental, Social, and Governance
EU	European Union
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GO	Guarantee of Origin
H_2	Hydrogen gas
H2Uppp	International Hydrogen Ramp-Up Programme
ICAO	International Civil Aviation Organisation
IoT	Internet of Things
ISCC	International Sustainability and Carbon Certification
ISO	International Standard Organisation
LBST	Ludwig Bölkow Systemtechnik
LCA	Life Cycle Assessment
LHV	Low Heating Value
MJ	Mega Joule
MWh	Megawatt hour
N_2	Nitrogen gas

NH_3	Ammonia
PCF	Product Carbon Footprint
PoS	Proof of Sustainability
PPA	Power Purchase Agreement
PtX	Power-to-X
RCF	Renewable Carbon Fuels
RFNBO	Renewable Fuel of Non-Biological Origin
SAP	Systems, Applications, and Products in Data Processing (company name)
TÜV	Technischer Überwachungsverein (Technical Inspection Association)
VAT	Value Added Tax

Introduction

Background

On behalf of the BMWK, the project 'International Hydrogen Ramp-Up Programme' (H2Uppp) supports the market ramp-up and the further development of markets for green hydrogen and its derivatives, called PtX products, in selected developing and emerging countries. Brazil is one of the partner countries of H2Uppp and has the potential to become a global player in green hydrogen production, domestic use, and export due to its green electricity matrix, ideal climatic conditions, and resulting favourable costs of PtX products. Developments in the market ramp-up of green hydrogen, both globally and in Brazil, are becoming increasingly dynamic. Developing and emerging countries, like Brazil, need targeted support to identify economic production and use paths, project opportunities along the value chain and to develop business models, as well as to improve their regulatory framework for PtX products.

Certification is an essential part of the regulatory requirements to trade green PtX products and is therefore crucial for the success of a sustainable hydrogen economy. Certification can be used to prove that certain PtX products meet defined criteria, while others do not meet these standards. Although there are no differences on a physical level, this can still enable transparent labelling of these commercial goods. In addition to providing a proof for the sustainability of the PtX products produced, the system is intended to create a basis of trust for the various actors along the entire value chain for both national and cross-border trade.

However, today, available processes and procedures for the certification of green hydrogen have still weaknesses and procedures are not harmonized, making it difficult for green PtX project developers. production plant owners and operators to understand and select a specific standard. In addition to the existence of different certification systems, the currently established processes and certificates, e.g. for green electricity or biofuels, are prone to falsification or fraud, e.g. by double counting the same certificate, as they are partly based on manual and analogue readings or evaluations, which makes the certification processes not very transparent and not always traceable and costly. Digitization of the certification process would therefore be a means of eliminating these procedural weaknesses.

The commitment to advancing the green hydrogen industry is further exemplified by the collaboration between GIZ and SAP. Within the framework of H2Uppp, the two companies are jointly investigating the requirements for developing an integrated digital tool that facilitates the exchange of relevant data between private companies, certifiers, public bodies, and other process participants. Subsequently, a digital pilot solution adapted to the Brazilian context will be developed outside of the project and then tested as part of the project. Expansion and replication in two other emerging and/or developing countries is planned.

Purpose and Approach

The analysis presented in this report was carried out to support the collaboration of GIZ and SAP, but also to share this knowledge publicly with a broader readership. The governing objectives of the study can be described threefold:

- The analysis is designed to serve a wide range of interested stakeholders, especially focusing on the private sector active in the development of green PtX projects in Brazil with the intention of obtaining a green product certificate.
- It also provides a comprehensive understanding of the similarities and differences between selected certification schemes applicable to the European market. This knowledge can serve as a targeted support for the development of regulatory requirements to trade green PtX products with partner countries such as Brazil.
- The overall project interest is on the future digitalization of the certification processes. Digitalization can help to improve transparency, traceability, and cost efficiency. To serve the information need in this regard, open questions on data requirements and stakeholders involved in the certification issuing process are clarified.

This was achieved by diving into the deeper intricacies and nuances of the procedures of selected certification schemes, namely the CertifHy™ Scheme, TÜV Rheinland Standard H2.21 and ISCC PLUS. These were selected based on factors such as the need for information in the context of the digitalization project, the availability of information and the willingness of the scheme owners to discuss and exchange questions and answers about their certification scheme with GIZ and SAP. The detailed exploration of these certification schemes aims to present insights that bridge both theoretical knowledge and practical implications. Therefore, for each of the selected certification schemes, an overview of their essential PtX features, a step-by-step guide to the certification process and a case study with practical relevance either for hydrogen, ammonia, or methanol is provided. For the sake of completeness, a cursory look is also taken at the TÜV SÜD CMS 70 standard by analyzing its essential PtX features. To establish comparability, the same features were analyzed for all certification schemes, which were assigned to the four groups 'availability', 'GHG emission savings', 'technologies' and 'monitoring and control system'.

It must be noted that the steps and processes described in this report for each certification scheme are based on the project team's own interpretation of publicly available documents. They are not absolute or definitive. Standards related to the certification of green hydrogen and/or its derivatives are still in a state of evolution, undergoing regular revisions. Consequently, the versions of the certification schemes based on standards discussed herein might have a limited validity window, subject to change upon the next revision.

Structure

The content of this report is structured in the following chapters:

- The first chapter briefly outlines digital solutions for green hydrogen and PtX certification and addresses in detail blockchain and other digital technologies, the advantages of digitalization, challenges and solutions in the certification landscape and best practices from other sectors.
- The second chapter on PtX certification systems in the EU explains the legal basis and purpose of certification and describes the core elements of a possible certification system for PtX products and their functions.
- Chapters three to six are each dedicated to one of the four certification schemes examined: CertifHy™ Scheme, TÜV Rheinland Standard H2.21, ISCC PLUS and TÜV SÜD Standard CMS 70. After a general explanation of the relevant background information, the essential PtX features are presented in tabular form. This is followed by a detailed description of the various steps of the certification process for the first three of the certification systems mentioned. Finally, the specific case studies that provide realistic examples of the value chain of PtX products are explained to give readers a better insight into the application of a particular system in relation to that specific example case.
- The report concludes with a summary of the key findings. This is done through a comparative analysis of the various certification systems, in which their respective differences and similarities are described. In addition, important explanations for these observations are provided.

Introduction to Digital Solutions

Technologies

Blockchain technology is gaining momentum in the energy sector due to its secure nature, allowing for a verifiable and unchangeable record of all certification-related transactions. This creates a chain of custody, ensuring the integrity of green hydrogen certificates from production to end-users. Moreover, blockchain technology can reduce the need for intermediaries, simplify the certification process by enabling the real-time data collection and eliminate the potential for errors that can occur in manual record-keeping. This can ultimately lead to a higher level of trust and confidence in the green hydrogen industry, promoting its growth and adoption.

However, in addition to blockchain, integrating Internet of Things (IoT) devices and smart contracts are also crucial to achieving greater transparency and traceability in green hydrogen certification, ensuring accuracy, and preventing errors in data entry. IoT devices can monitor numerous steps of the production process, from the source of the hydrogen to its delivery to customers. This data can be then used to create an accurate and reliable digital twin for every step in the process. Smart contracts, in turn, can automate the execution of contractual agreements.

Advantages

First and foremost, the certification of green hydrogen through digital solutions can provide several advantages. For instance, the use of digital solutions based on blockchain technology can help streamline the certification process, making it less time-consuming. Another benefit of digitalization is the reduction of paperwork and physical documents. With digital records, there is no need for physical storage of documents, which can also be prone to damage or loss. Digital records also enable real-time tracking of the green hydrogen's journey from production to consumption, ensuring transparency and accountability. Ultimately, digitalization can enhance traceability, making it easier to track the provenance of green hydrogen.

Additionally, when it comes to certification, digitalization can play a central role by facilitating data exchange. To ensure that data sharing is standardized and efficient, it is essential to have standardized data sharing standards in place and to standardize trade and communication between registries and databases for certificates. Furthermore, digitalization can help bridge gaps in data exchange by providing a common platform that is accessible to all stakeholders. This can foster collaboration and enable cross-border transactions to take place seamlessly. By improving communication and making data more readily available, digitalization has the potential to transform the way that certification is approached, making it more efficient, reliable, and accessible to all.

Challenges and Solutions

While digitalization has opened up new opportunities, it also poses significant challenges. As the regulatory landscape continuously evolves, adaptability in digital solutions is crucial. Therefore, to ensure compliance during audits, digital platforms must remain up to date with these changes. Consequently, maintaining adaptability is critical both to prevent instances of non-compliance and to meet changing certification requirements effectively. Additionally, the digital certification landscape raises valid concerns about data integrity and security. Double-counting is a significant risk in the analogue certification world, which is why a digital blockchain solution is specifically designed to address this issue by preventing any instances of double-counting. This occurs when the same certificate is used more than once to claim credits, and it entails the use of different standards to certify green hydrogen. Robust security measures, including encryption, access controls and firewalls, among others, are necessary to protect sensitive data and prevent unauthorized access. Addressing these issues is essential to ensure transparency and credibility in the emerging market of digitalization of green hydrogen certification process.

As certain data is sensitive and requires careful handling to maintain privacy, organizations must implement solutions that ensure secure and transparent data transfer while maintaining data privacy. One of the key solutions to address these concerns is data anonymization. By anonymizing data, organizations can protect sensitive information while still allowing for the transfer of necessary data. This approach can help build trust among stakeholders and ensure that data privacy concerns are addressed in the digital certification process. Implementation of such solutions can ensure that digital certification processes are effective and trustworthy.

Best Practices

Best practices in digital certification from other sectors, such as biomass certification, suggest that an ecosystem approach involving producers, customers, partners, and government entities fosters collaborative innovation. This approach ensures that the entire value chain benefits from digitalization and contributes to the development of a harmonized, globally recognized certification scheme. Additionally, to enhance transparency and traceability, the establishment of standardized registries and databases is essential. This emphasized that the importance of globally aligned certificate storage systems that provides a single source of information along the entire value chain. Such registries facilitate information exchange, prevent double-counting, and simplify the certification process, which would result in reduction of risk of fraud and improvement of the efficiency of the certification process.

To sum up, the digitalization in the green hydrogen certification landscape would enable an efficient, transparent, and streamlined process. While challenges exist, especially concerning trust, data integrity, and privacy, the potential of technologies like blockchain remains certain. With adequate measures in place and drawing from best practices in other sectors, a digital adaptation in green hydrogen certifications can pave the way for a more modern global green hydrogen economy. Additionally, the collaboration of industry stakeholders and the development of international standards will play a pivotal role in realizing the full potential of digitalization in green hydrogen certification.

PtX Certification Schemes in the EU

Purpose of Certification

There are various reasons for the need to prove the sustainability characteristics of PtX products through certification. The information contained in a certificate demonstrates the sustainability characteristics of a specific product unit. Market participants subject to either mandatory or voluntary requirements must therefore obtain a certain number of certificates with certain attributes within the reporting period.

Regulatory frameworks and incentives for hydrogen and its derivatives may incorporate certification as a key element, as chosen by policymakers in their respective jurisdictions. Several emerging national or regional legislative frameworks across different regions already offer incentives that are accessible through certificates that prove a unit of hydrogen or derivative meets the sustainability attributes defined by the support scheme or public policy framework. These policies may include targets, quotas, tax credits, and other incentives.

Market participants are thus required to use these certificates to comply with regulatory requirements and/or avail incentives designed under national or regional legislative frameworks for hydrogen and its derivatives. Compliance frameworks are anticipated to be the main driver for cross-border hydrogen trade as they encourage fuel transition to hydrogen and its derivatives in end-use sectors.

Certificates can also be used by companies for voluntary disclosure to inform consumers and facilitate their choices, allowing them to express their preference for hydrogen based on its sustainability attributes. Certificates used for voluntary disclosure can also enhance project bankability by not only proving the sustainability features of the produced hydrogen and its eligibility for government support, but also the project's social impact in the given jurisdiction. The use of such voluntary schemes for compliance with national legislation and access to government support depends on the government's recognition of the voluntary certification scheme, which is discussed in the following section.

Therefore, the two primary purposes for which market participants can use certification are to either demonstrate compliance with regulatory requirements and/or avail incentives designed under national or regional legislative frameworks for hydrogen and derivatives, or to demonstrate compliance with voluntary reporting and disclosure requirements, notably Corporate Social Responsibility (CSR)/Environmental, Social, and Governance (ESG) reporting.

To highlight the different purposes for certification, two different markets for hydrogen and derivatives are distinguished within this report:

- Compliance/mandatory markets refer to markets for certificates used for compliance with policy and regulatory requirements or enabling access to support schemes and
- Voluntary/reporting markets refer to markets for certificates used for voluntary reporting and disclosure purposes). [3]

Legal Anchoring

Hydrogen and its derivatives, which are produced using renewable energy sources, are becoming fundamental in reshaping the energy landscape in Europe. Their production processes, transportation methodologies and applications are forming a complex value chain that is essential for a carbon-neutral future. This sets green hydrogen apart from grey hydrogen, originating from fossil fuels or blue hydrogen, which also includes carbon capture.

Currently, the EU and various international organizations are working on creating a robust certification system that can provide clarity, uniformity, and credibility to the green PtX market. This is to ensure that PtX products, which are produced and traded worldwide and ultimately consumed in the EU, meet the Union's strict standards for renewable energy. This would not only foster trust among consumers and stakeholders but also facilitate trade and collaborations across nations, paving the way for a global sustainable and renewable future. In this context, the specifications in the RED II[4] and associated delegated acts for the so-called Renewable Fuels of Non-Biological origin (RFNBOs) and their certification are particularly relevant. This is already evident from the fact that the term green or renewable hydrogen is often used as a simplification for hydrogen that is considered an RFNBO within the meaning of the RED II.

[3] https://hydrogencouncil.com/wp-content/uploads/2023/08/Hydrogen-Certification-101.pdf
[4] To ensure consistency with the certification schemes analyzed, only RED II and not the recently adopted new version (RED III) is considered.

To be classified as an RFNBO, hydrogen must:

- Meet the definition of an RFNBO as outlined in Article 2(36) of RED II,
- Adhere to the regulations in Article 27(3) of RED II for sourcing renewable electricity,
- Achieve a 70 % reduction in greenhouse gas (GHG) emissions, and
- Be traceable through the supply chain according to the rules in Article 30(1) and (2) of RED II.

In this context, the hydrogen delegated acts, adopted under Articles 27(3) and 28(5) of RED II, provide specific rules for sourcing renewable electricity used in the production of RFNBOs and for calculating their GHG emission intensity (RED II GHG methodology).[5]

It is envisaged that producers of RFNBOs will have the option of either applying to a voluntary scheme or to a national scheme set up by the EU Member States to be certified. In contrast to the national schemes, the voluntary schemes are operated by the private sector. The European Commission (EC) has the authority to recognize schemes as adhering to the regulations outlined in the RED. For a scheme to gain this recognition, it must meet certain criteria. Typically, the legal validity of a decision made by the EC recognizing a voluntary scheme lasts for 5 years. However, obtaining the EC's recognition is not a mandatory step for certification. EU Member States have the discretion to accept proof from voluntary or national certification schemes established by EU Member States, even if these are not recognized by the EC. This is possible if the competent authorities in those countries have confidence in the quality of the certification services offered by these schemes. [6]

It should be noted that there are currently no certification schemes officially recognized by the EC to verify compliance with the RFNBO criteria. The implementing regulation (EU) 2022/996 [7] for Article 30(8) in RED II will be used in accordance with the examination procedure referred to in Article 34(3) of RED II to conduct assessment on certification schemes to facilitate mutual recognition. Notably, only recognized or officially accepted voluntary schemes can set standards for achieving the respective targets in the EU. They are then eligible to:

- Demonstrate compliance with Article 27(3), which is about the calculation of the share of renewable electricity,
- Demonstrate compliance with Article 28(2) and (4), which requires relevant economic operators to enter into the Union Database accurate and relevant information on the transactions made and the sustainability characteristics of the fuels, including their life cycle GHG emissions, starting from their point of production to the fuel supplier that places the fuel on the market, and
- Verify that the GHG emissions savings from the use of RFNBO is at least 70 % of the total emission from the fossil fuel comparator [8] , ensuring that this is accurately calculated in accordance with the RED II GHG methodology.

To elaborate, the implementing regulation (EU) 2022/996 contains a list of data to be specified by the voluntary schemes and to be ensured that the economic operators correctly enter all relevant information in the Union Database. This list includes the Proof of Sustainability (PoS), which is defined as the declaration by an economic operator, based on a certificate issued by a certification body, certifying the compliance of a specific quantity of feedstock or fuels with the sustainability and GHG emissions savings criteria.

This means that within the EU, PoS can be used as proof of target fulfilment in accordance with RED II Art. 25 to 30 [9]. This allows to classify PoS as sustainability certificates, which are a special type of certificate that proves the sustainability attributes of a specific product and the traceability of these attributes along the supply chain from production to consumption. The term 'sustainability certificate' can be traced back to certification systems that use mass balancing as a product chain model (see Figure 1). Such certificates have been used for compliance in some countries, e.g. for biofuels in the EU. [10]

However, RED II is also the basis of another type of certificate for hydrogen, the so-called Guarantees of Origin (GoO), which are defined in Art. 19. GoOs serve the sole function of providing evidence to a final customer that a given share of a quantity of energy was produced from renewable sources. The usage of GoOs pertains to the electricity suppliers that are required to comply with the Article 3(9) of Directive 2009/72/EC [11], which necessitates the disclosure of information such as

[5] Further information is provided in: https://ptx-hub.org/wp-content/uploads/2023/04/International-PtX-Hub_EU-Requirements-for-green-hydrogen-and-PtX.pdf
[6] https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/voluntary-schemes_en
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R0996
[8] The total emissions of the fossil fuel comparator for RFNBOs are defined to be 94 CO_2-eq/MJ in line with the value set out for biofuels and bioliquids in Directive (EU) 2018/2001.
[9] https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2023/STUDY_Establishing_a_National_Hydrogen_Standard.pdf
[10] https://hydrogencouncil.com/wp-content/uploads/2023/08/Hydrogen-Certification-101.pdf
[11] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0072

the contribution of each energy source to the overall fuel mix, or other suppliers to disclose the information on the energy they use. For this, the standard size of a GoO is defined to be 1 MWh.

The RED II requires the Member States or the designated competent bodies to make sure that the GoO is issued, transferred, or cancelled in an accurate, reliable, and fraud-resistant manner. The requirements set out by these parties must be compliant with the CEN-EN 16325 standard, while the minimum requirements of the contents of the GoO are stated in Article 19(7) of the RED II as well. According to this it is required that a GoO specifies whether it relates to electricity; gas [12], including hydrogen; or heating and cooling. Within the EU, the GoO issued in one country should be recognisable in another country unless the member state refuses to recognise a GoO with well-founded doubts. GoO issued by a non-EU country is only recognisable when the EU has concluded an agreement with that third country on a mutual recognition of the GoO.

It should be noted that the GoO serves mainly for the purposes of disclosing the energy mix for energy producers and for disclosing the source of energy for some suppliers to gain qualification for certain financial supports. GoOs serves no function in terms of the Member States' compliance with the emission reduction targets by 2030 and are not required to be submitted to the Union Database, unlike the PoS. For a harmonised regulation on promoting the use of renewable energy, the EC is taking steps to establish a Union-wide green label, with which the suppliers can use the GoO to demonstrate compliance.

On this basis, GoO can be classified as Energy Attribute Certificates (EAC), which provide information about the origin of the energy, its renewable source as well as the related information including date and location of production. The term EAC is often used in certification schemes which use the book and claim as the chain of custody model (see Figure 2). The certificates (e.g. EACs for renewable electricity) are issued under such schemes using the book-and-claim model currently only used by market participants to support product and company reporting. [13]

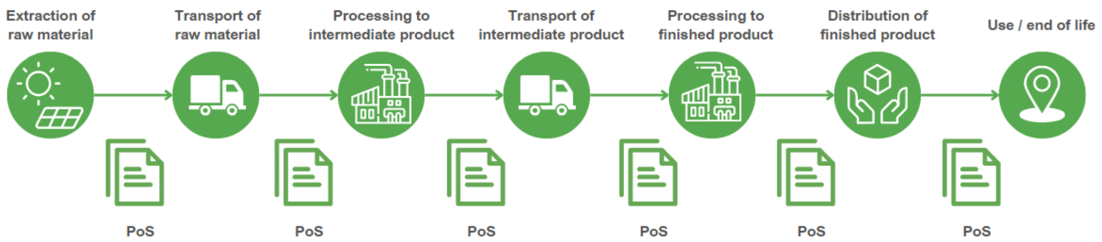

Figure 1: Visual representation of the mass balance model utilizing PoS.
Source: Fichtner GmbH & Co. KG

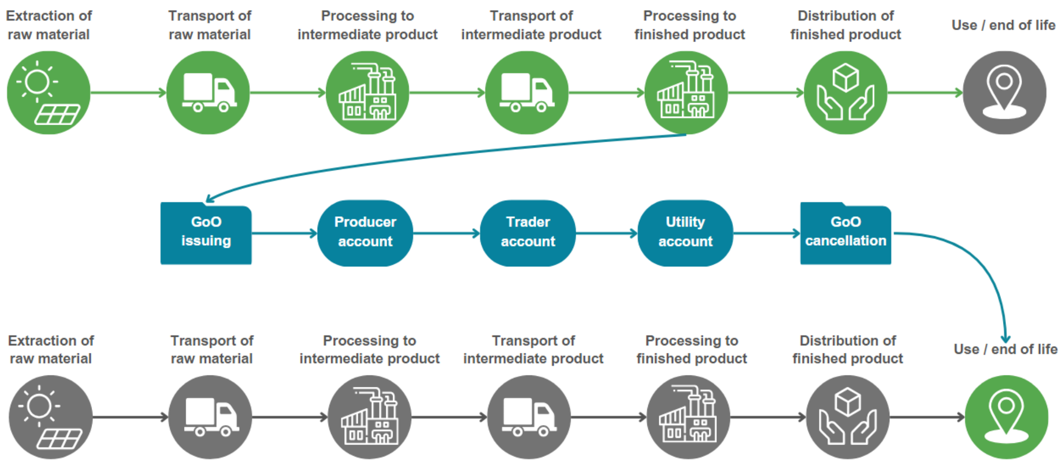

Figure 2: Visual representation of the book and claim model utilizing GoO.
Source: Fichtner GmbH & Co. KG

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[12] It is not clarified whether synthetic methane produced from hydrogen falls under the gas category. Due to this lack of clarity, this report only refers to hydrogen in the case of the GoO.
[13] https://hydrogencouncil.com/wp-content/uploads/2023/08/Hydrogen-Certification-101.pdf

Certification System Elements and their Functions

Issuing certificates for green PtX products requires going through a variety of processes that involve various elements. Recognising the importance of each element does not only help to navigate a complicated web of relationships, but also enables a more informed decision-making process. Figure 3 provides an overview of various key elements highlighting their positions and importance within the certification ecosystem. This simplified representation was derived based on existing certification schemes for biofuels, bioliquids and biomass fuels produced worldwide and sold in the EU, as the certification scheme for PoS for RFNBOs follows a similar direction. However, the focus of this report is on the project developers of PtX plants, who therefore take on the representative role of the actor to be certified.

