Deliverable 2:
Benchmark of international practices on low-carbon and green H_2 certification mechanisms

Consultancy Services for Technical Assistance Activity: Recommendations for a Green Hydrogen Certification Scheme in Chile that is compatible with national and international carbon markets

Document prepared by:

HINICIO

Carrera 5 #70A-74, Oficina 301

Bogotá, Colombia

Point of Contact

Julian González
julian.gonzalez@hinicio.com

And

Ludwig-Bölkow-Systemtechnik (LBST)

Daimlerstrasse 15

85521 Ottobrunn, Germany

Point of Contact

Matthias Altmann
Matthias.Altmann@lbst.de

Authors:

Matthias Altmann, Christian Fischer, Alexander Sicheneder

Version 2.0, 08 February 2021

CONTENTS

List of Tables

List of Figures

List of Abbreviations

AIB	Association of Issuing Bodies
CA	Competent Authority
CARB	California Air Resources Board
CCM	Credit Clearance Market
CEA	Commissariat à l'énergie atomique et aux énergies alternatives
CEM H2I	Clean Energy Ministerial Hydrogen initiative
CI	Carbon Intensity
EATS	Energy Attribute Tracking System
EC	European Commission
EEA	European Economic Area
EECS	European Energy Certificate System
EFTA	European Freed Trade Association
EU	European Union
FCH 2 JU	Fuel Cells and Hydrogen Joint Undertaking
FPC	Fuel Pathway Code
GHG	Greenhouse Gas
GO	Guarantee of Origin
H_2	Hydrogen
H2PA TF	Hydrogen Production Analysis Task Force
HRI	Hydrogen Refuelling Infrastructure
IB	Issuing Body
IPCC	Intergovernmental Panel on Climate Change
LBST	Ludwig-Bölkow-Systemtechnik
LCFS	Low Carbon Fuel Standard

NGER	National Greenhouse and Energy Reporting
RED II	Renewable Energy Directive recast (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; OJ L 328, 21.12.2018, p. 82–209)
SC	Supply Certificates
SMR	Steam Methane Reforming
ToR	Terms of Reference
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization
ZEV	Zero Emission Vehicle

1. Executive Summary

This report provides a benchmark of the state and trends of international practices on low-carbon – in general – and renewable – specifically – hydrogen certification, including an analysis of opportunities and implementation challenges of the relevant certification systems. Three systems are described in detail including governance strategies, policy definitions, implementation and operational costs (as far as available), as well as current and projected coverage of hydrogen markets. These are:

- the Low Carbon Fuel Standard (LCFS) in California, USA, since 2011, covering a wide variety of energy carriers supplied to the transport sector with hydrogen first appearing in 2015;
- CertifHy in Europe since 2019 focusing on hydrogen; and
- the TÜV SÜD standard on renewable hydrogen in Germany since 2011.

In addition, an overview is provided of less advanced systems or approaches globally. In addition to national systems or approaches to develop such systems, the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) has established the Hydrogen Production Analysis Task Force (H2PA TF) which is currently working to develop a mutually agreed upon methodology for determining the CO_2 equivalent and other pollutants emissions associated with the production of hydrogen.

While the Californian LCFS is a legal system requiring fuel suppliers to reduce over time the carbon footprint of transport fuels supplied to customers in California, CertifHy and TÜV SÜD are voluntary certifications. Australia intends to establish a hydrogen certification system supporting international trade of domestically produced hydrogen.

The LCFS is managed by a government agency, the California Air Resources Board, based on legal provisions. In contrast, CertifHy is based on a stakeholder platform governance structure where all scheme documents are approved by the stakeholder platform while it is ensured that all provisions are in line with legal provisions at European Union level. The TÜV SÜD hydrogen standard is owned and managed exclusively by TÜV SÜD.

Independent third-party verification, notably of greenhouse gas balances required for certification, has been introduced by the LCFS on 1 January 2020. Verifiers need to comply with specific requirements, do in-person training, and need to be accredited by CARB. CertifHy and the TÜV SÜD standard also require third-party verification. At present, TÜV SÜD carries out third-party verifications under both systems, while these are open to other verifiers demonstrating sufficient competence.

While CertifHy is very transparent with respect to operational costs, very little information is publicly available for the LCFS. Implementation has taken two to three years for both LCFS and CertifHy. The LCFS was amended and adjusted several times since its first implementation. Based on the experiences of the LCFS, CertifHy, and TÜV SÜD, and an anticipated international harmonization through the IPHE, the establishment of a new system in Chile should be possible in less time. A clear definition of the objective(s) is essential for its design and implementation.

This report furthermore provides two case studies on the most relevant systems, namely the Californian LCFS and the European CertifHy.

In the LCFS, companies can generate LCFS credits which they can sell to fuel suppliers obligated to gradually reduce the carbon intensity of their fuels. With respect to hydrogen, credits can be generated either by supplying hydrogen to road vehicles that has a carbon intensity lower than that of regular gasoline or diesel, or by establishing hydrogen refuelling stations in California. In the first case, the number of credits is determined by the carbon reduction achieved through the hydrogen quantities supplied. In the second case, the unused refuelling capacity is rewarded with credits as long as the station supplies hydrogen with at least 40% renewable content; unused capacity is calculated as the installed dispensing capacity minus the hydrogen quantities actually dispensed. At present, credits are worth around 200 USD per metric ton of CO_{2eq} reduced.

CertifHy issues Guarantees of Origin (GO) for the hydrogen quantities certified, which can be traded. In the development of CertifHy in 2018, four hydrogen production facilities were pilot certified. This included steam methane reforming with carbon capture, electrolysis powered by wind energy, and chlor-alkali electrolysis powered by renewable electricity. 76,600 CertifHy hydrogen GOs (equivalent to 2,298 t of hydrogen) were issued, of which 2,870 GOs (86 t of hydrogen) for hydrogen from renewable sources (electricity from wind and/or biogas) and 73,740 (2,212 t) for fossil energy-based hydrogen.

2. Introduction

This report provides a benchmark of the state and trends of international practices on low-carbon -in general- and green -specifically- hydrogen (H_2) certification, including an analysis of opportunities and implementation challenges of the most relevant schemes or mechanisms identified.

The Low Carbon Fuel Standard, California, USA, and CertifHy, Europe, have been identified as the most relevant to Chile given their current development stages. The former is well-established covering a significant market; the latter has been established in Europe representing a potentially large market and is about to be rolled out commercially.

Both schemes are described in detail including governance strategies, policy definitions, implementation and operational costs, as well as current and projected coverage of hydrogen markets, as far as information is available.

Other schemes, mechanisms and approaches are also listed and described, however, in less detail.

Two case studies are provided in which a project or a company made use of the scheme to certify commercialized H_2.

3. Analysis of hydrogen certification internationally

Certification of hydrogen is in its early stages globally. The Low Carbon Fuels Standard of California, USA, has been established in 2011 based on 2009 legislation. CertifHy in Europe has been established in early 2019 on a voluntary basis based on five years of development and with broad stakeholder support. Both schemes cover major markets, and are thus described in detail; further systems, mechanisms and approaches exist or are under development globally. International harmonization is notably pursued by IPHE[1] and is an explicit ambition of CertifHy.

This section includes an overview of the most relevant certification schemes for hydrogen as a first benchmark for Chile. Due to the fact that the different systems analyzed are at different stages of maturity and implementations, the structure and level of depth of the analysis varies by scheme.

[1] IPHE – International Partnership for Hydrogen and Fuel Cells in the Economy – established in 2003, has the mission to facilitate and accelerate the transition to clean and efficient energy and mobility systems using hydrogen and fuel cell technologies across applications and sectors; see section 3.5 below for more details.

The following table shows the main characteristics of the main hydrogen certification systems studied in following chapters:

	Low Carbon Fuel Standard	**CertifHy**	**TÜV SÜD**	**Australia**
Year of establishment	2011	2019	2011	planned for the next years
Public or private	Public/ governmental	private	private	Public/ governmental
Geographic scope	California, USA	Focus on European Economic Area; to be extended internationally	Focus on Germany; but applicable internationally	Australia (for international trade of hydrogen)
Objective	Compliance with legal requirements	Consumer disclosure; to be extended to compliance with legal require-ments in EU	Consumer disclosure (voluntary certification)	Support international trade
Governance	California Air Resources Board	Stakeholder Platform	TÜV SÜD	Not specified yet
Verification	Third-party verification for fuel pathways, otherwise: carried out by CARB	Certification bodies (third party; so far only TÜV SÜD recognized by CertifHy)	Carried out by TÜV SÜD or other certification bodies, who have a valid accreditation for certifications of products	Not specified yet
Quantification of emissions through	CI standard	Guarantee of Origin scheme for Green & Low Carbon Hydrogen	Green Hydrogen standard	Distinction of three types of emission scopes

3.1. Low Carbon Fuel Standard, California, USA

The implementation of the Californian **Low Carbon Fuel Standard** (LCFS) started in 2011 based on a regulation[2] adopted in 2009. The LCFS was adjusted and amended several times over the years. It is designed to encourage the use of cleaner low-carbon transportation fuels in California, encourage the production of those fuels, and therefore, reduce GHG emissions and decrease petroleum dependence in the land transportation sector. The LCFS standards are expressed in terms of the "carbon intensity" of gasoline and diesel fuel and their respective substitutes, which include biofuels,

[2] https://ww3.arb.ca.gov/regact/2009/lcfs09/lcfscombofinal.pdf

hydrogen, and electricity. The LCFS is well-documented and information and data for benchmarking is publicly available.

3.1.1. Policy definitions

Under the Assembly Bill 32 Scoping Plan[3] of 2006, the LCFS was identified as one of the nine discrete early action measures of California to help meet state-wide reductions in GHG emissions. It is a key part of a set of programs in California to cut GHG emissions and other air pollutants.

The LCFS focuses on California's transportation sector and started with the goal to reduce the carbon intensity (CI) of transportation fuels used in California by at least 10 percent by 2020 from a 2010 baseline. In the meanwhile, the California Air Resources Board (CARB) has relaxed legislation so that the reduction target of 10 percent must be met by 2022 rather than 2020. Furthermore, the applicability of the LCFS was extended to 2030. Now the goal is to achieve a reduction of 20 percent by 2030 from the same baseline, which is in line with a state-wide reduction of greenhouse gas (GHG) emissions to 40% below the 1990 level by 2030.

The Californian Executive Order B-48-18 announced a target of 5 million Zero Emission Vehicles (ZEVs) by 2030 and an eight-year $2.5 billion investment initiative to continue the state's clean vehicle rebates.

To achieve this, the LCFS encourages the use and production of cleaner low-carbon transportation fuels, which reduce the overall fuel consumption and therefore petroleum dependency in the transportation sector, and help to achieve air quality benefits. Significant co-benefits of the regulation are the transformation and diversification of the fuel pool in California.

3.1.2. Governance strategies

Within the LCFS framework, regular public workshops take place. In these workshops, potential amendments can be discussed and written stakeholder feedback, which is then shared via the LCFS website,[4] can be provided.

CARB is the overall ruling authority and defines the governing rules of the LCFS: It sets the long-term reductions for the transportation sector in line with the state-wide GHG reductions; it sets the CI standard for each year, and has made it become gradually more stringent over time. Furthermore, CARB publishes all transactions within the LCFS to ensure the transparency and efficiency of the program.

Since 2019, third-party verification of fuel pathway applications as well as of ongoing reporting of CI calculations and documentation is possible. The verification services are performed by qualified and trained verifiers that have demonstrated the absence of

[3] http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.pdf

[4] https://ww2.arb.ca.gov/resources/documents/lcfs-meetings-workshops-archive

conflicts of interest related to current or previous relationships with the LCFS regulated entities, in verifying reported data.

The process of third-party verification is as follows: The regulated entities are required to submit quarterly or annual reports throughout the lifetime of their projects. These reports must include information on the injection rate and volume of fuels, analysis of the CO_2 stream and all metered measurements for the calculation of GHG emissions reductions.

Moreover, all projects must submit an annual compliance report, which must include information on any storage re-evaluation or corrective action undertaken, any events that have led to the implementation of the emergency plan, and results from inspections and tests over the previous year.

If a regulated party fails to report, CARB, which acts within the LCFS framework as quasi-judicial authority, is responsible to set penalties and seek injunctive relief as permitted by State law. Any penalties received are deposited in the air pollution control fund. The use of the latter is restricted and needs to be appropriated by legislation before the funds can be spent.

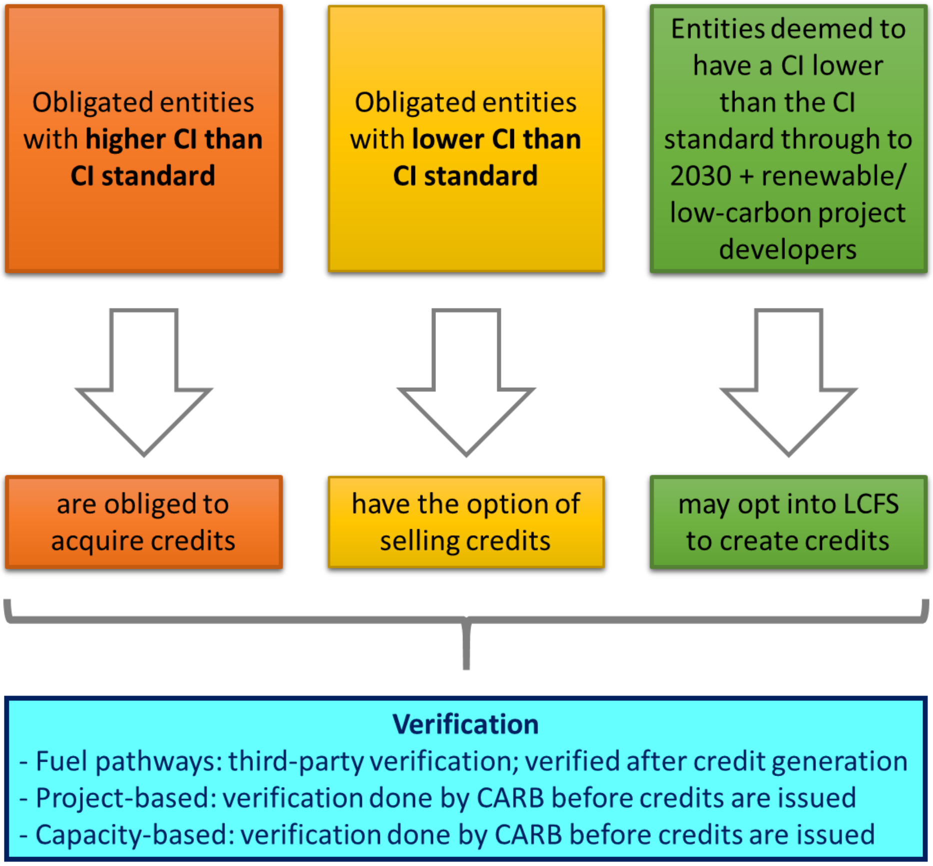
All submitted reports must be verified by an approved verification body which is required to review all plans, assessments and reports, and to summarize their findings in a verification report.

