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Guide for the Adoption of Guarantees of Origin for Green Hydrogen in Mexico

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Table of Units

CO_2eq	Carbon dioxide equivalent
CO_2eq/MJ	Carbon dioxide equivalent per mega joule
euro/kWh	Euro per kilowatt-hour
$CO_2eq\ /MJH_2$	Carbon dioxide equivalent per megajoule of hydrogen
g CO_2eq/MJ	Grams of carbon dioxide equivalent per megajoule
$CO_2e/MJLHV$	Carbon dioxide equivalent per megajoule of lower calorific value (low heating value)
kg	Kilogram
CO_2e/kgH_2	Carbon dioxide equivalent per kilogram of hydrogen
kWh	Kilowatt hour
g	Gram
MJ	Megajoule
$MtCO_2e$	Million tons of carbon dioxide equivalent
Mton	Million metric tons
MW	Megawatt
MWh	Megawatt-hour
ton	Ton
TWh	Terawatt hour

Table of Abbreviations

AFP	Alternative Fuel Portal
AIB	Association of Issuing Bodies
CAPEX	Capital Expenditure
CARB	California Air Resources Board
CBTS	Banking Credit and Transfer System
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CCUS	Carbon Capture, Use and Storage
CEL	Clean Energy Certificate
CENACE	National Energy Control Centre (Independent System Operator in Mexico)
CEN-EN	Central European Standard - European Standards
CFDis	Digital Tax Receipts
CFE	Federal Electricity Commission (State owned electricity company in Mexico)
CH_4	Methane
CI	Carbon Intensity
CO_2	Carbon dioxide
COFECE	Federal Economic Competence Commission

CONAFOR	National Forestry Commission
CRE	Energy Regulatory Commission
DOF	Official Journal of the Federation
EECS	European Energy Certificate System
EEE	European Economic Area
EPA	Environmental Protection Agency
ERGaR	European Renewable Gas Registry
ETS MRV	Emission Trading System Monitoring, Reporting and Verification
FCEV	Fuel Cell Electric Vehicle
FTC	Federal Trade Commission
GATS	Generation Attribute Tracking System
GEI	Greenhouse Gases
GO	Guarantees of Origin
H_2PA TF	Hydrogen Production Analysis Working Group
H_2TR TF	Working Group on Hydrogen Trade Rules
HRS	Hydrogen Refuelling Station
ICS	Independent Criteria Schemes
IEM	Internal Electricity Market
INECC	National Institute of Ecology and Climate Change
I-REC	International Renewable Energy Certificate Standard
IRENA	International Renewable Energy Agency
LBST	Ludwig-Bölkow-Systemtechnik
LCA	Life Cycle Assessment
LCFS	Low Carbon Fuel Standard
LGCC	General Law on Climate Change
LIE	Electrical Industry Law
LTE	Energy Transition Law
MEM	Wholesale Electricity Market
MENA	Middle Eastern - Northern African
N_2O	Nitrogen Oxide
NDC	Nationally Determined Contributions
NGC	Non Governmental Certificates
ODS	Sustainable Development Goals
ONGs	Non-governmental organizations
PEMEX	Petróleos Mexicanos
PNUMA	United Nations Environment Programme
PRODESEN	National Electricity System Development Program
REC	Renewable Energy Certificate

RED	Renewable Energy Directive
RENOVA	National Renewable Energy Registry
RET	Renewable Energy Targets
RFNB	Renewable fuels of non biological origin
ROCs	Renewables Obligation Certificate
RPS	Renewable Portfolio Standard
SAT	Sistema de Administración Tributaria
SCHP	Ministry of Finance and Public Credit
SE	Ministry of Economy
SEMARNAT	Ministry of the Environment and Natural Resources
SEN	National Electrical System
SENER	Secretary of Energy
SHCP	Ministry of Finance and Public Credit
SIF	Financial Integration Services
SMR	Steam Methane Reforming
SER	Ministry of Foreign Affairs
SSB	Provider of Basic Services
T-MEC	Trade Agreement between Mexico, the United States and Canada
UE	European Union
UK	United Kingdom
USD	United States Dollar
ZEV	Zero Emisión Vehicle

1. Executive Summary

1.1 Background

In recent years, numerous countries around the world have announced strategies to develop hydrogen as a key energy carrier. By 2021, 17 governments had hydrogen strategies in place and more than 20 had declared they were working on developing them. Simultaneously, there has been a great deal of interest in the net-zero commitment from numerous countries, cities and companies, who have adopted zero carbon dioxide emissions targets. This highlights the need and international interest in adopting hydrogen at a level that goes beyond its current status[1,2].

While the global demand for hydrogen has been steadily increasing over the past four decades, the problem is that conventional means of hydrogen production generate large volumes of CO_2, wasting the hydrogen great potential to contribute to the decarbonization goals of governments and companies. However, there are production alternatives with lower emissions of associated greenhouse gas (GHG) in comparison to traditional methods. This is where electrolysis technology coupled with renewable energy stands out, producing cleaner hydrogen often referred to as "green hydrogen". The aforementioned label (green hydrogen) depends on meeting certain requirements that vary depending on the country or system to which it is being referred, but the general idea is to label hydrogen with significantly lower GHG emissions compared to conventional hydrogen and that has also been produced using renewable energies. Thanks to the accelerated technological advances in electrolysis and the rapid decrease in the costs of renewable energies in recent decades, green hydrogen can become the ideal means to transport and store renewable energy globally[3]. Therefore, green hydrogen can play an important role in the energy transition.

Following in greater detail the idea of the previous paragraph, it is important to be clear that, because of its molecular properties, hydrogen can be produced using a variety of technologies (for example, via steam methane reforming —SMR, gasification, electrolysis, pyrolysis, etc.) using all kinds of energy sources, whether fossil or renewable. The use of colour nomenclature to refer to the different hydrogen production routes has recently become widespread in an attempt to facilitate its implementation (for example, green hydrogen refers to hydrogen from renewable energies, while blue refers to the production of hydrogen from natural gas with carbon capture, utilization and storage —CCUS). Due to the aforementioned versatility in production, and considering that the hydrogen molecules are identical regardless of their classification colour (the hydrogen molecules produced using renewable energy are identical to those of the hydrogen produced using fossil fuels), once obtained, it is not possible to determine their origin and the corresponding emissions associated to its production[1].

This results in the need to have a system that certifies characteristics of hydrogen production and that allows interested parties to trace its origin. In addition, certifying green hydrogen is necessary to be able to assess its lower GHG emissions compared to a baseline, which allows the creation of a new market in which these lower GHG emissions are valued with a greater willingness to pay. These certification systems are often referred to as "Guarantees of Origin" systems for hydrogen. Here it is important to be clear that, in general terms, a Guarantee of Origin is basically an electronic document that identifies the source and the method of production of one unit of energy (in this case hydrogen) and is related to a specific purpose, for example, the disclosure of the power surce or compliance of an obligation. The Guarantees of Origin system is the scheme that manages from beginning to end these electronic documents known as Guarantees of Origin.

A Guarantees of Origin system generates the confidence that enables purchase and sale transactions of low-carbon hydrogen, providing certainty of the origin of the energy used for its production. Since green hydrogen producers face higher costs compared to those who use more polluting traditional methods, Guarantees of Origin are necessary to guarantee green hydrogen as a product that stands out because of its cleaner characteristics.

The present study considers the aforementioned importance of Guarantees of Origin for the required ramp up of green hydrogen, and presents an overview of the most relevant international efforts (due to their deployment and progress) to adopt Guarantees of Origin for hydrogen, with the intention of detecting success cases and certification trends. In addition, national experiences with certification are also addressed,

[1] IRENA, 2021.
[2] IEA, 2021.
[3] Strategy&, 2020.

identifying the main challenges that Mexico has faced before. With this analyses and considering the perspectives of key actors in the hydrogen industry in Mexico, a roadmap for the adoption of a system of Guarantees of Origin of green hydrogen in the country is presented, as well as a series of recommendations to carry out such a roadmap.

1.2 Objectives and Scope

General Objective

Generate a set of recommendations for the adoption of Guarantees of Origin for green hydrogen in Mexico based on (i) international experiences on renewable certification (ii) and green hydrogen certification, (iii) national experiences in certification, (iv) current and expected trends according to leading international organisations in research and promotion of green hydrogen and its certification, and (v) the perspectives of key actors[4] in the hydrogen industry in Mexico.

Specific Objectives

1. Introduce the Guarantees of Origin in a general way for renewable energy and other examples.
2. Study the national experiences with renewable certification to consider the main challenges that have arisen in the country.
3. Review and analyse relevant international experiences of adopting Guarantees of Origin for green hydrogen (or low carbon hydrogen) to identify good practices and recommendations.
4. Present the current perspectives of key players in the hydrogen industry in Mexico on the adoption of Guarantees of Origin in the country.
5. Identify the potential benefits that could be driven by adopting a green hydrogen Guarantees of Origin system.
6. Elaborate a proposal of recommendations for the adoption of Guarantees of Origin in Mexico based on the analyses carried out of international and national experiences, points of view of international organizations and perspectives of key actors in the hydrogen industry in Mexico.