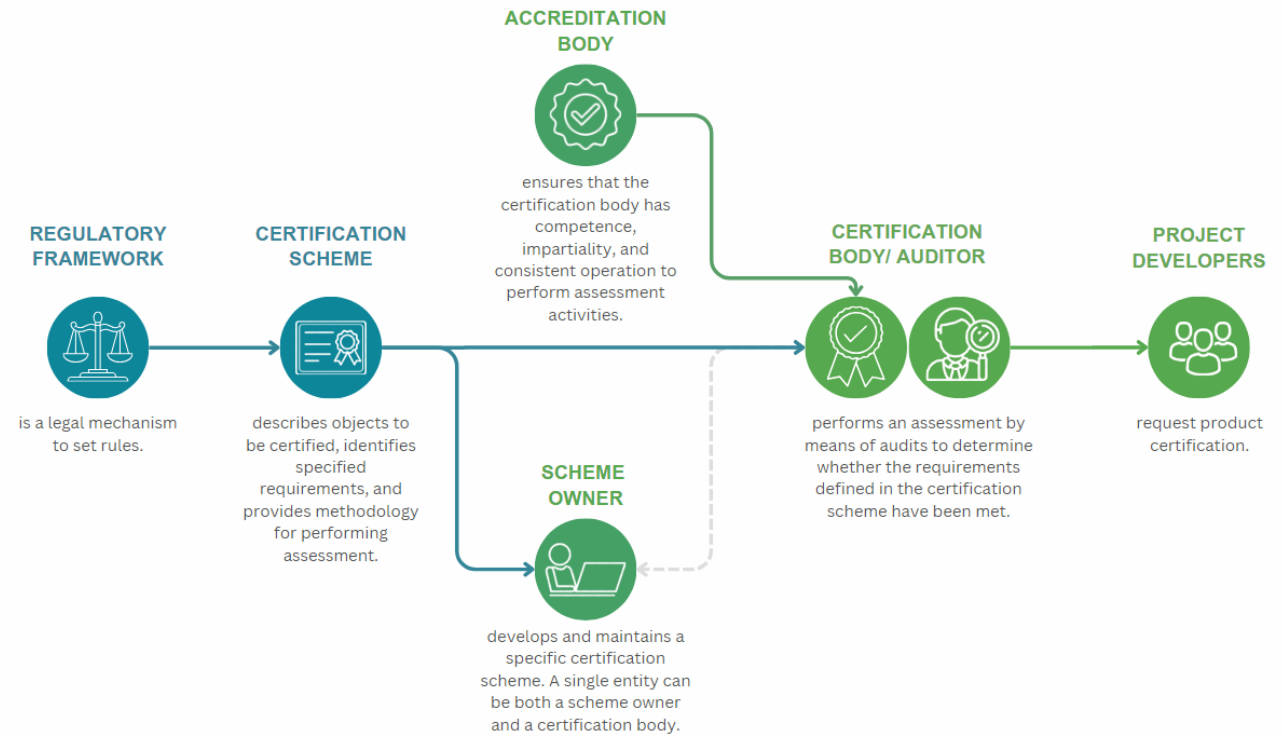

Figure 3: Relation between key certification elements and their functions. [14]
Source: Fichtner GmbH & Co. KG

The regulatory framework is a legal mechanism to set rules. The certification scheme establishes principles based on the underlying regulatory framework. This is done by describing objects to be certified, identification of specific requirements, and provision of a methodology to assess performance. The scheme recognises certification bodies. They perform the assessment to demonstrate that the requirements specified in the certification scheme have been fulfilled. The accreditation body ensures that the certification body has competence, impartiality, and consistent operation to perform the assessment activities. A scheme owner develops and maintains a specific certification scheme. The required audits are carried out by the auditors of the certification body. By doing this they have to interact with the project developers, who seek to obtain a certificate for their products.

It is possible that a single entity is both a scheme owner and a certification body. However, the primary role of the certification bodies is to ensure that products meet established standards by checking the process's integrity. Therefore, certification scheme owners that also act as a certification body are not eligible for the voluntary scheme status. To exemplify, TÜV Rheinland, a renowned certification body, has a certification standard titled TÜV Rheinland Standard H2.21. However, it cannot advocate for its standard to be recognised as a voluntary scheme under the EU framework. Instead, the TÜV Rheinland Standard H2.21 is earmarked for voluntary/reporting market-based use only. The reasoning behind this demarcation is clear: certification bodies, such as TÜV Rheinland, are entrusted with the responsibility of verifying if products meet specific standards. Their

[14] Based on J.H. Scheyl: PtX – Thematic Forum. Certification set-up of voluntary schemes. Presentation of GIZ, 24.02.2022

core function is to ensure the process's integrity. Should these entities simultaneously operate voluntary schemes, it may compromise this integrity.

The transition towards a more sustainable energy solutions has led to the development of different certification schemes. Each has its nuances, objectives, and operational models, which can result in different practical implications for entities seeking certification. The certification scheme owners analysed in this report are presented in Table 1. It is also shown whether they act as a certification body in general and within their own certification scheme, which means that their auditors carry out the audits of the production plant seeking certification.

Table 1: Overview of selected certification scheme owners and their roles.

Certification scheme owner	Functions as certification body	Performs audits within own scheme	Details
CertifHy™	No	No	CertifHy™, initiated by the EC and financed by the Clean Hydrogen Partnership, offers hydrogen certification schemes across Europe, supporting market growth and managing certificate lifecycles through a central European database.
TÜV Rheinland	Yes	Yes	TÜV Rheinland has introduced a new, practical specification for green hydrogen certification: the TÜV Rheinland Standard H2.21 for Renewable and Low-Carbon Hydrogen Fuels, catering to industry professionals and stakeholders.
ISCC	No	No	ISCC offers a sustainability certification for all feedstocks across various markets. Depending on the target market for a sustainable product, a specific certification from ISCC is required. The systems, ISCC EU, ISCC CORSIA (PLUS), and ISCC PLUS, are mostly aligned, meaning that a single audit can yield three certificates.
TÜV SÜD	Yes	Yes	TÜV SÜD has developed its own certification scheme called TÜV SÜD Standard CMS 70 and acts as an approved certification body in the CertifHy™ Scheme and ISCC PLUS.

CertifHy™ Scheme

Background and Essential PtX Features

CertifHy™ is a project initiated at the request of the EC and funded by the Clean Hydrogen Partnership. The project is being carried out by the CertifHy™ consortium, which is led by HINICIO and consists of GREXEL, Ludwig Bölkow Systemtechnik (LBST), AIB (Association of Issuing Bodies), CEA (Commissariat à l'énergie atomique et aux énergies alternatives) and TÜV SÜD. [15]

CertifHy™ has developed two different certification schemes. The 'CertifHy™ Scheme' [16] is a GoO system that issues 'CertifHy™ certificates', and the 'CertifHy™ Voluntary Scheme' [17] is a PoS system that issues 'CertifHy™ RFNBO certificates'. Consequently, CertifHy™ certificates are intended to disclose product characteristics to consumers and CertifHy™ RFNBO certificates are intended to demonstrate compliance with the requirements of RED II and the RED II Delegated Acts [18]. The CertifHy™ Voluntary Scheme has applied for recognition by the EC to certify RFNBOs in the EU [19]. The CertifHy™ Voluntary Scheme is not yet publicly available, which is why further consideration will focus on the CertifHy™ Scheme for H2 GoO.

A CertifHy™ certificate is an electronic document that proves that a certain quantity of hydrogen has been produced by a registered production device with a certain quality and a certain production process. CertifHy™ certificates are kept in a CertifHy™ registry, which is a tamper-proof central EU-wide database that manages the life cycle of CertifHy™ certificates for each account holder. The life cycle of a CertifHy™ certificate encompasses three phases: 'issuance', 'transfer & trade' and 'use & cancellation'. To manage the issuance, transfer, and cancellation of CertifHy™ certificates, each production unit or supplier holding CertifHy™ certificates must have an account in the CertifHy™ register. The validity of a CertifHy™ certificate automatically expires 12 months after the end of the production period. Expired certificates can no longer be transferred or canceled. [20]

The CertifHy™ Scheme offers two distinct types of labels:

- 'CertifHy™ Low Carbon Hydrogen' has a well-to-gate PCF below a defined threshold, which is at least 60 % below a defined fossil benchmark process.
- 'CertifHy™ Green Hydrogen' fulfills the same GHG emission saving criteria as CertifHy™ Low Carbon Hydrogen and, in addition, guarantees that the hydrogen originates from renewable sources.

Methane steam reforming as the best available technology for commercial hydrogen production serves as the fossil benchmark process for both labels. The well-to-gate PCF of methane steam reforming of 91 g CO_2-eq/$MJ_{LHV,H2}$ defines the comparator value. CertifHy™ states that it will regularly re-evaluate the benchmark and increase the percentage emission reduction targets over time to meet increasing climate requirements. It is important to clarify that certificates and labels are different. In general, a GoO certificate is the identity card of the molecule, while the label represents a 'flag', which is added to the CertifHy™ certificate or other GoO issued under a national scheme to refer to additional criteria that are met. This means that it is possible to issue CertifHy™ certificates without a label, e.g. if the electrolyzer uses grid electricity in times of low availability of renewable energy but maintains a well-to-gate PCF below the reference value. [21]

Regarding the criteria to be fulfilled, the following analysis focuses on CertifHy™ Green Hydrogen. An overview of the essential PtX features is shown in Table 2.

[15] https://www.certifhy.eu/stakeholder-platform/
[16] https://www.certifhy.eu/go-definition/
[17] https://www.certifhy.eu/certfhy-vs-for-rfnbo/
[18] https://www.certifhy.eu/our-mission-and-vision/
[19] https://www.certifhy.eu/certfhy-vs-for-rfnbo/
[20] https://www.certifhy.eu/lifecycle-of-a-go/
[21] https://www.certifhy.eu/go-labels/

Table 2: Overview of essential PtX features of the CertifHy™ Scheme for Green Hydrogen

Applicability	
Type of PtX products	Hydrogen [22]
Off-take applications	All applications in voluntary/reporting PtX markets [23]
Geographic coverage	European Union, the European Economic Area and Switzerland
Recognition	None [24]
GHG emission savings	
PCF calculation	CertifHy™ methodology [25]
PCF approach	Single [26]
Life cycle coverage	Cradle-to-gate [27]
Comparator value	91 g CO_2-eq/$MJ_{LHV,H2}$
GHG reduction target	At least 60 % of the comparator value
Technologies	
H_2 production technology	Not specified, but must use renewable energy as a core energy input
Dedicated energy sources	Renewable energy (RED II Art. 2(1)) [28]
Dedicated CO_2 sources	Not applicable, as derivatives are outside the scope
Monitoring and control system	
Chain of custody model	Book and claim
Traceability	CertifHy™ certificates are managed in the CertifHy™ registry [29]
Transparency	Freely accessible CertifHy™ documents and different reports are available in the CertifHy™ registry [30]
Labelling	CertifHy™ Green Hydrogen

[22] Re-bundling and re-labelling of certificates to produce derivatives is not allowed.
[23] The scope of CertifHy™ Scheme is limited to the production of hydrogen. The application of the hydrogen in the different off-take markets is therefore not specified. However, when the hydrogen is consumed or converted into another energy carrier, the CertifHy™ certificate must be cancelled upon use in the CertifHy™ registry.
[24] The CertifHy™ Scheme is compliant with AIB's EECS as well as the CEN EN16325 standard applicable to all GoOs in Europe. Therefore, CertifHy™ certificates are comparable to other EU hydrogen GoOs issued under a national scheme.
[25] The method for calculating the PCF was developed by CertifHy™ in collaboration with its stakeholders and follows an attributive approach in accordance with ISO 14067.
[26] The PCF calculation is only carried out once for the selected life cycle coverage.
[27] The system boundary at the gate is defined with hydrogen having a purity of at least 99.9 vol.-% and a gauge pressure of at least 3 MPa.
[28] The renewable origin of the energy consumed in form of electricity, gas or heat from the grid or district heating network must be established by cancelling of GoOs.
[29] The CertifHy™ registry generates a unique CertifHy™ certificate for each registered production device and tracks it throughout its life cycle.
[30] The CertifHy™ certificate is stored in the CertifHy™ registry together with the corresponding production batch audit report. In addition, different kind of reports, e.g. for the account holder itself, for competent bodies and for European and national statistics, can be provided by the CertifHy™ Registry.

Certification Process

CertifHy™ provides detailed information about the certification process on its website [31] and structures it up to the issuance of the CertifHy™ certificate in the three blocks 'Registration as Account Holder', 'Registration of the Production Device' and 'GoO Issuance', which in turn are subdivided into sub-steps. The following analysis deviates from this process by replacing the last block 'GoO Issuance' with its six sub-steps. This results in a total of eight steps, which can be seen in Figure 4 and are explained below.

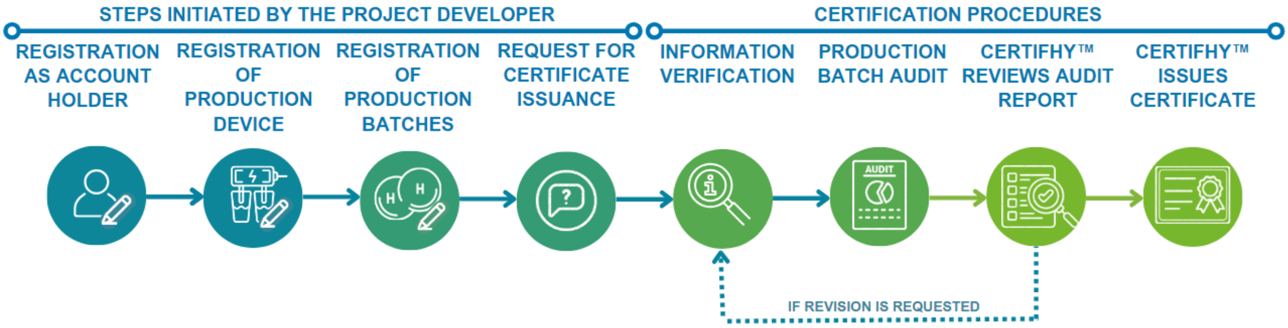

Figure 4: Flow chart of CertifHy™ green hydrogen certification process.
Source: Fichtner GmbH & Co. KG

Step 1: Registration as Account Holder

The issuance of a certificate is only possible within an account on the CertifHy™ registry, making the successful registration of both organizations and individuals as account holders mandatory.

Process and eligibility:

- Applicants, which must be a recognized legal entity, must submit their registration form and identity proof to the issuing body, which is covered by CertifHy™ [32]. Only one account per legal entity is allowed.
- CertifHy™ assesses the validity and completeness of the application. This also includes a check on the business integrity based on lessons-learnt from double counting and VAT carousel fraud cases in the field of CO_2, biofuel, and electricity certificates with the help of a 'know your customer' questionnaire.
- Once accepted, applicants gain access to the CertifHy™ registry. Account holder can apply for the issue of certificates as well as manage the transfer and cancellation of certificates.
- The account holder must verify annually that its information in the CertifHy™ registry is up to date.
- CertifHy™ may carry out ad hoc checks on a sporadic basis and may request evidential information from the account holder to ensure that the CertifHy™ registry is accurate at all times.

Required data and documents are:

- Completed registration form,
- Legal entity's identity proof,
- Completed 'know your customer' questionnaire,
- Any additional documentation as specified by the issuing body. [33]

Step 2: Registration of Production Device

Producers must also register their production device in the CertifHy™ registry.

[31] https://www.certifhy.eu/producers/
[32] Since CertifHy™ assumes the role of the issuing body, direct reference is made to CertifHy™ here.
[33] https://www.certifhy.eu/wp-content/uploads/2022/06/CertifHy_P0.1_Registration-of-Account-Holder_V2.0_2022-04-28_endorsed_CLEAN-1.pdf

Process and eligibility:

- Only account holders duly authorised by the owner of the production device, which has provided adequate evidence of such authorisation and that it can comply with the requirements of CertifHy™ with respect to the imposition of duties on the owner and/or operator of the production device, can register a production device in the CertifHy™ registry.
- The account holder must send the registration form containing details of the production device to CertifHy™.
- In an initial review, CertifHy™ verifies the information provided to ensure that the applicant is registered on the CertifHy™ registry and has provided proof that it is legally entitled to apply for registration of the production device; that the applicant complies with the signed Declaration of Honor and that there is no link to fraudulent activity; that the production device and the measurement procedures for its inputs and outputs meet the CertifHy™ criteria and that the production device is unique on the CertifHy™ registry.
- If accepted by CertifHy™, the account holder can select and commission a CertifHy™ approved certification body for a production device audit.
- The certification body is tasked with conducting a thorough audit using all necessary resources to confirm the precision and comprehensiveness of the registration application. The production device audit encompasses various aspects, including an examination of the production device, determination of the renewable energy content and GHG emissions [34]. The auditors of the certification body check whether the applicant's internal processes are designed in such a way as to ensure that all changes to the production device are reported to the CertifHy™ registry. In addition, they must carry out a risk evaluation or risk assessment, which result will determine the intensity of the audit and influences the size of the sample.
- Once the audit has been completed, the certification body prepares a production device audit report and forwards it to CertifHy™.
- CertifHy™ checks the audit report of the production device to determine whether the information provided by the applicant is consistent with the audit report of the production device and thus with the representation of the production device in the CertifHy™ registry. This review can lead to registration, improvements requests, or rejection from the CertifHy™ registry.
- CertifHy™ will, at its own discretion, check other known registries to make sure that it has not been certified in other registries for the same production device.
- Upon clearance by CertifHy™ the production device is registered into the CertifHy™ registry including its key characteristics. The earliest date of registration that can be requested by an account holder must be no earlier than 12 months prior to the date on which the production device registration application is received by CertifHy™.
- The account holder must report significant device modifications and comply with CertifHy™ terms post-registration.
- The account holder must adhere to mandatory annual inspections of the production device. This annual inspection includes a verification of the dedicated energy sources, which implies a verification of the overall energy content of the inputs used by the production device with a feasibility check to obtain the reported output.
- Onsite production device audits are required every 5 years.
- CertifHy™ may carry out ad hoc inspections and request ad hoc audits of the production facilities to ensure that the CertifHy™ registry is always correct.

Required data and documents are:

- Completed production device registration form with supporting evidence,
- Production device operational details, including type of fuel and technology used,
- Carbon footprint and emission factors of substances constituting inputs,
- Access to the production device and its in- and output measurements records. [35]

[34] CertifHy™ conducts a case study for each production route and develops a specific methodology for the allocation of greenhouse gas emissions, which is then used within the CertifHy™ scheme. The well-to-gate PCF of hydrogen is calculated using the methodology developed by CertifHy™, for which CertifHy™ auditors are trained.
[35] https://www.certifhy.eu/wp-content/uploads/2022/06/CertifHy_P0.2_Registration-of-Production-Device_V2.0_2022-04-28_endorsed_CLEAN-1.pdf, https://www.certifhy.eu/producers/

Step 3: Registration of Production Batches

After registering the production device, producers must also register the production batches for which they are seeking certification in the CertifHy™ registry.

Process and eligibility:

- The maximum production batch period to register for certificate issuing is twelve months.
- The issuance of certificates for individual production batches must be unique and exclusive. It is the sole responsibility of the account holder to ensure that production batches do not receive or attempt to receive duplicate or multiple values for attributes that are equal or similar to CertifHy™ attributes.
- Certificates for production batches can only be issued upon the provision of evidence-based information into the CertifHy™ registry, which must be provided during the batch production audits.