The tasks of a verification body include among others site visits to locations where site-specific CI data is generated, risk-based site visits to specified source feedstock suppliers, verification of CI calculations using verified data, as applicable, interviews with key personnel, review of data management systems, data capture systems, accounting practices, fuel pathway code (FPC) allocation methodology, and supporting evidence for CI and fuel quantity reports.

3.1.3. Implementation and operational costs

The first implementation of the LCFS regulation began on January 1, 2011 by CARB. First amendments to the regulation were implemented on January 1, 2013, which allowed refiners to receive credits for the deployment of innovative crude production technologies, such as solar steam generation or carbon sequestration and capture. On January 1, 2016, the re-adoption of the LCFS became effective to address procedural deficiencies of the original regulation. In 2018, amendments to the regulation were approved, which included strengthening and smoothing the carbon intensity benchmarks through 2030 in line with California's 2030 GHG emission reduction target enacted through Senate Bill32, adding new crediting opportunities to promote zero emission vehicle adoption, alternative jet fuel, carbon capture and sequestration, and advanced technologies to achieve deep decarbonization in the transportation sector. Since then, the goal of the LCFS regulation is to reduce the CI of the transportation sector in California by at least 20 percent by 2030 from a 2010 baseline.

In general, all petroleum fuel producers, importers, refiners and wholesalers selling fuel in California are subject to the LCFS[5] and must meet each year's CI standard established by CARB. CI measures greenhouse gas emissions over the lifespan of a fuel type in grams of carbon dioxide equivalent per megajoule. Fuels that have a CI lower than the target generate LCFS credits, whereas one credit represents one metric ton of carbon dioxide equivalent reduced. Fuels that have a CI higher than the target generate deficits, whereas one deficit represents one metric ton of carbon dioxide equivalent above the target LCFS credits do not expire. A fuel producer with deficits must have enough credits through generation and acquisition to be in annual compliance with the standard. Credit owners can only sell their credits to deficit holders. Credit trade is only allowed among regulated parties. Entities which are deemed to have CI below the CI standard through to 2030 are not mandatory restricted by LCFS. However, to ensure that there are enough credits available, the LCFS regulation allows them as well as renewable energy and low-carbon-fuel project developers, aggregators and utilities to opt into the program and become regulated entities, which enables them to produce and sell LCFS credits. Parties outside the LCFS are not allowed to hold any LCFS credits. The following diagram shows the basic functioning of the LCFS:



[5] More detailed explanation of the regulated parties is provided in section 3.1.4.

There are three ways to generate credits in the LCFS. Credits can be earned by supplying hydrogen for use as a transportation fuel (fuel pathways/ project-based) or by installing zero-emissions-vehicle refueling infrastructure (capacity-based).

Fuel pathways: Providers of low carbon fuels used in Californian transportation generate credits by obtaining a certified CI on their used fuel and reporting transaction quantities on a quarterly basis. Credits are calculated relative to the annual CI standard. Verification occurs after the generation of credits.

Project-based: Projects are defined as actions reducing GHG emissions in the petroleum supply chain as for example carbon-capture-and-sequestration projects do. Crediting for projects is based on life cycle emission reductions. Verification is done by CARB and occurs before credits are issued.

Capacity-based: The 2018 amendments added a new crediting mechanism, which is designed to support the deployment of Zero Emission Vehicle (ZEV) infrastructure. Crediting for ZEV infrastructure is based on the difference between the capacity of the hydrogen station or electric vehicle fast charging site and the actual fuel dispensed. Thus, the number of credits awarded for installing hydrogen fuel infrastructure declines as sales increase. Verification is done by CARB and occurs before credits are issued.

The market for the credits consists of suppliers of petroleum-based fuels. Such companies usually generate deficits and must balance this by buying credits.

The following graph from the Data Dashboard of CARB[6] shows the prices of certificates (red line; left axis) over time and the volume of credits transacted (blue columns; right axis).

Data is available as from January 2013 and show that the LCFS credit prices have increased gradually by showing considerable variation over time. This variation is a result of the dependence of the LCFS credit price on the current demand and the future expected LCFS credit price. A high price volatility provides a weak economic incentive to all stakeholders, which posed a problem to the program. This was solved in 2015 by adding a cost containment mechanism. The mechanism contains of a Credit Clearance Market (CMM), which provides additional compliance flexibility to regulated parties who have not met their previous year-end obligation. The first and so for last CCM was held in 2016 as in all subsequent years the regulated entities met their compliance obligations. The LCFS regulation established the maximum price for credits traded in CCM at $200 in 2016. This price is to be adjusted by a Consumer Price Index deflator in all years subsequent to 2016.This mechanism is providing more certainty in the long-term LCFS credit value. Roughly since the beginning of 2019, the monthly credit price is stable at around $200.

[6] https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

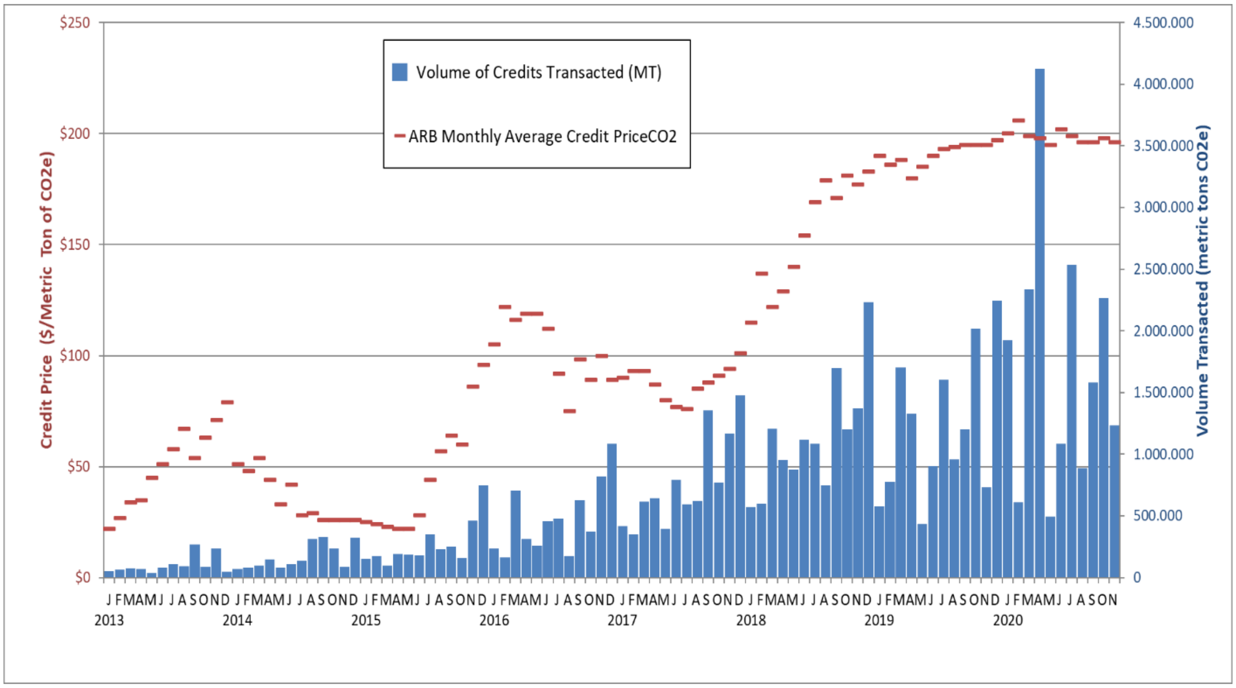


Figure 1: Monthly LCFS Credit Prices

Published information on certification costs under LCFS is scarce. Third-party verifiers need to be accredited by CARB for conducting verification services. CARB has engaged a contractor to assist in development and delivery of LCFS verifier accreditation training. The fee charged by the contractor for delivering the training is not allowed to exceed $1800 for the week-long training program[7].

3.1.4. Current and projected coverage of hydrogen markets

The LCFS geographic scope is limited to the state of California. Here, it specifically focuses on the transportation sector, where it encourages the transformation of the production as well as the use of fuels. Suppliers of fuels deemed to have CI below the standard CI through to 2030 are excluded from the obligation regulated in the LCFS. Nevertheless, these entities are encouraged to participate in the program in order to receive credits for the fuels they sell. Furthermore, fuels used for military vehicles, locomotives, ocean-going vessels (not applicable to recreational or commercial harbor craft) and aircraft as well as fuel suppliers whose combined fuel production is below 420 Million MJ per year are not covered by the LCFS. These exemptions are implemented due to the inter-state, respectively international, nature of these modes of transport, which consequently fall outside the jurisdiction of California.

[7] https://ww2.arb.ca.gov/resources/fact-sheets/accreditation-requirements-third-party-verifiers-californias-low-carbon-fuel

Looking beyond California, one can see that other jurisdictions are joining the LCFS. This is evident in the Pacific Coast Collaborative, which is a regional agreement between California, Oregon, Washington, and British Columbia (Canada), to strategically align policies to reduce GHG emissions, and promote clean energy. CARB has been routinely working with these jurisdictions. Over time, these programs are supposed to build an integrated West Coast market for low-carbon fuels that are expected to create greater market pull and synergistic implementation and enforcement programs. Furthermore, there is engagement with representatives from Canada and Brazil as they develop similar clean fuels program.

3.2. CertifHy, Europe

Financed by the Fuel Cell and Hydrogen Joint Undertaking (FCH JU)[8], a public-private partnership with the European Commission representing the public side, CertifHy[9] has been developed with a wide-ranging number of stakeholders through a consensus-based approach and implemented over the past 6 years. Its development continues, with phase 3 having started recently. CertifHy serves as a catalyst for establishing and implementing an EU-wide Guarantee of Origin (GO) scheme for Green & Low Carbon Hydrogen. The CertifHy Issuing Body has started operation in 2019 on a voluntary, non-governmental basis, with a commercial roll-out having started recently, and as such the number of certifications is still limited.

A CertifHy GO discloses information on the hydrogen production plant (location, start date of operation, operator, subsidies received, etc.), the energy source of the hydrogen, its time of production, greenhouse gas intensity (amount of CO2 equivalent per unit of energy) and date of GO issuing. The scheme is managed and operated from a central registry that takes care of issuance, transfer and cancellation. Two labels have been implemented: 'Renewable Hydrogen' and 'Low-carbon Hydrogen'. Renewable hydrogen is produced frm renewable energies as defined in the Renewable Energy Directive[10], while low-carbon hydrogen is produced from non-renewable energy sources. "In both cases, the greenhouse gas (GHG) intensity of the hydrogen, considering the whole production pathway ("well-to-gate"), is [...] at least 60% below the production of hydrogen from natural gas."[11] The reduction level of 60% was selected as this was the most ambitious reduction level required from biofuels in the Renewable

[8] The first phase of CertifHy received research funding from FCH JU in additional to private contributions by the project partners; in phases 2 and 3, tasks to achieve specific objectives are fully financed by FCH JU, while work required for commercial operation are carried out without FCH JU funding.
[9] https://www.fch.europa.eu/page/certifhy-designing-first-eu-wide-green-hydrogen-guarantee-origin-new-hydrogen-market
[10] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources, Art. 2 (1): "'energy from renewable sources' or 'renewable energy' means 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".
[11] CertifHy, CertifHy - The first European Guarantee of Origin for Green & Low Carbon Hydrogen, https://www.certifhy.eu/images/media/files/CertifHy_Leaflet_final-compressed.pdf

Energy Directive in the adopted version at that time.[12] This reduction value is to be adapted to the recast of the Renewable Energy Directive (RED II)[13] and the delegated acts stipulated therein, as soon as the latter are available (see below for more details).

CertifHy applies a book&claim approach: "The CertifHy GO Scheme allows for the decoupling of physical hydrogen supply and its environmental attributes. As a result, a CertifHy GO enables EU-wide consumption of Green and Low-carbon Hydrogen regardless of geographical location. By using a GO, the corresponding quantity of hydrogen consumed de-facto acquires the properties of the hydrogen covered by the GO."[14] "The GO is cancelled upon use, so that it may only be used once for claiming hydrogen consumed as Green or Low Carbon Hydrogen. The provided electronic cancellation statement includes a link for on-line access to the full GO content."[11]

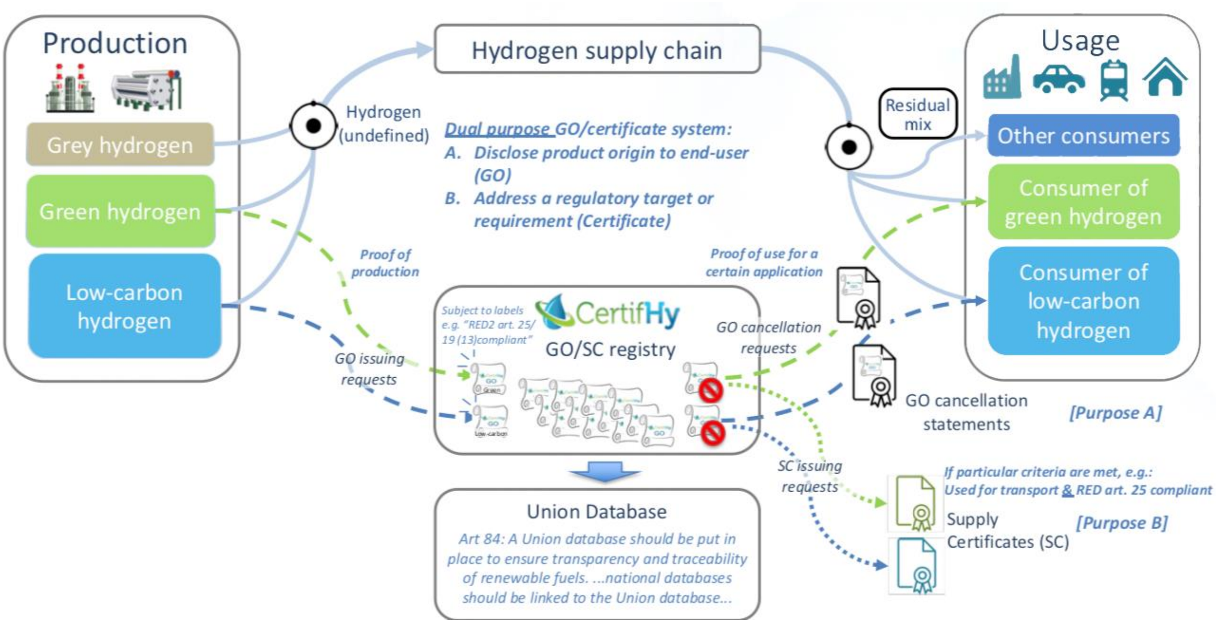


Figure 1 CertifHy Scheme compliant with Art 19, Art 3, 7, 23, 25-27 and 29 of the Renewable Energy Directive II.[15]

[12] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources as amended by Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015.