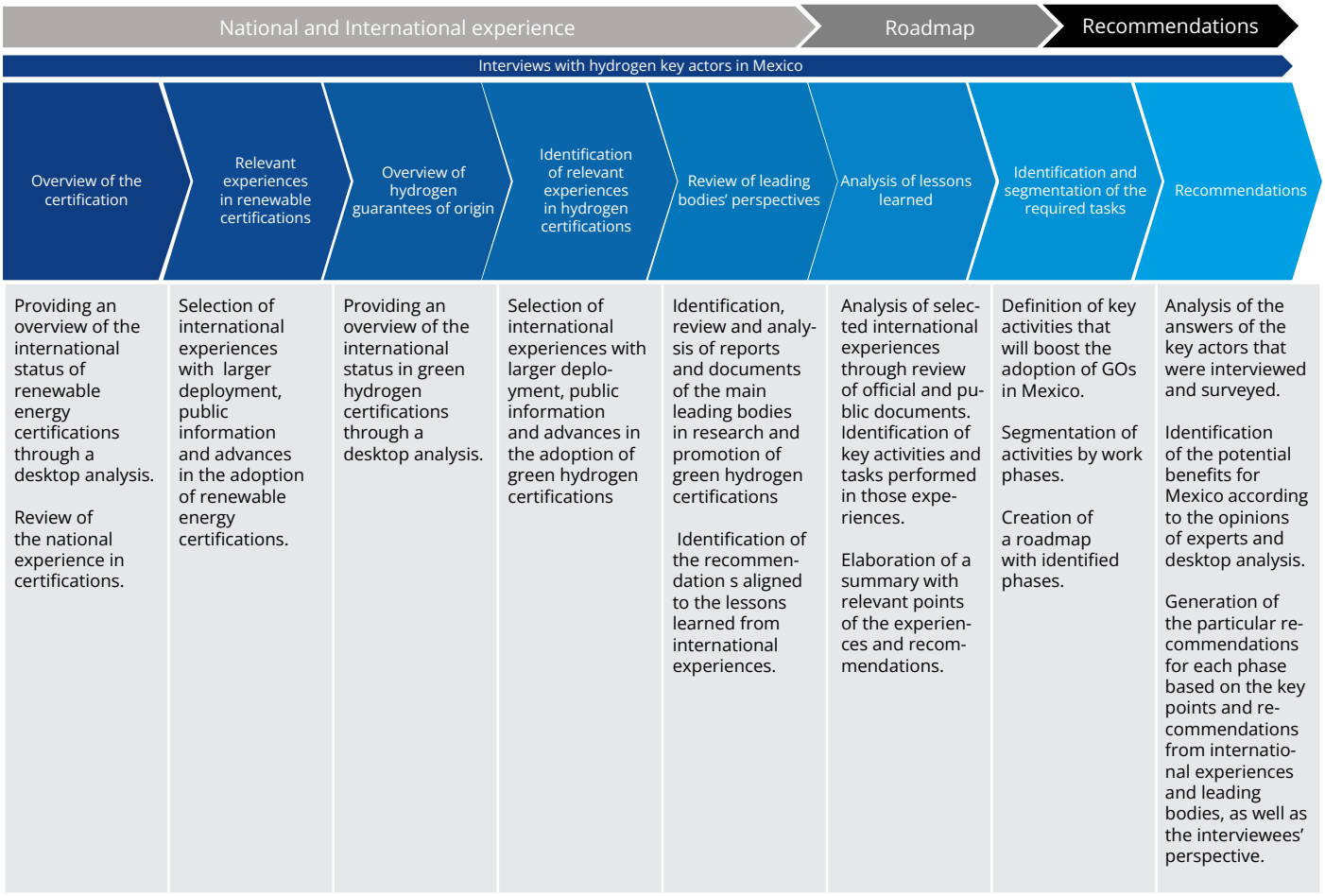
1.3 Methodology

For the elaboration of recommendations for the adoption of Guarantees of Origin of green hydrogen in Mexico, the following tasks were carried out: (i) desktop research of the most relevant international experiences in renewable energy certification; (ii) analysis of the most relevant international experiences in green hydrogen certification, identifying the key points of their systems and the lessons learned; (iii) review of national experiences in renewable energy certification, with special attention to the challenges that have arisen in the country; (iv) review of the recommendations and views on green hydrogen certification of recognised international organisations and leaders in research and promotion of green hydrogen and its certification; and (v) interviews and a survey of key actors in the hydrogen industry in Mexico, to know their perspectives on the implementation of Guarantees of Origin in Mexico.

Once the information is obtained both from international experience, national experiences and opinions of key actors, the data was selected, analysed, segmented and evaluated, in such a way that the roadmap proposal was created based on the key activities necessary for a successful adoption of Guarantees of Origin in the country, and with the goal that the general and specific recommendations for each phase of the roadmap arised from following the lessons learned and the international certification trends, also considering the current context of Mexico in the field of hydrogen and green certification. In addition to the roadmap, the potential benefits that Mexico would have by implementing a system of Guarantees of Origin are presented.

[4] The key players interviewed include actors from the academia and industry sector.

Figure 1. Methodology for the Recommendations proposal



Source: Own elaboration

Note: The content of this document includes the collection and analysis of publicly available information with a publication date of January 2022.

1.4 Roadmap and recommendations

The following general recommendations are relevant to boost the production of green hydrogen through a system of Guarantees of Origin:

- Adopt a system of Guarantees of Origin already established, which has international recognition, specifically by identified countries to which Mexico would potentially export its production of green hydrogen that is not for local consumption. This is the most efficient approach to achieve compatibility of the systems implemented between Mexico and the target importing countries. In addition, it is considered that the adoption of an advanced international system is more agile compared to the design, development and implementation of a national system.
- Generate the efforts to have a system of Guarantees of Origin in Mexico in the short term and in an agile way, that is, that they are aligned with the general efforts of adoption and use of hydrogen, without having to wait for a stage of greater maturity of the industry and the market in the country. In an initial scenario, based on an analysis of the time required by the CertifHy system of the European Union, it is estimated that the adoption of the system and its deployment could take between 4 and 8 years.

Considering these general recommendations, there are specific activities that would help Mexico to adopt a system of Guarantees of Origin of green hydrogen in an agile way. The following roadmap shows the 6 phases identified for the adoption of a Guarantees of Origin system in the country; each of them has key activities and recommendations[5].

[5] Section 6 of the document also mentions the main threats (general and for each phase of the roadmap).

Figure 2. 1.4 Roadmap and Recommendations

Main activities for each phase					
Establishing a Work Consortium Creation of a Stakeholders Forum Promotion of new studies (about exports, safety norms, etc.) Dissemination and rollout of information Mexico alignment with international initiatives of hydrogen and certifications.	Defining the certification system to adopt. Creating the Work Plan Committing and aligning involved actors towards a better objective. Defining work groups with assigned tasks.	Gathering members of working groups through an open call. Kick-off and development of work plan activities.	Defining roles and people in charge of the Guarantees of Origin Systems Trying out the functionality of the system with a limited numbers of producers and consumers. Getting hands-on experience in technical and administrative aspects. Applying lessons learned.	Testing the compatibility with the international system Identifying relevant information about complications during implementation Fostering international trade agreements	Deploying the system in national territory Enable exports with target countries.
Recommendations Summary					
Involve government institutions. Set certification commitments in the regulatory framework. Consolidate agreements with countries that import green hydrogen.	The system should consider a robust methodology for the renewable characteristic and the carbon footprint Allow the Guarantee s of Origin to have market value. System open to international trade.	Study the possibility of including environmental and social impact criteria in the system, like the sustainable use of water.	Start with small scale projects to test specific parts of the system. Train those responsible of the system's functions and scope.	Consolidate agreements with importing countries.	Constant Review and update of the system.

Source: Own elaboration

2. Introduction to Guarantees of Origin

The Guarantees of Origin are an electronic certificate that endorses and informs about the attributes of a unit of a produced sustainable product; these products can vary from oranges, palm oil, renewable energy, and of course, green hydrogen.

This section will address the different types of Guarantees of Origin identified and the markets in which they participate. Subsequently, the use of Guarantees of Origin for renewable energies in the European Union (EU), governance in its Member States will be detailed, and the types of relevant governmental and voluntary guarantees will be explained. Finally, it will cover the use of renewable energy certificates in the United States of America (USA) as well as in the EU, the systems of government and voluntary certificates will be described.

The objective of the section is to give a general knowledge about the Guarantees of Origin and examples applied to renewable energy in other countries, identifying the most relevant applicable regulation elaborated, the governance systems and possible structures on which Mexico can rely for a future certification system for green hydrogen.

2.1 General Aspects of Guarantees of Origin

In the world, various methods have been developed to guarantee the origin of different products. Some of these forms are applied through Energy Attribute Certificates (EACs) to the energy sector, in companies that are dedicated to the transport and supply of energy (for example, gas and electricity) and that by their way of operating are known as energy carriers.

These energy carriers generally require an extensive distribution and marketing infrastructure, which translates into high investment costs, so the infrastructure is usually shared. The possibility exists that certain energy have attributes differentiators, such as sustainability and the low emissions content, which in turn implies an increase in its cost and price in comparison with its equivalent "traditional" that does not have such attributes; however, it is common that the energy will have to be distributed and marketed through the same infrastructure, regardless of its attributes, which, once mixed, makes it impossible to tell them apart physically. One solution to this problem is the use of EACs.