Required data and documents are [36]:

- Production batch details: amount, production start and end date, fuel or heat source used, share of renewable energy, well-to gate PCF,
- Metering data comprising at least the hydrogen output of the production device and respective energy inputs, including information qualifying the type and origin of the energy input, over the same production period,
- Consumption declaration indicating the share of core energy input from each energy source in the total core energy input in case hydrogen production involves multiple energy sources,
- Information to avoid double counting of production batch, e.g. registration of the production device under a different scheme. [37]

Step 4: Request for Certificate Issuance

After submitting the information on the production batch to the CertifHy™ registry, the account holder must apply for the issue of certificates, whereby an application may cover one or more production batches. It is interesting to note that even if a gas storage facility is not considered a production device, it is possible to apply for the issue of certificates if one of the following two cases is met:

- CertifHy™ certificates are cancelled for proving the attributes of the energy fed into the storage device, or
- Energy fed into the storage device has demonstrably been produced on the site of the storage device, reflecting the attributes that are requested to be indicated on these CertifHy™ certificates, has not been or will not be subject to issuance of CertifHy™ certificates, and will not be disclosed other than in relation with the CertifHy™ certificates issued in relation with the hydrogen output of this storage device. [38]

Step 5: Information Verification

CertifHy™ bodies and/or approved third parties verify the accuracy of the CertifHy™ registry's data, ensuring no duplications across systems. To accomplish this, they can request adjustments to audit frequency, timing, and intensity. For the issuance of CertifHy™ certificates within the respective time limit the following rules apply:

- Prior to the first validation of the production batches, only 90 % of the CertifHy™ certificates are issued.
- After the first validation and positive behavior provided, 100 % of the CertifHy™ certificates may be issued.
- Certificates for new production batches are only issued if the non-audited production batches have not reached the deadline of twelve months from the earliest start date of the production batch. The backlog of non-audited production batches must be validated before new certificates can be issued. [39]

Step 6: Production Batch Audit

Depending on the track record of the account holder, the production device and previous certificate issuances, an audit of the production batch is required. The audit is carried out by a certification body that has been approved by CertifHy™ and

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[36] The data and documents required for the request for certificate issuing in step 5 and the audit of the production batch in step 6 are listed in step 3 to avoid repetition.
[37] https://www.certifhy.eu/wp-content/uploads/2022/06/CertifHy_P1.1_CC-Issuing_V2.0_2022-04-28_endorsed_CLEAN.pdf, https://www.certifhy.eu/wp-content/uploads/2023/03/CertifHy-GO-System-Document_CB_Requirements_230208.pdf
[38] see footnote Nr. 37
[39] see footnote Nr. 37

contracted by the account holder. Usually, this certification body has previously carried out the audit of the production device. The audit must be performed in accordance with ISO 14064-3 as well as the EU Directive 2003/87/EC regarding its level of assurance and the materiality threshold. The auditor is tasked to perform the audit with all due means to verify accuracy and completeness of the production batch registration. This includes the verification of the applicant's internal processes to avoid double counting and to ensure consistency of the production batch registration. The auditor must also verify the energy attributes of the production batch, such as the share of renewable energy and well-to-gate PCF. As in the case of the production device audit, a risk evaluation or risk assessment must also be conducted for the production batch audit. The results of the audit are documented in an audit report, which the certification body submits to the account holder and to CertifHy™. [40]

Step 7: CertifHy™ Reviews Audit Report

CertifHy™ reviews the production batch audit to ensure that the information provided by the account holder during the registration of the production batches conform with the production batch audit report and thus with the representation of the production batch in the CertifHy™ registry. CertifHy™ also checks the CertifHy™ register to ensure that the same production batches have not already been registered with other energy attributes and checks other known registries to ensure that the production batches and their feedstock are not prone to receive energy attribute certificates from other schemes for the same production batch. This leads either to the clearance of the certificate issuance in the CertifHy™ registry, to post-processing of the registration and to further inspections or to rejection of the certificate issuance. [41]

Step 8: CertifHy™ Issues Certificate

Once cleared, a downloadable CertifHy™ certificate will be made available to the account holder in the CertifHy™ registry. Each CertifHy™ certificate has a value of 1 $MWh_{LHV,H2}$ and contains the following information:

- CertifHy™ GO identity: unique ID number, date of issuing, cancellation date,
- Information on the plant which produced the hydrogen (location, start date of operation, name of operator),
- Time of production of the hydrogen,
- Energy source of the hydrogen (fuel or heat) and technology,
- Whether the hydrogen production has received financial support or not,
- Share of renewable energy,
- GHG intensity [42] of the hydrogen in g CO_2-eq/$MJ_{LHV,H2}$.[43]

[40] see footnote Nr. 37
[41] see footnote Nr. 37
[42] In this case the greenhouse gas intensity of hydrogen is equivalent to the well-to-gate PCF of hydrogen, which was calculated according to the CertifHy™ methodology.
[43] https://www.certifhy.eu/go-definition/, https://www.certifhy.eu/wp-content/uploads/2022/06/CertifHy_Scheme-Document_V2.0_2022-04-28_endorsed_CLEAN.pdf

Case Study for Hydrogen

The Brazilian company A produces hydrogen using an electrolyzer with a capacity of 10 MW. The renewable electricity comes via direct line from a neighboring wind farm. In addition, Company A uses tap water, which comes from a public water system provider. After production, the hydrogen is compressed to the required tube trailer filling pressure, making it ready for road transportation. This hydrogen will be used by the off-taker to fuel coaches and heavy-duty vehicles. The elements of the value chain are depicted in Figure 5. Both the production and use of hydrogen are in Brazil, meaning that certification under the CertifHy™ Scheme is not possible. However, as CertifHy™ is seeking to expand its geographical coverage and a corresponding initiative already exists [44], the following case study is nevertheless carried out hypothetically based on the requirements of the CertifHy™ Scheme.

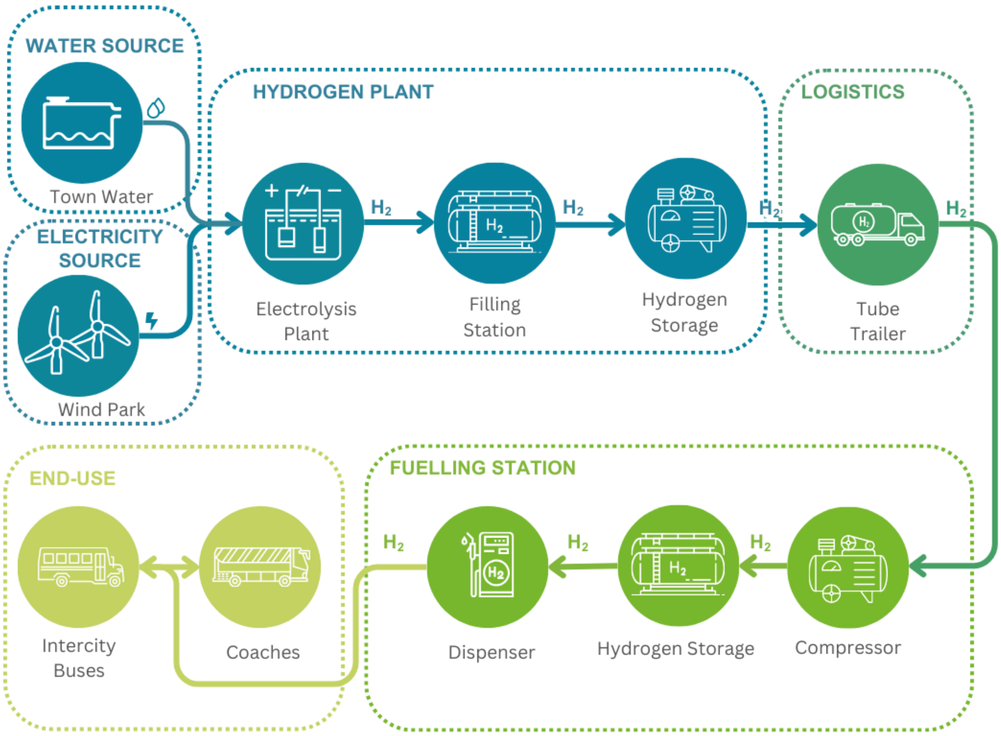

Figure 5: Elements of the value chain for the case study of green hydrogen production.
Source: Fichtner GmbH & Co. KG

Step 1: Registration of Account Holder

Brazilian Company A submits its registration form and identity proof to CertifHy™. After CertifHy™ assesses the application's validity and completeness, Company A gains access to the CertifHy™ registry.

Step 2: Registration of Production Device

To register its production device Company A provides all the relevant information to CertifHy™ who performs an initial review. Upon clearance from initial review, Company A selects and contracts a CertifHy™ approved certification body. The auditors of the certification body perform the production device audit at the production site. During the audit they receive information not only on the electrolyzer and its core energy input but also on the auxiliary systems such as water treatment and compressors. Since the core energy input of the electrolyzer is renewable electricity directly sourced from a wind farm, its emission intensity is assumed to be equal to zero. According to the CertifHy™ methodology, the calculation of the PCF value of the hydrogen from the source to the gate must consider the amount of energy used by the auxiliary systems, e.g.

[44] https://publications.iadb.org/publications/english/viewer/Guide-for-the-Implementation-of-a-Hydrogen-Certification-System-in-Latin-America-and-the-Caribbean.pdf

compression. Since the pressure at the transfer point to the trailer, which is the production gate, is above 3 MP, the system limit requirements defined by CertifHy™ are met. This results in a PCF below the threshold of 36.4 g CO_2-eq/$MJ_{LHV,H2}$. Consequently, the criteria for classifying as CertifHy™ Green Hydrogen are met. Once the audit has been completed, the certification body forwards the audit report to CertifHy™, which reviews it and, after ensuring that all requirements have been met, grants approval for registration of the production device.

Step 3: Registration of Production Batches

Company A registers its hydrogen batches by submitting the required production batch details. They ensure that there are no compliance issues.

Step 4: Request for Certificate Issuing

Company A applies for the issue of certificates for its production batches in the CertifHy™ registry.

Step 5: Information Verification

Company A's hydrogen production batch data is checked to ensure accuracy and avoid duplication.

Step 6: Production Batch Audit

The designated auditor from the certification body focuses on Company A's accuracy in registering its hydrogen batches. After ensuring consistency, uniqueness, and adherence to standards, the auditor compiles an audit report, which is forwarded to CertifHy™.

Step 7: CertifHy™ Reviews Audit Report

CertifHy™ checks the audit report of company A, compares it with the information in the CertifHy™ registry and ensures that there are no duplicates. It also checks other registries to prevent duplicate certificates being issued.

Step 8: CertifHy™ Issues Certificate

Once Company A clears all the stages and meets the criteria, the CertifHy™ certificate is issued under their name in the CertifHy™ registry. They are notified of the issuance and are provided with a downloadable certificate. Company A ensures that the hydrogen output's end date, certificate issuance timeline, and other criteria align with the CertifHy™ rules.

TÜV Rheinland Standard H2.21

Background and Essential PtX Features

As an independent third party, TÜV Rheinland provides testing services for technical systems, products and services, supports projects and tests processes for companies and organizations [45]. The TÜV Rheinland Standard H2.21 Renewable and Low-Carbon Hydrogen Fuels [46] was launched as a new version in February 2023, replacing the prior TÜV Rheinland Standard H2.21 Carbon-Neutral Hydrogen from July 2021 [47]. The standard has already been updated twice since February 2023. The analysis in this report is based on the most recently published version 2.1, for which the designation TÜV Rheinland Standard H2.21 is used in the following for the sake of simplicity.

The aim of TÜV Rheinland is to use this standard to give hydrogen and hydrogen derivatives producers and traders the opportunity to demonstrate their sustainable production and thus strengthen stakeholder confidence and market presence. With its standard, TÜV Rheinland is endeavoring to act as a certification system serving voluntary reporting and disclosure requirements. Recognition by the EC is not being sought. This would also not be permissible, as TÜV Rheinland acts as both scheme owner and certification body for the TÜV Rheinland Standard H2.21.

With its standard, TÜV Rheinland offers a flexible system for classifying different types of hydrogen and derivatives that is orientated towards current regulatory developments. It distinguishes between the two major hydrogen classifications of 'Renewable Hydrogen' and 'Low-Carbon Hydrogen', which both share the same GHG emission saving target:

- Renewable Hydrogen refers to hydrogen produced by electrolysis of water or aqueous solutions using electricity from renewable non-biological sources. The reduction target must be at least 70 % of the fossil fuel comparator set out in RED II, which corresponds to 94 g CO_2-eq/MJ_{LHV}.
- Low-Carbon Hydrogen refers to all hydrogen production pathways and therefore enables the certification of all technologies and processes. The reduction target must be at least 70 % of the fossil fuel comparator value of 94 g CO_2-eq/MJ_{LHV}.

Depending on additional requirements, further sub-categories can be distinguished in both cases. In the category Renewable Hydrogen sub-categories are 'Green Hydrogen' and 'RFNBO (RED II)'. In the category Low-Carbon Hydrogen the sub-categories 'Blue Hydrogen (CCS/CCU)', 'Turquoise Hydrogen', 'Pink Hydrogen' and 'Carbon Neutral Hydrogen' exist. The designation of the sub-categories corresponds to the 'keyword' within the test mark whose rights of use are transferred by TÜV Rheinland together with the certificate after successful certification.

The following analysis is limited to the subcategory RFNBO (RED II). Table 3 provides an overview of the essential features. It is interesting to note, that within the scope of the analysis carried out here, no evidence of a database for managing TÜV Rheinland certificates could be found. It is also unclear how a change of ownership of the certificate and/or the underlying physical product should be handled to track the product attributes along the supply chain. Since no specifications regarding traceability are included in TÜV Rheinland Standard H2.21, it can therefore be assumed that a chain of custody model does not exist.

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[45] https://www.tuv.com/world/en/about-us/t%C3%BCv-rheinland-at-a-glance/
[46] https://www.tuv.com/content-media-files/master-content/global-landingpages/images/hydrogen/tuv-rheinland-hydrogen-standard-h2.21-v2.1-2023-en.pdf
[47] https://www.tuv.com/content-media-files/master-content/global-landingpages/images/hydrogen/tuv-rheinland-hydrogen-standard-h2.21_v1.0-en.pdf

Table 3: Overview of essential PtX features of TÜV Rheinland Standard H2.21 for RFNBO (RED II)

Applicability	
Type of PtX products	Hydrogen and derivatives
Off-take applications	All applications in voluntary/reporting PtX markets
Geographic coverage	Not specified, probably global
Recognition	None
GHG emission savings	
PCF calculation	RED II GHG methodology
PCF approach	Single [48]
Life cycle coverage	Cradle-to-X, where X is a point in the life cycle defined by the certification applicant
Comparator value	94 g CO_2-eq/$MJ_{LHV, PtX\ product}$ [49]
GHG reduction target	At least 70 % of the comparator value
Technologies	
H_2 production technology	Electrolysis of water or aqueous solutions
Dedicated energy sources	Electricity from non-fossil non-biological sources [50] fulfilling criteria for additionality [51], temporal [52] and geographical correlation [53]
Dedicated CO_2 sources	CO_2 sources outlined in the RED II GHG methodology [54]
Monitoring and control system	
Chain of custody model	Not specified, probably non-existent
Traceability	Not specified, probably non-existent
Transparency	Standard is freely accessible, no information about certificate holders
Labelling	TÜV Rheinland test mark and keywords [55]

[48] The PCF calculation is only carried out once for the selected life cycle coverage, whereby it is possible to include values outside the customer's sphere of influence. This also includes PCF calculations for upstream and downstream sections of the supply chain in relation to the reference point under consideration.
[49] Corresponds to fossil fuel comparator for transport according to RED II.
[50] This includes wind, solar (solar thermal and solar photovoltaic), geothermal energy, hydropower, tide, wave and other ocean energy.
[51] Criteria for additionality: For fuel production facilities that come into operation after 01.01.2028, the commissioning date of the renewable electricity plant shall not be more than 36 months prior to the start of fuel production. Furthermore, financial support for the RE plant is not allowed (after repowering). Support for land and for grid connection or support that does not constitute net support (i.e., if repaid) is allowed. For fuel production facilities that come into operation before 01.01.2028, no additionality criteria are applied to the renewable energy plant until 31.12.2038. Similarly, facilities located in a bidding zone where the emission intensity of electricity is lower than 18 g CO_2-eq/MJ_{el} do not have to demonstrate additionality.
[52] Criteria for temporal correlation: The RFNBO and the renewable electricity shall be produced within the same calendar month, until 31.12.2029, and from 01.01.2030, the fuel shall be produced during the same one-hour period as the renewable electricity produced.
[53] Criteria for geographical correlation: Renewable electricity and electrolysis facilities must be in the same electricity Bidding Zone, as defined in Regulation (EU) 2019/943. If electricity grid congestion between the facilities may be precluded, the installations may also be in neighboring electricity bidding zones. In countries outside of Europe an equivalent concept shall apply.
[54] This includes CO_2 from an activity listed under Annex I of Directive 2003/87/EC (EU ETS) and within the EU, corresponding CO_2 has been considered upstream in an effective carbon pricing, CO_2 from Direct Air Capture, CO_2 from biofuels, CO_2 from geological sources.
[55] Applicable keywords in this sub-category are Renewable Hydrogen, RFNBO (RED II), Green Hydrogen

Certification Process

The TÜV Rheinland Standard H2.21 describes the certification process in five major steps, which correspond to steps 4 to 5 of the certification process explained below. Steps 1 to 3 shown here were added to emphasize the special features of the TÜV Rheinland Standard H2.21 and the associated preparatory work for the project developer seeking certification. This results in a total of eight steps, which can be seen in Figure 6.

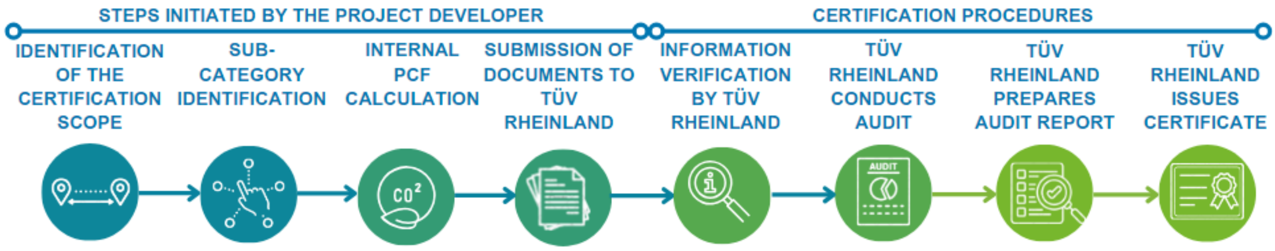

Figure 6: Flow chart of the TÜV Rheinland Standard H2.2 certification process.
Source: Fichtner GmbH & Co. KG

Step 1: Identification of the Certification Scope

As the life cycle coverage can be defined flexibly within the framework of the TÜV Rheinland Standard H2.21, the certification applicant must first define the variable point X in the life cycle. Depending on the applicant's choice, the life cycle coverage can extend from cradle-to-gate, cradle-to-tank, or cradle-to-wheel.

Step 2: Sub-Category Identification

Another preparatory step is the definition of the sub-category based on the production pathway used. The definition of the sub-category then determines the requirements that the certified product must fulfil to receive the corresponding label. For example, for a product to be classified as RFNBO (RED II), it must use electrolysis of water or aqueous solutions as the H_2 production technology, and only electricity from non-fossil, non-biological sources meeting the criteria of additionality, temporal and geographical correlation can be used. In addition, the CO_2 must come from a source fulfilling the requirements described in the RED II GHG methodology (see Table 3).

Step 3: Internal PCF Calculation

To ensure in advance that the required GHG emission savings can be achieved, the applicant can carry out an internal calculation of the PCF.

Process and eligibility:

- The applicant must use the method described in RED II GHG methodology. However, as this methodology is designed to calculate the cradle-to-wheel PCF, the applicant must adjust or omit elements of the calculation formula if only a partial PCF is to be calculated.
- If the criteria regarding additionality, temporal and geographical correlation are met, or exceptions as defined in the RED II GHG methodology apply (e.g., downward re-dispatch, renewable grid, etc.), the electricity must be attributed zero greenhouse gas emissions. Otherwise, indirect emissions associated to the generation of renewable electricity must be fully accounted.
- Identified errors, omissions or discrepancies in the calculation of the PCF must not exceed, in the aggregate of their effects on the overall result, the materiality threshold of 5 % of the calculated PCF.
- The calculated PCF must be below the specified limit of 28,2 g CO_2-eq/$MJ_{LHV,\ PtX\ product}$. [56]

[56] https://www.tuv.com/content-media-files/master-content/global-landingpages/images/hydrogen/tuv-rheinland-hydrogen-standard-h2.21-v2.1-2023-en.pdf

Required data and documents are:

- Processing unit specifics such as energy- and mass balances including effluents and leakages,
- Emission factors and emission intensities, e.g. for process specific inputs, electricity and heat consumption,
- Sources of used emission factor vales with publication year,
- Records of electricity used in electrolysis processes.

Step 4: Submission of Documents to TÜV Rheinland

The applicant must compile all required documents and submit them to TÜV Rheinland.

Required data and documents are:

- Description of all production and distribution processes,
- Quantity records of all mass, volume and energy flows,
- Emission factors, emission intensities and or partial PCFs of upstream resources and processes required for the PCF calculation.

Step 5: Information Verification by TÜV Rheinland

TÜV Rheinland evaluates submitted data and documents for completeness, plausibility, and consistency with established standards and norms as part of a 'desk review'.

Step 6: TÜV Rheinland Conducts Audit

In an audit the submitted documents and data are verified by auditors of TÜV Rheinland. The audit can take place on-site at the customer's premises, or via video conference call and screen sharing.

Step 7: TÜV Rheinland Prepares Audit Report

TÜV Rheinland verifies the data from the audit against the requirements set out in the TÜV Rheinland Standard H2.21 and documents corresponding results in an audit report.

Step 8: TÜV Rheinland Issues Certificate

Upon successful completion of the audit, the certificate is issued by TÜV Rheinland. The certificate is a document of one-page stating that the specific criteria have been checked and complied with. If applicable, in addition to the test mark the relevant key word is individually highlighted on the certificate. The validity of the certificate amounts to 12 months.

It is interesting to note that TÜV Rheinland also makes the testing of the criteria listed in TÜV Rheinland Standard H2.21 available to other certification bodies that can demonstrate conformity in accordance with the requirements defined by TÜV Rheinland. However, TÜV Rheinland makes clear that no liability is assumed for tests, assessments, certifications, and statements of any kind by third parties and external certification bodies that refer to the TÜV Rheinland Standard H2.21. Therefore, it is unclear how the interaction with an external certification body works, i.e. whether it is only involved in carrying out the audit and the audit report is then checked again by TÜV Rheinland, or whether in this case the entire certification process, including the issuing of the certificate, is carried out externally.

Case Study for Methanol

The Brazilian company B uses wind and solar energy provided as part of a PPA to generate hydrogen, which is then used to synthesize methanol. The renewable hydrogen is produced in an electrolysis process with a capacity of over 100 MW, whereby the required raw water is obtained from a river. The hydrogen produced is compressed and combined with CO_2 from a biomass plant to produce methanol (CH_3OH). The methanol is transported in tank cars on the local rail network for a short distance to the port. At the port, the methanol is shipped to Germany, where it is used directly in the port as fuel for cargo ships. Figure 7 contains a graphical representation of the value chain considered in this case study. The corresponding certification steps are briefly explained below focusing on the activities of Company B to achieve the keyword RFNBO (RED II) for its methanol.