[13] 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; OJ L 328, 21.12.2018, p. 82–209

[14] FCH 2 JU, 2019, Towards a Dual Hydrogen Certification System for Guarantees of Origin and for the Certification of Renewable Hydrogen in Transport and for Heating & Cooling - Final Report of Phase 2, https://op.europa.eu/en/publication-detail/-/publication/3d66be8f-6284-11ea-b735-01aa75ed71a1/prodSystem-cellar/language-en/format-PDF

[15] Veum K., Vanhoudt W., 2019, CertifHy 2 Final Stakeholder Conference and Plenary Session 4.1 – Perspectives and key actions for the next phase of CertifHy and beyond, https://www.certifhy.eu/images/media/files/Certifhy_2_Other_publications/Perspectives_and_Key_actions_of_CertifHy.pdf

3.2.1. Policy definitions

Article 19 of RED II constitutes the legal footing for Guarantees of Origin (GO) from renewable energy "for the purposes of demonstrating to final customers the share or quantity of energy from renewable sources in an energy supplier's energy mix. [RED II Art 19(1)] […] MS shall ensure that a GO is issued in response to a request from a producer of energy from renewable sources [and] that the same unit of energy from renewable sources is taken into account only once. [RED II Art 19(2)] [To do so] appropriate mechanisms to ensure that GOs are issued, transferred and cancelled electronically and are accurate, reliable and fraud-resistant" [RED II Art 19(6)] in compliance with CEN- EN 16325[16,17] shall be put in place.

A GO in compliance with RED II Art. 19(7) must at least "specify (i) the energy source from which the energy was produced and the start and end dates of production; (ii) whether it relates to electricity; gas, including hydrogen; or heating or cooling; (iii) the identity, location, type and capacity of the installation where the energy was produced; (iv) whether the installation has benefited from investment support and whether the unit of energy has benefited in any other way from a national support scheme, and the type of support scheme; (v) the date on which the installation became operational; and (vi) the date and country of issue and a unique identification number." "MS shall recognise guarantees of origin issued by other MS in accordance with this Directive" [RED II Art. 19(9)] [and GOs issued from third countries] "where the Union has concluded an agreement with that third country on mutual recognition of guarantees of origin issued in the Union and compatible guarantees of origin systems established in that third country, and only where there is direct import or export of energy." [RED II Art 19(11)]

Over the ten years since the adoption of RED, the national electricity GOs have converged through substantial efforts towards a harmonized European approach allowing for transfers of GOs throughout the Union. For hydrogen, phases 1 and 2 of CertifHy have developed harmonized requirements towards renewable hydrogen GOs at European level with broad stakeholder support. Through transposition of the Directive into national law, MS shall ensure that Hydrogen GOs are issued in a similar fashion as GOs have been issued for renewable electricity based on RED. MS are in the process of transposing RED II into national law, including necessary provisions related to hydrogen GOs.

[16] CEN-EN 16325 specifies requirements for Guarantees of Origin of Electricity from all energy sources. As part of the implementation of RED II it is currently being revised to develop an accurate, reliable and fraud-resistant system of Guarantees of Origin (GO) for electricity, gas including hydrogen and heating & cooling. It establishes the relevant terminology and definitions, requirements for registration, issuing, transferring and cancellation in line with the RES, Energy Efficiency and IEM Directives. while covering measuring methods and auditing procedures.

[17] Among CertifHy stakeholders, there is a consensus on the need for coherent standardisation of GOs for all types of energies. This could be addressed through a core standard applicable to GOs for any type of energy carrier, with energy-specifics detailed in schemes.

Specific sectoral targets, such as the one laid out in Article 25 of RED II, are important for the future direction of CertifHy. Article 25 sets a target of 14% renewables in transport by 2030, and electricity and hydrogen are eligible since 2015. However, GOs are not eligible to prove target compliance, i.e. they shall not be used for purposes other than consumer disclosure. In concrete terms, GOs shall not be used for demonstrating compliance with the obligation put on fuel suppliers in the European Union by the Member States based on RED II (articles 25 and following) aimed at increasing the renewable share in transport energy consumption. This has been carried out in principle by national and voluntary schemes in the past (see Art. 30); however, national and voluntary schemes have been limited to biofuels so far. Developing a system that integrates GOs as well as certificates that can be used for target compliance is a major value proposition of the current CertifHy phase for the scheme's future implementation (see section 3.2.3). In this regard, additional regulation including requirements for hydrogen's RED II compliance, that is yet to be passed, is of particular relevance to CertifHy. This includes delegated and implementing acts, which cover Art. 25(2), related to the appropriate minimum thresholds for GHG emissions savings of recycled carbon fuels; Art. 27(3), regarding the additionality framework for a methodology to account for renewable electricity for the production of renewable liquid and gaseous transport fuel of non-biological origin; Art. 28(2+5), the establishment of a Union Database as well as defining the methodology for assessing greenhouse gas emission (GHG) savings from renewable fuels of non-biological origin (RFNBO) and from recycled carbon fuels (RCF); and Art.30(5+8) detailing voluntary schemes' implementation and compliance with the transport target.

In light of the European Green Deal, efforts on many fronts related to hydrogen GOs are expected to be scaled-up to contribute inter alia to supplying clean, affordable and secure energy, mobilizing industry for a clean and circular economy as well as mobilizing research and fostering innovation.[18] The European Commission's Hydrogen strategy envisions hydrogen to play a significant role in these fundamental transitions as an intrinsic part of an "[…] integrated energy system, with at least 40 GW of renewable hydrogen electrolyzers and production of up to 10 million tons of renewable hydrogen in the EU by 2030. [Onwards], renewable hydrogen will be deployed at a large scale across all hard-to-decarbonise sectors."[19]

In order to boost demand and scale-up production of hydrogen, the European Commission aims to introduce a comprehensive terminology and European-wide criteria for the certification of renewable and low-carbon hydrogen by June 2021. A comprehensive terminology and supportive policy framework to efficiently and

---

[18] Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee, and The Committee of the Regions, The European Green Deal, COM/2019/640 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1596443911913&uri=CELEX:52019DC0640#document2

[19] Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee, and The Committee of the Regions, A hydrogen strategy for a climate-neutral Europe, COM/2020/301 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0301

equitably decarbonize particular sectors and geographies will play a key role in achieving these goals. According to the EC, it will include emission thresholds for the promotion of "hydrogen production installations based on their full life-cycle greenhouse gas performance, considering the already existing CertifHy methodologies developed by industry initiatives."[19]

The European Commission envisions a supportive policy framework for hydrogen production, where full life-cycle GHG emission thresholds, similar to CertifHy, "could be defined relative to the existing ETS benchmark for hydrogen production"[ibid.] and an emission reduction target derived from the Renewable Energy Directive. The specific, complementary functions that Guarantees of Origin (GOs) and sustainability certificates already play in the Renewable Energy Directive can facilitate the most cost-effective production and EU-wide trading. This framework shall be developed "in consistency with the EU taxonomy for sustainable investments" [ibid.] as well as "European-wide criteria for the certification of renewable and low-carbon hydrogen possibly building on the existing ETS monitoring, reporting and verification and the provisions set out in the Renewable Energy Directive."[ibid.]

The sustainability criteria of the EU taxonomy related to sustainable investments are potentially of particular interest to third countries on both ends of the public and private equity markets, as they may benefit from investors' geographic diversification in similarly certified assets, partake in a race to the top, or a bigger market for their sustainability criteria compliant energy products.[20] The draft Taxonomy delegated acts set out the technical screening criteria according to which an economic activity (i) would be considered to significantly contribute to climate mitigation and adaptation and (ii) does no significant harm to any of the other environmental objectives. Note that these drafts have not been adopted or endorsed by the European Commission yet.

[20] Taxonomy Delegated Act - Text - 20.11.2020, Taxonomy Delegated Act - Climate Mitigation - 20.11.2020 and Taxonomy Delegated Act - Climate Adaptation - 20.11.2020 can be found here: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy

BOX 1 – CertifHy and the European Energy Certificate System (EECS®)

The EECS® of the Association of Issuing Bodies is "a commercially funded, integrated European framework for issuing, holding, transferring and otherwise processing electronic records (EECS® Certificates) certifying, in relation to specific quantities of output from production devices, attributes of its source and/or the method and quality of its production. […] These certificates will guarantee that for example, the electricity is from a renewable source and has been produced from [e.g.] wind energy. [It serves] to secure, in a manner consistent with the EN-16325 standard, European Union law and relevant national laws, that systems operating within the EECS framework are reliable, secure, and inter-operable."[1] Once a Scheme is adopted in the EECS® Rules, by AIB members' decision, it easily interacts with the other schemes adopted by AIB Members. AIB's legal framework binds the AIB members to the EECS® Rules (as per the AIB Hub Participant Agreement, a contract which allows to use the AIB Hub for cross border transfers).

CertifHy seeks recognition by AIB to become an EECS® Compliant Issuing Body (IB). This IB will contribute within the AIB Gas Scheme Group to the elaboration of an H_2 chapter under EECS®, which can then act as the basis for H_2 GO implementation within all AIB members. Moreover, this IB will focus on giving hydrogen producers and consumers, in countries where no Competent Authority (CA) has been appointed yet, the opportunity to use H_2 GOs, ensuring the highest degree of harmonization, (cost) efficiency and effectiveness.

[1] AIB, 2020, Principles and Rules of Operation, https://www.aib-net.org/sites/default/files/assets/eecs/EECS%20Rules%20Release%207%20v12-web.pdf

3.2.2. Governance strategies

CertifHy has a stakeholder platform governing scheme design and development (see Figure 2).

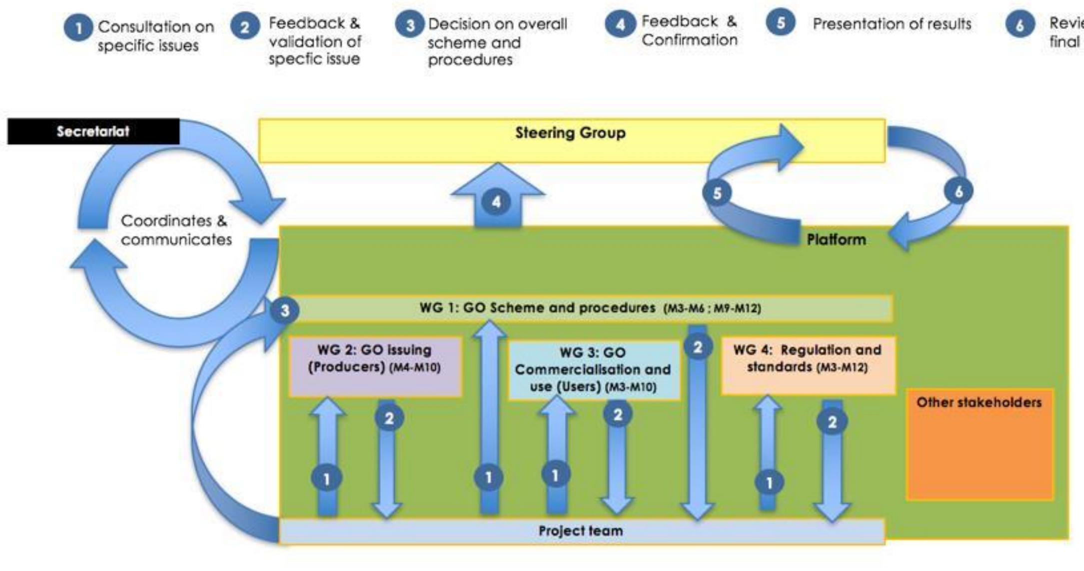


Figure 2 A schematic representation of the different governance bodies and their interactions within the CertifHy stakeholder platform.[21]

Governance structure

With the secretariat support of a consortium led by HINICIO, composed of AIB, CEA, Grexel, Ludwig-Bölkow-Systemtechnik (LBST), and TÜV SÜD, and financed by the FCH 2 JU, CertifHy governs itself in the form of a Stakeholder Platform. This platform brings together a large number and wide range of stakeholders. Currently, nearly a thousand members, inter alia from the private sector, associations and NGOs are part of it, with increasing international participation from the US, Canada, Japan and Australia. This continues to ensure that a broad tapestry of views and interests are being considered in the elaboration of the CertifHy Scheme. In short, it includes all relevant stakeholders that oversee the development and application of the certification scheme and its fit within existing national and international regulation.

The "highly inclusive and successful project governance structure"[21] consists of three main bodies, i.e., the steering group, four working groups[22] and the secretariat. The

[21] FCH 2 JU, 2019, Towards a Dual Hydrogen Certification System for Guarantees of Origin and for the Certification of Renewable Hydrogen in Transport and for Heating & Cooling - Final Report of Phase 2, https://op.europa.eu/en/publication-detail/-/publication/3d66be8f-6284-11ea-b735-01aa75ed71a1/prodSystem-cellar/language-en/format-PDF

[22] A fifth Working Group is about to be established.