According to CertifHy, one of the most developed EACs is the Guarantees of Origin system for electricity[6]. These Guarantees facilitate the spread of the use of different types of energy sources, and enable consumers to make informed purchasing decisions based on the origin of the generated electricity.

Classification of Guarantees of Origin According to the Life Cycle

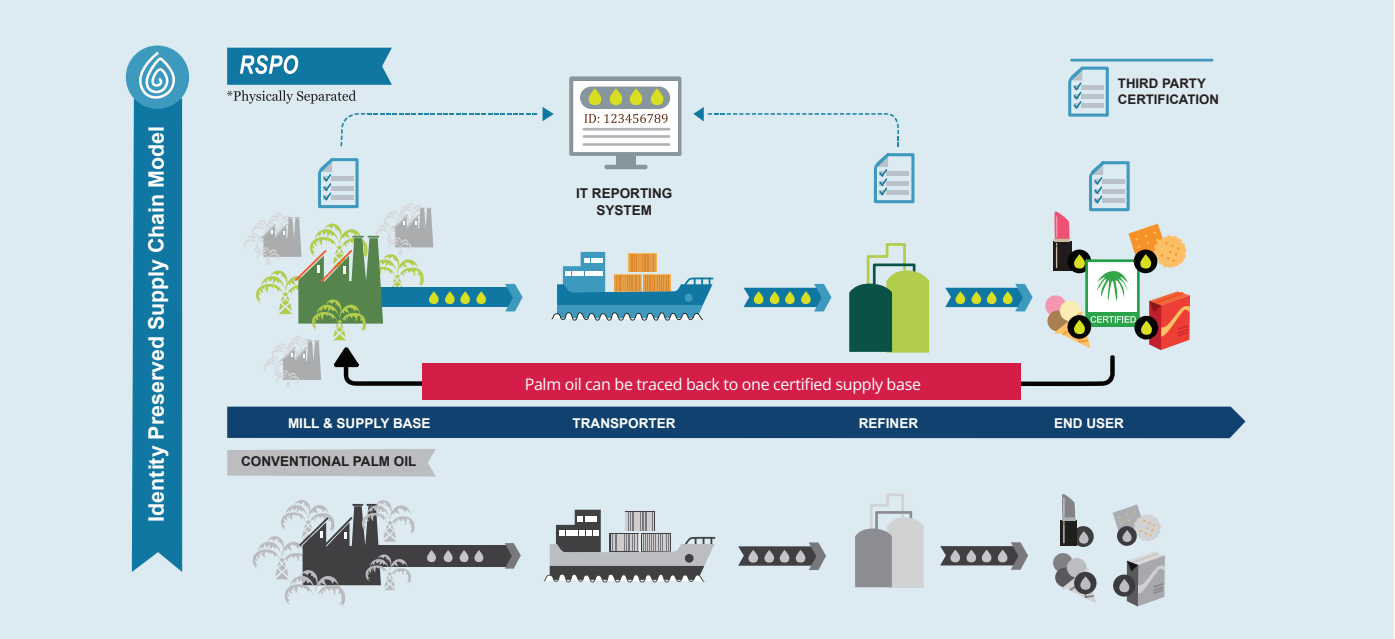
There are different types of Guarantees of Origin according to the life cycle of certain products. CertifHy[7] illustrates this with the types of certifications available for palm oil, which can be applied to energy, developed by the organization Round Table and Sustainable Palm Oil (RSPO)[8] which are mentioned below:

Name	Identity Preserved
Description	The sustainable product comes from a single certified and identifiable source, has a specialized supply chain and is kept separate from the non-sustainable product throughout the supply chain.
Advantage	Provides confidence to the consumer, since the production in question is not mixed with the production of other plants or with what is produced in non-sustainable plants.
Disadvantage	High costs and investment are incurred to make a specialized value chain.

[6]CertifHy, 2015
[7]CertifHy, 2017
[8]RSPO, s.f.

The following image exemplifies the type of Preserved Identity certification:

Figure 3. Example of Certification - Identity Preserved



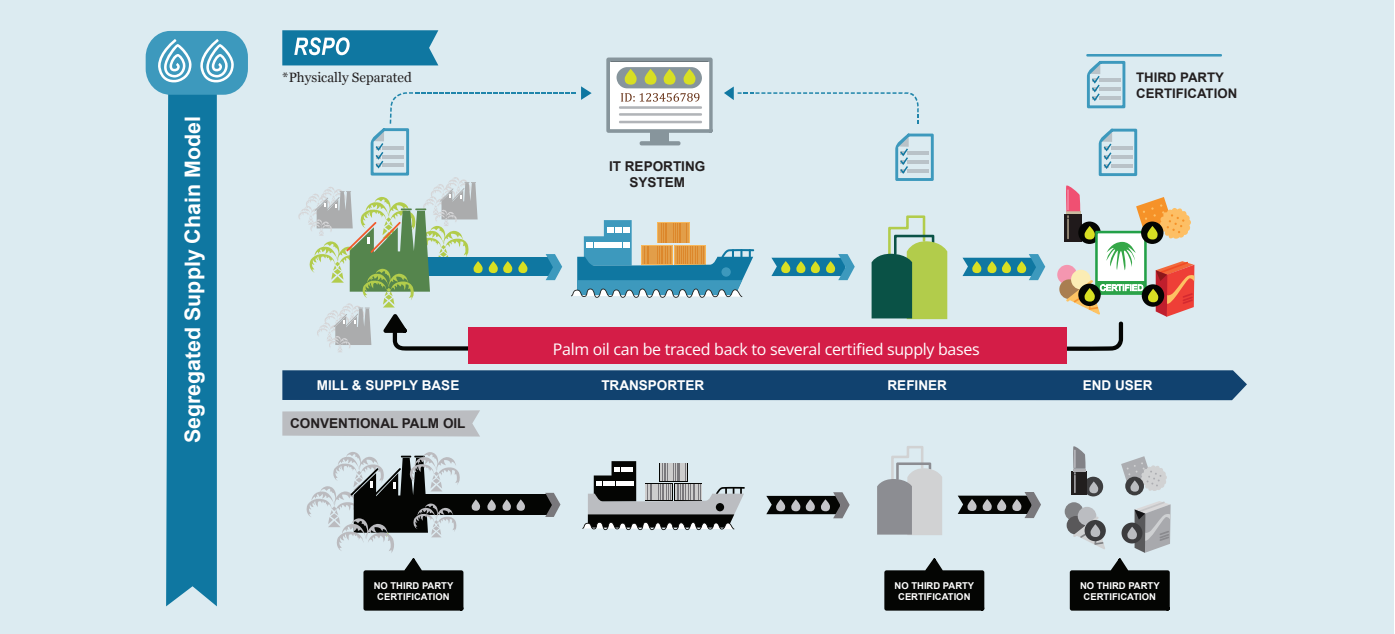
Source: Image taken from RSPO website.

Name	2. Segregated
Description	The production of sustainable plants is mixed in the same value chain (for example, in the distribution or sales channels), but it is kept separate from the non-sustainable product supply chain.
Advantage	The supply chain is optimized for sustainable plants.
Disadvantages	A company can claim that its product comes from a sustainable plant, but there is no total certainty and trust for the consumer. Additionally, distribution costs are not optimized because two different supply chains are kept.

Name	3. Mass Balance
Description	This approach connects the certificate with the physical delivery of the product. The product of sustainable plants is mixed with the product of conventional plants. The amount of product that can be sold as sustainable corresponds to the same amount of sustainable product that was entered into the supply chain. The mass balance serves to track a sustainable product, from its production to its use.
Advantage	The value chain is made efficient since it enables the sustainable product to be processed or transported in a cost-efficient way.
Disadvantage	A company cannot argue that its product comes from a sustainable plant, but it can propose that, by purchasing any of its products, economic support is provided to sustainable plants.

The following image exemplifies the type of Segregated certification:

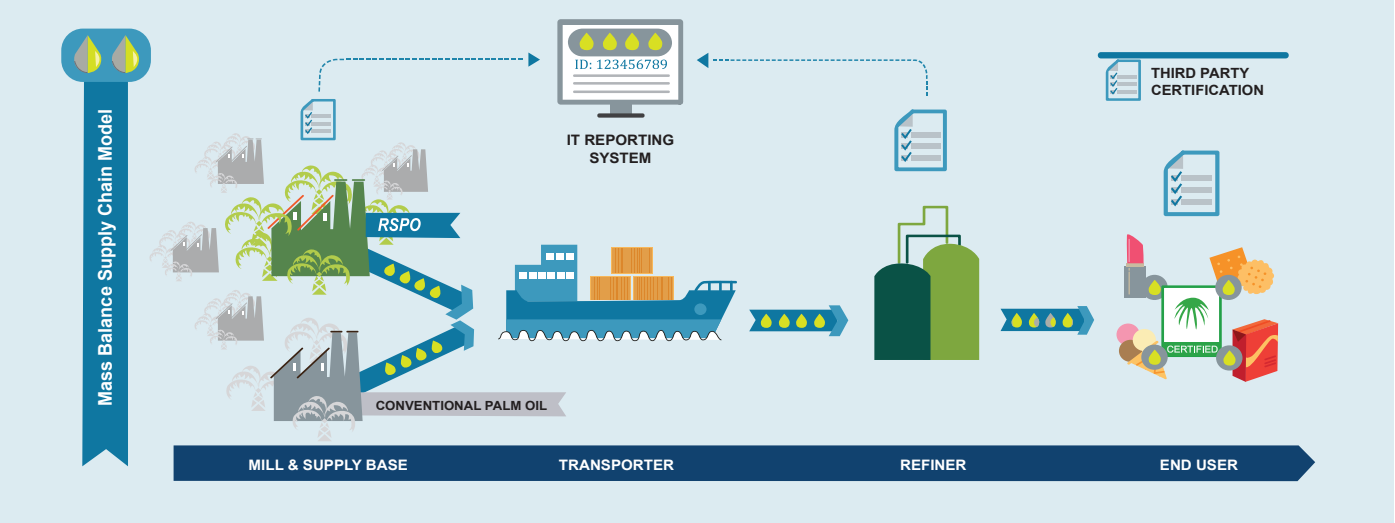
Figure 4. Example of certification - Segregated



Source: Image taken from RSPO website.