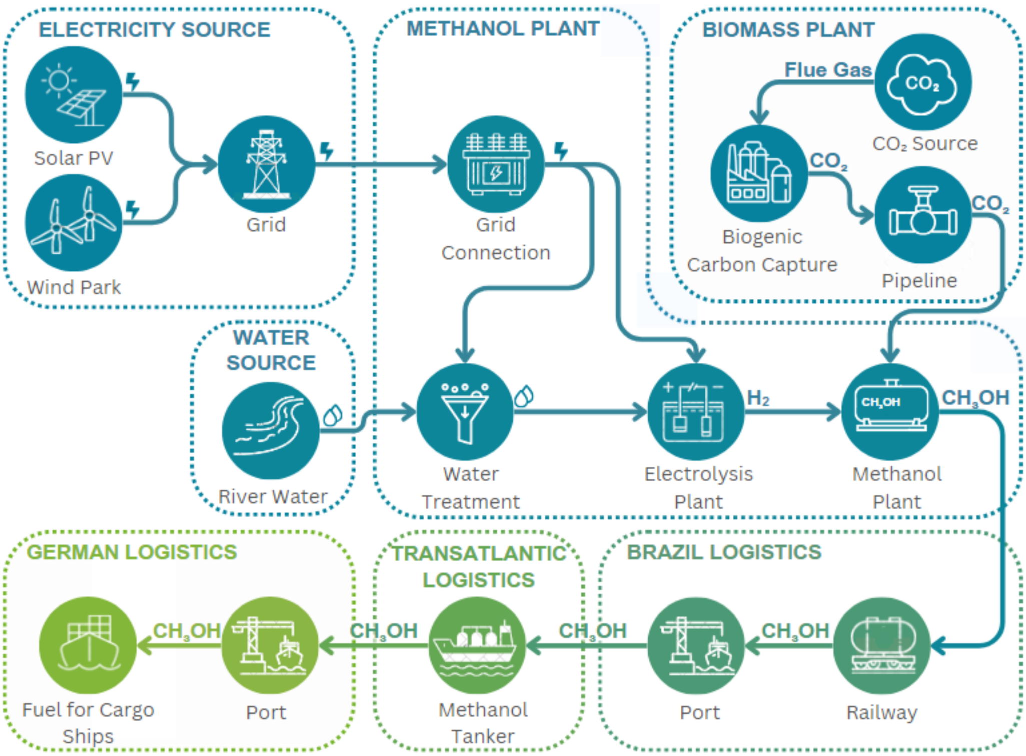

Figure 7: Elements of the value chain for the case study of green methanol.
Source: Fichtner GmbH & Co. KG

STEP 1: Identification of the Certification Scope

Company B decides that the life cycle coverage should be cradle-to-wheel, which means that the utilization of methanol as a fuel for the cargo ships is withing the scope.

STEP 2: Sub-Category Identification

Company B will opt for the RFNBO sub-category as it uses renewable electricity from wind and solar energy and in addition they use biogenic CO_2, which is a compliant CO_2 source. Assuming that the commissioning date is after 01.01.2028, Company B must provide proof of additionality. In addition, if their electricity and hydrogen production from renewable energy takes place within the specified time periods and at the specified locations, they should also meet the criteria for temporal and geographical correlation specified for the RFNBO subcategory.

STEP 3: Internal PCF Calculation

Company B compiles all required data and calculates the cradle-to-wheel PCF for methanol using the RED II GHG methodology. Since the electricity of the methanol plant, including electrolysis, water treatment and methanol synthesis, is fully provided by renewable energy sources that meet the requirements for the RFNBO sub-category, the emission intensity of the electricity used in the methanol plant can be set to zero. They make sure that identified errors, omissions, or discrepancies in the calculation of the PCF do not exceed, in the aggregate of their effects on the overall result, the materiality threshold of 5 % of the calculated PCF.

STEP 4: Submission of Documents to TÜV Rheinland

Company B submits their description of all production and distribution processes, quantity records of all mass, volume and energy flows, and other required data for the PCF calculation to TÜV Rheinland.

STEP 5: Information Verification by TÜV Rheinland

TÜV Rheinland checks the materials provided for completeness, plausibility, and consistency.

STEP 6: TÜV Rheinland Conducts Audit

An auditor from TÜV Rheinland visits Company B's production facility or conducts a virtual audit. They verify all the processes involved, from water treatment to methanol production. In addition, they must check all data for the calculation of the PCF that relates to the supply chain after the production gate.

STEP 7: TÜV Rheinland Prepares Audit Report

TÜV Rheinland compares the data from the audit of Company B's production facility with the requirements of TÜV Rheinland Standard H2.21 and documents the corresponding results in an audit report.

STEP 8: TÜV Rheinland Issues Certificate

After compliance with the requirements of the subcategory has been confirmed in the audit report, TÜV Rheinland awards the certificate and the right to use its test mark and the keyword RFNBO (RED II) to company B. This can be used by company B for the next year vis-à-vis its customers.

ISCC PLUS

Background and Essential PtX Features

The International Sustainability and Carbon Certification (ISCC) is an independent multi-stakeholder initiative, which is responsible for the development, surveillance, revision, and continuous improvement of the ISCC certification system. The aim of ISCC is to utilize certification to decrease GHG emissions and create sustainable production with fully traceable supply chains from the source to the end user by enforcing social, economic, and environmental standards [57]. The day-to-day operations, management, and development of the ISCC system are delegated to the ISCC System GmbH [58]. It operates globally applicable certification systems for demonstrating compliance with sustainability requirements according to legal regulations or voluntary agreements [59].

ISCC is a sustainability certification system applicable to all feedstocks and markets, necessitating the selection of a specific certification system based on the market for the sustainable material. The ISCC EU, ISCC CORSIA (PLUS) and ISCC PLUS certification systems are largely harmonized. In consequence, it is possible to issue three certificates to supply all markets with one audit [60]. However, they differ in their stage of development and in the products and markets addressed, which is explained below regarding their current eligibility for the certification of hydrogen and its derivatives.

ISCC EU is a voluntary scheme for the biofuels markets in the EU that has been formally recognized by the EC to demonstrate compliance with the sustainability and GHG emission saving criteria of the RED II. Since it covers additional ecological and social requirements, it goes beyond the legal requirements of the RED II [61]. ISCC has applied for recognition by the EC to extend the ISCC EU scope to cover RFNBOs and renewable carbon fuels (RCF) [62]. Since the recognition is still pending, ISCC EU cannot yet be used to certify PtX products [63]. Details are not yet known, but it is expected that in addition to mirroring the RED II requirements, other criteria such as social impact and water consumption will be addressed.

Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), developed by the International Civil Aviation Organisation (ICAO), is an instrument to mitigate the rise in aviation's total CO_2 emissions. It's the first market-based measures scheme for an industry on a global scale. ISCC CORSIA (PLUS) covers sustainable aviation fuels eligible under the ICAO CORSIA scheme and is officially recognized by ICAO to demonstrate compliance with the sustainability criteria [64]. However, in the case of ISCC EU, ISCC CORSIA cannot yet be applied to certify PtX products [65].

ISCC PLUS is a voluntary certification scheme for biofuels, bioenergy, food, feed, chemicals, plastics, packaging, textiles, and renewable feedstock markets outside the EU. It mirrors ISCC EU's requirements but offers customization for various markets and applications [66]. The certification of PtX products is already possible today under ISCC PLUS [67]. In addition, GHG emission requirements can be covered on a voluntary basis under ISCC PLUS by applying the GHG Emissions Add-On [68] [69]. When the add-on is applied, the relevant ISCC requirements relating to GHG emissions apply to ISCC EU and ISCC PLUS with minor differences. ISCC PLUS with GHG Emissions Add-On was therefore selected for the detailed step-by-step analysis of the certification process [70]. Under ISCC PLUS the three raw material categories 'bio', 'bio-circular and circular' and 'renewable-energy-derived', which arise at the beginning of the supply chain, can be certified. In the following only the renewable-energy-derived feedstock category comprising products which use renewable energy, e.g. renewable electricity or other renewable energy sources except for biomass, as an integral part of the production will be examined (see Table 4).

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[57] https://www.iscc-system.org/
[58] https://www.iscc-system.org/governance/multi-stakeholder-initiative/
[59] https://www.iscc-system.org/wp-content/uploads/2023/03/ISCC_255_Terms_of_Use_10-03-2023_EN.pdf
[60] https://www.iscc-system.org/certification/iscc-certification-schemes/
[61] https://www.iscc-system.org/certification/iscc-certification-schemes/iscc-eu/
[62] https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/voluntary-schemes_en?prefLang=de#voluntary-schemes-under-the-recast-renewable-energy-directive
[63] https://www.iscc-system.org/wp-content/uploads/2022/12/Juliane-Pohl-Senior-System-Manager-ISCC-System-The-ISCC-Certification-approach-for-RFNBOs.pdf
[64] https://www.iscc-system.org/certification/iscc-certification-schemes/iscc-corsia/
[65] See footnote Nr. 63.
[66] https://www.iscc-system.org/certification/iscc-certification-schemes/iscc-plus/
[67] See footnote Nr. 63.
[68] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_205_Greenhouse-Gas-Emissions-v4.0.pdf
[69] Several ISCC EU system documents were updated on January 1. As the analysis for this report was completed in October 2023, these and other updates, e.g. the introduction of the ISCC Hub, are therefore not included here.
[70] At the time this report was prepared, the ISCC methodology only covered the calculation of GHG emissions from biomass fuels, bioliquids and biofuels. The extent to which emissions from PtX applications can also be meaningfully mapped on this basis is beyond the scope of this examination. Furthermore, it can be assumed that the inclusion of RFNBOs in the scope of the ISCC EU certification system will also result in an update of the ISCC methodology. Therefore, it is assumed within this report that the ISCC methodology can be used to calculate GHG emissions to demonstrate this aspect of the certification process.

Table 4: Overview of essential PtX features of ISCC PLUS with GHG Emissions Add-On.

Applicability	
Type of PtX products	Hydrogen and derivatives
Off-take applications	All applications in voluntary/reporting PtX markets
Geographic coverage	Global
Recognition	None
GHG emission savings	
PCF calculation	ISCC methodology [71] [72]
PCF approach	Cumulative [73]
Life cycle coverage	Cradle-to-gate or cradle-to-grave [74]
Comparator value	None
GHG reduction target	None
Technologies	
H_2 production technology	Not specified, but must use renewable energy as an integral part of the reaction
Dedicated energy sources	Renewable energy (RED II Art. 2(1)) except for biomass [75]
Dedicated CO_2 sources	Biogenic, atmospheric, and post-industrial CO_2 [76]
Monitoring and control system	
Chain of custody model	Mass balancing, physical segregation, or controlled blending [77]
Traceability	Sustainability declarations record and accompany the physical flow of sustainable material along the supply chain [78]
Transparency	Freely accessible ISCC documents and information about certificate holders [79]
Labelling	ISCC logo and claim 'ISCC Compliant', voluntary add-on claims are possible

[71] See footnote Nr. 70.
[72] Calculated values from a LCA which is based on an ISO 14040/44 or ISO 14067 and differentiates from the ISCC methodology need to be communicated separately and cannot be used to replace a GHG calculation based on the ISCC methodology.
[73] The PCF is calculated cumulatively within the system boundaries of the respective certified supply chain elements along the supply chain until the life cycle coverage is reached. Accordingly, certain elements of the supply chain are responsible for calculating the individual elements of the PCF calculation formula.
[74] The GHG add-on must be implemented in the entire supply chain up to the entity claiming a value on outgoing product. It must always be clearly highlighted on the sustainability declaration of the product if the cradle-to-gate approach is used.
[75] The renewability of electricity can be proven via EACs, PPAs combined with EACs, comparable documentation, or via a direct connection/link of the processing unit with the respective unit producing renewable electricity.
[76] Biogenic CO_2 originates from biomass and atmospheric CO_2 from direct air capture. Post-industrial CO_2 is captured from industrial processes, which use fossil sources to deliberately produce electricity, heat, or materials. The CO_2 must not be produced deliberately for the usage in the PtX production processes.
[77] In processes where electricity enables chemical reactions to produce products, mass balancing is limited a 'proportional' or 'stoichiometric' approach, assigning a sustainable share to all products based on their production ratio per electricity unit used.
[78] Every element in the supply chain that generates, processes or trades sustainable material must be covered by certification. The individually certified market operators issue sustainability declarations for sustainable materials and products to the next element in the supply chain. The sustainability characteristics of a sustainable material are recorded and passed along the supply chain through these sustainability declarations.
[79] Certificates and summary audit reports get published by ISCC.

Certification Process

To be able to analyze the required steps for certification in as much detail as possible, the step of the original certification process described in the ISCC PLUS Certification Guide [80], which relates to the performance of the audit, has been further subdivided here. In addition, a further step 'Sustainable Material Handling' was added at the end to explain the handling of certified products along the supply chain. As the focus of the initial audit is on the procedures necessary for the appropriate implementation and application of the ISCC requirements, the steps 'Internal Risk Assessment', 'Internal PCF Calculation', 'Preparation for the Audit' and 'Independent Risk Assessment', prior to 'Certification Body Audit', have been added here. Instead of the six steps in the original certification process, ten steps are therefore explained below and illustrated in Figure 8. Since ISCC certificates are site specific and valid for one year, a certification audit is required for the PtX processing unit at least every twelve months. These recertification audits are retrospective and focus on the verification of operations and claims made during the previous certification period including the issuance of sustainability declarations [81]. However, this recertification process is not discussed below.

Figure 8: Flow chart of the ISCC PLUS certification process.
Source: Fichter GmbH & Co. KG

Step 1: Selection of Certification Body

Depending on the type of product and market, the economic operator must first select a suitable certification system, which has already been done here with the selection of ISCC PLUS. In addition, the economic operator must select a certification body that is recognised by ISCC and sign a contract with them. ISCC offers a list of all cooperating certification bodies with contact details on its website, which generally conduct audits on a global scale. [82]

Step 2: Registration as ISCC System User

Registration for ISCC certification takes place online by using the registration form on the ISCC website.[83]

Process and eligibility:

- The economic operator must familiarize himself with the ISCC fee structure. Main fees include the certification fee, which is turnover based [84]. The costs associated with the certification bodies are not included in the fee structure and must be discussed with the certification body directly [85].
- The economic operator must use the online-registration form provided by ISCC and fill it completely and truthfully. It can only be submitted after the contract with the certification body has been signed.
- When filing the registration, the economic operator agrees to accept the ISCC Terms of Use [86] valid at the time the registration form is sent.

[80] https://www.iscc-system.org/wp-content/uploads/2023/04/ISCC-PLUS-Certification-Guideline_042023.pdf
[81] A 'sustainability declaration' is a delivery document containing relevant information about the sustainable material that must be issued by the supplier for each delivery of sustainable material within the ISCC certification framework. Produces and suppliers of sustainable fuel often use the term 'proofs of sustainability' (PoS) when referring to sustainability declarations. However, PoS is a term whose application is directly related to the legal provisions under RED II Art. 25 to 30 as proof of target fulfillment within the EU. In the case of biofuels, this means that PoS are issued by the final biofuel producer under ISCC EU. Other than that, all the supply chain elements issue sustainability declarations. Therefore, the term PoS is not used when describing the certification process within ISCC PLUS for PtX products.
[82] https://www.iscc-system.org/certification/certification-bodies/, https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_201_System_Basics-v4.0.pdf
[83] See footnote Nr. 69.
[84] https://www.iscc-system.org/wp-content/uploads/2022/07/ISCC-Fee-Structure-valid-from-01.09.22.pdf
[85] https://www.iscc-system.org/certification/certification-process/certification-fees/
[86] https://www.iscc-system.org/certification/certification-process/iscc-terms-of-use/

- A separate registration process must be done for each operational site that is applying for ISCC certification as the ISCC registration numbers are unique and site-specific.
- The certification body will review the registration and can request changes from the economic operators or ask for further information if required. Before registering economic operators that are not known, ISCC performs rigorous checks by reviewing their certification history. This includes checking new applicants against the lists of valid, withdrawn, and suspended certificates of other voluntary certification schemes, if such lists are available.
- Once ISCC has sent an email confirming the conclusion of a system user agreement between ISCC and the economic operator, the economic operator is a registered ISCC system user. They will then receive a ISCC registration number and access to a comprehensive guide on audit requirements.

Required data and documents are:

- Completed registration form with basic information, including the address of the operational site, legal company information, details of certification body,
- Name and contact details of at least one member of staff who can be contacted by ISCC for all matters regarding the registration or certification,
- Information on the certification history of the economic operator under any other certification scheme recognised under the RED,
- Any additional supporting documents or clarifications if requested by the selected certification body or ISCC during the review process. [87]

STEP 3: INTERNAL RISK ASSESSMENT

Every system user is required to carry out a self-assessment of their adherence to ISCC standards at least annually. This evaluation is a crucial component of the system user's audit preparation process and should concentrate on the ISCC criteria relevant to their specific certification scope and associated risks. The ISCC EU System Document 204 'Risk Management' [88] is equally valid for ISCC PLUS and further classifies various risk indicators, including general risk indicators, those for farms or plantations, and risks for waste residues and by-products. General risks include 'hopping', which means switching certification systems, and individual calculations of GHG emissions.

Process and eligibility:

- The system user can carry out its internal risk assessment based on the principles and risk indicators defined in the ISCC EU System Document 204. The first step during the risk assessment is to identify potential risks by analyzing the risk indicators. The second step of the risk assessment is to evaluate and classify the identified risks.
- Based on the outcome of the self-assessment, the system user should design its internal (quality) management system to adequately address risks that its activities may have on the integrity of ISCC.
- The results of the internal assessment must be documented, reviewed, and signed by the management of the system user. In addition, they must be made available to the certification body during the certification audit.
- All system users are obliged to participate in the integrity checks provided by ISCC as part of the ISCC Integrity Programme.

Required data and documents are:

- Geographical status data,
- Organisational workflows, subcontracting, management of service providers, quality management systems,
- Proof of transparency in reporting, stakeholder relations, conflict of interest handling, and anti-corruption measures,
- Information on the yield or conversion factors of internal processes, individual calculations of GHG emissions (if applicable) and certification history,
- Worker security verification documents,
- Other potential risk indicators. [89]

[87] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_201_System_Basics-v4.0.pdf
[88] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_204_Risk_Management-v4.0.pdf
[89] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_204_Risk_Management-v4.0.pdf, https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_201_System_Basics-v4.0.pdf

Step 4: Internal PCF Calculation

This step has been included to explain the specifics of determining GHG emissions in accordance with the requirements of ISCC and how they relate to the determination of the PCF. In this context, it is important to emphasize that the disclosure of GHG emissions along the supply chain under ISCC PLUS is voluntary and is not subject to any legally binding requirements regarding the GHG calculation methodology to be applied or the savings to be achieved compared to a specified comparative value. However, if the GHG Emissions Add-On is applied, the calculation of the GHG emissions must be based on the ISCC methodology [90] [91]and must be implemented in the entire supply chain up to the entity claiming a value on outgoing product. It could therefore be used for an internal check of the achievable PCF of the respective PtX processing unit and the PCF value at the end of the supply chain, whereby only the first case is discussed below.

Process and eligibility:

- The system user can choose whether the life cycle coverage should be cradle-to-grave or cradle-to-gate. In either case, the GHG add-on must be implemented throughout the supply chain up to the point that specifies a value for the outgoing product.
- The system user must apply the method for calculating GHG emissions specified in the ISCC EU System Document 205 but must consider the deviating requirements of ISCC PLUS especially regarding the electrolysis processes.
- The chain of custody model links the forwarding of the sustainability characteristics and the GHG emissions savings to an individual consignment of material. Therefore, the system user as to specify the chain of custody model to be applied, when issuing sustainable declarations after the processing unit was certified (see Step 10).
- An individual GHG emission calculation is not performed for the whole supply chain but only within the system boundary of a certified supply chain element. Any recipient of physical material must determine the upstream transport emissions and must transmit these values to the recipient of the material. The final processing unit also must determine the downstream transport and distribution emissions to the final market.

Required data and documents are:

- Processing unit specifics such as energy- and mass balances including effluents and leakages,
- Emission factors, e.g. for process specific inputs, electricity and heat consumption,
- Sources of used emission factor vales with publication year,
- Records of electricity used in electrolysis processes. [92]

Step 5: Preparation for the Audit

System users should become familiar with the ISCC requirements, as non-compliances with those may delay the certification process. Therefore, ISCC suggests forming an audit team to identify and complete missing information and conduct an internal audit.

Process and eligibility:

- ISCC offers templates for audit procedures that can also be used for internal audits. The audit procedures contain all relevant ISCC requirements. Each requirement is complemented by verification guidance information and information on what evidence may be provided.
- For the raw material category 'renewable-energy-derived' evidence is required to prove the renewability of the electricity. A directly connected renewable energy plant is one of the options, in which case the metering information must be used to prove that the electricity is used to produce hydrogen. Under ISCC PLUS, renewable EACs can only be cancelled to label a product as renewable-energy-derived if the certificate is valid at cancellation time and is cancelled within 18 months of the corresponding energy unit's production.

Required data and documents are:

- All verified data from previous steps,
- All certification scheme names the system user participates in,
- Description of all production and distribution processes with energy and mass balances,
- Individual GHG calculations as well as the input data used for the calculation,

[90] See footnote Nr. 70.
[91] See footnote Nr. 72.
[92] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_205_Greenhouse-Gas-Emissions-v4.0.pdf, https://www.iscc-system.org/wp-content/uploads/2023/08/ISCC-PLUS_v3.4.1.pdf

- EACs, or comparable documentation [93], or evidence of direct connection link of the processing unit with the respective unit producing renewable electricity,
- Databases to handle sustainable material,
- Contracts with relevant subcontractors/service providers, suppliers, and recipients of sustainable products. [94]

STEP 6: INDEPENDENT RISK ASSESSMENT

The certification body must employ a risk-based audit approach for ISCC audits, incorporating new technologies and tools where suitable. Therefore, the certification body carries out an independent risk assessment before auditing a system user to a certain the risk level, which dictates the audit's intensity. The risk level can be categorized as regular, medium, or high. A higher risk rating necessitates a more intense audit, potentially involving a larger sample size, if sampling is part of the audit, and/or a greater number of documents for the certification body to verify. During this risk assessment, the certification body should consider the self-assessment results from the system user and the design of the user's management system, especially in relation to the identified risks. An important part of the independent risk assessment is the evaluation of the certification history of the system user. The certification body must check whether the scheme user is currently suspended or excluded from certification under another certification scheme recognized under RED II. Once the risk has been identified and evaluated, it must be effectively managed to continuously reduce the likelihood of non-compliance with ISCC requirements. [95]

STEP 7: CERTIFICATION BODY AUDIT

For the initial audit, templates of traceability, quantity bookkeeping, mass balance, and GHG emissions must be readily available to the auditor. In the consequent audits, up-to-date records of such data must be available to the auditor. If a company holds or has held other similar sustainability certifications within the past year, details of these must be shared, including the scheme name and scope. Records related to quantity bookkeeping and mass balance for these other schemes should also be accessible to prevent double accounting of sustainable material and to reduce the risk of scheme hopping, where companies switch schemes to avoid recertification and inspection of previous transactions. Regarding quantity bookkeeping, the auditor for example checks whether discrepancies between the physical stock and the recorded stock arise. A deviation of up to 0.5 % between the physical and recorded stock is acceptable without further clarification.