Steering Group[23] functions as the Platform's decision-making and conflict resolution body. "It has been consulted on key issues and has provided advice on how to resolve these. It has endorsed the final design of the CertifHy Scheme and its subsidiary documents and the Roadmap. "[21]

The five Working Groups (WG), with representatives of all actors across the GO value chain, provide input for the development of a Europe-wide Green and Low Carbon Hydrogen GO scheme. In particular, WG 1 "has contributed to the design of the overall GO scheme, providing information on how (other) GO schemes function, and what documents need to be developed to ensure the scheme is functional"[21], while drafting all scheme documents and has adjusted them based on feedback from other WGs and the pilot experiences. "WG 2 has focused on reaching consensus on the requirements which should apply to hydrogen production. It has also focused on gathering practical input from GO issuers (hydrogen producers) on their ability to collect and share information to determine whether their hydrogen production can be labelled as Green or Low-carbon. WG 3 has provided input on what information Green and Low-carbon Hydrogen users need from the GO, and sought to define end-user expectations and requirements for a hydrogen GO scheme. WG 4 has focused on identifying alignment issues with current and upcoming regulations, including evaluating whether the current RED 2 Directive presents any barriers to the proposed EU-wide hydrogen GO scheme."[21] A shortly to be established WG 5 for Issuing Bodies and the Pentalateral Energy Forum[24] will work on refining the future lessons learnt from the "H_2 piloting scheme in 4 Domains across 3 Member States (MS), where Issuing Bodies (IB) have been appointed by their relevant Competent Authority: Flanders, Wallonia, Austria, Netherlands."[25] Lastly, the Secretariat is in charge of the coordination, communication and general logistical organization.

GO Scheme structure

The CertifHy GO Scheme has an organizational structure comparable to the EECS. It consists of the following entities and functions: **National Competent Authorities**, usually

[23] "The Steering Group is composed of 2 colleges. The first college represents the Stakeholder Platform Working Groups with each elected Working Group Chairs and co-Chairs holding a position on the Steering Group. The second college regroups European Institutions: the FCH JU (as project financer) and the European Commission's DG MOVE, DG ENER and DG CLIMA." https://www.certifhy.eu/contributors/steering-group.html;. "Each member of the Steering Group holds 1 vote. The representatives of the European Commission hold observer status and therefore hold no vote although they can express their opinions and provide recommendations." CertifHy – Stakeholder Platform Governance rules, V.1 of 11 January 2018, https://www.certifhy.eu/images/180118_SP_Governance_Rules_Draft.V.2.1_CL.pdf

[24] A government-to-government forum comprising the Ministers of Energy from Benelux-DE-FR-AT-CH which already have a dedicated Working Group on GOs to coordinate a harmonized transposition of RED II art.19 at MS level

[25] CertifHy, 2020, Press Release: CertifHy phase III will implement a harmonized H2 Guarantee of Origin (GO) scheme across Europe & beyond, build a market for H2 GO trade in close collaboration with market actors, and design a Certification Scheme for compliance with RED II renewable fuels for transport https://www.certifhy.eu/images/media/files/201214_Press_release_CertifHy_3_Launch_EN_Final.pdf

governmental authorities, to oversee matters related to compliance with national environmental goals, designate competent certification bodies to oversee the deployment of H_2 GOs and to appoint Issuing bodies. Their interaction with CertifHy is described in Box 1 above.

As mentioned above, the **Stakeholder platform**, includes all relevant stakeholders that oversee the development and application of the certification scheme and its fit within existing national and international regulation. Figure 3 shows the schematic stakeholder structure of CertifHy.

Certification Bodies verify the eligibility of production devices through a 'production device audit', and verify the attributes of production batches, i.e. the amount of H_2 produced by a registered production device between any two points in time selected by the Operator for which the quantity of GOs is calculated, through a 'production batch audit'[26]. Certification bodies thus carry out all audits necessary to verify all relevant aspects including the GHG reduction of the produced hydrogen. So far, only one certification body has been recognized by CertifHy, namely TÜV SÜD. Further interested parties demonstrating the necessary competence can apply for being recognized by CertifHy. As soon as further certification bodies have been recognized by CertifHy, operators of hydrogen production facilities are free to choose one of the recognized certification bodies and commission them to do the required audits.

A CertifHy **Issuing Body** is tasked with issuing, transferring and cancelling CertifHy GOs based on the compliance with minimum criteria set forth by the scheme's documents. Issued GOs are registered in a central registry that keeps track of issued, traded and cancelled Guarantees of Origin. Operators of hydrogen production facilities apply to the Issuing Body for issuance of GOs. To that end, operators commission certification bodies to carry out the necessary audits. The certification bodies submit the audit reports to the Issuing Body, which checks them and requests remedies where shortcomings are identified. Based on satisfactory audits reports and all other criteria being fulfilled, the Issuing Body issues the GOs.

The **CertifHy Registry** is operated by GREXEL[27]. This registry will be expanded towards a CertifHy database to additionally cover Supply Certificates (SC). This database will need to comply with requirements of the Union Database, the establishment of which RED II foresees by 2021. The exact digital infrastructure that will be put in place to integrate CertifHy with the Union Database in the most efficient manner is still unclear, as is the future role of existing national databases. Developing this further is part of CertifHy 3, which launched recently.

[26] GO issuing before Production Batch Auditing may require detailed reconsideration of how Batch Audit Reports can be linked to the GOs in the CertifHy Registry

[27] https://cmo.grexel.com/Lists/PublicPages/Statistics.aspx?AspxAutoDetectCookieSupport=1

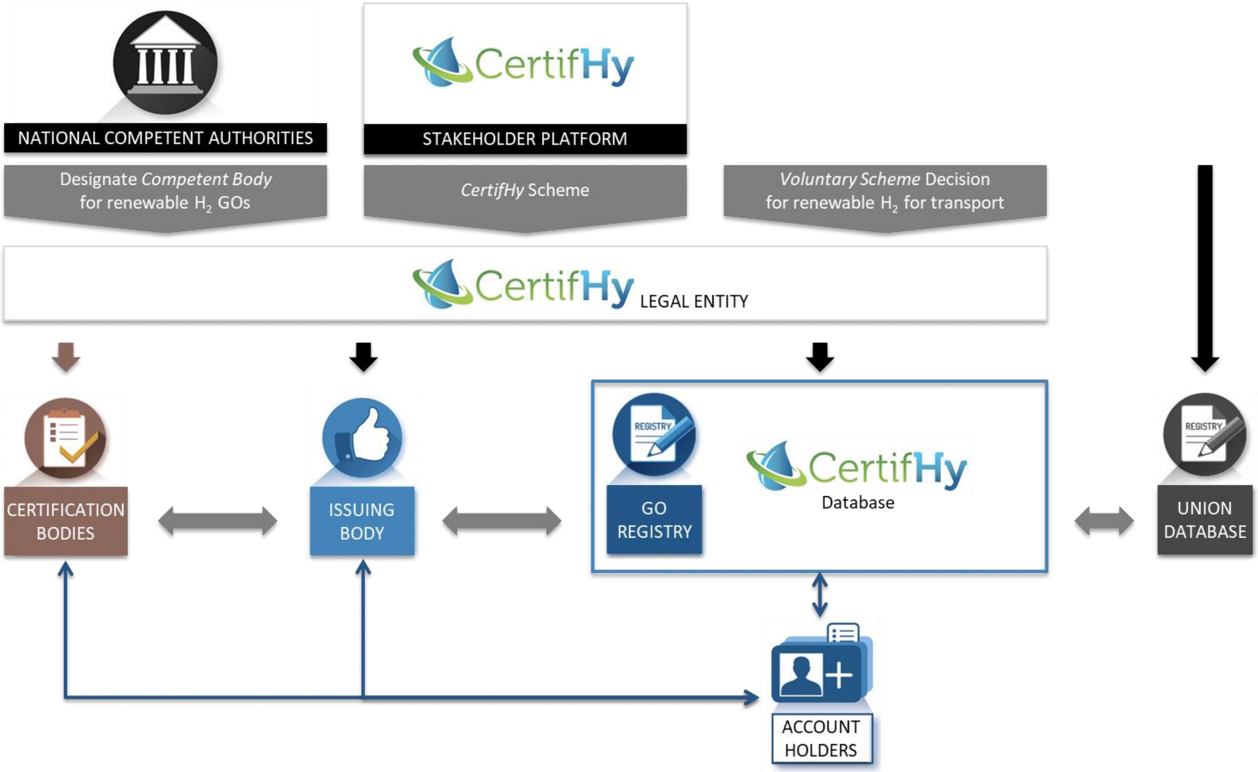


Figure 3 Schematic stakeholder structure of CertifHy.[28]

Account Holders at the CertifHy registry have in their accounts production devices and/or CertifHy Guarantees of Origin. It is the responsibility of the Account Holder to cancel a GO only against physical hydrogen consumption that he can ascertain as belonging to the specified GO system scope. They hold an account within the registry, which enables them to ask for product certification (via the Certification Bodies), and for issuing, transfer or cancellation of GOs to the Issuing Body. There are three major groups of account holders[29]: Hydrogen producers, traders and brokers as well as suppliers and end-users, for all of which CertifHy offers distinct advantages. "For producers of Green and Low-carbon Hydrogen, CertifHy enables (improved) business cases. First of all, by allowing the market to make a distinction between Green and Low-carbon Hydrogen as well as 'grey' hydrogen, and thereby creating a demand for these higher-value products. Secondly, as a GO has a certain monetary value, this will serve as yet another stream of additional income for producers. […] For traders, CertifHy opens

[28] Veum K., Vanhoudt W., 2019, CertifHy 2 Final Stakeholder Conference and Plenary Session 4.1 – Perspectives and key actions for the next phase of CertifHy and beyond, https://www.certifhy.eu/images/media/files/Certifhy_2_Other_publications/Perspectives_and_Key_actions_of_CertifHy.pdf

[29] Assuming the final architecture of CertifHy covers the entire supply chain both through GOs and supply certificates mandated through voluntary scheme requirements in RED II.

new business opportunities in various sectors that include industry, transport, heating and cooling. Back in 2014, traders and brokers were requesting for a limited number of products ("Renewable" and "Low Carbon") to ensure market liquidity. There seems to be a tendency to request more niche products for which a higher price can be captured. This may include special requirements based on consumer preferences, e.g. excluding bioenergy or hydrogen from the renewable input energies, or regional production of renewable input electricity, etc. CertifHy can also cater for those more specialized labelling needs based on the detailed data available on the GO, and by allowing other labels to be applied based on such GO information. Regarding suppliers and end-users of hydrogen, CertifHy enables the EU-wide consumption of Green and Low-carbon Hydrogen regardless of geographical location; by using a GO, the corresponding quantity of hydrogen consumed acquires the properties of the hydrogen covered by the GO. This allows suppliers and/or end-users to evidence the purchase of Green and Low-carbon Hydrogen. It can enable suppliers to differentiate themselves by contributing to reducing a company's emissions as well as the lifetime emissions of sold products." [30]

3.2.3. Implementation and operational costs

Implementation

The CertifHy development project was established in 2014 and through October 2016 "the first CertifHy-phase successfully delivered a definition for a label for Green and Low-carbon Hydrogen through a consensus building process with industry, policy makers and civil society, a GO scheme outline, and a roadmap for the implementation of such an initiative throughout the EU. [The second phase] was initiated in October 2017 with [the] initial objective to define the scheme's governance, processes and procedures over the entire GO life cycle: from auditing hydrogen production plants, to certification of green or low-carbon hydrogen production batches and the issuing, trading and use of a GO."[30] Within this second phase, the Stakeholder platform was established, a pilot GO scheme was set up to gain practical experience for a large-scale EU-wide scheme and further emphasis was placed on compatibility with EU legislation.[31] As of January 2019, CertifHy had issued 75000+ CertifHy Green and Low Carbon Hydrogen GOs that are available on the market.[32] While the project has so far developed a Scheme for

[30] FCH 2 JU, 2019, Towards a Dual Hydrogen Certification System for Guarantees of Origin and for the Certification of Renewable Hydrogen in Transport and for Heating & Cooling - Final Report of Phase 2, https://op.europa.eu/en/publication-detail/-/publication/3d66be8f-6284-11ea-b735-01aa75ed71a1/prodSystem-cellar/language-en/format-PDF

[31] More information on CertifHy pilot projects is available here: to https://www.certifhy.eu/79-slideshow/119-pilot-projects.html

[32] CertifHy, 2020, Towards a new Hydrogen market - CertifHy Green Hydrogen Guarantees of Origin are launched, https://www.certifhy.eu/news-events/169-towards-a-new-hydrogen-market-certifhy-green-hydrogen-guarantees-of-origins-are-launched.html

Guarantees of Origin, the objective of the next, currently running phase ('CertifHy 3') is to expand the CertifHy system for handling both GOs and Supply Certificates.

As mentioned in above, RED II further recognizes and expands the role of GOs for all types of energy carriers including hydrogen, and sets targets on the share of renewable energy in various major sectors such as transport and Heating & Cooling. According to RED II Art. 30(3), "Member States shall take measures to ensure that economic operators submit reliable information regarding the compliance with the greenhouse gas emissions savings thresholds."[33] As further laid out, such obligations also require a certification and tracking instrument to be implemented in order to monitor their fulfilment. "Here, instead of informing the end user, the purpose is to account for the amount of renewable hydrogen supplied by economic actors to designated sectors, in accordance to specific targets, by means of supply certificates."[34] Conditions for issuance of such supply certificates may differ from those applied for issuing and cancelling of a GO, which has the sole function of consumer disclosure. However, both systems have similar certification and tracing requirements. In particular, hydrogen producers will want to mutualize the certification burden for both purposes. For GOs, the focus is on the origin of the energy input, and the GHG balance of the production including upstream emissions. For Supply Certificates, RED II foresees additional criteria, among others extending the GHG balance from hydrogen production over the full supply chain until the point of consumption, additionality and "new installations" criteria as well as geographical and temporal correlation of renewable electricity production and hydrogen production. The latter are not yet defined in detail, which will be done in delegated acts of the European Commission by the end of 2021.