Figure 5 exemplifies the type of Mass Balance certification

Figure 5. Certification Example - Mass Balance

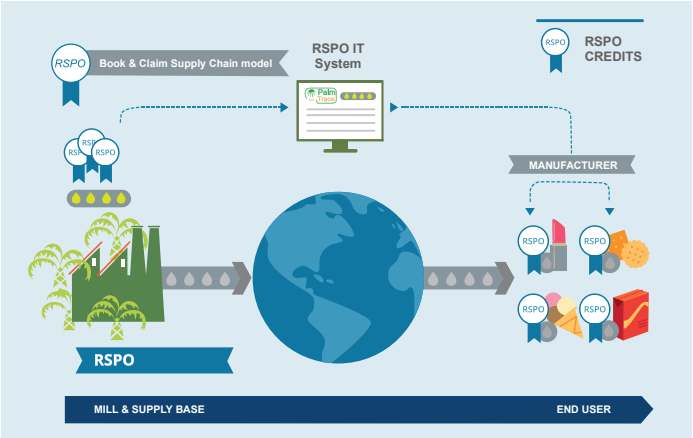


Source: Image taken from RSPO website.

Name	4. Book & Claim
Description	It is a certificate trading mechanism in which the supply chain is not checked for the presence of sustainable product, so the physical delivery of the sustainable product and the issuance of the respective certificate are not linked to each other. Certificates represent a certain amount of sustainable product and require a governance scheme, including a registration base that guarantees traceability and mitigates the risk to avoid double counting of a certificate.
Advantages	The value chain is made efficient. Purchase of sustainable products is enabled, even if it is not physically delivered. It allows to separate the attributes of a sustainable product and the physical product; these attributes can be transferred separately to the product through a Book & Claim registry. It facilitates the scalability of a market, infrastructure and distribution costs are saved.
Disadvantages	It does not allow detailed monitoring of the product supply chain. The certificate states that a certain amount of sustainable product was produced, but they do not claim that such amount of product was transported to the consumer to whom the certificate is addressed.

The following image exemplifies the type of Preserved Identity certification:

Figure 6. Example of Certification - Book & Claim



Source: Image taken from RSPO website.

Classification of Guarantees of Origin by Market Type

In addition to the classification of Guarantees of Origin based on their life cycle, they can also be classified by market type:

Market	Description	United States	European Union
Compliance Market	Certificates function as evidence of compliance with obligations such as standards or quotas.	Renewable Portfolio Standard (RPS)[9] is a regulatory mandate that exists in different states to increase the production of energy from renewable sources. With this standard, a certain percentage of the energy consumed by certain agents is required to be renewable and its origin must be proven.	In the EU Member States are required to introduce disclosure schemes of the source of electricity, i.e., electricity suppliers are required to show on receipts the contribution of each energy source the types of fuel, CO emissions2, etc., of the total mix of energy provided to customers by the supplier[10].
Voluntary Market	It refers to buyers who decide to purchase renewable energy regardless of the regulation or obligations of their country or state.	There are certain states that do not have mandatory RPS, but use the certificates to affirm that they use renewable energy.	There are various types of certificates to emphasize attributes of different products, for example, sustainability. These certificates are not mandatory, but they help consumers know what options are available to them when buying a certain product.

[9]EIA, 2021.
[10]Directive 2019/944/EC.

The reliable, robust and transparent energy attribute traceability systems, which will be addressed in this document, such as the EU Guarantee of Origin, Renewable Energy Certificates (REC) in the United States, and the International REC Standard, are the fundamental basis for creating reliable renewable energy markets. The following section deals in detail with the experiences of international Guarantees of Origin systems mentioned in the European Union and in the United States.

2.2 European Union

Promoting the use of renewable energy is one of the most important objectives of the EU energy policy in recent years. Its adoption and the intensification of its use is a fundamental part of the necessary measures to reduce greenhouse gas emissions, according to what was agreed both in the Paris Agreement, as well as with the Framework for Climate and Energy for 2030 (EU Policy Framework for Climate and Energy 2020 to 2030).

As mentioned at the beginning of this section, a Guarantee of Origin is an electronic document that identifies the source and method of production of an energy unit, and relates to a specific purpose, such as the disclosure of the energy source or the fulfilment of an obligation[11].

Guarantees are created, change ownership and eventually become non-transferable under a carefully designed, implemented and managed control infrastructure. In the European Union there is a regulatory governmental system and a voluntary system, which will be detailed in the following sections

The Association of Issuing Bodies (AIB) is a non-profit association representing the national operators of Guarantees of Origin systems in the European Union; the association created the European Energy Certificate System (EECS) to facilitate transfers of these certificates between Member States. Under this system, the standardization of processes of issuance, transfer and cancellation of various types of mandatory and voluntary certificates is sought, including Guarantees of Origin for renewable energies. This is done through an electronic hub that facilitates the concentration of information by connecting national registries. The regulation does not require Member States to accept and adopt the ECCS, however, many use it while continuing to operate their national certificates in parallel.

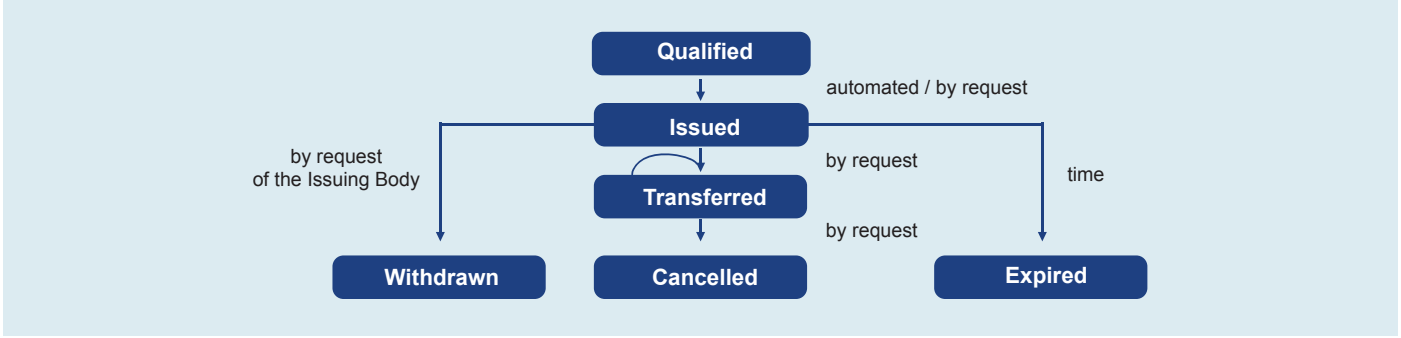
The following figure illustrates the EECS certification process and its respective steps:

Step	Description
Issuance	An electronic certificate is issued for each MWh of electricity generated.
Transfer	After the certificate has been issued, its holder can transfer it to the account of another holder by notifying the issuing body. The issuing body registers the transfer of ownership in the registry, files any documentation related to the transaction and confirms to the seller that the transfer has taken place. The issuing body notifies the buyer.
Cancellation	EECS certificates are cancelled when they are "used", for example, when an electricity supplier reveals to its customers the source of its energy or when a consumer does so to advertise their environmental credentials. The cancellation is irrevocable.
Expiration Date	Guarantees of Origin expire after a period from their generation (for example, one year)
Withdrawal	An issuing body may withdraw a certificate from the register when it has been issued by mistake.

Government System

Through the IEM 2019/944, the EU liberalised the electricity markets of its Member States and it created the common electricity market framework, which requires energy supplier companies to introduce labelling systems for the detailed disclosure of the type of electricity sold to end consumers, giving them details of the contribution of each energy source to the total mix of fuels supplied and the respective environmental impact. This requires a procedure for assigning the "attributes" of electricity generation, such as the type of fuel (or energy source), CO_2 emissions, etc., to electricity suppliers and their customers. The legislative framework for this detailed disclosure of the attributes of the energy supplied to the end user is not yet fully developed for non-electric energy carriers such as hydrogen, gas, heating and cooling. For this disclosure, Guarantees of Origin are a viable tool.