Audits should be held at the system user's registered site with ISCC for both initial and consequent re-certification audits. Remote ISCC audits are possible under a few extreme conditions if tools providing equal assurance as on-site audits are used, including independent traceability databases. However, ISCC must approve these tools. If a remote audit doesn't provide enough assurance or shows non-conformities with ISCC, the certification body must take further actions for compliance verification. This could involve additional document verification or on-site requirement verification.

Auditors must use the latest Audit Procedure System (APS) during ISCC audits to minimize human errors and automate implausibility detection within audit reports. The certification body must submit audit procedures to ISCC for each conducted certification audit, even those with negative results. For each successful audit, the certification body must prepare and submit both the main audit report and the summary audit report to ISCC based on the audit procedures' collected information. The summary report will be published on the ISCC website with their corresponding certificates. The summary report includes non-confidential information about the audit date, with some details voluntarily provided. It must contain information about the certification body, the certified system user, the risk assessment, a summary of the system user's activities, and audit results.

To obtain an ISCC certificate, all non-compliances must be rectified. The system user must take corrective actions, which the certification body verifies for compliance within 40 days post-audit. If not rectified within this period, the certificate won't be issued, and a re-audit is required. The certification body must report failed audits to ISCC. [96]

STEP 8: CERTIFICATION BODY ISSUES CERTIFICATE

The certification body issues the ISCC certificate after a successful audit confirming compliance with all ISCC requirements. These certificates are valid for a year, with the start and end dates clearly marked on the certificate. The validity begins from the date on the certificate, not from its publication on the ISCC website. Certificates must be issued within 60 days of the audit, including a 40-day window for the system user to make necessary corrections. The certification body can issue a

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[93] Minimum information must fulfil the requirements of RED II, Art. 19(7).
[94] https://www.iscc-system.org/wp-content/uploads/2023/04/ISCC-PLUS-Certification-Guideline_042023.pdf, https://www.iscc-system.org/certification/certification-process/, https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_201_System_Basics-v4.0.pdf
[95] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_204_Risk_Management-v4.0.pdf, https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_201_System_Basics-v4.0.pdf
[96] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_201_System_Basics-v4.0.pdf

certificate up to a week before its validity period to avoid gaps or overlaps between certificates. The validity period can't start before the certificate's issuance date. [97]

STEP 9: Review and Publication by ISCC

Certification bodies must promptly send a copy of the certificate, summary audit report, and other required documents to ISCC upon issuance. ISCC conducts an internal review of the certificate and associated documentation and post these certificates on their website. However, ISCC reserves the right [98] to delay the publication of valid certificates if the provided documentation is incomplete, inconsistent, or if the system user has outstanding payments to ISCC, until all issues are resolved.

A certificate can encompass multiple scopes and its scope can be modified by the certification body within its validity period. The certification body must use the ISCC-provided template for issuing certificates, but can modify the layout as per internal guidelines, ensuring all template information is included. The certification body must update any incorrect information in the certificate, with ISCC being notified of such changes. Each certificate must include a unique certificate identifier, the ISCC seal, logo of the issuing certification body, certificate holder's name and address, name and address of certification body, validity period with start and end date, certification scope, issuance place and date, stamp and signature of issuing certification body, any annexes, as well as version number and date. Depending on the relevant scope to be certified, an annex detailing sustainable material handled or a list of group members covered may be included. [99]

Step 10: Sustainable Material Handling

After the successful completion of the certification process, the system user must issue sustainability declarations for each delivery of sustainable material. Uncertified supply chain elements can't manage sustainable material or issue sustainability declarations. Declarations can't be issued beyond a certificate's validity period. Recipients of sustainable material must verify their supplier's certification at the material's physical dispatch date. Sustainability declarations must contain a range of information specified in ISCC PLUS System Document [100]. However, no provisions are made regarding the form or layout of the sustainability declarations. The interrelation of a sustainability declaration and the respective physical delivery depends on the chain of custody option applied.

The various methods for managing the chain of custody of sustainable materials throughout the supply chain include product segregation, mass balance, and controlled blending. ISCC PLUS outlines specific requirements for attributing sustainability criteria to outgoing material batches on sustainability declarations. For segregated deliveries, the sustainability declaration accurately represents the physically delivered product. However, if traceability is based on mass balance or controlled blending, the sustainability declaration may not exactly match the physically delivered product. This is because the mass balance and controlled blending system maintains the sustainability attributes of material batches on a bookkeeping basis, even when physical mixing of materials with varying sustainability characteristics, including sustainable and non-sustainable materials, is permitted. Nonetheless, the sustainability declaration should at least correspond to the product group of the physically delivered product. [101]

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[97] https://www.iscc-system.org/certification/certification-process/, https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_201_System_Basics-v4.0.pdf
[98] https://www.iscc-system.org/updates/27-october-2023/
[99] See footnote Nr. 97.
[100] https://www.iscc-system.org/wp-content/uploads/2023/08/ISCC-PLUS_v3.4.1.pdf
[101] https://www.iscc-system.org/wp-content/uploads/2022/05/ISCC_EU_203_Traceability_and_Chain-of-Custody-v4.0.pdf, https://www.iscc-system.org/wp-content/uploads/2023/08/ISCC-PLUS_v3.4.1.pdf

Case Study for Ammonia

Brazilian Company C harnesses wind and solar power via a PPA to produce hydrogen which is then used for the synthesis of ammonia. The renewable hydrogen is produced in an electrolysis process with a capacity of over 500 MW, whereby the required deionized water is obtained from seawater by means of a desalination process. The produced hydrogen is compressed and combined with nitrogen (N_2) from an Air Separation Anit (ASU) to produce ammonia (NH_3). The required energy sources are directly connected to the ammonia plant. The renewable ammonia is transported through a short-distance pipeline to a nearby port. The ammonia is transformed back into hydrogen at the port in Europe prior to its delivery via pipeline to the off-taker. This hydrogen is then utilized as chemical feedstock in a refinery, which produces fuel for the mobility sector. Figure 9 contains a graphical representation of the value chain considered in this case study. The corresponding certification steps are briefly explained below focusing on the activities of Company C.

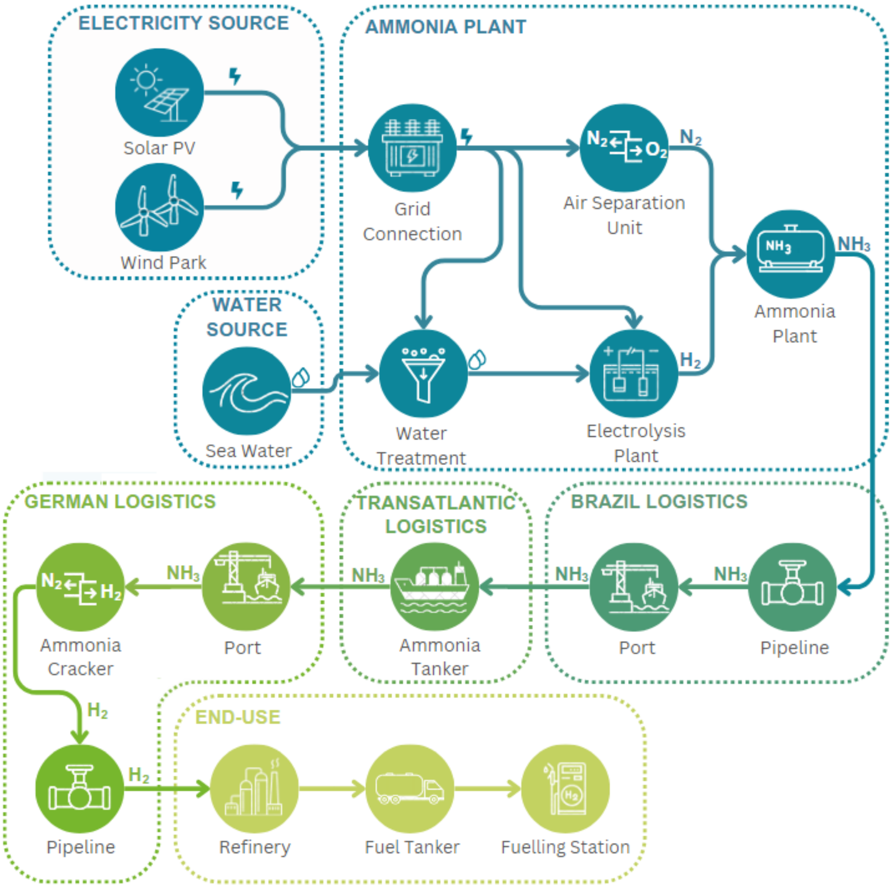


Figure 9: Elements of the value chain for the case study of green ammonia.
Source: Fichtner GmbH & Co. KG

Step 1: Selection of Certification Body

Company C selects a certification body recognized by ISCC, negotiates the audit fees, and signs a contract with them.

Step 2. Registration as ISCC System User

Company C registers with ISCC by providing all the necessary information, such as company and legal information and the name of the certification body. After acceptance, it receives access to further information about the audit requirements as a system user.

Step 3: Internal Risk Assessment

Company C carries out an internal risk assessment for which it can follow the guidelines provided by ISCC. Potential risks are identified and assessed. Based on this assessment, Company C adapts its management system to address any risks to the integrity of ISCC. The results of the assessment are documented, reviewed, and signed off by Company C's management. In addition, Company C accepts to participate in ISCC's integrity programme.

Step 4: Internal PCF Calculation

Company C decides to monitor the GHG emissions on a voluntary basis. In addition, they decide that the life cycle coverage should be from cradle-to-grave, which means up to the final use of the produced fuel in Germany. As mixing with non-sustainable material is unavoidable for some elements of the value chain, Company C chooses the mass balance approach as the chain of custody model. To obtain the necessary data for the GHG calculation, Company C measures all incoming and outgoing mass and energy flows and determines the respective emission factors or emission intensities where necessary using ISCC compliant official sources. They then calculate the GHG emissions for the ammonia based on the ISCC methodology for actual values (individually calculated values) [102]. The system boundaries for this calculation include the ammonia plant, the electricity and water source (see Figure 9). The resulting GHG emissions per ammonia produced correspond to the PCF from the cradle to the gate.

Step 5: Preparation for the Audit

Company C familiarizes itself with ISCC requirements and puts together an audit team. The audit team collects all the necessary evidence, including 'Certificados de Energia Renovável' (Renewable Energy Certificates or RECs), which prove that the electricity used comes from renewable sources. They complement missing information and conduct an internal audit using ISCC templates.

Step 6: Independent Risk Assessment

The certification body conducts an independent risk assessment prior to the audit to determine the risk level, which influences the depth of the audit of Company C. The certification body considers Company C's internal risk assessment results and management system design. The certification body also evaluates Company C's certification history and checks if it's currently suspended or excluded from any RED II recognized certification scheme.

Step 7: Certification Body Audit

The initial audit occurs at Company C's registered site with ISCC. Company C makes all required information, such as current records on traceability, quantity bookkeeping, mass balance, and GHG emissions, available to the certification body. The certification body submits the audit procedures to ISCC. After the audit, the certification body prepares a summary audit report based on the information gathered during the audit process and submits it to ISCC. Company C carries out corrective actions within a period of 40 days after the audit, which are reviewed by the certification body.

STEP 8: Certification Body Issues Certificate

Within 60 days post-audit, Company C receives the ISCC certificate. The certification body forwards the summary audit report and other required documents to ISCC. Company C pays the fees for the audit to the certification body. The validity of the certificate begins on the date of issue by the certification body.

STEP 9: Review And Publication by ISCC

ISCC conducts an internal review of the audit documents received from the certification body. After Company C has paid any open fees to ISCC, the certificate and the summary report get published.

STEP 10: Sustainable Material Handling

Company C must issue a sustainability declaration for each delivery of sustainable material, which contains the required information in accordance with the ISCC specifications, whereby the layout can be freely chosen. Recipients of sustainable material of Company C must verify its certification at the material's physical dispatch date. Every physical transfer of the ISCC compliant ammonia between the different elements of the value chain is accompanied by a sustainability declaration.

The system boundary for calculating the GHG emissions of hydrogen leaving the ammonia cracking plant extends from the pipeline that delivers ammonia to the harbor in Brazil to the pipeline that delivers hydrogen to the refinery in Germany. The

[102] See footnote Nr. 70.

partial PCF of the ammonia produced by Company C in Brazil are used as an input value for this calculation. Since the refinery in Germany is the final processing unit in the value chain it must determine the downstream transport and distribution emissions to the fueling station in addition to the upstream transport emissions up to the ammonia cracker. The partial PCF of the hydrogen leaving the ammonia cracker is used as an input value. In addition, also the utilization of the fuel must be considered. The resulting value thus gives the cradle-to-grave PCF, which can serve as proof of compliance with voluntary chosen GHG emission limits.

TÜV SÜD Standard CMS 70

Background and Overview

TÜV SÜD is an independent technical testing organization that offers services in the areas of consulting, testing, certification, and training. The TÜV SÜD Standard CMS 70 to produce green hydrogen was introduced in 2011. The latest version is from November 2021, which is based on the requirements of RED II and, in a broader sense, the EU's 'Fit for 55' strategy. The analysis in this report is based on this version. The aim of the TÜV SÜD certification standard is to enable companies to demonstrate their commitment to a sustainable and future-proof energy source and to provide their customers with information on the emissions of their upstream products. [103]

The TÜV SÜD Standard CMS 70 [104] offers the two labels 'GreenHydrogen' and 'GreenHydrogen+' depending on the requirements fulfilled. Hydrogen can be certified and labeled as GreenHydrogen if its production meets the basic requirements defined in TÜV SÜD Standard CMS 70 (see Table 5). In addition to the basic requirements, further requirements are formulated in the standard. If these additional requirements are met, the GreenHydrogen+ label can be used (Table 6).

The TÜV SÜD Standard CMS 70 does not explain which methods are used to implement the two chain of custody models book and claim for the GreenHydrogen label and mass balance for the GreenHydrogen+ label. Consequently, the procedure and tools, e.g. the type of databases used, for managing a change of ownership of the certificates or the associated physical product, especially when tracking product attributes throughout the supply chain, cannot be answered here.

[103] https://www.tuvsud.com/en/themes/hydrogen/hydrogen-services-that-enable-safety-for-your-ideas/green-hydrogen-certification
[104] https://www.tuvsud.com/de-de/-/media/de/industry-service/pdf/broschueren-und-flyer/is/energie/tv-sd-standard-cms-70_grund--und-zusatzanforderungen-deutsch-englisch.pdf

Table 5: Overview of essential PtX features of the TÜV SÜD Standard CMS 70 for GreenHydrogen

Applicability	
Type of PtX products	Hydrogen [105]
Off-take applications	All applications in voluntary/reporting PtX markets
Geographic coverage	Global [106]
Recognition	None [107]
GHG emission savings	
PCF calculation	According to ISO 14040 and ISO 14044 as well as Annex V and VI of RED II [108]
PCF approach	Single [109]
Life cycle coverage	Cradle-to-gate [110]
Comparator value	Application related either 80 g CO_2-eq/$MJ_{LHV,H2}$ [111] or 94 g CO_2-eq/$MJ_{LHV,H2}$ [112]
GHG reduction target	At least 70 % of the comparator value or below 91 g CO_2-eq/$MJ_{LHV,H2}$ [113]
Technologies	
H_2 production technology	No restrictions
Dedicated energy sources	Renewable energy (RED II Art. 2(1)) [114], waste, residual materials, or by-products [115]
Dedicated CO_2 sources	Not applicable, as derivatives are outside the scope
Monitoring and control system	
Chain of custody model	Book and claim
Traceability	Not specified, probably non-existent [116]
Transparency	Standard is freely accessible, no information about certificate holders
Labelling	GreenHydrogen

[105] No indication could be found that derivatives are included in the scope.
[106] The TÜV SÜD Standard CMS 70, although rooted in European law, is essentially applicable globally. It presumes that countries adhere to their own or a state association's rules for producing hydrogen from renewable sources. If such rules are absent in any country, the fundamental requirements outlined in TÜV SÜD Standard CMS 70 are to be followed.
[107] It is planned that the TÜV SÜD Standard CMS 70 will be recognized as an independent criteria system from this date and in the countries that have joined a hydrogen GuO system and can then be shown as an additional quality on a corresponding certificate.
[108] The calculation methodology in the aforementioned documents must be adapted accordingly for hydrogen. The greenhouse gas balance of hydrogen must correspond to a LCA, which is achieved if it complies with the requirements of the GHG Protocol, ISO 14067 or PAS 2050.
[109] The PCF calculation is only carried out once for the selected life cycle coverage.
[110] The system boundary used to determine the GHG impact of the hydrogen produced must include all life cycle stages from the extraction and processing of raw materials to the production and delivery of a marketable product at the factory gate or for injection into the hydrogen or natural gas grid. The system limit at the gate is defined with a purity of at least 99,9 % and a pressure of at least 3,0 MPa.
[111] Applies to certified hydrogen used to produce steam/heating or cooling.
[112] Applies to hydrogen which is not used to produce steam/heating or cooling.
[113] If the hydrogen device was already in operation before the initial certification, the well-to-gate PCF of the hydrogen must be below the threshold value of 91 g CO_2-eq/$MJ_{LHV,H2}$.
[114] For electricity, proof of GuO (within EU) or comparable EAC (outside EU) must be provided; for biogas or biomethane, proof from a national renewable gas register or equivalent must be provided.
[115] No clear indications as to which substances fall into this category. For example, the pyrolysis/gasification of sustainable biomass or sustainable, biogenic residues (e.g. glycerine) is permitted.
[116] No reference to the management of TÜV SÜD Standard CMS 70 certificates in a registry or database system could be found.

Table 6: Overview of essential PtX features of the TÜV SÜD Standard CMS 70 for GreenHydrogen+

Applicability	
Type of PtX products	Hydrogen [117]
Off-take applications	All applications in voluntary/reporting PtX markets
Geographic coverage	Global [118]
Recognition	None [119]
GHG emission savings	
PCF calculation	According to ISO 14040 and ISO 14044 as well as Annex V and VI of RED II [120]
PCF approach	Single or cumulative [121]
Life cycle coverage	Cradle-to-tank [122]
Comparator value	Application related either 80 g CO_2-eq/$MJ_{LHV,H2}$ [123] or 94 g CO_2-eq/$MJ_{LHV,H2}$ [124]
GHG reduction target	At least 70 % of the comparator value or below 91 g CO_2-eq/$MJ_{LHV,H2}$ [125]
Technologies	
H_2 production technology	No restrictions
Dedicated energy sources	Renewable energy (RED II Art. 2(1)) [126], waste, residual materials, or by-products [127]
Dedicated CO_2 sources	Not applicable, as derivatives are outside the scope
Monitoring and control system	
Chain of custody model	Mass balancing [128]
Traceability	Not specified, probably non-existent [129]
Transparency	Standard is freely accessible, no information about certificate holders
Labelling	GreenHydrogen+

[117] See footnote Nr. 105.
[118] See footnote Nr. 106.
[119] See footnote Nr. 107.
[120] See footnote Nr. 108.
[121] The entire supply chain from the generation plant to delivery to the end consumer is part of the scope of certification or must be certified separately according to this standard or according to the TÜV SÜD Standard CMS 70 including GHG balancing.
[122] The system boundary for meeting the additional requirements for GreenHydrogen+ does not end at the gate of the production plant but includes transportation and possible conditioning steps up to the delivery point at the customer's premises or up to delivery to the filling station.
[123] See footnote Nr. 111.
[124] See footnote Nr. 112.
[125] See footnote Nr. 113.
[126] See footnote Nr. 114. Statutorily subsidized electricity from renewable energy that receives an increased payment per kilowatt hour fed into the grid (production support) is not recognized for GreenHydrogen+ unless it was purchased in a nationally regulated auction as defined by RED II. For the use of electricity from renewable energies in an electrolyzer, requirements are formulated for the renewable electricity installation time, grid supply and simultaneous generation as well as grid supply and regionality or avoidance of grid bottlenecks.
[127] See footnote Nr. 115. For the production from glycerin, other biomass (pyro-reforming) or from biomethane (steam-reforming), a mass balance sustainability proof according to RED II is required.
[128] The physical hydrogen and the certified renewable, climate-protecting (green) attribute must be always marketed together (bundled).
[129] See footnote Nr. 116.

Summary of Findings and Conclusion

The transition to more sustainable energy solutions and to a decarbonized economy has led to the development of various certification systems to guarantee the quality and authenticity of sustainably produced materials, fuels, and energy carriers. Green hydrogen can contribute to this transition as an energy source and as a raw material for various products. The CertifHy™ Scheme, TÜV Rheinland Standard H2.21, ISCC PLUS, TÜV SÜD Standard CMS 70 stand as prominent examples of such certification schemes within the hydrogen sector. Each has its nuances, objectives, and operational models, which can result in different practical implications for entities seeking certification.

After the various certification systems have been examined in detail in the previous chapters, they are compared in this chapter based on the identified essential PtX features. To this end, similarities and differences in the categories of applicability, GHG emission savings, technologies, as well as monitoring and control system are explained. Finally, the certification process for the CertifHy™ Scheme, the TÜV Rheinland Standard H2.21 and ISCC PLUS are compared.

Applicability

Regarding the applicability of the certification schemes, the different objectives of the respective certification scheme owners in relation to the target group for the use of the certified PtX products must be emphasized. Three categories can be distinguished here:

- The first category comprises PoS-type certification schemes, which are intended to serve as proof of compliance with RFNBO targets within the EU and for which it is therefore important that they are recognized by the EC. Appropriately certified RFNBOs can then be used on the corresponding compliance/mandatory markets.
- The second category comprises GoO-type certification schemes. Here, the EU Member States or the designated competent bodies are responsible; recognition by the EC does not take place. As hydrogen GoOs are only used to prove to an end customer that a certain proportion of an energy quantity has been generated from renewable sources, they are only permitted for applications in voluntary/reporting markets. The GoOs are relevant in the compliance market only for electricity producers in the EU, which are obliged to disclose the contribution of each energy source.
- The third category consists of 'customized' certification schemes, which are intended for off-take applications in voluntary/reporting markets based on customer needs. This means that they can be used by a production company to serve the need of its customers who want PtX products with certain individually chosen sustainability criteria. These certificates are not subject to any legal framework, which means that both the sustainability criteria and the chain of custody model can be chosen freely.