Given these developments, part of the overarching ambition for CertifHy's third phase is to create an EU-wide CertifHy Certification Scheme that covers both Guarantees of Origin and Supply Certificates for target compliance. "The certification system would thus provide an "infrastructure" for tracking product characteristics suitable for various purposes: customer disclosure ([RED II] Art. 19), certification of quantities contributing to the renewable fuels targets ([RED II] Art. 25 & 27) and possibly other environmental targets, including besides energy, also feedstock used in industry or taxonomy criteria for climate change mitigation and adaption. Such a system would leverage major synergies between the purposes, e.g. provide proof for two (or more) purposes based

[33] 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; OJ L 328, 21.12.2018, p. 82–209

[34] FCH 2 JU, 2019, Towards a Dual Hydrogen Certification System for Guarantees of Origin and for the Certification of Renewable Hydrogen in Transport and for Heating & Cooling - Final Report of Phase 2, https://op.europa.eu/en/publication-detail/-/publication/3d66be8f-6284-11ea-b735-01aa75ed71a1/prodSystem-cellar/language-en/format-PDF

on one audit and using one integrated infrastructure."[35] Having a single energy attribute tracking system (EATS) that accommodates GOs as well as demonstration of compliance - through Supply Certificates - with regulatory requirements, such as RED II targets on the share of renewables in various sectors, is essential for logical integrity. Indeed, if GOs and SCs are handled by independent systems, the same unit of energy could be claimed to have been used in two different sectors, which is a form of double counting. "Through an EECS-compliant H_2 GO scheme, flexibility at national level will remain possible, as it is often necessary to comply with national law and requirements. Piloting at MS level will therefore be necessary to test the H_2 GO scheme. This will allow learning from the issues that might arise at local level and provide input for an update of the Renewable Hydrogen Scheme within AIB [Gas Scheme Group]"[36]

Costs

"Experiences with GOs so far indicate that it is difficult to foresee or predict the market value of GOs for energy carriers, such as renewable electricity, [hydrogen,] methane or heat. As GOs serve the purpose of consumer disclosure, it is the balance of demand and supply that sets the price. Also, GO prices are notoriously non-transparent: there is no common trading platform for them in which price developments can be monitored easily.

An important feature of hydrogen is that this energy carrier is usually produced from another energy carrier, such as natural gas (in the case of SMR [Steam Methane Reforming]) or electricity (in the case of electrolysis). This implies that the prices of GOs for CertifHy Green [or Low-Carbon] Hydrogen [...] will probably relate to the prices of GOs for renewable methane and renewable electricity, as (some of these) GOs can be converted into a CertifHy Green [or Low-Carbon] Hydrogen GO along with the conversion process (and taking into account the process conversion efficiency)."[37] The market will typically need to find this out in practice.

In general, publicly available price information on GOs is scarce. Figure 4 illustrates the weighted average prices for different GOs for electricity produced from renewable energy sources, which may serve as a rough indication of price ranges for certifying 1 MWh of using CertifHy GOs under a fully developed market, taking into account the energy losses in hydrogen production from electricity of approximately 30%, and taking

[35] CertifHy, 2019, Taking CertifHy to the next level – Roadmap for building a dual hydrogen certification infrastructure for Guarantees of Origin and for Certification of renewable hydrogen in transport https://www.certifhy.eu/images/media/files/CertifHy_2_deliverables/190319_CertifHy2_Roadmap_Final_Draft_as_endorsed_by_the_Steering_Group.pdf

[36] CertifHy, 2020, Press Release: CertifHy phase III will implement a harmonized H2 Guarantee of Origin (GO) scheme across Europe & beyond, build a market for H2 GO trade in close collaboration with market actors, and design a Certification Scheme for compliance with RED II renewable fuels for transport https://www.certifhy.eu/images/media/files/201214_Press_release_CertifHy_3_Launch_EN_Final.pdf

[37] CertifHy, 2016, Roadmap for the establishment of a well-functioning EU hydrogen GO system, https://www.certifhy.eu/images/media/files/D5_1_Implementation_Roadmap-v15-final.pdf

into account additional equipment for hydrogen production from electricity. Some price and market analysis of electricity GOs is provided by a 2018 report by Oslo Economics[38].

Figure 4 ILR (Institute Luxembourgeois de Régulation) auction results for GOs for electricity produced from renewable energy sources.

Generally, GOs make up a fraction of the total cost and revenue associated to commercial hydrogen operations, as illustrated in Figure 5. Typical auditing costs for economic operators depend on the base registration fee, their number of registered sites and quantity of product that is subject to certification[39]. Depending on the geographic and sectoral scope of potential certification bodies participating in the CertifHy scheme, it may be feasible to adapt their individual fee structure to the respective local circumstances so as not to undermine competitiveness of local players.

For CertifHy, the costs associated to certification include various elements, including an account opening fee (600 €), an annual account fee (300 €), a production device registration fee ranging from 500 € (<1 MW) to 2500 € (>20 MW) based on the installed hydrogen output capacity at the plant gate[40], as well as a GO issuing price at 0.05€ per GO (1 MWh). Taking an average energy content of 33 kWh per kg of Hydrogen, this yields ~33 MWh per ton of hydrogen, which translates into 33 GOs and 1,65 € in GOs per ton of hydrogen. Note that for new plants, a plant audit is needed; hydrogen production requires production batch audits at least annually. Prices for both plant audit and the

[38] Olso Economics: Analysis of the trade in Guarantees of Origin, Economic analysis for Energy Norway OE-report 2017-58, 16 January 2018.

[39] REDCert, 2020, Fee schedule for Scheme participants, https://www.redcert.org/images/Fee_schedule_Vers.8.pdf

[40] Note that while plant device registration efforts are rather independent of plant size, the cost differentiation is deliberate in order to avoid market distortions to the detriment of distributed generation, i.e. supporting a more level-playing field also for small holders and systems

GO batch verification vary depending on the modes of hydrogen production[41] (see Table 1). The GO batch verification price is fixed per verification process and does not depend on the amount of hydrogen verified. Batches can be defined by the hydrogen production plant operator, but must not span more than 12 months. Note that these numbers are indicative and subject to change in the future. The indicative auditing costs relate to the fact that there is only one certification body thus far; the recently started phase 3 of CertifHy will allow more certification bodies to be accepted to carry out CertifHy audits, which will lead to auditing prices being determined by market forces in the future.

Table 1 Indicative Costs for Plant audit and GO batch verification within CertifHy

	Water electrolysis	Chloralkali electrolysis	SMR without CCS	SMR with CCS	Pyrolysis	Other processes
Plant Audit	4 900 €	5 600 €	5 775 €	6 650 €	7 350 €	9 450 €
GO batch verification	3 150 €	3 850 €	4 725 €	5 600 €	5 600 €	6 300 €

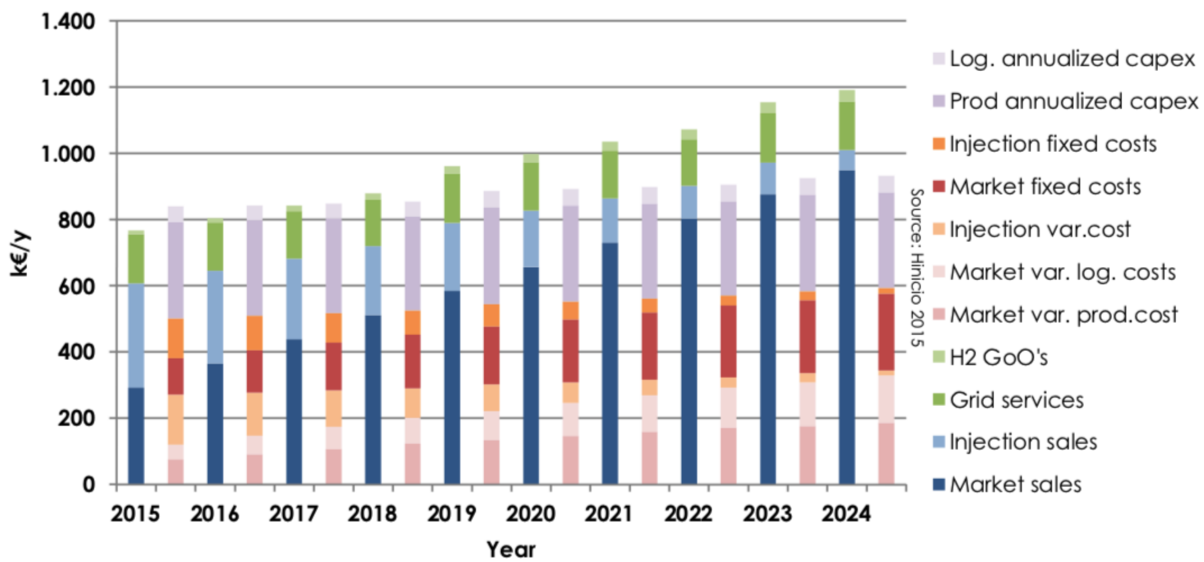


Figure 5 Cost and revenue associated to a semi-centralised power-to-gas system under a reference scenario based on simplified modelling framework of the German and French context across variables that would affect costs and benefits.[42]

For a semi-centralised power-to-gas system, the reference scenario in Figure 6 illustrates the advantage of having alternative revenue streams from hydrogen injection into the

[41] CertifHy, 2019, Going into deployment

[42] p.61-86, Vanhoudt W., Schmidt, P., et al., 2016 Short term and long-term opportunities to leverage synergies between the electricity and transport sectors through power-to-hydrogen, http://www.lbst.de/download/2016/Hinicio-LBST_2016_PtH2-study_Fondation-Tuck.pdf

natural gas grid and by providing grid services to compensate for the limited market demand for hydrogen. The costs include grid services, injection market and H_2 GO sales. On the right hand side, the bar representing costs includes all the operational costs (hydrogen production and transport), fixed and variable costs as well as the capital investment costs. The capital costs are divided into the capital costs for logistics (trailers and storage) and the capital costs for hydrogen production (electrolyser, conditioning). These capital costs are annualised over the first 10 years of the project.

Establishing the CertifHy scheme was done in two phases. In phase one, a research project was carried out ("CertifHy 1") over a two-year period funded by the FCH JU with an overall budget of 551,609 € and an EU funding contribution of 432,552.53 €.[43] Phase 2 of CertifHy ("CertifHy 2") was initiated in October 2017 and was finalized in March 2019 with the launch of the scheme. It had a total budget of 598,879 € for a period of one and a half years. [44]

Phase 3 of CertifHy ("CertifHy 3"); see above) extending CertifHy to create an EU-wide Certification Scheme that covers both Guarantees of Origin and Supply Certificates for target compliance, to support and accelerate the establishment of harmonised and mutually recognised Guarantees of Origin Schemes across EU Members States, and further objectives, has a total budget of 1.499 million € for a period of three years.[ibid.]

CertifHy 2 has estimated the operational costs of an EU-wide GO scheme in a simplified costs and revenue approach in order to demonstrate the cost savings compared to a situation with 27 national GO schemes in the European Union (see Figure 6 below):

"A cost & revenue model was developed to estimate the costs and possible revenue streams of a complete GO scheme. Two configurations were studied: (i) implementation of a single registry and issuing body at EU level, (ii) extension of existing registries for electricity or gas GO in each country to cover hydrogen GOs.

Based on rough estimates of the yearly operating costs of the different functional elements of a GO scheme (registry operator, issuing body, accreditation body, competent body, hub in the case of national registries), the total yearly cost of a single EU registry-based GO system is estimated at 1.6 M€ (1.3 M€ excluding audits), whereas the total yearly additional cost of a hydrogen GO system implementing 27 country registries and issuing bodies is estimated at 11.7 M€ (11.4 M€ excluding audits). This is in line with the total income generated by fees on electricity GO accounts and

[43] https://cordis.europa.eu/project/id/633107
[44] https://ted.europa.eu

transactions of ca. 15 M€ in 11 countries charging such fees (for a total yearly volume of ca. 420 TWh)."[45]

Figure 6 Cost and revenue estimate for an EU-wide GO Scheme[46]

3.2.4. Current and projected coverage of hydrogen markets

Europe is leading on the development of a hydrogen certification standard, through CEN. EU Industry calls for policy support for a scale up of the hydrogen economy, preparation of the CEN standard to be adopted worldwide and rolling out a robust certification system to proof renewable or GHG reduction nature of the to-be-financed H_2 economy infrastructure. On the way there, a credible renewable H_2 certification will accelerate policy makers' and market participants' trust and fast-track the necessary policy instruments to be created, not only for adoption of the EU Standard but also to give the EU technology providers and potentially participating stakeholders in third countries an edge in worldwide export markets. There is a strong consensus amongst stakeholders that there is a need for harmonization action now so that a fragmented H_2 GO market is avoided. To cater to this sentiment, "CertifHy will [inter alia] provide input

[45] FCH 2 JU, 2019, Towards a Dual Hydrogen Certification System for Guarantees of Origin and for the Certification of Renewable Hydrogen in Transport and for Heating & Cooling - Final Report of Phase 2, https://op.europa.eu/en/publication-detail/-/publication/3d66be8f-6284-11ea-b735-01aa75ed71a1/prodSystem-cellar/language-en/format-PDF, p. 14.

[46] FCH 2 JU, 2019, Towards a Dual Hydrogen Certification System for Guarantees of Origin and for the Certification of Renewable Hydrogen in Transport and for Heating & Cooling - Final Report of Phase 2, https://op.europa.eu/en/publication-detail/-/publication/3d66be8f-6284-11ea-b735-01aa75ed71a1/prodSystem-cellar/language-en/format-PDF, p. 14.

to the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) work group on hydrogen certification to ensure a harmonization between EU and the international methodology being shaped."[47]

While the current geographic scope is defined as the European Economic Area (EEA) including the European Union plus additional European countries, future plans include exploring the possibilities of imports and export of GOs with countries outside of the EEA. RED II Art 19(11) foresees this provided that direct import/export of energy takes place and that the EU has made an agreement with the country regarding mutual recognition of the GOs. The agreement between the EU and a third country in practice will require the existence of a GO system similar to the one defined by RED II in that third country.

One possible option for the third countries seeking the export of GOs to EU would be for them to implement the CertifHy H_2 GO scheme - or another GO system complying with RED II Art 19 including CEN-EN 16325, and even becoming a member in the AIB. In that case the technical connection would automatically exist via the AIB Hub. The CertifHy consortium actively pursues awareness raising and cooperation in third countries on how installing a legislative disclosure system, as part of applications for AIB membership, can facilitate future economic opportunities for international hydrogen markets.[48]

As described in the above sections, CertifHy 3 will expand the CertifHy system for handling both GOs and Supply Certificates for RFNBOs according to RED II.[49] CertifHy has focused in the past on hydrogen, but will extend to all RFNBOs, such as synthetic "power to liquids" drop-in fuels, methanol or ammonia, etc.