Figure 7. EECS Certification Process



Source: Image taken from the AIB website. (Adapted format)

[11] ECCS, 2021.
[12] Internal Electricity Market Directive (IEM) (2019/944 y sus predecesoras 2009/72/EC, 2003/54/EC y 1996/92/EC).

The Renewable Energy Directive REDII(2018/2001/EC) promotes a substantial increase in the proportion of electricity generated from renewable energy sources throughout the European Union, and it also determines that the Member States shall ensure that the origin of renewable sources can be guaranteed according to objective, transparent and non-discriminatory criteria.

Guarantees of Origin have the purpose of showing an end customer that a certain amount of energy was produced from renewable sources. The directive requires Member States to provide producers on request, the opportunity to obtain electronic Guarantees of Origin for energy generated from these sources, for electricity, gas (including hydrogen), heating and cooling[13]. The system is voluntary and individual producers can decide whether to make the request for a guarantee of origin; however, it is mandatory to have a guarantee of origin to communicate the sustainability of energy.

Article 19 of the directive addresses the issue of Guarantees of Origin and emphasizes the following points:

- A maximum of one guarantee of origin will be issued for each unit of energy produced (1 MWh).
- Member States shall ensure that the same unit of energy from renewable sources is accounted only once.
- The Guarantees of Origin will be valid for a period of twelve months from the production of the corresponding energy unit.
- A Member State may decide whether to issue Guarantees of Origin for non-renewable sources.
- Member States, or designated competent bodies, shall supervise the consignments, transfers, and cancellations of Guarantees of Origin.
- The designated competent bodies will not have responsibilities that overlap geographically and will be independent of production, trade, and supply activities.
- Member States, or designated competent bodies, shall introduce appropriate mechanisms to ensure that Guarantees of Origin are issued, transferred and cancelled electronically, and are accurate, reliable and fraud resistant.
- When an electricity supplier is required to prove the share or amount of energy from renewable sources in its energy mix, it will do so using Guarantees of Origin, except under specific conditions (relating to IEM 2019/944, mentioned above).
- Member States shall recognise Guarantees of Origin issued by other Member States.
- The Member States do not recognise Guarantees of Origin issued by a third country, except when the EU has concluded with the latter an agreement for the mutual recognition of Guarantees of Origin issued in the EU and other systems of Guarantees of Origin compatible established in that third country, and only when there are imports or exports, and direct energy.

It should be mentioned that, since the RED II was adopted, no agreement has been carried out by the European Union and a third country for the mutual recognition of Guarantees of Origin[14], which represents a potential opportunity for Latin America and, of course, for Mexico.

The following table details the contents of a guarantee of origin in accordance with the directive:

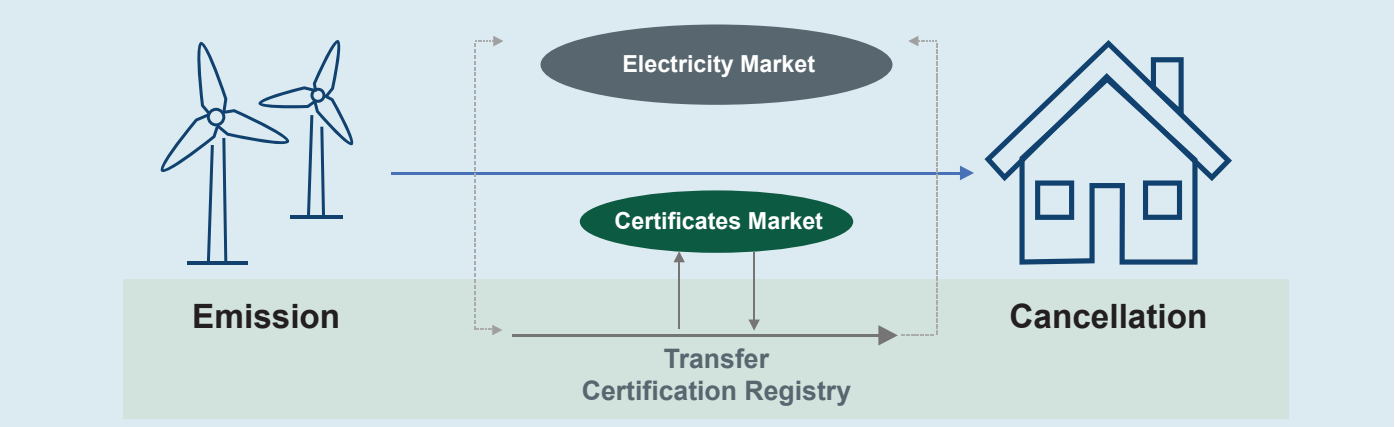
Content of the Guarantee of Origin	• Energy source from which the energy has been produced and the start and end dates of its production; • Type and capacity of the production facility; • If the guarantee of origin relates to electricity, gas (including hydrogen), heating or cooling; • If the facility has benefited from investment support or any other form of support, what type and to what extent; • Date the facility came into operation; • Date and country of issue, and • Unique identification number.

The Guarantees of Origin of the directive follow the Book & Claim scheme. One of the advantages of this scheme is that it allows to separate on the one hand the sustainability attributes and on the other hand the physical product, which makes it possible for the attributes to be transferred separately to the physical product, allowing an optimized distribution of the product. The aforementioned enables a buyer to acquire green or renewable energy even when there are no power plants producing this type of energy nearby, since the solution would consist in acquiring Guarantees of Origin at the time of the physical supply of the energy, with which the energy would acquire the sustainable attributes of the guarantee of origin. For example, an energy supplier that delivers energy generated with fossil fuels to an end user can purchase a renewable energy guarantee of origin from a renewable producer in another European Union country, and attribute said guarantee of origin to the energy it is providing to the end user, thereby being able to affirm that the energy it is providing is renewable energy. This guarantee is cancelled at the time of affirmation by the supplier.

[13] Renewable Energy Directive (2018/2001/EC), art. 19.
[14] GIZ, 2021.

The following scheme visually exemplifies a system of Guarantees of Origin for renewable energy:

Figure 8. Visual outline of a Guarantee of Origin system for renewable energy



Source: Schema taken from CertifHy documentation. (Adapted format)

RED II mentions the CEN-EN 16325 standard, which specifies requirements for the Guarantees of Origin of all sources of electrical energy, establishes terminology, definitions, requirements for the issuance, registration, use, transfer and cancellation in line with the IEM and RED II directives. This standard emphasizes that Member States must issue a guarantee of origin in response to a request by an energy supplier and that the same energy measure be considered only once. This is achieved thanks to an appropriate mechanism that ensures that guarantees are issued, transferred and cancelled electronically.

In addition, the RED II Directive establishes that by 2030 Member States must ensure that the share of energy from renewable sources used in all forms of transport is at least 14% of final energy consumption, a viable target through the addition of biofuels. To ensure that biofuels marketed in the EU are sustainable, RED II establishes that only those biofuels with a sustainability certificate will be counted towards the 14% target. Most of the supply certificates for this purpose are volunteers, recognized by the European Commission.

To ensure that renewable fuels of non-biological origin (RFNBOs), such as those made with hydrogen, are sustainable, the electricity used to produce the fuel must be completely renewable.

For this, a draft Delegated Act was published in May 2022 with the objective of developing the methodology to ensure that the electricity used to produce these RFNBOs has defined rules to (i) establish a temporal and geographical correlation between the unit of electricity produced and fuel production and (ii) ensure that the fuel producer is adding to the deployment of renewable energies or their financing.

The rules proposed in this methodology for accounting the electricity used as completely renewable for the production of RFNBOs apply in a differentiated way to fuel production facilities connected directly to the renewable generation plant, and facilities connected to the electricity grid.

For the first case, the renewable generation plant and the fuel production process must be directly interconnected or located within the same installation. In addition, the installation where the process is carried out must not be connected to the electricity grid, or otherwise it must have a smart meter to ensure that the energy from the network is not used in the process. It also establishes a maximum period in which the renewable generation plant must come into operation prior to the fuel production facility.

For the case of fuel production with renewable energy from the grid, the rules consider criteria such as the location of the fuel production facility in supply zones with renewable electricity percentages above a defined threshold. It is also possible to acquire renewable energy through purchase-sale contracts, considering the following criteria: the date of entry into operation of the renewable energy plant, the fact that the plant does not have subsidies or financial support, the temporality of electricity generation and consumption, as well as the geographical location of the plant and the electrolyser. Finally, it is also possible to purchase electricity from renewable energy plants that are re-dispatched by the operator.

The national systems of Guarantees of Origin that comply with the RED II directive are coordinated through the AIB, which ensures the development, use and promotion of a standardized system for energy carriers through its EECS. This system is based on structures and procedures that ensure the credibility of certification systems in Europe with objective, non-discriminatory, transparent and cost-efficient criteria.

The following table lists the actors involved in a system of Guarantees of Origin:

Actors involved in a government guarantee of origin system	• The national regulatory agency responsible for monitoring the market and its participants; • The operator of the renewable energy traceability system, who issues the certificates; • The AIB; • European Commission associations overseeing the implementation of the directive; • Renewable energy generators; • The operational actors of the electricity infrastructure; • Auditors of renewable energy plant installations; • Electricity suppliers; • Commercial actors using Guarantees of Origin to support claims of sustainable energy use, and • End users of renewable electricity.