Table 7: Comparison of the applicability of selected EU PtX certification schemes.

CertifHy™ Scheme	TÜV Rheinland Standard H2.21	ISCC PLUS with GHG Emissions Add-On	TÜV SÜD Standard CMS 70 for GreenHydrogen	TÜV SÜD Standard CMS 70 for GreenHydrogen+
Type of PtX products				
Hydrogen	Hydrogen and derivatives	Hydrogen and derivatives	Hydrogen	Hydrogen
Off-take applications				
All applications in voluntary/reporting PtX markets	All applications in voluntary/reporting PtX markets	All applications in voluntary/reporting PtX markets	All applications in voluntary/reporting PtX markets	All applications in voluntary/reporting PtX markets
Geographic coverage				
European Union, the European Economic Area and Switzerland	Not specified, probably global	Global	Global	Global
Recognition				
None	None	None	None	None

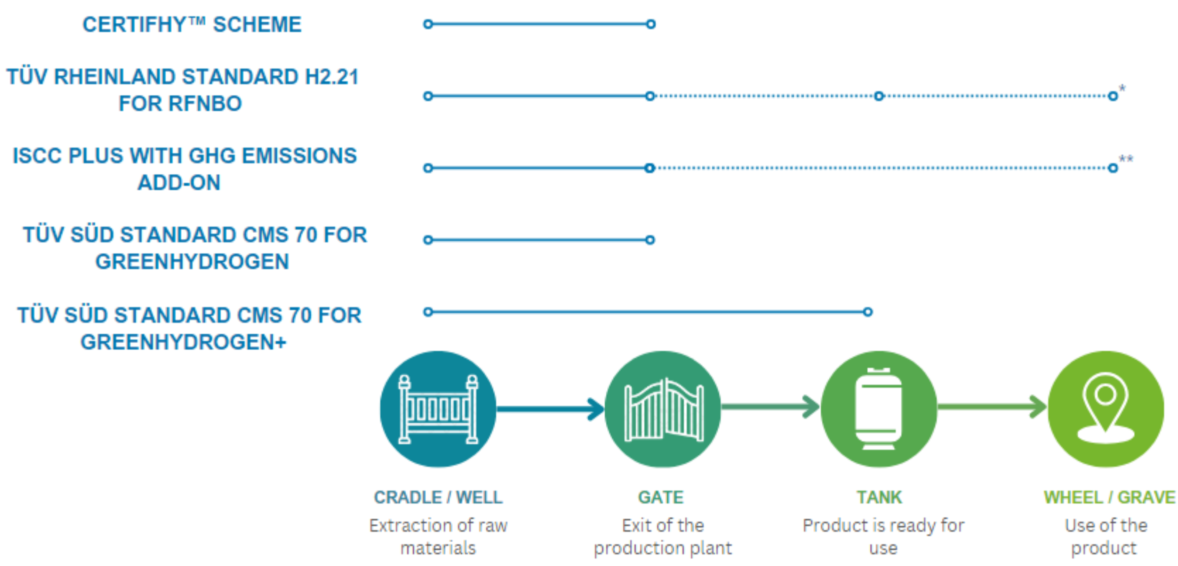
As no certification system for RFNBOs has yet been recognized by the EU, none of the analyzed certification schemes can be assigned to the first category (see Table 7). The CertifHy™ Voluntary Scheme and ISCC EU have both applied for recognition by the EC to certify RFNBOs in the EU. CertifHy™ and TÜV SÜD are striving to have their standards accepted as an independent criteria system for hydrogen specific GoOs, but this step has not yet been taken. Therefore, all certification schemes examined here can currently only be assigned to the third category.

The differences in the type of certifiable PtX products and the geographic coverage (see Table 7) can also be explained based on the three categories. RFNBOs include hydrogen and derivatives, GoOs target only hydrogen that is transported via general supply networks and for customized certification schemes it is useful to be able to cover a wide range of products. In the case of RFNBOs, the relevant RED regulations do not impose any restrictions on the place of production, but the benefits associated with their use can only be claimed within the EU. The designation of hydrogen on GoO is only mandatory within the EU.

GHG Emission Savings

Regarding the GHG emission savings, there are very large differences between the various certification systems (see Table 8). As different PCF calculation methodologies and different end reference points, e.g. gate, tank or wheel/grave, along the value chain are defined for the life cycle coverage within the certification systems, the resulting PCFs are not comparable between the different certification schemes. For better understanding, Figure 10 illustrates the life cycle coverage of the different certification schemes throughout the supply chain. Differences in the life cycle coverage influence the comprehensiveness of each scheme, making them suitable for distinct contexts and target groups. However, in the case of TÜV Rheinland Standard H2.21 and TÜV SÜD Standard CMS 70, it is surprising that the comparator value is not adjusted according to the life cycle coverage.

Notably, the terms 'cradle' and 'well' were often used interchangeably in the different certification schemes. While the term well is traditionally associated with a LCA of fossil fuels, cradle is a broader term used in LCA. The terms wheel and grave were also used interchangeably, which can be attributed to the fact that PtX products are completely consumed during use and are indeed synonymous terms in this case. The fact that different terms are used for one and the same thing is because the certification of PtX products is still under development and neither a standardized nor a specific language usage has been established.



*The TÜV Rheinland Standard H2.21 for RFNBO leaves it up to the customer to decide which life cycle coverage should be used for the certification of the product.
** ISCC PLUS covers the two life cycle options cradle-to-gate and cradle-to-grave. For fuels, energy sources and chemical feedstocks that are completely consumed during use, the term grave corresponds to the term wheel.

Figure 10: Differences in the life cycle coverage of selected certification schemes.
Source: Fichtner GmbH & Co. KG

Table 8: Comparison of the GHG emission saving requirements of different EU PtX certification schemes.

CertifHy™ Scheme	TÜV Rheinland Standard H2.21	ISCC PLUS with GHG Emissions Add-On	TÜV SÜD Standard CMS 70 for GreenHydrogen	TÜV SÜD Standard CMS 70 for GreenHydrogen+
PCF calculation				
CertifHy™ methodology	RED II GHG methodology	ISCC methodology	According to ISO 14040 and ISO 14044 as well as Annex V and VI of RED II	According to ISO 14040 and ISO 14044 as well as Annex V and VI of RED II
PCF approach				
Single	Single	Cumulative	Single	Single or cumulative
Life cycle coverage				
Cradle-to-gate	Cradle-to-X, where X is a point in the life cycle defined by the certification applicant	Cradle-to-gate or cradle-to-grave	Cradle-to-gate	Cradle-to-tank
Comparator value				
91 g CO_2-eq/$MJ_{LHV,H2}$	94 g CO_2-eq/$MJ_{LHV, PtX\ product}$	None	Application related either 80 g CO_2-eq/$MJ_{LHV,H2}$ or 94 g CO_2-eq/$MJ_{LHV,H2}$	Application related either 80 g CO_2-eq/$MJ_{LHV,H2}$ or 94 g CO_2-eq/$MJ_{LHV,H2}$
GHG reduction target				
At least 60 % of the comparator value	At least 70 % of the comparator value	None	At least 70 % of the comparator value or below 91 g CO_2-eq/$MJ_{LHV,H2}$	At least 70 % of the comparator value or below 91 g CO_2-eq/$MJ_{LHV,H2}$

Technologies

The comparison of the technological requirements of the different EU PtX certification schemes is shown in Table 9. Only the TÜV Rheinland Standard H2.21 explicitly specifies that the H_2 production technology must be an electrolysis process of water or aqueous solutions. All other schemes do not state the hydrogen production technology to be used, but indirectly specify the technological requirements via the dedicated energy sources to be used. Regarding the accepted dedicated energy sources, it can be stated that the use of biomass is permitted in the CertifHy™ Scheme and the TÜV SÜD Standard CMS 70 for both GreenHydrogen and GreenHydrogen+. Only TÜV Rheinland Standard H2.21 is aligned with the requirements for energy and CO_2 sources defined in RED II and the corresponding delegated acts for RFNBOs. None of the current versions of the studied certification schemes includes requirements on the technology or source of the water utilized in the production process. The technology, e.g. desalination, can only be considered indirectly via its energy requirement, which increases the PCF.

Table 9: Comparison of the technological requirements of different EU PtX certification schemes.

CertifHy™ Scheme	TÜV Rheinland Standard H2.21	ISCC PLUS with GHG Emissions Add-On	TÜV SÜD Standard CMS 70 for GreenHydrogen	TÜV SÜD Standard CMS 70 for GreenHydrogen+
H_2 production technology				
Not specified, but must use renewable energy as a core energy input	Electrolysis of water or aqueous solutions	Not specified, but must use renewable energy as an integral part of the reaction	No restrictions	No restrictions
Dedicated energy sources				
Renewable energy (RED II Art. 2(1))	Electricity from non-fossil non-biological sources fulfilling criteria for additionality, temporal and geographical correlation	Renewable energy (RED II Art. 2(1)) except for biomass	Renewable energy (RED II Art. 2(1)), waste, residual materials, or by-products	Renewable energy (RED II Art. 2(1)), waste, residual materials, or by-products
Dedicated CO_2 sources				
Not applicable, as derivatives are outside the scope	CO_2 sources outlined in the RED II GHG methodology	Biogenic, atmospheric, and post-industrial CO_2	Not applicable, as derivatives are outside the scope	Not applicable, as derivatives are outside the scope

Monitoring and Control System

The chain of custody models used differ depending on the type and purpose of the certification as can be seen in Table 10. Both the book-and-claim model, which is typically used for GoO certificates, and the mass balancing model, which is prescribed for PoS certificates, are used. Only in the case of ISCC, there are two further models, but strictly speaking these represent a special case of mass balancing. In the case of TÜV Rheinland Standard H2.21, it was not possible to clarify how the actual monitoring management of certificates along the value chain is accomplished.

Another difference lies in the number and detail of publicly available guidance documents. While some certification schemes provide comprehensive guidance, procedure manuals and reference materials for stakeholders, others provide a more condensed version or limit public access. Publicly available guidelines provide more transparency, making it easier to analyze the suitability of a certification system for a company's purposes.

Table 10: Comparison of the monitoring and control system of different EU PtX certification schemes.

CertifHy™ Scheme	TÜV Rheinland Standard H2.21	ISCC PLUS with GHG Emissions Add-On	TÜV SÜD Standard CMS 70 for GreenHydrogen	TÜV SÜD Standard CMS 70 for GreenHydrogen+
Chain of custody model				
Book and claim	Not specified, probably non-existent	Mass balancing, physical segregation, or controlled blending	Book and claim	Mass balancing
Traceability				
CertifHy™ certificates are managed in the CertifHy™ registry	Not specified, probably non-existent	Sustainability declarations record and accompany the physical flow of sustainable material along the supply chain	Not specified, probably non-existent	Not specified, probably non-existent
Transparency				
Freely accessible CertifHy™ documents and different reports are available in the CertifHy™ registry	Standard is freely accessible, no information about certificate holders	Freely accessible ISCC documents and information about certificate holders	Standard is freely accessible, no information about certificate holders	Standard is freely accessible, no information about certificate holders
Labelling				
CertifHy™ Green Hydrogen	TÜV Rheinland test mark and keywords	ISCC logo and claim 'ISCC Compliant', voluntary add-on claims are possible	GreenHydrogen	GreenHydrogen+

Certification Process

The certification process, which was divided into various steps as part of this analysis, shows clear differences between the various certification schemes. Figure 11 provides a comparative overview. However, it should be noted that each of the analyzed certification processes ultimately leads to the award of a certificate. Due to the very different nature and purpose of these certificates, the underlying procedures for their issuance are also difficult to compare.

Each of the steps shown in Figure 11 involves a series of actions to be carried out by the various actors involved, which vary depending on the complexity of the certification process. This has a corresponding effect on the effort required by a company wishing to have its products certified. An audit of the production facility takes place in all the certification schemes examined. In the case of the TÜV Rheinland Standard H2.21 the end of the process is already reached when the applying company received the certificate for its production plant. However, within the CertifHy™ Scheme this is comparable with the registration of the production device, which takes place already in step 2 of the certification process. The subsequent steps deal exclusively with the certification of the production batch which also involves audits to be conducted. The issuance and cancellation of the GoO for hydrogen must also be handled by the hydrogen producer for which the CertifHy™ registry has to be used. ISCC PLUS also provides for a review of the accuracy of the sustainability declarations which are issued for each production batch, but this usually only takes place during recertification audits. In addition, the certified company can use its own bookkeeping system, provided it meets the requirements. There are requirements for the type of information a sustainability declaration must contain, but there are no requirements for the layout to be used.

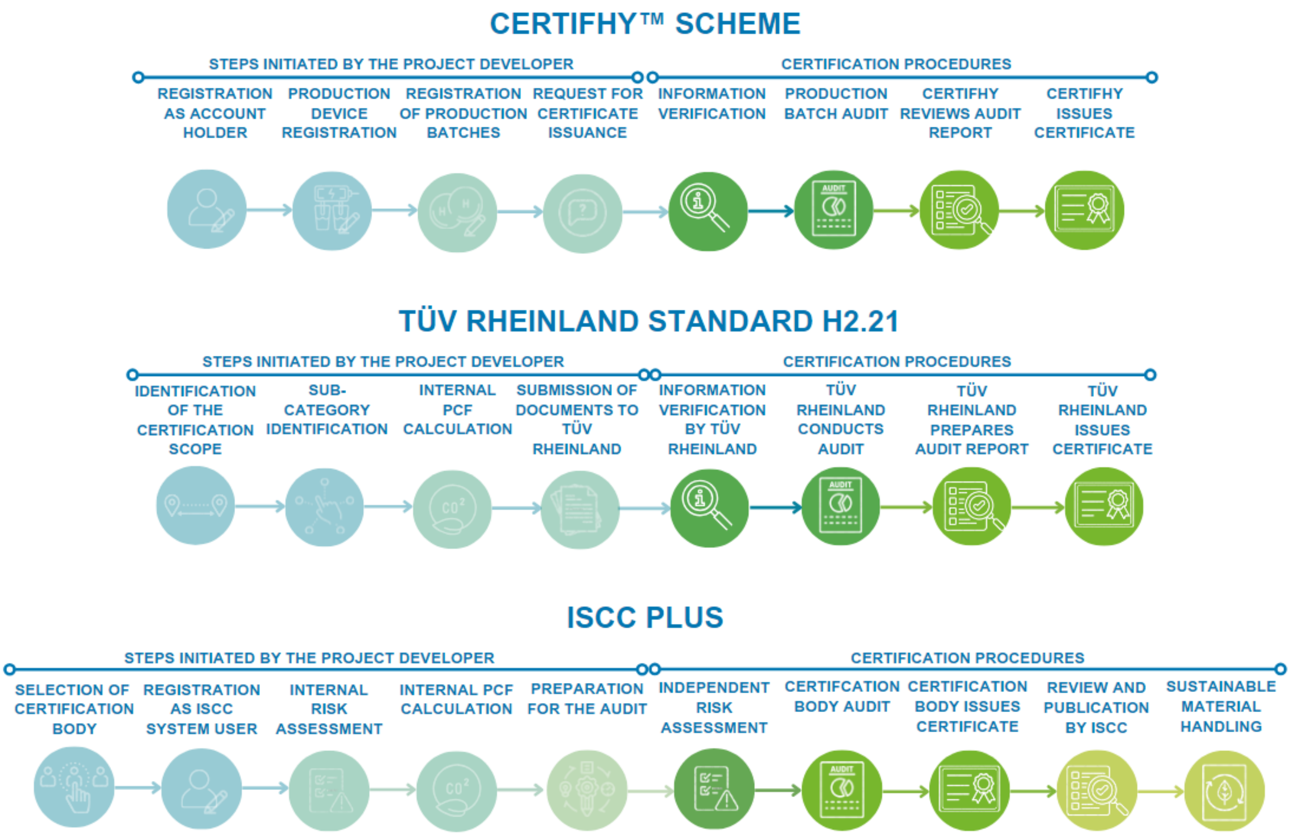


Figure 11: Visual representation of the certification process stages in selected certification schemes.
Source: Fichtner GmbH & Co. KG

Conclusion

All certification schemes examined can only be used to certify PtX products for use in voluntary/reporting markets, for example, by companies to voluntarily disclose their sustainability claims as part of their ESG reporting. Except for the CertifHy™ Scheme, all schemes are globally applicable, which means that they could in principle also be used for domestic purposes by companies in Brazil. As discussed throughout the report, the criteria and methodologies underlying each certification scheme are different. In this regard especially those pertaining to GHG emission saving requirements and technological requirements must be considered by PtX project developers when looking for a suitable certification scheme, as this will determine the scope of interest of their certified product.

The differences outlined between PoS- and GoO-type certificates and the purposes they serve in the European market are important in the context of the development of regulatory requirements for cross-border trade in green PtX products. As part of the digitalization project that forms the framework for this analysis and focuses on global trade, the criteria and methods for the necessary monitoring and control system for PoS are particularly relevant. However, there is currently no certification scheme officially recognized by the EC for the RFNBO compliance/mandatory market in the EU. Consequently, an analysis of such a scheme to clarify open questions on data requirements and stakeholders involved in the certification issuing process was not possible. However, ISCC PLUS and ISCC EU are largely harmonized. ISCC EU has already gained official recognition by the EC to comply with the sustainability and GHG emission saving criteria of the RED II within the biofuel sector. As the regulatory requirements for biofuels and RFNBOs are very similar regarding certification, it is concluded here that ISCC PLUS is the most suitable of the examined schemes to serve as a template for the development of corresponding digital solutions for global trade. In particular, the procedural requirements described in ISCC PLUS for implementing mass balancing as the chain-of-custody model have made it clear that a key challenge in PtX certification is that many different companies are involved along the supply chain, between which information must be exchanged to ensure a successful certification process. This is where digital solutions have enormous potential and can make a valuable contribution to improving the integrity, efficiency and safety of the entire process and pave the way for a more modern global green hydrogen economy.

Annex 1 Carbon Boarder Adjustment Mechanism

Overview of Certification Issues under the Carbon Border Adjustment Mechanism (CBAM)

I. Background and Principles of CBAM

Purpose

The CBAM[130] has been introduced as a new mechanism by the EU as part of its European Green Deal[131] and one of the central pillars of the EU's ambitious Fit for 55 Agenda. One aim of the CBAM is to prevent carbon leakage. Carbon leakage refers to the situation where companies would transfer their production to countries with less strict emission rules for the purpose of lowering their costs. Therefore, the CBAM will impose a carbon cost on imports of certain goods from non-EU countries, ensuring that the price of imports more accurately reflects their carbon content. In addition to preventing carbon leakage, another aim of the CBAM is to encourage non-EU industry and its international partners to reduce their emissions and contribute to a more ambitious climate policy in a broader sense. Products whose countries of origine participate in the EU ETS or have an emissions trading scheme linked to it are therefore excluded from the CBAM, so that carbon price is not paid twice for the same product. This is for instance the case for Switzerland and members of the European Economic area (EEA), namely Norway, Iceland, and Liechtenstein. The CBAM will ensure that the carbon price of imports is equivalent to the carbon price of domestic production, and that the EU's climate objectives are not undermined. CBAM is designed to be compatible with World Trade Organization (WTO) rules.

Legal Anchoring

On July 14, 2021, the European Commission (EC) has published a "Proposal for a Regulation of the European Parliament and of the Council establishing a carbon boarder adjustment mechanism"[132]. On May 15, 2023, the Regulation (EU) 2023/956 of the European Parliament and of the Council of 10 May 2023 establishing a carbon border adjustment mechanism 133, in the following referred to as CBAM Regulation, was finally adopted and published after a lengthy consultation process in the Official Journal of the European Union. The CBAM Regulation is binding in its entirety and directly applicable in all EU Member States. Consequently, CBAM is not implemented by national law in the EU Member States, but at EU level. However, CBAM may have implications for national law, as EU Member States will need to enforce it and may need to adjust their own policies and regulations accordingly. The CBAM Regulation requires each EU Member State to designate a national competent authority (NCA) responsible for implementing the CBAM Regulation. A provisional list of NCAs[134] was drawn up and published in the Official Journal of the EU on February 24, 2024. The EC will regularly revise and update this list of NCAs.

The CBAM does not target countries, but the embedded emissions of products imported into the EU of specific sectors that are within the scope of the EU ETS and the most at risk of carbon leakage. The sectors that have already been considered in the proposal of the CBAM Regulation are "cement", "iron and steel", "aluminum", "fertilizers", and "electricity". With the publication of the CBAM Regulation, Annex I, which refers to the list of goods covered by CBAM and their relevant greenhouse gases, was expanded to include the "chemicals" sector. For the sake of clarity, all goods of the covered sectors listed in Annex I of the CBAM Regulation are referred to as CBAM goods. This also includes some precursors and some downstream products of the sectors. For example, hydrogen is listed in Annex I under the chemicals sector[135] and ammonia under the fertilizer sector, which makes both CBAM goods.

Generally, the CBAM Regulation will be implemented by several implementing regulations, and further secondary legislation such as additional delegated and implementing acts under CBAM. The administrative tasks in the implementation of CBAM will be shared between the EC, the NCA and the customs authorities of the EU Member States. The following implementing regulation has already been published and is ready for use:

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[130] https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en
[131] https://taxation-customs.ec.europa.eu/news/commission-proposes-new-carbon-border-adjustment-mechanism-and-revision-energy-taxation-directive-2021-07-14_en
[132] https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021PC0564
[133] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0956
[134] https://taxation-customs.ec.europa.eu/document/download/5595ce5b-9fd2-42f6-9908-ed6325338ffa_en?filename=231117%20Updated%20provisional%20list%20of%20NCAs.pdf
[135] There is currently no other CBAM good listed.