As part of phase 3, CertifHy will design and seek to test the technical means to allow for imports and exports of GOs including relevant data fields supporting proof of sustainability and mass balancing. Fostering international harmonization is a core objective of CertifHy.

"Outside of EU boundaries, a collaboration is being set up with the Moroccan Ministry of Energy, Mines and Environment with the intent to experiment a pilot cross border GO transaction with the European Union. The pilot with Morocco will be one of the learnings CertifHy will use in a working group on H_2 GOs which CertifHy will lead within the (Middle

---

[47] CertifHy, 2020, Press Release: CertifHy phase III will implement a harmonized H2 Guarantee of Origin (GO) scheme across Europe & beyond, build a market for H2 GO trade in close collaboration with market actors, and design a Certification Scheme for compliance with RED II renewable fuels for transport https://www.certifhy.eu/images/media/files/201214_Press_release_CertifHy_3_Launch_EN_Final.pdf

[48] The AIB's geographical scope is currently limited to the EU + former and future EU members + European Freed Trade Association (EFTA) + Energy Community. The scope is likely to be extended at the time of an EU agreement with a third country, but formally still subject to a formal decision in AIB

[49] CertifHy, 2020, Press Release: CertifHy phase III will implement a harmonized H2 Guarantee of Origin (GO) scheme across Europe & beyond, build a market for H2 GO trade in close collaboration with market actors, and design a Certification Scheme for compliance with RED II renewable fuels for transport https://www.certifhy.eu/images/media/files/201214_Press_release_CertifHy_3_Launch_EN_Final.pdf

Eastern – Northern African) MENA Hydrogen Alliance to work towards the region creating an H2 GO scheme harmonized with Europe."[47]

"CertifHy will also provide input to the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) work group on hydrogen certification to ensure a harmonization between EU and the international methodology being shaped." [47]

3.3. TÜV SÜD, Germany

TÜV SÜD of Germany has established a private Green Hydrogen standard and certification system that can, in principle, be applied worldwide, but has a focus on Germany and Europe -- referring to German and European legislation as well as to international standards. It covers renewable hydrogen; low-carbon hydrogen from non-renewable sources is not certified.

The standard is owned and managed by TÜV SÜD, and has been established some ten years ago. TÜV SÜD has consulted selected stakeholders on the standard in late 2019, and has revised it in early 2020 based on stakeholder feedback, and published the current version of the standard in January 2020 with the validity starting on 1 January 2020[50].

Certification (auditing) according to the standard is carried out by TÜV SÜD. However, the standard allows for other certification bodies to carry out certification as long as they have a valid accreditation for certifications of products, processes or services, e.g. according to DIN EN 45011:1998, ISO/EIC 17065:2012 or acceptance under the German Renewable Energy Act.

The standard defines requirements related to feedstocks and input energies, and to the greenhouse gas intensity of the production. It offers a number of options including using book&claim (as for GOs) or mass balancing for physical hydrogen delivery with green hydrogen certification. TÜV SÜD Green Hydrogen offers three alternative options to conform with additionality[51] requirements related to renewable electricity used for hydrogen production[50]:

1. Share of new installations: Electricity from renewable sources has a share of 30 % from new facilities, which started their operation within the last 36 months.
2. Technology mix: Electricity from renewable sources has a share of either 15% hydropower from plants <2 MW or 30% wind power or 5% solar, geothermal or

[50] In German language; https://www.tuvsud.com/de-de/-/media/de/industry-service/pdf/broschueren-und-flyer/is/energie/standard-cms-70-greenhydrogen-ts-is-ut.pdf

[51] Additionality requirements are discussed in Europe with the objective of avoiding competition for renewable electricity from hydrogen production and conventional electricity consumption. Additional renewable capacities commissioned for hydrogen production would not compromise decarbonisation of grid electricity. RED II, as a major example, established additionality requirements, which are to be defined in detail by delegated acts by the European Commission by the end of 2021.

biomass/biogas power from plants <2 MW. These plants must have been put into operation after 01/01/2020.

3. Funding: 0.2 ct/kWh of used electricity in the green hydrogen production are paid to a fund for projects promoting renewable energies, efficiency, innovation and compensation.

The standard applies to hydrogen consumption in the following applications and sectors: hydrogen as (chemical) feedstock, transport, or electricity storage (including hydrogen injection into the natural gas grid).

TÜV SÜD has also contributed to the development of CertifHy, and considers its own standard as providing requirements (e.g. on mass balancing) that go further than the (book & claim) CertifHy scheme, and can be carried out on top of CertifHy certification. "The certified amounts of GreenHydrogen can be registered in the CertifHy guarantee-of-origin (GO) system for hydrogen produced from renewable sources, supported by the European Union."[52]

Information on TÜV SÜD Green Hydrogen is scarce, but certification according to this standard is limited in the number of certifications, and geographically it is limited to Germany thus as far as information is available. Although TÜV SÜD generally publishes the certified companies in the clean energy domain on its website[53], it does not provide such information in relation to the green hydrogen standard. One example of hydrogen certification according to the TÜV SÜD standard is hydrogen produced by Linde in Germany from glycerin, which was certified by TÜV SÜD in 2012, according to a Linde publication[54].

3.4. Australia

On 22 June 2020, the **Australian** Department of Industry, Science, Energy and Resources closed a consultation on its proposal to develop an international certification scheme to classify hydrogen produced in Australia according to its environmental impact, including in relation to the production of greenhouse gas emissions. Responses of stakeholders having given permission to do so have been published[55]. This is focused on general aspects and timelines, e.g., most respondents suggest 2021 or 2022 to be the ideal date to have a certification scheme in place. The Australian government proposes an initial international certification scheme to track production technology, scope 1 and scope 2 carbon emissions, and production location. The scheme could be expanded

[52] TÜV SÜD 14 February 2020, Press Release: TÜV SÜD provides GreenHydrogen certification, https://www.tuvsud.com/en/press-and-media/2020/february/tuev-sued-provides-greenhydrogen-certification

[53] https://www.tuvsud.com/de-de/branchen/energie/erneuerbare-energien/energiezertifizierung/zertifizierungsstandards

[54] http://www.linde.com.sg/en/news_and_media/global_news/news_120423.html

[55] https://consult.industry.gov.au/national-hydrogen-strategy-taskforce/hydrogen-certification-survey/consultation/published_select_respondent

later to include water consumption and other factors according to the government. A concrete draft hydrogen certification scheme has not been proposed yet.

The National Greenhouse and Energy Reporting (NGER) scheme of Australia (see below) is a national framework for reporting and disseminating company information about greenhouse gas emissions, energy production, energy consumption and other information, which requires estimation and reporting of scope 1 and scope 2[56]. Thus, basing an Australian hydrogen certification scheme on scope 1 and scope 2 emissions would make it consistent with the NGER.

3.4.1. Differentiation between scope 1, scope 2 and scope 3 emissions

In order to quantify emissions related to hydrogen production the scope of emissions to be included needs to be defined. Following the National Greenhouse and Energy Reporting Regulations 2008[57], Australia distinguishes in its National Hydrogen Strategy Issue Paper on Guarantees of Origin[56] three types of emission scopes as follows:

"**Scope 1 emissions** are those released into the atmosphere as a direct result of an activity, or series of activities at a facility. For hydrogen produced through electrolysis, scope 1 emissions would be zero, for hydrogen produced from natural gas without CCS, scope 1 emissions would be around 10 kg CO_2-e per kg of hydrogen."

➔ This scope is the simplest to determine; for electrolysis, hydrogen produced from electricity independent of the source of the electricity is zero emissions based on scope 1.

"Scope 2 emissions are indirect greenhouse gas emissions from consumption of purchased electricity, heat or steam. Most scope 2 emissions represent electricity consumption, but can include other forms of energy transferred across facility boundaries. For hydrogen produced from 100% renewable energy, scope 2 emissions would be zero. For hydrogen produced from grid electricity, scope 2 emissions would be almost 55 kg CO_2-e per kilogram of hydrogen. For hydrogen produced from fossil fuels, they would vary from plant to plant."

➔ Scope 2 is more complex to determine than Scope 1 and differs by technology and source of energy.

"Scope 3 emissions are indirect emissions from other sources. These might include emissions from business travel, water use, emissions from the production of fuels used at a facility, emissions associated with disposing of waste (such as carbon capture and storage), or emissions from transporting finished products to an end user. Scope 3 emissions are always specific to choices that a company makes in deciding what to

56 Australian Government, COAG Energy Council: National Hydrogen Strategy, Issues paper series, 4 Guarantees of Origin, https://consult.industry.gov.au/national-hydrogen-strategy-taskforce/national-hydrogen-strategy-issues-papers/supporting_documents/NationalHydrogenStrategyIssue4GuaranteesofOrigin.pdf

57 https://www.legislation.gov.au/Details/F2020C00673, page 20

include, so it is not possible to make a general estimate of scope 3 emissions for hydrogen production."

"**Lifecycle emissions**, which are often used in consumer labelling schemes, provide a systems perspective and include emissions generated from natural resource extraction, processing, manufacturing, transportation, through to disposal of a product, material, or service. This will include scope 1 and scope 2 emissions, and some or all scope 3 emissions."

➔ Lifecyle emissions are the most complex to determine as the calculation of it requires to consider all presented scopes.

3.4.2. National Greenhouse and Energy Reporting scheme of Australia

The scheme was established by the National Greenhouse and Energy Reporting Act[58] in 2007 and is a national framework for reporting and disseminating company information about greenhouse gas emissions, energy production, energy consumption and other information specified under NGER legislation. Thus, when reporting emissions, energy production and energy consumption data, only those activities, fuels and energy commodities for which there are applicable methods under the NGER Scheme are reported. As for instance, the above-described emission scopes are defined in NGER. Except for the definition of scope 1, 2 and 3 in NGER, which may potentially be applied to an Australian hydrogen certification scheme, there is no link to a future hydrogen certification scheme in Australia for the time being.

All controlling corporations[59] that meet a threshold under the NGER scheme must be registered under the NGER Act.

There are two types of thresholds which are summarized in the following table[60]:

Facility threshold:

- 25 kt or more of greenhouse gases (CO_2-e) (scope 1 and scope 2 emissions)
- production of 100 TJ or more of energy, or
- consumption of 100 TJ or more of energy.

58 https://www.legislation.gov.au/Details/C2019C00263

59 Controlling corporations are constitutional corporations that do not have an Australian incorporated holding company. It is usually the corporation at the top of the corporate hierarchy in Australia and can be a 'non-operational' holding company that does not handle day-to-day business. It can also be a foreign incorporated entity that operates directly in Australia without an Australian incorporated subsidiary.

60 Reporting thresholds, cleanenergyregulator.gov.au

Corporate group threshold[61]:

- 50 kt or more of greenhouse gases (CO_2-e) (scope 1 and scope 2 emissions)
- production of 200 TJ or more of energy, or
- consumption of 200 TJ or more of energy.

Furthermore, under the safeguard mechanism all responsible emitters of a registered controlling corporation's group must be registered. The safeguard mechanism [62] provides a framework to measure and report the emissions of Australia's largest emitters. It does this by encouraging large facilities, whose net emissions exceed the safeguard threshold[63], to keep their emissions at or below the emissions baselines[64]. If a facility exceeds its baseline it can reduce the facility's net emissions by purchasing or surrendering credits to offset their emissions. For entities which are required to do so the Emissions and Energy Reporting System[65] has been established.

3.5. IPHE and CEM, international

As put down in the European Commission's 2020 communication on "A hydrogen strategy for a climate-neutral Europe", the European Union aims at promoting in multilateral fora the development of **international** standards and the setting up of common definitions and methodologies for defining overall emissions from each unit of hydrogen produced and carried to final use as well as international sustainability criteria. The EU is already highly involved in IPHE, co-leads the Clean Energy Ministerial Hydrogen initiative (CEM H2I), and is cooperating internationally on clean hydrogen in other frameworks.

Both CEM and IPHE promote the global development of harmonized standards for the certification of hydrogen.

Created in 2010, the **Clean Energy Ministerial** (CEM) is a global forum where major economies and forward leaning countries work together to share best practices and promote policies and programs that encourage and facilitate the transition to a global clean energy economy. CEM members account for approximately 75% of global greenhouse gas emissions and 90% of global clean energy investments. In 2019, CEM

61 The table shows the current corporate group threshold. However, the corporate group threshold was introduced progressively over three years (2008-2010). Corporations need to consider whether they have historic obligations from past years when determining whether they meet the NGER threshold. The thresholds from 2008-2010 can be found on the website under the latter footnote.

62 Following information taken from: [The safeguard mechanism, cleanenergyregulator.gov.au]

63 Applies to facilities with scope 1 emissions of more than 100,000 tonnes of carbon dioxide equivalent (CO_2-e) per year.

64 Baselines are set in different ways depending on whether the facility is new, on the facility's industry sector and whether the baseline is fixed or annually adjusted for production.

65 http://www.cleanenergyregulator.gov.au/OSR/EERS/The-Emissions-and-Energy-Reporting-System

has established the CEM Hydrogen Initiative aiming at promoting the deployment of hydrogen energy. Chile is scheduled to host the CEM12 Ministerial Meeting in 2021.

The **International Partnership for Hydrogen and Fuel Cells in the Economy** (IPHE), established in 2003, has the mission to facilitate and accelerate the transition to clean and efficient energy and mobility systems using hydrogen and fuel cell technologies across applications and sectors. In October, 2019, at the 32nd IPHE Steering Committee Meeting in Seoul, IPHE Partners agreed to the formation of a Hydrogen Production Analysis Task Force (H2PA TF) specifically to address challenges brought forth by governments and industry stakeholders on the need for a consistent framework and methodology in assessing hydrogen production technologies from diverse sources. On March 10, 2020, the Terms of Reference (ToR) for this Task Force were adopted.[66]

The scope of the H2PA TF is defined as: "The H2PA TF aims to trigger a process and at taking initial steps to develop a mutually agreed upon methodology for determining the CO_2 equivalent and other pollutants emissions associated with the production of hydrogen."

The H2PA TF process is described as follows in the ToR:

- "Development of the methodology is driven through a consensus-based approach, engaging government, industry, and non-governmental organizations; […]
- Work will be carried out through a series of meetings and information sessions to:
    i. Get background information and an understanding of current methodologies;
    ii. Use a common terminology of the different origins and methods of produced hydrogen;
    iii. Reach out and engage key stakeholders representing other hydrogen initiatives (CEM, MI [Mission Innovation], etc.) and industry (e.g., Hydrogen Council and other entities) seeking their expertise and requesting them to provide input to the H2PA TF in the technical development and assessment of this methodology;
- Updates on activities and outcomes will be presented, discussed, and validated at the IPHE Steering Committees[67] […] and shared at CEM H2I advisory board meetings."