There are certain issues that should be considered when implementing Guarantees of Origin, such as:

I. The accounting of conversion from one energy source to another (for example, from renewable electricity to hydrogen), which could be solved by having a clear accounting and a correct process design.

II. ii. In guarantee of origin systems, energy losses along the chain are not considered, since the guarantee is issued at the time of generation.

III. There is no measurement of the "additionality" that guarantees provide to renewable energies, that is, the increase in renewable energy thanks to Guarantees of Origin.

According to the directive, the price of a guarantee of origin will be set according to demand. It is observed that there is an increase in the cost for generators to have to carry out the procedures for applying for Guarantees of Origin, but these costs may be distributed among more certificates as the guarantees market grows.

In France, the income from a guarantee of origin is returned to the government as a form of remuneration to taxpayers for subsidizing or financing renewable projects. In Spain, those who receive the money from the sale of a guarantee are obliged to invest it in environmental projects and pay the government for the support they have received to produce that energy. Guarantees of Origin can be used so that the end customer does not absorb the entire cost of renewable energy, serving as a subsidy for end users.

Voluntary Systems

(Non-governmental Certificates)

Non-governmental certificates (NGC) (formerly RECs) are independent systems and have a similar or identical structure to Guarantees of Origin, but their legal status is different: they are guaranteed by commercial law rather than national Guarantees of Origin legislation. Some countries have renewable energy quotas to be reached, and for this it is not allowed to use Guarantees of Origin, so countries use other commercial certificates (such as Renewable Obligation Certificates (ROCs) in UK[15] and the Electricity Certificate (Elcerts) in Sweden and Norway[16]) and in parallel they use Guarantees of Origin for disclosure to consumers. These two types of certificates are marketed and administered independently.

Independent Certification Systems

Independent Criteria Schemes (ICS) classify certain types of energy sources or supplier products under a specific sustainability system according to an agreed set of criteria. These have been defined and governed by independent organizations

A system of independent criteria informs consumers about aspects that may go beyond the minimum legal requirements. Its connection with the AIB and the EECS certificates (GO and NGC) avoids the confusion and double accounting that could result from the ICS's separate handling of the energy attribute tracking system that constitutes EECS. Some examples of this system are:

EKOenergy[17]

It is a Finnish non-profit communication tool to help consumers announce their commitment to environmental sustainability internationally. The eco-label can be used for electricity and other energy vectors. It has been built thanks to a continuous collaboration between electricity producers and suppliers, consumer organizations, environmental NGOs and authorities.

Renewable energy is getting cheaper and cheaper, therefore EKOenergy is becoming more relevant, as its eco-label works as a guide to highlight the best renewable energy options available. For every MWh of energy sold with the EKOenergy label, 10-euro cents are paid into the EKOenergy Climate Fund. Through this fund, EKOenergy finances new clean energy projects to fight energy poverty in developing countries.

TÜV SÜD Generation EE[18]

This German organization certifies electricity produced from renewable resources where the generation can be attributed to a clearly identifiable source. Certification of electricity generation can be used as a private sector proof of origin in electricity trading or serves as a basis for the issuance of EU-compliant national Guarantees of Origin. TÜV SÜD provides certification services for traditional "ecoenergy" and "ecogas" products, generation of commercial certificates from renewable sources to demonstrate the sustainability of biofuels and even for green hydrogen.

[15] Office of Gas and Electricity Markets, 2021.
[16] NECs, 2021.
[17] Eckoenergy,s.f.
[18] AIB, s.f.

Naturemade[19]

It is the Swiss certificate for renewable energy. The highest degree of certification in this system indicates that the energy was produced with special respect for the environment, that it comes from 100% renewable sources and that it guarantees compliance with stricter and more complete ecological requirements. The requirements are based on eco-balances of each energy system and scientific criteria on the power generation plant.

Electricity from hydroelectric, photovoltaic, wind and biomass plants are currently certified. In this system the plants and the products are independently certified, this ensures that the origin of each kWh of energy sold is known, thus avoiding double alienation. The sale of certified products additionally supports the construction of new plants.

2.3 United States

Government System

The Renewable Portfolio Standards (RPS) are policies designed to increase the use of renewable energy sources for electricity generation. These policies require or encourage electricity suppliers to provide their customers with a defined minimum share of electricity from renewable resources.

Although national RPS or other clean energy policies have been proposed, there is currently no federal RPS or a similar policy in the United States. However, most states have enacted their own RPS programs[20]. By 2020, 38 states had established RPS and/or renewable targets, and 12 states committed to having 100% clean electricity by 2050.

A common feature of the RPS is that they have a trading system for renewable energy certificates (renewable electricity certification/credits - REC). A REC is a legal instrument that conveys to its owner the right to claim the associated environmental attributes of its generation; these help to track renewable energy from the point of generation and are available for sale, purchase or exchange.

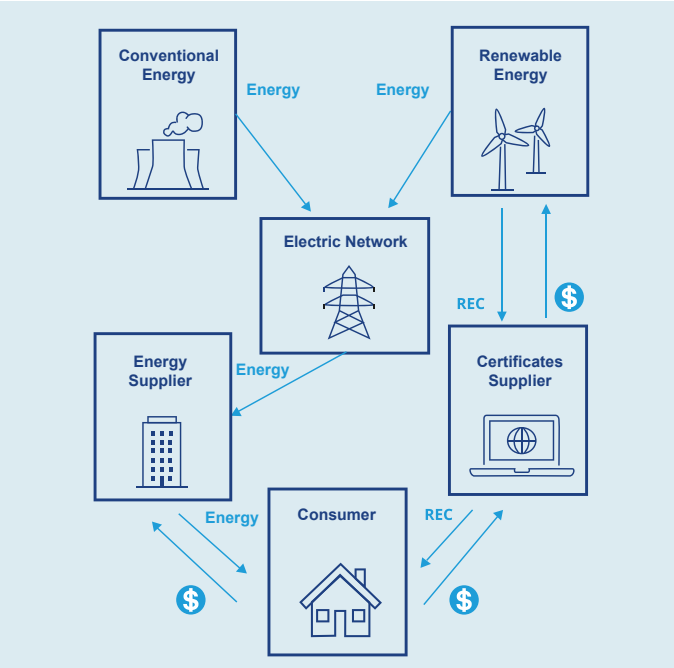
RECs provide buyers with the flexibility to offset a percentage of their annual non-renewable electricity use with renewable energy, even when renewable energy products are not available locally, reducing the cost of complying with the RPS. RECs are mentioned in state, as well as federal regulations (for example, Executive Order 13423[21]), where it is mentioned that RECs are essential for claims related to renewable energies and adjustments to GHG emissions.

The RECs follow the Reserve & Claim scheme, and represent the environmental benefits of 1 MWh of generation. A company or state that generates renewable electricity in excess of the requirement established in the RPS may exchange or sell RECs to other electricity providers, who may not have enough renewable electricity to meet their RPS requirements. Only one entity, the generator or the REC holder, may take credit for the RPS-eligible renewable generation attribute. Once the REC is sold separately from the electricity, the electricity is no longer considered renewable.

Some factors, such as the reduction of renewable energy prices, federal incentives for RPS certified generators and complementary policies, have promoted a favourable environment for RPS and RECs .En la figura 9 se ejemplifica un sistema de certificación de RECs[22].

A RECs certification system is exemplified in the following scheme:

Figure 9. REC Certification Scheme



Source: Image taken from RSPO website. (Adapted format)

The state or regional electronic traceability systems issue RECs to the generators that have been registered and notify the verified generation to the system. Certified traceability systems ensure that RECs are only in the hands of one organization, assigning a unique identification number to each REC to ensure that only one is issued for each MWh of generation reported, thus minimizing the double issuance of certificates. In this way, these systems together with the certification facilitate and simplify the verification of green energy purchases.

Content of the RECs	• Type of renewable resource; • Location of the renewable resource; • Stamp of Generation Date; • Emissions profile of the generator, and • Unique identification number.

[19] Naturemade, s.f.
[20] EPA, 2021.
[21] CRS, 2005.
[22] EIA, 2021.

The functionalities of the RECs are:

- Serve as a signal to the market, to influence the types of renewable generation in the electricity market;
- Encouraging the development of new renewable projects;
- Serve as evidence to meet corporate objectives and with RPS, and
- Affirm the use or generation of renewable energy with zero emissions, once it is affirmed, the REC is cancelled.

To sell a REC, the seller can enter a platform and publish information about the RECs or cover the request of a specific buyer. It can also be done through an intermediary (trader). An example of a platform is the Generation Attribute Tracking System (GATS)[23].

Voluntary Systems

When consumers choose to buy green energy above what is required or what they are subject to, they do so because they want to contribute positively to the care of the environment and because it is part of their organizational culture.

Voluntary markets and programs require RECs as proof of green energy. The Federal Trade Commission (FTC) has issued guidelines establishing the requirement of ownership of RECs to substantiate commercial claims of renewable energy . The voluntary green energy market is shaped by supply and demand dynamics with little regulatory oversight. To address these concerns, a best practice is to purchase green energy[24] products that are certified and verified by an independent third party. Verification helps to ensure that there is a traceable path back to an identifiable generator, and that no other consumer can claim the attributes of that MWh of generation.