- Commission Implementing Regulation (EU) 2023/1773 of 17 August 2023 laying down the rules for the application of Regulation (EU) 2023/956 of the European Parliament and of the Council as regards reporting obligations for the purposes of the carbon border adjustment mechanism during the transitional period[136]

For ease of reading, the Commission Implementing Regulation (EU) 2023/1773 of 17 August 2023 will be referred to in the following as "CBAM Implementing Regulation". The CBAM Implementing Regulation sets out details of the transitional reporting obligations for EU importers of CBAM goods and the transitional methodology for calculating embedded emissions released during the manufacturing process of CBAM goods.

Secondary legislation will be prepared in form of additional delegated acts, such as:

- For the accreditation of verifiers (CBAM Regulation Art. 18) and the selling and repurchasing of certificates (CBAM Regulation Art. 20) (publication expected mid-2025) and
- If necessary, on exempted countries, rules on electricity and anti-circumvention.

Secondary legislation will also be prepared in form of additional implementing acts, such as on:

- The authorization of declarants (CBAM Regulation Art. 5 and 17), and the CBAM Registry (CBAM Regulation Art. 14) (publication expected mid-2024).
- The indirect emissions (CBAM Regulation Annex IV), verification (CBAM Regulation Art. 8), accreditation of verifiers (CBAM Regulation Art. 18), carbon price paid (CBAM Regulation Art. 9), information for customs (CBAM Regulation Art. 25), continental shell (CBAM Regulation Art. 2), average ETS price (CBAM Regulation Art. 21), CBAM declaration (CBAM Regulation Art. 6), methodology (CBAM Regulation Art. 7) and free allocations (CBAM Regulation Art. 31) (publication expected mid-2025).

There will also be two review reports prepared by the EC before the end of the transitional period, one due already by the end of 2024 (Article 30(3) of the CBAM Regulation) and the second one by the end of 2025 (Article 30(2) of the CBAM Regulation).

Phases and Principles of CBAM Implementation

CBAM will be implemented in different phases. There will be a transitional and a definitive period. Table 11 outlines the key characteristics of the two distinct periods.

To provide businesses and other countries with legal certainty and stability, the CBAM is being phased in gradually. The transition phase lasts from October 1, 2023, to December 31, 2025, and is designed as a "learning phase". During this period, the "reporting declarant" will be required to submit a "CBAM report" each quarter of a calendar year via the "CBAM Transitional Registry"[137] to the EC. The reporting declarant is the entity which is responsible for the reporting of embedded emissions of imported goods. In principle, the reporting declarant is the "importer" of the CBAM good. However, in practice there are different options depending on the person lodging the customs declaration (see Chapter 3.1). The CBAM report must include information on the CBAM goods imported in terms of volume, embedded direct and indirect emissions and the carbon price due in a country of origin for the embedded emissions in the imported CBAM goods, which is not subject to a rebate or other form of compensation on exportation. There will be simplified rules for determining embedded emissions. The verification of embedded emission data by a third-party verifier is purely voluntary, but incomplete or incorrect CBAM reports might be subject to a correction procedure. To ensure efficient implementation of the reporting obligations, the EC has developed an electronic database called the CBAM Transitional Registry, in which the information reported during the transitional period is collected. Since January 1, 2024, reporting declarants have been able to submit their first CBAM report. The reporting is required for CBAM goods listed in Annex I of the CBAM Regulation, as was explained in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. However, before the end of the transitional period, the EC will collect the information necessary to extend the CBAM scope to other goods than those initially covered and to further develop methods to calculate embedded emissions. Currently, the EC is preparing further secondary legislation, and is carrying out the planned analysis. Based upon a review of the data collected during the transition phase a decision will be taken before 2026 on whether to extend the scope to other goods at risk of carbon leakage.

[136] https://eur-lex.europa.eu/eli/reg_impl/2023/1773/oj
[137] https://cbam.ec.europa.eu/declarant

From 2026, the definitive period of the CBAM will apply. In this period, the CBAM Transitional Registry will be updated to become the CBAM Registry. It will be accessible automatically and in real time to customs authorities and the NCA. CBAM declarants will need to be authorized by their NCA to get access to the CBAM Registry. Only authorized CBAM declarants will be allowed to import CBAM goods into the EU. The authorized declarants will have to bear in addition to the CBAM reporting obligation a surrendering obligation, meaning that they must purchase and surrender "CBAM certificates" for the embedded emissions of their imported CBAM goods. A CBAM certificate is a certificate in electronic format corresponding to one tonne of CO_{2e} of embedded emissions in goods. The surrendering obligation, which results in the number of required CBAM certificates, is determined based on the embedded emissions of the imported CBAM goods minus a reduction for the carbon price paid abroad and an adjustment to reflect free allocation within the EU. The CBAM certificates will be phased in from 2026 to 2033 in line with the phasing out of free allowances under the EU ETS (see Chapter 3.3). From 2034, all embedded emissions of the CBAM goods will be covered by CBAM certificates and no free allocation will be given under the EU ETS for these goods. As the price for CBAM certificates will derive from the EU ETS allowance price, and since Monitoring, Reporting and Verification (MRV) rules have been designed based on the MRV system of the EU ETS, this will equalize the price of carbon incurred between imported CBAM goods and goods produced in installations participating in the EU ETS. Furthermore, in the definitive period the CBAM report will be replaced by the "CBAM declaration", which the authorized CBAM declarant submits via the CBAM Registry to the EC. The CBAM declaration must be submitted annually by 31 May on the previous year's activities and must contain information on the quantity of each type of import, total embedded emission in the goods, number of CBAM certificates surrendered and copies of various verification reports. The verification reports must be prepared by accredited third-party verifiers, which are tasked with verifying the declared embedded emissions of the CBAM goods. These verifiers must be accredited according to specific accreditation rules to be established by the EC during the transition period. Penalties are imposed if a CBAM declarant brings goods into the customs territory of the Union without complying with the obligations set out in the CBAM Regulation. This includes, for example, the acquisition of too few CBAM certificates.

Table 11: Key characteristics of the implementation phases of CBAM

Features	Transitional Period	Definitive Period
Period	01.10.2023 to 31.12.2025	From 01.01.2026
MRV rules	Monitoring and reporting according to CBAM Implementing Regulation and Article 32, 33 and 35 of CBAM Regulation	Monitoring, reporting and verification according to CBAM Regulation and secondary legislation.
Scope[138]	Cement, iron and steel, aluminum, fertilizers, electricity, and chemicals	Scope might be extended to certain precursors, and a limited number of downstream products. The goal is to include all sectors under EU ETS in the scope by 2030.
Reporting and certification requirements	CBAM report must be submitted quarterly. No CBAM certificates need to be acquired.	The CBAM declaration must be submitted annually. CBAM certificates must be purchased and surrendered annually.
Verification of reported embedded emission data	Not required, but reporting should be as accurately and completely as possible. If verification has been undertaken this should be noted in the CBAM report.	Mandatory verification by an accredited verifier. Copies of verification reports are handed in as part of the CBAM declaration.
Flexibilities	Simplified rules for the determination of embedded emissions are permitted. CBAM reports can be modified up to two months after the reported quarter.	No flexibilities anymore.

Types of Embedded Emissions and CBAM Goods

[138] Scope refers to the covered CBAM goods imported to the EU.

Determining the embedded emissions of CBAM goods is crucial for fulfilling the reporting and surrendering obligations of CBAM, as explained in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. Two types of embedded emissions - "direct emissions" and "indirect emissions" - are distinguished in the CBAM Regulation. Direct embedded emissions cover the emissions generated during the production processes of CBAM goods, including emissions attributed to the production of heating and cooling, irrespective of the location of the production of the heating and cooling. This means that when the production of heating and cooling takes place outside the installations, the resulting emissions are counted as direct embedded emissions. Indirect embedded emissions cover the production of electricity that is consumed during the production of CBAM goods. The direct and indirect embedded emissions of relevant precursors, that are required as input material to produce certain CBAM goods, are also considered when determining the specific embedded emissions.

To determine the embedded emissions at product level, i.e. the CBAM good, the actual emissions of an installation, which means a stationary technical unit where a production process is carried out, are used as a starting point. The installation's emissions are attributed to the emissions of its production processes. For installations in which several production processes take place simultaneously, the CBAM Regulation contains guidelines for the allocation of emissions to the individual processes. The main principle is that emissions should be allocated to the production processes for CBAM goods in proportion to their share of the facility's production to ensure a fair and accurate representation of the carbon footprint of each good. Then all relevant embedded emissions from precursors, if applicable, are added and the result is divided by the activity level of each production process, which gives the "specific embedded emissions" of the goods resulting from the production process. This is in line with the definitions in Annex IV of the CBAM Regulation, where specific embedded emissions are understood to be the embedded emissions of a ton of goods, expressed as tons of CO_{2e} emissions per ton of goods.

Taking these considerations into account, the CBAM Regulation classifies CBAM goods other than electricity into "simple goods" and "complex goods" based on their production processes and associated embedded emissions. Simple goods are goods produced in a production process requiring exclusively precursors and fuels having zero embedded emissions. The approach to determine the embedded emissions of simple goods therefore only involves direct embedded emissions from the production process and, where relevant, indirect embedded emissions from e.g., the production of electricity consumed in the production of that CBAM good. Conversely, complex goods are defined as goods other than simple goods and require a comprehensive account of embedded emissions, since not only direct and, if applicable, indirect embedded emissions but also the embedded emissions of the precursors consumed in the production process must be considered. The calculation process thus requires identifying the specific embedded emissions of these precursors and integrating them into the total embedded emissions calculation. Table 12 illustrates the reporting metrics for embedded emissions for the different CBAM sectors per production unit, as well as the types of greenhouse gases covered, the emissions coverage during the transition period and the definitive regime, and the method for determining direct and indirect embedded emissions.

The basic calculation method for determining the embedded emissions of simple and complex goods is described in Annex IV of the CBAM Regulation. However, the detailed rules for the calculation of embedded emissions have yet to be fully resolved including determining system boundaries of production processes and relevant precursor materials, emission factors, installation-specific values of actual emissions and default values. For the transition phase, the methodologies described in the CBAM Implementing Regulation apply. When developing the methodologies for reporting and calculating the emissions contained in these goods, the specific characteristics of the individual sectors reflecting the EU ETS were considered. Aligning the methodologies for determining embedded emissions of CBAM and the EU ETS is necessary to ensure that imported CBAM goods are burdened in the same way as domestically produced goods.

Table 12: Overview on the embedded emissions to be reported for each CBAM sector[139]

Issue	CBAM good					
	Cement	Fertilizer	Iron/Steel	Aluminum	Chemicals	Electricity
Reporting metrics	per tonne of good					per MWh
Greenhouse gases covered	Only CO_2	CO_2 (plus nitrous oxide for some fertilizer goods)	Only CO_2	CO_2 (plus perfluorocarbons (PFCs) for some aluminum goods)	Only CO_2	Only CO_2

[139] Based on https://taxation-customs.ec.europa.eu/document/download/013fa763-5dce-4726-a204-69fec04d5ce2_en?filename=CBAM_Questions%20and%20Answers.pdf

Emission coverage during transitional period	Direct and indirect		Only direct
Emission coverage during definitive period	Direct and indirect	Only direct, subject to review	Only direct
Method for determining direct embedded emissions	Based on actual emission data (EU Method). Estimations (including default values) can be used for up to 100 % of the specific direct embedded emissions for imports until 30 June 2024 (i.e. CBAM reports due until 31 July 2024) and for up to 20 % of the total specific embedded emissions of complex goods for imports until 31 December 2025.		Based on default values, unless several cumulative conditions are met
Method for determining indirect embedded emissions	Based on actual electricity consumption (EU Method) and default emission factors for electricity unless certain conditions are met (i.e. direct technical connection or power purchase agreement). Estimations (including default values) can be used for up to 100 % of the specific indirect embedded emissions for imports until 30 June 2024.		Not applicable

As shown in Table 12, during the transition phase, the reporting declarant must report both direct and indirect embedded emissions for monitoring purposes for all CBAM goods. In the definitive regime the scope of the CBAM is limited to direct embedded emissions for iron and steel, aluminum, and chemicals, while for cement and fertilizers both direct and indirect embedded emissions must be reported.

Regarding the reporting obligation on embedded emissions of CBAM goods produced in an installation, the CBAM Implementing Regulation provides for flexibility and offers three options for their determination. These are referred to below as the "EU Method", the "Equivalent Method" and the "Estimation Method". Apart from the EU method, their application is limited to certain periods:

- EU Method: The specific embedded emissions of the CBAM goods produced in an installation are determined using one of the following approaches based on the choice of monitoring methodology in accordance with Annex III to the CBAM Implementing Regulation, either
  - Calculation-based approach, which requires the determination of emissions from material flows based on activity data obtained from laboratory analyses or default values using measurement systems and calculation factors, or
  - Measurement-based approach, which requires the determination of emissions from emission sources by continuous measurement of the concentration of the relevant GHGs in the waste gas and the waste gas stream.
- Equivalent Method: Until December 31, 2024, the following three alternatives can be used, if they lead to a similar coverage and accuracy of emissions data as the EU method:
  - A carbon pricing scheme where the production site is located, or
  - A compulsory emission monitoring scheme where the installation is located, or
  - An emission monitoring scheme at the installation which can include verification by an accredited verifier.
- Estimation Method: Until July 31, 2024, for any import of CBAM goods for which the reporting declarant does not have all the information, the reporting declarant may use other methods to determine the embedded emissions, including the default values[140] provided and published by the EC for the transitional period or other default values in accordance with Annex III to the CBAM Implementing Regulation. In such cases, the reporting declarant must specify and refer to the method used to determine these values in the CBAM reports. After July 31, 2024, a quantitative limit will apply for the

[140] https://taxation-customs.ec.europa.eu/system/files/2023-12/Default%20values%20transitional%20period.pdf

remainder of the transition phase in the form that only up to 20 % of the total embedded emissions of complex goods may be based on estimates provided by the operators of the installations. Using the default values provided by the EC is considered an estimate.

Indirect emissions are determined by multiplying the electricity consumed to produce a CBAM good[141] with a relevant emission factor, which could be based on the electricity grid or represent an actual emission factor. For the transitional period, the default emission factors for electricity are based on data from the International Energy Agency. Alternatively, any other emission factor of the country-of-origin grid may be used if it is based on publicly available data. Actual emission factors for electricity may be used in the case of a direct technical link between the electricity-generating source and the installation producing the CBAM good or in the case of a power purchase agreement between the electricity producer and consumer.

Comparison with Other Regimes

When comparing the determination of embedded emissions according to the CBAM with the EU ETS, and the concept of the product carbon footprint (PCF) from a life cycle analysis (LCA) perspective, a clear difference can be observed (see

[141] The amount of electricity consumed is determined using an appropriate method in accordance with the EU method.

Table 13). The scope of the ETS is based on installations carrying out activities that lead to GHG emissions, while the scope of the CBAM is based on goods imported into the EU. To achieve alignment, the CBAM adapts the EU ETS calculation methodologies for emissions at installation level to apply to imported goods. This adjustment involves setting rules that refine the boundaries of the system from whole production facilities to the level of individual goods. Therefore, in the context of the CBAM, the notion of embedded emissions is derived from, yet not entirely consistent with, the concept of a PCF. A PCF typically represents the total GHG emissions associated with a product, measured in tonnes of CO_{2e} per unit of product, and considers all significant emissions across the product's life cycle, including raw material extraction, production, transportation, usage, and disposal. However, the CBAM's scope is more limited than that of a PCF. It aims to encompass only those emissions that would be regulated under the EU ETS if the production occurred within the EU. As a result, the CBAM, like the EU ETS, excludes downstream emissions related to product use and disposal, as well as emissions from transporting materials between sites and from earlier stages in the supply chain (see *Figure 12*). For example, emissions caused by using mobile machinery, e.g. trucks, forklifts, etc., are excluded from the scope of the CBAM, while emissions caused by transportation on conveyor belts, in pipelines and by the utilization of other stationary equipment within an installation are included. These are the same rules as in the EU ETS. In addition, the CBAM Regulation and the CBAM Implementing Regulation specify that emission factors derived from LCA or life-cycle inventory databases are not accepted for calculating embedded emissions, except under certain specific conditions during the transitional phase. This stance is to ensure that the calculated emissions accurately reflect the scope covered by the EU ETS, avoiding the overestimation of emissions that could result from the broader scope of LCAs (see Figure 13).

The system boundaries for the determination of embedded emissions under CBAM also clearly deviate from the ones used in the GHG calculation methodology for Renewable Fuels of Non-Biological Origin (RFNBOs), which is described in the Commission Delegated Regulation (EU) 2023/1185[142]. The latter covers greenhouse gas emissions along the entire value chain, while the CBAM only takes part of it into account.

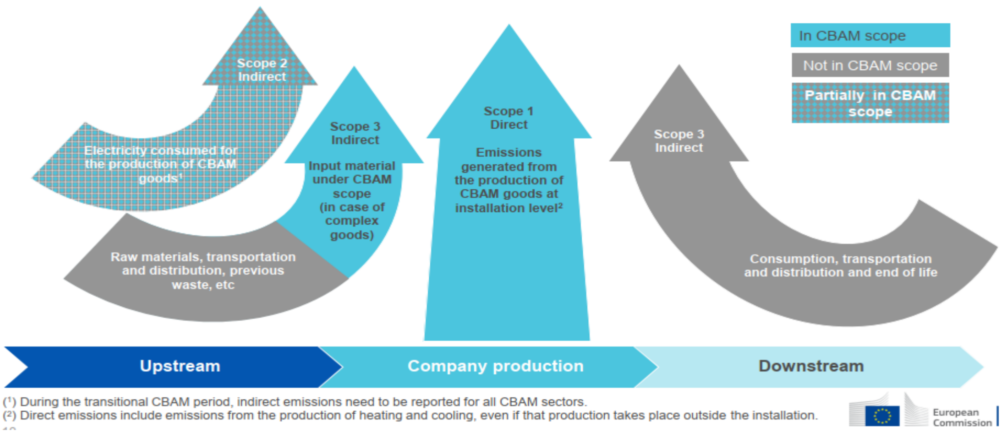

Figure 12: Comparison of GHG protocol scope categories with system boundaries for embedded emissions under CBAM along the value chain.[143]

[142] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1185
[143] https://www.wb6cif.eu/wp-content/uploads/2023/09/Presentation-Implementation-of-the-CBAM_What-changes-for-Western-Balkans-companies_-06.9.23-1.pdf

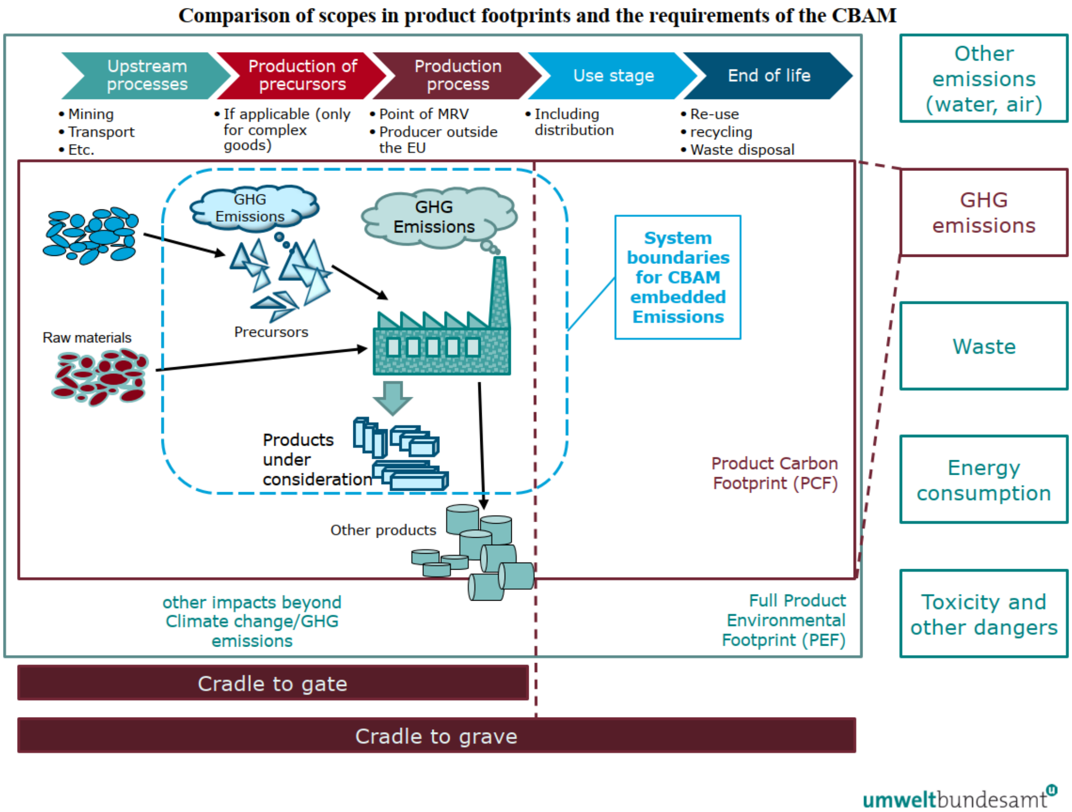

Figure 13: Comparison of the system boundaries of different PCF with the requirements for embedded emissions under CBAM along the value chain.[144]

[144] https://taxation-customs.ec.europa.eu/system/files/2023-11/CBAM%20Guidance_EU%20231121%20for%20web_0.pdf

Table 13: Comparison of the GHG emission scope of the CBAM, the EU ETS, and the definitions contained in widely used standards (ISO 14064-1 and the GHG Protocol)[145]

Parameter	ISO 14064-1 (Annex B)	GHG protocol	EU ETS	CBAM
Direct emissions				
Stationary emissions	Category I	Scope 1	Subject to system boundaries of each EU ETS installation	Direct emissions are defined as "Emissions from the production processes of goods including emissions from the production of heating and cooling consumed during the production processes, regardless of the location of the heating and cooling"
Mobile emissions, e.g. forklift, cars			Outside the scope	Outside the scope
Indirect emissions				
Upstream emissions of heating/cooling imported	Category 2	Scope 2	Covered if produced in an EU ETS installation	Included under direct emissions
Upstream emissions of electricity imported			Covered if produced in an EU ETS installation	Indirect emissions are defined as "Emissions from the production of electricity, which is consumed during the production processes of goods, regardless of the location of the production of the consumed electricity"
Upstream emissions of fuels imported	Category 3	Scope 3	Outside the scope	Outside the scope
Transport emissions			Outside the scope	Outside the scope
Upstream emissions of (precursor) materials imported	Category 4		Covered if produced in an EU ETS installation	To the extent precursors are defined as relevant in the implementing act
Downstream and other emissions, e.g. use of product, end-of-life emissions	Category 5		Outside the scope	Outside the scope

[145] https://taxation-customs.ec.europa.eu/system/files/2023-12/Guidance%20document%20on%20CBAM%20implementation%20for%20installation%20operators%20outside%20the%20EU.pdf

II. CBAM Elements and Their Interdependencies

Transitional Period

By CBAM, a new operational process has been established in the EU that involves different elements. These elements consist of various stakeholders, electronic databases as well as information and workflows that are exchanged between them. The key elements and their interdependencies during the transitional period are shown in Figure 14, which are explained below in the order of the numbering shown. The tasks and responsibilities of the different stakeholders are limited during the transitional period to reporting obligations set out in Article 33, 34 and 35 of the CBAM Regulation. These are also explained below and, where helpful for understanding, the definitions according to the CBAM Regulation and the CBAM Implementing Regulation are given.