According to the ToR, countries confirming interest in working on the H2PA TF include France, European Commission, United States, Japan, Korea, Netherlands, United Kingdom, South Africa, Costa Rica, and Norway with a Co-lead being France, European Commission, and United States. Countries expressing interest in participating are

[66] https://www.iphe.net/working-groups-task-forces

[67] IPHE Steering Committee Meetings take place biannually; the next meeting will take place in summer 2021.

Australia, Germany, and Canada. Other countries are welcome to join the H2PA TF, according to the ToR.

The H2PA ToR include the following tasks to be carried out:

a) Develop a common understanding of **terminology**

Scope: Review of the different definitions used by various international organisations (e.g., IEC, ISO, UNECE, CEN/CENELEC).

Deliverable: Document with the definition of terms to be used during the H2PA TF.

Draft due Q2 2020, final document Q4 2020[68].

b) Review of **boundary conditions of H_2 production analysis**

Scope: agreement on upstream and downstream boundary limits in calculating the emissions related to hydrogen production.[69]

Deliverable: Document defining the upstream and downstream boundaries for H_2 production analysis.

Draft due Q2 2020[70].

c) Review of **methodologies already used or under development** by various jurisdictions

Scope: Tabling and consideration of background information and understanding of approaches used to determine GHG emissions of H_2 production, such as part of UNFCCC obligations/national goals, starting with the European CertifHy project, followed by other relevant projects and including the 2019 refinement to the 2006 IPCC GHG Inventory Guidelines. Reflection of ongoing analysis for the implementation of EU legislation on renewable energy.

Deliverable: Compendium of the key existing or under-development approaches to determine GHG emissions.

Draft due Q3 2020[71].

d) Development of the methodology to evaluate the emissions related to hydrogen production

[68] Status of the deliverable is unclear, no published yet

[69] ToR: "For example, the upstream boundary condition might include the emissions of the primary energy production using renewable, nuclear energies or fossil fuels, and the downstream boundary could consider H_2 stored at 30 bar at the exit of the H_2 production plant."

[70] Status of the deliverable is unclear

[71] Status of the deliverable is unclear

Scope: Based on the previous outcomes, this task will consider the following items:

i. Identify and report on the main different possible pathways to produce hydrogen; coming to a consensus on the GHG emission methodology in hydrogen production
ii. Apply the chosen approach to several case studies as examples;
iii. Prepare documentation for broad stakeholder (e.g., government, industry associations, environmental organisations) engagement and information sharing to build broad understanding and potential agreement;
iv. Identify and specify content necessary in any technical report based on the agreed approach; and,
v. Technical report describing the agreed to approach.

Deliverable: Document describing the methodology to assess the emissions of hydrogen production.

Draft due Q4 2020[72], final document Q2 2021[73].

The H2PA carried out a survey gathering information on the methodologies in use, under development, or in planning that define the greenhouse gas emissions associated with the production of hydrogen. Responses from Australia, France, Germany, Japan, Korea, Netherlands, Norway and the USA were included in a 21 April 2020 results summary.

3.6. Other schemes and mechanisms

In **Japan**, the Council for a Strategy for Hydrogen and Fuel Cells discussed the need for establishing a standard and certification scheme in Japan, and the 2019 revised version of the Strategic Roadmap for Hydrogen and Fuel Cells[74] identifies a need for CO_2 reduction along the entire hydrogen supply chain. So far, no draft standard or certification scheme has been proposed for Japan. However, at the regional level, the Aichi Prefecture has established a certification system for CO2-free hydrogen in early 2018, which distinguishes between hydrogen based on electrolysis using renewable power or based on steam methane reforming of biogas on the one hand, and hydrogen based on fossil sources with compensations of CO_2 emissions through renewable or GHG reduction certificates.

In 2019, the government of **Korea** released the "Hydrogen Economy Roadmap of Korea" and the "National Roadmap of Hydrogen Technology Development" including targets until 2040. In early 2020, the National Assembly of Korea adopted the Hydrogen Economy Promotion and Hydrogen Safety Management Law" as the legal basis for support to hydrogen, which according to a mid-2018 announcement by the

[72] Status of the deliverable is unclear

[73] The deliverable would be in time for the next IPHE Steering Committee meeting in summer 2021

[74] https://www.meti.go.jp/english/press/2019/0918_001.html

government should amount to 22 billion US dollars for establishing a hydrogen vehicle ecosystem by 2022.

The Hydrogen Roadmap Korea repeatedly mentions renewable hydrogen or hydrogen from fossil fuels using carbon capture and storage, and it includes as one of six recommendations to develop electrolysis technology at a utility scale, through policy support and subsidies, and to develop a hydrogen import supply chain for "green" hydrogen. However, there are no concrete activities to develop hydrogen certification nationally.

China has very recently published a hydrogen standard.[75] The standard aims to guide the transition from traditional hydrogen production processes to low-carbon hydrogen, clean hydrogen and renewable hydrogen production processes encouraging applying organizations to such processes. The standard applies to the production, storage and transportation of hydrogen in the production facility. Standard holder is the China Industry-University-Research Cooperation Promotion Association.

Three types of hydrogen are defined:

1. Low-carbon hydrogen: refers to hydrogen whose greenhouse gas emission value is lower than 14.51 kg CO_{2e}/kg_{H2} in the production process.
2. Clean hydrogen: refers to hydrogen whose greenhouse gas emission value is lower than 4.90 kg CO_{2e}/kg_{H2} in the production process.
3. Renewable hydrogen: refers to hydrogen whose greenhouse gas emissions is the same as that of clean hydrogen, and the energy consumed is renewable energy (renewable energy is defined in the "People's Republic of China Renewable Energy Law"[76])

GHG emissions are calculated on a life-cycle basis as defined in Chinese standard GB/T 24040-2008.[77]

For certification consist of the following steps:

1. The applying organization submits a formal verification application to the hydrogen energy industry big data center
2. Submitted documents are reviewed by the verification agency, which confirms whether the application documents are complete and meet the requirements of low-carbon hydrogen, clean hydrogen or renewable hydrogen
3. On-site verification is carried out by the agency.

[75] http://www.ttbz.org.cn/upload/file/20201030/6373966575981359813325969.pdf
[76] http://www.china.org.cn/china/LegislationsForm2001-2010/2011-02/14/content_21917464.htm
[77] https://www.chinesestandard.net/PDF/English.aspx/GBT24040-2008

In case all steps have been accomplished successfully, the hydrogen energy industry big data center will issue low-carbon hydrogen, clean hydrogen or renewable hydrogen certificates to the applying organization.

Annual supervision and audits are carried out by the verification agency to ensure that the certified organization continues to meet the requirements of the standard. According to the results of the supervision and review, suggestions are made to the hydrogen energy industry big data center to maintain and update the certificates or cancel them.

4. Case studies

Comment: Two case studies will be covered here in which a project or a company made use of the scheme to certify commercialized H_2. In consultation with the client, the LCFS and CertifHy have been identified for the case studies (see below).

This chapter will be elaborated in January 2021; elements included below are preliminary.

4.1. Low Carbon Fuel Standard, California, USA

Generating LCFS credits through hydrogen is possible by either producing hydrogen, which has a lower carbon intensity (CI) than the CI standard (fuel pathways-based crediting) or by providing Zero Emission Vehicle (ZEV) infrastructure (capacity-based crediting).

All fuel pathways used for credit generation must be verified. In general, hydrogen pathway applications fall into one of two types: either a Lookup Table application or a Tier 2 application.

"A fuel pathway CI consists of the sum of the greenhouse gases emitted throughout each stage of a fuel's production and use […]. CI is expressed as the amount of life cycle greenhouse gas emissions per unit of fuel energy […] [and] includes the direct effects of producing and using this fuel, as well as indirect effects that may be associated with how the fuel affects other products and markets."[78]

Lookup Table pathways: A number of hydrogen Lookup Table pathways are available for reporting hydrogen produced in California and dispensed to vehicles under the LCFS. For Lookup table applications, companies must ensure that they meet the assumptions of the respective Lookup Table pathway such as, for example, the predetermined CI values. If they do so, the entities submit the documents of their application through the Alternative Fuels Portal[79]. As next step the documents are evaluated by CARB. Based on this evaluation, CARB decides about the certification of the submitted application.

Tier 2 applications: Tier 2 applications are required if the hydrogen to be reported in the LCFS does not meet the requirements of the Lookup Table pathways. In general, Tier 2 applications are more complex than applications to Lookup Table pathways as it does not have a complete set of predetermined site-specific input fields. However, to the extent that the physical pathway is consistent with requirements of applicable Lookup Table pathways, the requirements of a Tier 2 application may be significantly reduced. Similarly to Lookup Table pathway applications, companies submit the documents of their application through the Alternative Fuels Portal. The submitted data is reviewed for completeness by CARB. If complete, the application will be validated by a third-party

[78] https://ww2.arb.ca.gov/resources/documents/apply-lcfs-fuel-pathway
[79] https://ssl.arb.ca.gov/lcfsrt/Login.aspx

verifier and afterwards undergo an engineering review by CARB. As next step, CARB posts the application to its webpage[80] for public comment. Comments on each posted application are accepted for ten business days. Comments identifying potential errors in an application will be forwarded to the applicant, which must either correct the errors and submit a revised application packet or submit a detailed response to the Executive Officer explaining why no revisions are necessary. Having undergone this procedure successfully, the application is certified by CARB and as last step verified by the third-party verifier.

Currently certified fuel pathways for hydrogen include[81]:

- Electrolysis: zero carbon electricity, solar electricity, or grid electricity
- North American Natural gas
- Landfill gas, biogas from digestion of manures,
- On-site reforming of renewable feedstocks
- Coproduct hydrogen produced at a sodium chlorate plant

Capacity-based crediting is based on the unused capacity of ZEV infrastructure including hydrogen refuelling stations; unused capacity is the installed capacity of a hydrogen refuelling station minus the amount of fuel actually dispensed. Equally to the applications for fuel pathways entities intending to participate in the LCFS by providing hydrogen refuelling infrastructure (HRI) must submit their applications through the Alternative Fuels Portal using an application template.[82] The submission of applications will be cut off if the estimated potential HRI credits from approved applications in a quarter exceed 2.5% of deficits in the prior quarter. If the CI value for hydrogen is not known at the time of application (e.g., for a station yet to be built), the entity has to estimate it based on expectations for the next one to two years of hydrogen supply. If the application is accepted, the entity is required to report quarterly in the Alternative Fuels Portal (e.g. CI and quantity of hydrogen dispensed). On the basis of the submitted data the Alternative Fuels Portal will automatically calculate the company-wide volume-weighted average CI, the difference between station capacity and dispensed hydrogen and the number of HRI credits. Capacity for infrastructure crediting will be based on the amount of hydrogen that can be dispensed over a 12-hour period. Capacity-based credits can be earned every day for 15 years and will cover up to the first 1,200 kg/day of capacity at a station. Credits will only be granted if a minimum of 40% renewable content is demonstrated for all fuel dispensed by the company. All stations must be connected to the Station Operational Status System where customers can view real-time fueling availability[83] and report their uptime status. Uptime will be calculated as the fraction of time (from 6 am to 9 pm or the hours that the station is

80 https://ww2.arb.ca.gov/resources/documents/lcfs-pathways-requiring-public-comments
81 https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities
82 https://www.arb.ca.gov/fuels/lcfs/guidance/hri_application.xlsm.
83 https://m.cafcp.org/

permitted to operate, whichever is less) during the quarter that the station is available. Eligibility for infrastructure crediting is subject to a maximum CI of 75 g_{CO2e}/MJ.

As of October 30, 2020, 52 hydrogen refuelling stations were approved in the LCFS program[84]. The excel spreadsheet called "HRI stations" to be found under the same link names the following participating companies:

- Air Liquide Hydrogen (participates with three stations)
- First Element (participates with 41 stations)
- Shell (participates with seven stations)
- United Hydrogen (participates with one station)

The data dashboard[85] on generated credits does not yet display hydrogen explicitly (see Figure 7) as hydrogen represents less than 1% of all credits[86]. However, the number of credits generated by hydrogen has grown from 50 in the third quarter of 2015 to 3,029 in the second quarter of this year. The monthly price for one credit is, as described in section 3.1.3, since early 2019 at around $200.

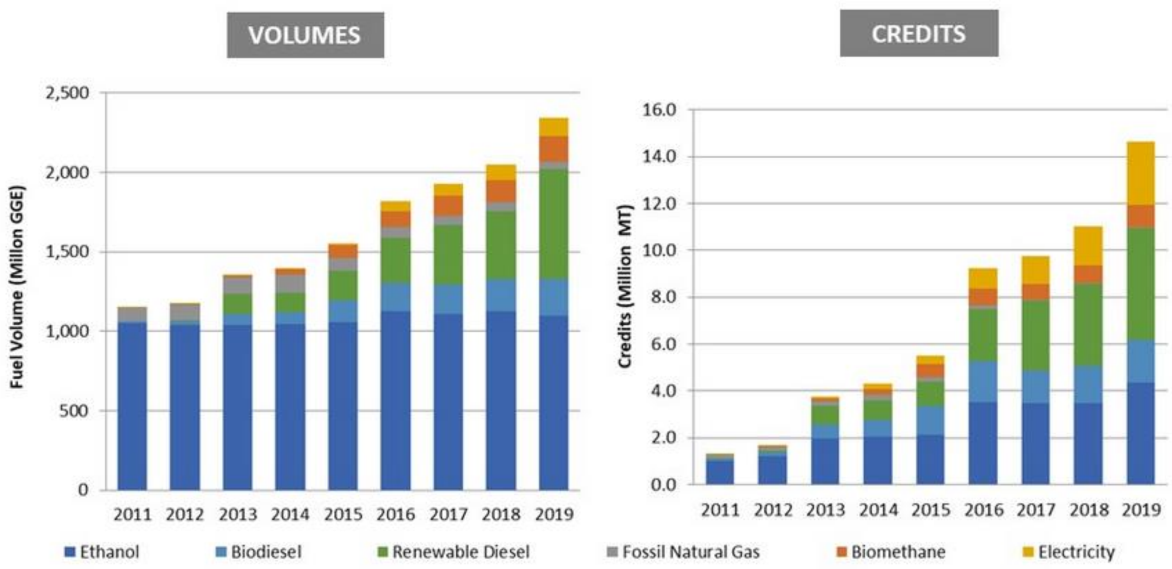


Figure 7 LCSF alternative fuel volumes in California

4.2. CertifHy, Europe

In CertifHy, 4 pilots have been carried out for hydrogen certification in 2018/2019:

During the 1st phase, the CertifHy Scheme was designed and the Green and Low-Carbon Hydrogen labels established, the 2nd phase elaborated the different procedures

---

84 https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting

85 https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

86 Data behind figure 2: https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

for GO issuing, transfer and cancellation and tested them by means of the pilots. The pilots consisted of four different producers with different production pathways that were chosen in order to test different complexities and challenges in the full chain from auditing the plants to verification of hydrogen production batches and handling GHG allocation issues, to the issuance of GOs.[87]

A key objective in CertifHy 2 was to gain practical experience with an operational pilot GO scheme, in order to ensure that the practical issues raised by the implementation of the newly designed GO scheme for hydrogen (see section 2.5) are identified and addressed. For this purpose, a pilot scheme was launched consisting of four different producers with different production pathways: [ibid.]