Green-e[25]

It is the trusted leader in carbon offsetting and clean energy certification in the United States. It makes it easier for businesses and individuals to buy verified clean energy with confidence, and for consumers to choose sustainable products and services. Since 1997, it has been part of a program of the Non-profit Center for Resource Solutions in San Francisco. As a third-party certifier, Green-e does not sell renewable energy, but offers these links to retailers that do. All certification program standards are reviewed every five years, or more frequently if necessary.

2.4 International REC (I-REC)[26]

The International REC Standard Foundation is a non-profit organization that provides standards for developing an international energy traceability system. The international renewable energy certificates (I-RECs) are global standards that have been introduced in different continents where they do not currently have a similar system. They were built based on the lessons learned from the North American RECs and the Guarantees of Origin of the European Union.

The International Standard REC (International REC Standard) is the one who governs the commercial and issuance operations of the I-RECs, ensuring that the market facilitators adhere to good practices and principles of good governance for traceability. The I-REC is committed to ensuring unbiased access to product information and enabling end users to confidently purchase products whose origins are well documented and clearly accounted for, boosting renewable energy consumption options worldwide and supporting sustainability claims.

I-RECs are issued voluntarily by energy companies; in addition to non-governmental certificates (Non-Governmental Certificates - NGC) presented in section 2.2., there are I-RECs in other countries outside the European Union (e.g., Australia, Thailand and Singapore). To illustrate the handling of I-RECs in another country, the following paragraphs will address the case of Australia:

In Australia, Renewable Energy Targets (RET) are a government plan designed to reduce greenhouse gas emissions in the electricity sector and encourage additional electricity generation from sustainable and renewable sources. This plan operates through the creation of negotiable certificates that create an incentive for additional generation of electricity from renewable sources. Certificates are created and issued through the REC Registry; an online trading platform managed by the Clean Energy Regulator (Clean Energy Regulator). RET manages two systems:

- The Large-scale Renewable Energy Target: Encourages investment in renewable power plants.
- The small-scale renewable energy system Supports small-scale installations such as household solar panels and solar systems for hot water.

Through these systems, which follow the Book & Claim scheme, large renewable power plants and owners of small-scale systems are eligible to create certificates for each MWh of energy generated, creating the "offer" of the certificate market. Wholesale electricity buyers purchase these certificates to meet their renewable energy obligations, which makes up the "demand" of the certificate market. Wholesale electricity buyers then hand over these certificates to the Clean Energy Regulator in percentages set by regulation each year.

[23] PJM-EIS, 2022.
[24] EPA, 2018.
[25] Green-e, s.f.
[26] The International REC Standard, 2020.

3. Certification Background in Mexico

In this section, the certification background in Mexico will be reviewed to provide an overview of the current situation in the country, based on certificates of origin as an instrument for validating the production of goods, the clean energy generation goals and the 2030 agenda to understand the essential parameters and concepts in which the country is advancing to meet the Sustainable Development Goals (SDGs) related to the generation of affordable and non-polluting energy.

In addition, the instrument known as the Clean Energy Certificate (CEL) will be addressed, which is the mechanism recognized by the current regulatory framework to promote investment in electricity generation infrastructure from clean sources.

The Mexican Carbon Platform will also be delved into, as a platform for the promotion of environmental markets based on the General Climate Change Law (LGCC), the National Climate Change Strategy and the Paris Agreement.

Finally, the Mexican tax system focused on the subject of this document will be reviewed, which since 2005 has implemented a digital platform that has enabled strict control of the commercial operations carried out by the country and that, with the obligation to comply with the Consignment Note as a complement to billing, provides elements that can be observed to capitalize on these advances in the green hydrogen custody chain that gives certainty to the Guarantees of Origin generated in Mexico.

Certificates of Origin in Mexico

For the establishment of a system of Guarantees of Origin in Mexico, it is relevant to know the other certification mechanisms, such as certificates of origin, which are instruments issued by the Ministry of Economy to guarantee that a product was produced in Mexican territory. They arise from the need to export consumer goods, industrial inputs and, in general, any merchandise that requires validation to corroborate its origin, in the sense of taking advantage of preferential treatment granted by International Treaties in which Mexico is part of[27].

There are treaties in which the official expedition of a certification issued by a competent authority is necessary, as the case of the European Union, in accordance with Article 3.18 "Conditions for Issuing a Declaration of Origin" of the Free Trade Agreement between Mexico and the European Union (TLCUEM)[28]. The intervention of the Ministry of Economy is necessary for its issuance. There are other cases, such as the Agreement between, the United States of America, the United Mexican States and Canada (USMCA), in which issuing a Certificate of Origin does not require the intervention of an authority for its issuance[29].

In this sense, for cases in which it is necessary to validate the issuance of a Certificate of Origin, the Ministry of Economy has set up a website for its authenticity[30].

Clean Energy Generation Targets and the 2030 Agenda

With the publication of (i) the General Law on Climate Change (LGCC) in June 2012, (ii) the Law of the Electrical Industry (LIE) in August 2014, and subsequently (iii) the Law of Energy Transition (LTE) in December of 2015, Mexico takes the commitments set out in the international environmental treaties, that to dateadd up to 72 international treaties, linked to environmental matters, highlighting the Convention of the United Nations Framework on Climate Change, the Kyoto Protocol and the Paris Agreement[31].

In the Paris Agreement[32], Mexico set its own targets established in the Nationally Determined Contributions (NDC), agreeing on "Unconditioned Commitments", which focus on reducing 22% of greenhouse gas (GHG) emissions and 51% of black carbon emissions, and "Conditional Commitments", which contribute to reducing GHG emissions by up to 36% and 70% of black carbon emissions by 2030 compared to the business-as-usual (BAU)[33] scenario (see below)..

In this sense, Mexico commits to a greater participation in clean energy generation as part of the efforts to comply with the NDCs, setting a goal of clean energy generation at 35% by 2024[34].

This understanding is in force through the publication of two documents by the Ministry of the Environment and Natural Resources (SEMARNAT):

1. Special Climate Change Program 2021-2024

   In November 2021, the Special Climate Change Program 2021-2024 was published, in which it states in its policy 2.1.1. the planning of the incorporation of clean energies in electricity generation, under conditions of safety, quality, continuity and efficiency; as well as economic sustainability of the National Electricity System to reach a 35% share of clean electricity by 2024[34].

2. Update of the Energy Transition Strategy

   The Update of the Energy Transition Strategy was published in the Official Gazette of the Federation on February 7, 2020[25], it establishes that the clean energy generation target for 2024 will be 35%, with an energy efficiency rate of 2.2% reduction in the intensity of final energy consumption for the period 2020 to 2035.

[27] National Foreign Trade Information Service, s.f.
[28] Free Trade Agreement between Mexico and the European Union, 2020
[29] North American Free Trade Agreement, chapter 5 "Origin Procedures", art. 5.2 Applications for Preferential Tariff Treatment, 2019
[30] Ministry of Economy, s.f.
[31] House of Senators 20197
[32] Paris Agreement, 2015
[33] SEMARNAT, 2020.
[34] SEMARNAT, 2021.
[35] SEGOB, 2020.

Table 1. Goals of the Energy Transition Strategy

Year	% Total Clean Electricity Generation
2024	35%
2033	39.9%
2050	50%

Source: Own elaboration with information from SENER

Table 2. Energy Efficiency Goals

Period	Average Annual Rate of Reduction in Energy Intensity
2020 – 2035	2.2%
2035 – 2050	2.5%

Source: Own elaboration with information from SENER

Additionally, in the Third Transitional Article of the LGCC, the objective of achieving at least 35% of electricity generation based on clean energy for the year 2024. Along these lines, it is valid to make a distinction between clean and renewable energy sources; an energy source can be renewable and clean, but a clean one may not be renewable according to the concepts of law shown below:

Clean Energy - LIE	Renewable Energy - LTE
Definition: *Those energy sources and electricity generation processes whose emissions or residues, when any, do not exceed the thresholds established in the regulatory provisions that are issued for this purpose.* *Emphasis added.*	*Definition:* *Those whose source resides in phenomena of nature, processes or materials susceptible to being transformed into usable energy by the human being, that they regenerate naturally, so they are available continuously or periodically, and that when generated they do not release polluting emissions.* *Emphasis added.*

For these considerations, the following are coincident renewable energy sources in both the LIE and the LTE:

- Wind,
- Solar Radiation,
- Ocean Energy,
- Geothermal energy,
- Bioenergetics[36], and
- Hydroelectric Power Plants[37].

The following are the additional clean energy sources in the LIE that are not currently considered renewable:

- Energy Generation from Waste (methane utilization),
- Hydrogen[38],
- Nuclear,
- The one obtained from agricultural shears or urban solid waste,
- Efficient cogeneration,
- The one generated by sugar mills,
- The energy generated by thermal power plants with geological capture and storage processes or carbon dioxide biosequestration,
- Technologies considered to be low-carbon according to international standards, and
- Other technologies determined by SEMARNAT.