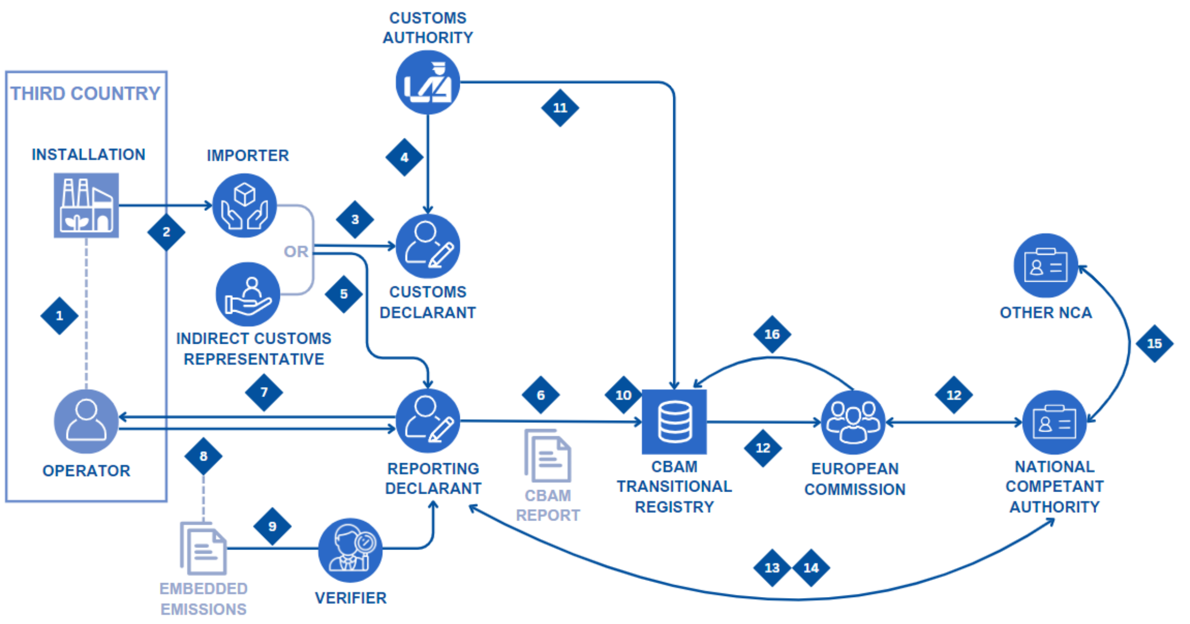

Figure 14: Key elements of CBAM and their interdependencies during the transitional phase.

1. CBAM goods get produced in an "installation" located in a "third country". An installation means a stationary technical unit where a production process is carried out. Third country refers to a country or territory outside the "customs territory of the Union"[146]. The "operator" is the person who operates or controls an installation in a third country.
2. The importer receives CBAM goods from one or various installations. All CBAM goods are listed in Annex I of the CBAM Regulation with a Common Nomenclature (CN) code for their identification[147].
3. For each import, the importer may lodge a customs declaration either on its own behalf or through an appointed direct or indirect customs representative[148]. The person who lodges a customs declaration for the release of goods for free circulation in its own name or on whose behalf such a declaration is lodged becomes the customs declarant. This can be either the importer or its indirect custom representative.
4. The customs authority of the EU Member State concerned is responsible for checking and clearing the import. They are also in charge of assigning the Economic Operators Registration and Identification (EORI) number to businesses, or sometimes individuals, that engage in importing or exporting goods into or out of the EU. During the transitional period, they must inform customs declarants of their CBAM reporting obligation at the latest at the time of import.

[146] What belongs to the customs territory of the Union is defined in Article 4 of Regulation (EU) No 952/2013.
[147] CN (Common Nomenclature) codes are the EU version of the HS (Harmonised System) codes for international trade. CN codes consist usually of 8 digits (the first 6 digits are identical to the HS code). Where Annex I to the CBAM Regulation contains fewer digits, it means that all CN codes starting with those digits are covered.
[148] In case of direct representation, a customs agent lodges a custom declaration in the name of and on behalf of the importer. The importer is the custom declarant and, as such, responsible for the custom declaration. In case of indirect representation, a customs agent lodges a customs declaration in his or her own name but on behalf of an importer. A customs agent who acts as an indirect representative is the customs declarant and, as such, responsible for the content of the declaration.

5. This CBAM reporting obligation applies either to the importer or, in certain cases, to the indirect customs representative, but never to the direct customs representative. The indirect customs representative is automatically responsible if the importer is not established in the EU. If the importer is based in the EU, its CBAM reporting obligation can be transferred to the indirect customs representative if it agrees to this. The person responsible for submitting the CBAM report is referred to as the "reporting declarant". It is important to note that the reporting declarant is not automatically the same as the customs declarant, e.g. if the importer is established within the EU and the indirect custom representative refuses to assume the role of reporting declarant.
6. The reporting obligation of the reporting declarant includes the submission of a report, called "CBAM report", containing information on the goods imported during the quarter in question to the EC no later than one month after the end of the quarter in question. The CBAM reports are due quarterly in accordance with the specified submission deadlines. The last CBAM report in the transitional period covers the months October to December 2025 and is due on January 31, 2026. The CBAM report contains information on
    a. the total quantity of each type of goods, specified for each installation producing the goods in the country of origin,
    b. the actual total embedded emissions,
    c. the total indirect emissions,
    d. the carbon price due in a country of origin for the embedded emissions in the imported goods, considering any rebate or other form of compensation available.
7. To be able to fill out the CBAM report the reporting declarant must request the relevant data on specific embedded emissions of the imported CBAM goods from the operator. In practice, this may involve intermediary traders, who would have to forward the request to the operator of the installation which produced the CBAM goods.
8. The latter respond by providing the requested data, if possible, using the template provided by the EC for this purpose. This communication template[149] is optional and has been developed to facilitate the exchange of information between operators and reporting declarants. The tool allows operators to determine the emissions contained in CBAM goods according to the methodology set out in the CBAM Implementing Regulation.
9. The data on the embedded emissions provided by the operators may be voluntarily verified by third-party verifiers.
10. Once the reporting declarant has received all relevant data, it can submit the CBAM report via the CBAM Transitional Registry[150] to the EC. The CBAM Transitional Registry, developed by the EC and available since October 1, 2023, is a standardized and secured electronic database that contains common IT components for reporting during the transitional period and ensures access, case handling and confidentiality. Among the common IT components are the CBAM Trader Portal, the CBAM User Access Management and the CBAM Competent Authorities Portal with segregated spaces for the NCA and for the EC. The CBAM Transitional Registry also serves as a communication platform between the EC, the NCA, the customs authorities of the EU Member States and reporting declarants. The information collected in the CBAM Transitional Registry will feed into data analysis and collection during the transitional period.
11. The customs authority informs the EC via the CBAM Transitional Registry of the import of CBAM goods, including processed products resulting from the outward processing procedure. Such information includes the EORI number of the customs declarant and of the importer, the eight-digit CN code, the quantity, the country of origin, the date of the customs declaration and the customs procedure.
12. This information provided by the customs authorities is used by the EC to check the completeness and accuracy of the quarterly CBAM reports. An information exchange between the EC and the NCA in the Member States takes place. The EC informs based on the customs data, which reporting declarants are expected to submit CBAM reports. Furthermore,

[149] https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Ftaxation-customs.ec.europa.eu%2Fdocument%2Fdownload%2F2c15cd0e-2447-4ef8-ab70-68b80b66ede8_en%3Ffilename%3DCBAM%2520Communication%2520template%2520for%2520installations_en_071123.xlsx%26prefLang%3Dde&wdOrigin=BROWSELINK

[150] For access to the transitional registry: https://customs.ec.europa.eu/taxud/uumds/cas/uumds-wayf/wayf?loginRequestId=ECAS_LR-220058-jnxFlBUiIW2DdzhmaLAyooQGQ6W72p6OuUQloJUTkHTPNTII1S43TAEml4EHCVWEPStYGyM3wy4k59HfQkMzlzG-CiDsmZJBYJeAB3PRRszzzK0-czKUPNzrfY2UEtKmCDKl3Y8jzRCGN3xSlELTK70hbrBBwXZbC4k4wBodtR9LhZQCS81bSzsoVMIS28y4Yc77sYC

the EC can perform spot checks of actual CBAM reports and check their completeness with regards to the customs data. Where irregularities are identified, the EC informs the NCA of this.

13. The NCA will then follow up, usually by getting in contact with the reporting declarant and requesting rectification of the irregularity, or submission of the missing CBAM report. If the reporting declarant does not correct the mistakes, the NCA can ultimately impose a financial penalty where appropriate. Reporting declarants may face penalties between EUR 10 and EUR 50 per tonne of unreported emissions.
14. In addition, the tasks and responsibilities of the NCA include verifying the legitimacy of reporting declarant's resident in their Member State who submit a request for access to the CBAM Transitional Registry, subsequently granting access permission in the event of a consistent check.
15. Each NCA is responsible for the enforcement of certain provisions of the CBAM Regulation, on which they exchange relevant information with each other.
16. The EC manages the CBAM Transitional Registry and makes the information available to the NCA and the customs authorities. It regularly updates the list of NCAs, monitors the implementation of CBAM, progress, and risk of circumvention, as well as analyzes the impact of CBAM on exports, downstream products, trade flows and Least Developed Countries. It will also prepare secondary legislation with a view to the definitive regime (see Chapter 2.2). Furthermore, the EC provides a dedicated website for the CBAM, with further guidance documents, online training materials and webinars, sector-specific factsheets, and a step-by-step checklist to support businesses during the transitional period[151].

Definitive Period

Further elements will be added to the CBAM system for the definitive period, which are shown in Figure 15. In addition, the tasks and responsibilities of the various stakeholders involved will be expanded so that, in addition to the reporting obligations, there will also be an obligation to verify emission data and to purchase and surrender CBAM certificates. The key elements and their interdependencies, including the tasks and responsibilities of the different stakeholders, are explained below according to the numbering of Figure 15. However, to avoid repetition, only changes compared to the transitional phase are discussed here.

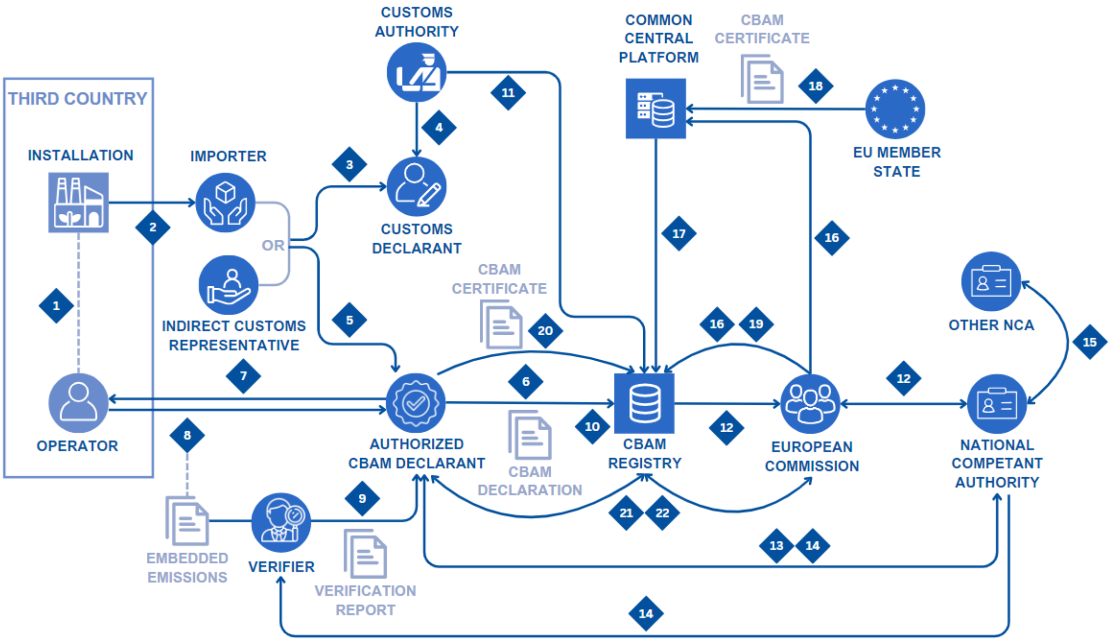

Figure 15: Key elements of CBAM and their interdependencies during the definitive phase.

[151] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4685

1. Corresponds to the transitional period (see Chapter 3.1).
2. Corresponds to the transitional period (see Chapter 3.1).
3. Corresponds to the transitional period (see Chapter 3.1).
4. Corresponds to the transitional period (see Chapter 3.1), with the difference that the customs authorities now draw the attention of the customs declarants to the need to request the status of authorized CBAM declarants. The customs authorities will not allow the import of goods by any person other than an authorized CBAM declarant.
5. Corresponds to the transitional period (see Chapter 3.1), with the difference that the status of reporting declarant will be replaced by the status of authorized CBAM declarant. This means that the importer or the indirect custom representative need to apply to their NCA for the status of authorized CBAM declarant. To be admitted, the applicant must prove that it has not been involved in a serious infringement or repeated infringements of customs law, tax rules, market abuse rules or the CBAM Regulation, that it proves its financial and operational capacity, that it is established in the EU Member State where the application has been submitted and that it has been assigned an EORI number. Once an application has been authorized by the NCA, each authorized CBAM declarant will be assigned a CBAM account number by the EC, which will allow access to the CBAM Registry.
6. The CBAM reporting obligation of the authorized CBAM declarant includes the submission of an annual declaration, called "CBAM declaration", by 31 May, starting in 2027. The CBAM declaration contains information on
    a. the total quantity of each type of CBAM goods imported during the preceding calendar year,
    b. the total embedded emissions in the CBAM goods, calculated and verified in accordance with the CBAM Regulation,
    c. The total number of CBAM certificates corresponding to the total embedded emissions, to be surrendered, after the reduction due on the account of the carbon price paid in a country of origin and the adjustment necessary to reflect the extent to which EU ETS allowances are allocated free of charge,
    d. copies of verification reports, issued by accredited verifiers.
7. Corresponds to the transitional period (see Chapter 3.1), except that the CBAM report is replaced by the CBAM declaration.
8. Corresponds to the transitional period (see Chapter 3.1), with the difference that the embedded emissions must be determined using the EU Method. There are no flexibilities anymore.
9. The data on the embedded emissions provided by the operator must be verified by a third-party verifier, which must be accredited in accordance with specific accreditation rules[152]. The verifier must prepare a verification report based on the principles set out in Annex VI of the CBAM Regulation. Copies of the verification reports must be submitted as part of the CBAM declaration.
10. Corresponds to the transitional period (see Chapter 3.1), except that the CBAM Transitional Registry is replaced by the CBAM Registry, and the reporting declarant will become the authorized CBAM declarant.
11. Corresponds to the transitional period (see Chapter 3.1), except that the CBAM Transitional Registry is replaced by the CBAM Registry, and the reporting declarant will become the authorized CBAM declarant.
12. Corresponds to the transitional period (see Chapter 3.1), except that the CBAM Transitional Registry is replaced by the CBAM Registry, and the reporting declarant will become the authorized CBAM declarant.
13. Corresponds to the transitional period (see Chapter 3.1), except that the CBAM Transitional Registry is replaced by the CBAM Registry, and the reporting declarant will become the authorized CBAM declarant.
14. The tasks and responsibilities of the NCA include to grant the status of authorized CBAM declarant if the applicant meets certain criteria (see point 4). In addition, the accreditation of the verifiers will be the task of NCA.
15. Corresponds to the transitional period (see Chapter 3.1).
16. The EC manages the CBAM Registry and makes the information available to the NCA and customs authorities. It will also monitor the implementation of CBAM, progress and risks of circumvention. In addition, the EC will establish and manage the Common Central Platform (CCP) following a joint procurement procedure between the EC and the EU Member States.

[152] The EC will work during the transitional period on secondary legislation that will establish the rules on accreditation and verification. This legislation will encompass two implementing acts, in accordance with Article 8 and 18 of the CBAM Regulation, for the verification principles and the alignment of the verification scopes of the EU ETS and the CBAM, and, secondly, a delegated act in accordance with Article 18 of the CBAM Regulation that will specify the conditions for accreditation of verifiers.

17. The CCP will be established to manage the sale and repurchase of CBAM certificates. The EC and the NCA will have access to the information on the CCP. At the end of each working day, the information on the sale, repurchase and cancellation of CBAM certificates in the CCP is transferred to the CBAM Registry.
18. The Member States sell the CBAM certificates via the CCP to authorized CBAM declarants established in that Member State. The price of the certificates will be calculated by the EC depending on the weekly average auction price of EU ETS allowances expressed in € per tonne of CO_2 emitted.
19. Each CBAM certificate is assigned a unique identification number when it is created. The EC will register the unique identification number and the price and date of sale of the CBAM certificate in the CBAM Registry in the account of the authorized CBAM declarant purchasing that certificate.
20. By 31 May of each year, the authorized CBAM declarant submits several CBAM certificates via the CBAM Registry, which correspond to the embedded emissions declared and verified for the previous calendar year. Surrendered certificates will be removed by the EC from the CBAM Registry. To be able to surrender the correct number of CBAM certificates, the authorized CBAM declarant must ensure that the required number of CBAM certificates is available in its account in the CBAM Registry.
21. After the surrender of CBAM certificates, EU Member States may, upon request, repurchase the excess CBAM certificates remaining in the account of the authorized CBAM declarant. The repurchase request needs to be made no later than 30 June of each year during which the CBAM certificates were surrendered. The number of certificates subject to repurchase is limited to one third of the total number of CBAM certificates purchased by the authorized CBAM declarant during the previous calendar year.
22. On July 1 of each year, the EC cancels all CBAM certificates acquired in the year preceding the previous calendar year and remaining on the account of an authorized CBAM declarant in the CBAM Registry. These CBAM allowances will be canceled without any compensation.

CBAM Interaction and Comparison with EU ETS

Established in 2005, the EU ETS is a cap-and-trade system that limits GHG emissions from major industries, including power and heat generation, aviation, and soon, maritime transport. It operates on a principle where a cap is set on the total amount of certain GHGs that can be emitted, and companies are granted emissions allowances which they can sell or buy depending on their carbon output. To mitigate the risk of carbon leakage, the industry sectors covered by the EU ETS have been receiving a part of their allowances free of charge, which are called "free allowances". The system has evolved over time to reduce the number of free allowances, introducing more stringent caps, and extending its scope to cover more sectors and gases, with the aim of reducing emissions by 62 % by 2030 compared to 2005 levels.

The CBAM mechanism targets carbon-intensive goods and is designed to complement the EU ETS by adjusting the price of imports to reflect their carbon content. The integration of CBAM with EU ETS is evident in the planned phasing-out of free allowances for sectors covered by the EU ETS, occurring simultaneously with the phasing-in of CBAM certificates, ensuring that both, produced goods within the EU and imported goods into the EU are subject to comparable carbon pricing. Table 14 outlines the phasing-in of CBAM certificates and phasing-out of free allowances from 2026 to 2034 under the EU ETS. The percentage of CBAM certificates will gradually increase from 2.5 % in 2026 to 100 % by 2034. Concurrently, the percentage of free allowances under the EU ETS will decrease from 97.5 % in 2026 to 0 % by 2034.

The CBAM has specific features when compared to the EU ETS. This refers to the calculation of the price of CBAM certificates, the possibilities to trade them and their period of validity. The CBAM will guarantee that imported products receive treatment that is no less favorable than that of EU goods, thanks to three key aspects of its design: Firstly, the CBAM acknowledges the "actual values" of emissions contained within products, which means that companies reducing their carbon footprint when exporting to the EU will benefit from lower CBAM charges. Secondly, the cost for CBAM certificates, which importers must acquire for bringing CBAM-regulated goods into the EU, will be aligned with the prices faced by EU producers under the EU ETS. Lastly, any carbon pricing that has been paid in a non-EU country, possibly through an emissions trading system, will be credited against the CBAM charge to prevent double pricing[153]. Unlike the EU ETS the CBAM is not a cap-and-trade system. This means that an unlimited number of CBAM certificates can be purchased. However, these cannot be traded among the authorized CBAM declarants. The buyback of a limited amount of CBAM certificates is only possible for EU Member States, while all surplus CBAM certificates are canceled once a year.

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[153] The EC will develop detailed regulations and procedures to account for carbon prices paid in other countries before the end of the transition period.

Table 14: Phasing-in of CBAM certificates and phasing-out of free EU ETS allowances planned [154]

	2026	2027	2028	2029	2030	2031	2032	2033	2034
CBAM certificates (%)	2.5	5	10	22.5	48.5	61	73.5	86	100
Free EU ETS allowance (%)	97.5	95	90	77.5	51.5	39	26.5	14	0

[154] https://www.europarl.europa.eu/news/en/press-room/20221212IPR64527/climate-change-deal-on-a-more-ambitious-emissions-trading-system-ets

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The International Hydrogen Ramp-up Programme (H2Uppp) of the German Federal Ministry for EconomicAffairs and Climate Action (BMWK) promotes projects and market development for green hydrogen in selected developing and emerging countries as part of the National Hydrogen Strategy.