	Uniper	**Nouryon/ Air Products**	**Colruyt**	**Air Liquide**
Country	Germany	Netherlands	Belgium	France
Plant	Water Electrolysis based on wind power	Chlor-alkali electrolysis (H_2 by-product)	Water electrolysis fed by different electricity sources, mainly wind power	Steam methane reforming (SMR) with carbon capture and use (CCU)
H_2 Production Capacity	~450 kg per day	~400,000 kg per day	~190 kg per day	~100,000 kg per day

The pilot has successfully led to the issuance of Guarantees of Origin to the market. The first GO was issued in December 2018. Since then, 76,600 CertifHy hydrogen Guarantees of Origin (i.e. 2,298 t of hydrogen), of which 2,870 GOs (86 t of hydrogen) were for hydrogen from renewable sources (electricity from wind and/or biogas) and 73,740 (2,212 t) for fossil energy-based hydrogen (from steam reforming of natural gas).[ibid.]

4.2.1. Uniper (Falkenhagen, Germany): hydrogen from wind power by electrolysis

Uniper is an international energy company with about 11,000 employees with a balanced portfolio of technologically advanced large-scale energy assets. Uniper, headquartered in Germany, is active in more than 40 countries, has approximately 34 GW of installed power generation capacity, 7.7 bcm gas storage capacity, etc.

The pilot of Uniper in Falkenhagen, Germany, produces renewable hydrogen from wind power via water electrolysis, that can be fed into the natural gas grid mixing with the methane there, or used as input for a methanation process to produce pure methane for injection into the gas grid. The plant produces a maximum output of about 405 kg of hydrogen per day. The installation is special in the sense that hydrogen can be directly

[87] CertifHy 2, Final Report, 2019

injected into the natural gas grid; however, regulations need to be obeyed limiting the mixing ration between hydrogen and methane in the gas grid. For certification purposes the following has been done in this case:

- The plant was audited and registered in the CertifHy registry;
- Hydrogen Guarantees of Origin were issued in the CertifHy registry based on a production batch audit;

As the hydrogen is injected into the gas grid blending with the methane there, a test was carried out whether CertifHy GOs could be cancelled to create biogas Guarantees of Origin in the German DENA biogas registry. For this purpose, the following steps were carried out:

- The CertifHy hydrogen Guarantees of Origin were cancelled;
- A transfer communication file was generated from the cancellation statement;
- The communication file and cancellation statement were sent to DENA;
- DENA processed the file;
- DENA Biogas Guarantees of Origin were issued to the DENA registry with the data present in the transfer communication file.

It is only in the case of direct injection into the gas grid that one biogas GO can be created by cancelation of one hydrogen GO (both referring to 1 MWh of energy). The test demonstrated that DENA can recognize CertifHy certification documentation.[88]

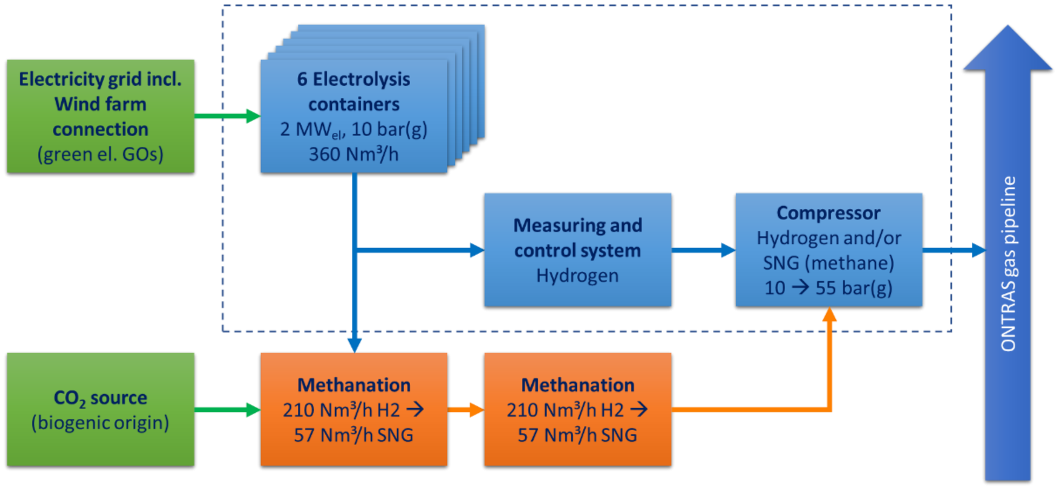


Figure 8: Scheme of Uniper Falkenhagen plant production process.[89]

---

[88] CertifHy, Final Report, 2020

[89] Based on https://www.certifhy.eu/images/media/files/CertifHy_-_Pilot_case_studies_WG2_webmeeting_2018-03-01_v3.pdf; SNG – synthetic natural gas

4.2.2. Nouryon, Air Products (Rotterdam Botlek, Netherlands): hydrogen by-product from chlor-alkali electrolysis

Air Products is global player in the energy market with 750+ production facilities worldwide and a market capitalization of about 35 billion USD. The company has concrete experience with hydrogen refueling across the EU, including various bus operators, Alstom train lines as well as forklifts and car refueling stations in the United Kingdom and Germany. The Air Products pilot project within CertifHy used the by-product hydrogen from Nouryon's industrial chlor-alkali electrolysis process in Botlek, Rotterdam (200 MW electrolysis). To do so within the CertifHy requirements for green hydrogen, Nouryon acquired green electricity required for the electrolysis in the form of Dutch wind power through a Power Purchase Agreement, to be precise from the Krammer and Bouwdokken windfarms. Air Productcs then purifies and compresses the by-product hydrogen for injection into its existing hydrogen pipeline. As of 2019, the first 1.6 GWh of CertifHy renewable hydrgen GOs were issued to Air Products and transferred to customers in hydrogen transportation. [90] The first customer "is H2 MOBLITY Deutschland, an organisation operating a network of hydrogen fuelling stations in Germany. The second is London's integrated transport authority, Transport for London, which operates hydrogen buses across the United Kingdom's capital."[91] In total, 1,660 Guarantees of Origin for renewable hydrogen were used (cancelled) to claim supplied hydrogen as being CertifHy Green to these two customers.[92] H2 MOBILITY Deutschland acquired renewable hydrogen GOs from Air Products for 40 tons of hydrogen, equivalent to 1,333 MWh of hydrogen, or 1,333 GOs.[93]

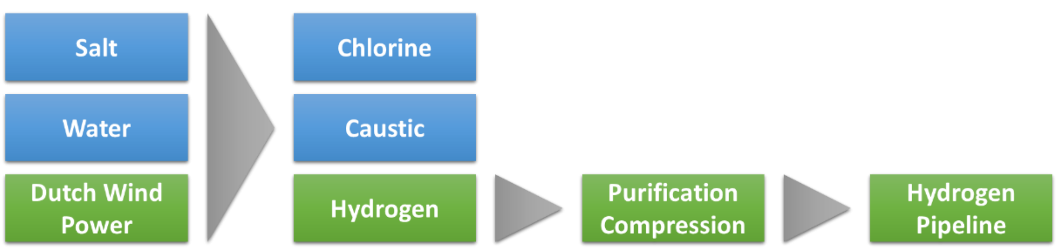


Figure 9: Air Products/Nouryon CertfiHy pilot project scheme[94]

[90] Frank Schnitzeler, Air Products/Nouryon CertifHy pilot Guarantees of Origin for renewable byproduct H2, 2019, CertifHy 2 Final Stakeholder Conference and Plenary

[91] https://www.certifhy.eu/9-uncategorised/171-ir-products-delivers-first-certifhy-green-hydrogen-to-h2mobility-deutschland-and-transport-for-london.html

[92] Final Report, CertifHy 2020

[93] H2 Mobility Deutschland, press relase of 11 February 2019: H2 MOBILITY nutzt grünen Wasserstoff-Herkunftsnachweis CERTIFHY GO; https://h2.live/presse; last accessed on 5 February 2021.

[94] Based on https://www.certifhy.eu/images/media/files/CertifHy_-_Pilot_case_studies_WG2_webmeeting_2018-03-01_v3.pdf

4.2.3. Colruyt (Halle, Belgium): hydrogen from wind power by electrolysis

The Colruyt group is a Belgian retail corporation, that inter alia includes the Colruyt supermarket retail stores. The CertifHy pilot of the Colruyt Group site at Halle, Belgium, produces renewable Hydrogen (at 99,98% purity) with polymer electrolyte membrane electrolysis as well as alkaline water electrolysis for their forklifts (up to 75 units), heavy duty vehicles and passenger cars (minimum 5 vehicles). Their system also contains a 20 MPa backup storage, an indoor and outdoor service hydrogen dispensing facility for the company as well as a public hydrogen refuelling station. As a retailer, Colruyt demonstrates on-site hydrogen production for its fleet in Belgium.

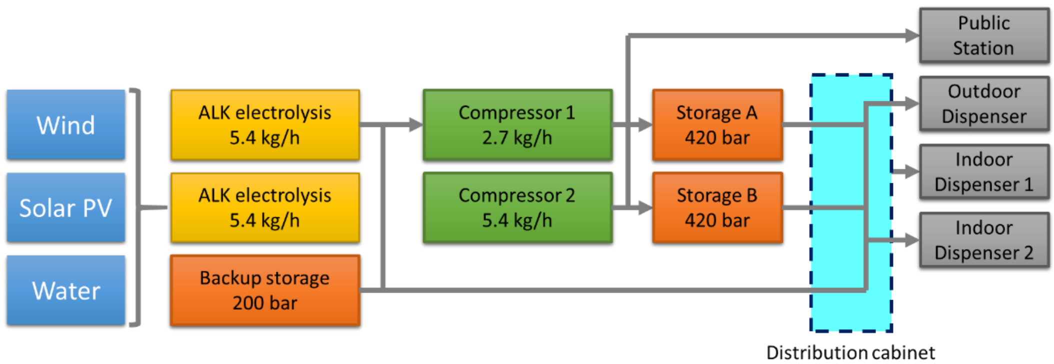


Figure 10 Scheme of Colruyt pilot[95]

4.2.4. Air Liquide (Port Jérôme, France): hydrogen from steam methane reforming with (partial) carbon capture and use

Air Liquide is a French multinational company with operations in more than 80 countries, which supplies industrial gases and services to various industries including medical, chemical and electronic manufacturers. The company aims to encourage the development and consumption of low-carbon hydrogen while providing full transparency on its origin and method of production. The pilot plant by Air Liquide in Port Jérôme, France, produces hydrogen using steam methane reforming with a carbon capture unit; where biomethane is used as a feedstock, renewable hydrogen is produced. The plant has an output of up to 100 t of hydrogen per day which goes to the refining industry or other merchant markets. The captured CO_2 is used in the food industry, water treatment, PH control or green houses. As of 2019, 1,960 Guarantees of

[95] Based on https://www.certifhy.eu/images/media/files/CertifHy_-_Pilot_case_studies_WG2_webmeeting_2018-03-01_v3.pdf

Origin for fossil-based hydrogen were used to claim compliance with a proprietary label developed by Air Liquide called 'Blue Hydrogen'.[96]

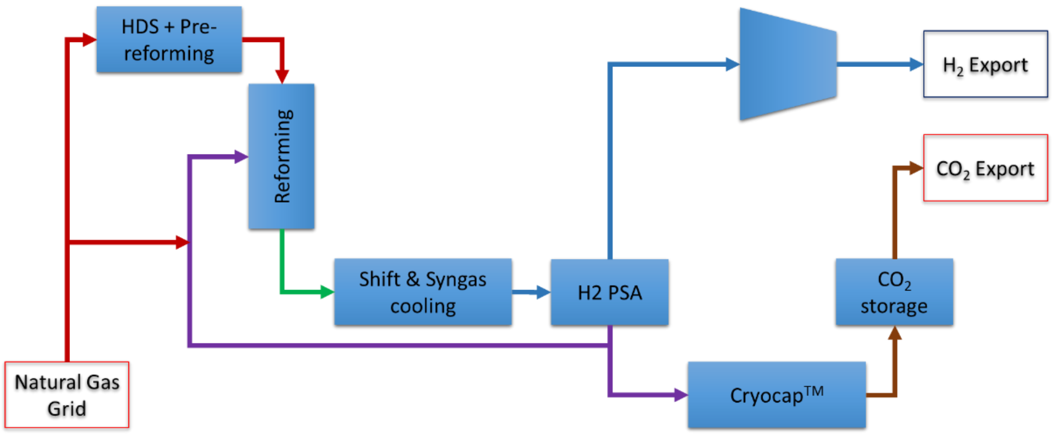


Figure 11: Air Liquide Pilot plant production process scheme[97]

[96] Final Report, CertifHy 2020

[97] Based on https://www.certifhy.eu/images/media/files/CertifHy_-_Pilot_case_studies_WG2_webmeeting_2018-03-01_v3.pdf

Contact

Hinicio Chile

Av. Eliodoro Yáñez N°2979, 6th floor.

Santiago, Chile

www.hinicio.com

https://www.linkedin.com/company/hinicio

https://twitter.com/HinicioSA