For the purposes of energy produced from the use of hydrogen, efficient cogeneration, that one obtained from sugar mills, thermal power plants with carbon capture processes and technologies considered low emissions, Resolution RES /1838/2016 published in the DOF on December 22, 2016 by the CRE, indicates the efficiency criteria and calculation methodology to determine the percentage of fuel-free energy, is applicable.

From the lasts paragraph, it is clear that clean energy may not be in all cases of renewable sources, and to classify them as such, must meet the efficiency criteria set by the CRE and/or SEMARNAT in each case.

[36] The energy corresponding to bioenergetics; they will be those that are determined by the Law of Promotion and Development of Bioenergetics (LPDB)
[37] In the LTE, it is described as "The movement of water in natural channels or in artificial ones with existing reservoirs, with generation systems with a capacity less than or equal to 30 MW or a power density, defined as the ratio between generation capacity and reservoir surface area, greater than 10 watts/m2;"

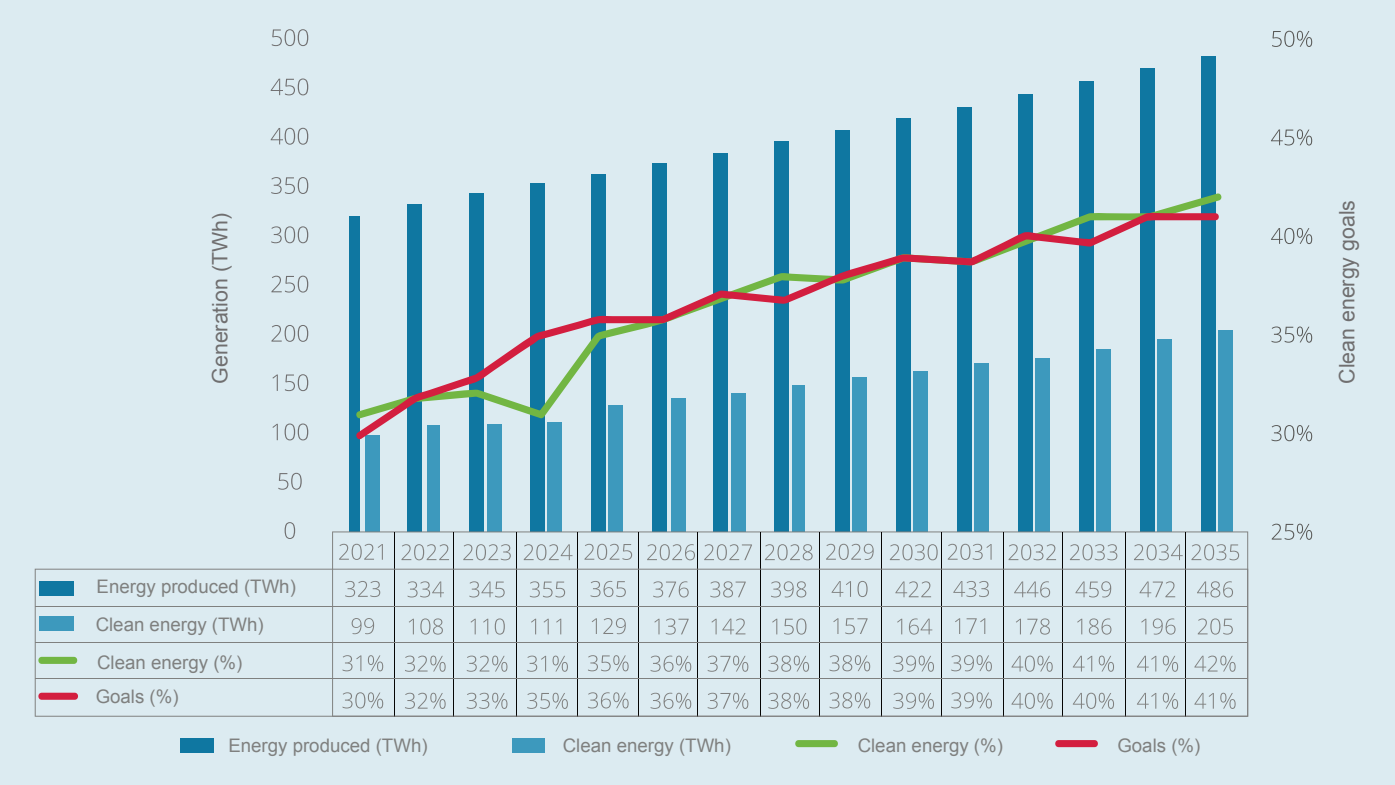
[38] The law cites "Use of hydrogen through its combustion or its use in fuel cells, as long as it meets the minimum efficiency established by the CRE and the emission criteria established by the Ministry of Environment and Natural Resources in its life cycle;"

Having this consideration is important to understand the degree of success that Mexico can have in achieving the Sustainable Development Goals established in the 2030 Agenda, through the follow-up of the established roadmap and that SDG 7 establishes as an objective to guarantee access to affordable, reliable, sustained and modern energy for all. In this sense, in SDG 7.2, Mexico commits to significantly increase the share of renewable energy in its energy mix[39].

To observe the progress of these objectives, through an analysis done by the Federal Commission of Economic Competition (COFECE) in May of 2021, it is predicted that Mexico will not fulfil with the objectives of producing electricity using clean energy sources by 2024, estimating a deficit of 5.2% of the goal of 35% of clean generation committed[40].

This hypothesis is reinforced by the analysis made by SENER in the National Electricity System Development Program (PRODESEN) 2021-2035 which, in section 5.5. CO emissions$_2$, estimates in Figure 5.15 "Generation Evolution and Clean Energy Goals", that 111 Terawatt-hours (TWh) will be produced in 2024 with a total produced energy reference of 355 TWh, resulting in 31% compliance with the established goal of 35%[41] as shown below:

Figure 10. Generation evolution and clean energy goals



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Energy produced (TWh)	323	334	345	355	365	376	387	398	410	422	433	446	459	472	486
Clean energy (TWh)	99	108	110	111	129	137	142	150	157	164	171	178	186	196	205
Clean energy (%)	31%	32%	32%	31%	35%	36%	37%	38%	38%	39%	39%	40%	41%	41%	42%
Goals (%)	30%	32%	33%	35%	36%	36%	37%	38%	38%	39%	39%	40%	40%	41%	41%

Source: Image taken from the PRODESEN 2021-2035. (Adapted format)

[39] SEGOB, s.f.
[40] COFECE,2021.
[41] PRODESEN 2021-2035, Chapter 5, page 96

Clean Energy Certificates

For a better understanding of the challenges facing Mexico in the adoption of a system of Guarantees of Origin for hydrogen, it is necessary to see the direct reference to the currently available certification of energy produced from clean sources.

The Clean Energy Certificate (CEL) was designed to contribute to the achievement of the clean energy generation goals. The LIE defines the CEL as the "title issued by the CRE that recognises the production of a certain amount of electrical energy from Clean Energies and that serves to meet the requirements associated with the consumption of demand centres"[42].

Clean energy generators are the beneficiary subjects to receive a CEL for each Megawatt hour (MWh) produced, which they can alienate to the obligated subjects (suppliers or demand centres).

According to the LIE, the requirements for acquiring Clean Energy Certificates are established as a proportion of the total electric energy consumed at demand centres. In Article 123, it is stated that the following are obliged to comply with clean energy obligations: Suppliers, Qualified Users, Market Participants and End Users who are supplied by the isolated supply, as well as the holders of Legacy Interconnection Contracts that include demand centres, whether public or private.

Under this reasoning, the most important obligation to acquire CELs is the Federal Electricity Commission (CFE) in its capacity as a Supplier of Basic Services (SSB), by covering 81% of the total demand of the National Electricity System (SEN), with CFE being the only supplier of basic services registered in the Wholesale Electricity Market (MEM) operated by the National Energy Control Centre (CENACE).

Since its inception, the CELs were established to promote investments in electricity generation infrastructure from clean energy sources. Each CEL represents 1 Megawatt hour (MWh) of clean energy, they are issued by the CRE and managed through the Management System of Certificates and Compliance with Clean Energy Obligations (S-CEL).

CELs can be purchased through the S-CEL by the participants of the MEM or in a spot market. In this regard, the spot market has lagged, since the Operational Provisions of the Market that establish the rules, calculation mechanics, and procedures for the operation of the short-term CELs market have not been published[44].

In case of non-compliance with CELs purchase, the sanctioning authority is the CRE, which is empowered to impose fines in accordance with the methodology established in Resolution number RES/248/2016, ranging up to fifty days of minimum wage per MWh of unfulfilled obligations[45]. However, as COFECE points out, to date no sanctions have been applied for this concept[43]

Generators[46] and exempt generators[47] that produce electricity from clean energy sources, consider in their business model the following elements of income stream generation as contemplated in Article 96 of the LIE:

I. Electric power;

II. Related services to be included in the MEM;

III. Power or any other product that guarantees the sufficiency of resources to meet the electrical demand;

IV. The above products, via import or export;

V. Financial Transmission Rights;

VI. Clean Energy Certificates, and

VII. Other products, collection rights and penalties that are required for the efficient operation of the National Electricity System.

Therefore, CELs represent an important part in the business scheme of clean energy generators, therefore, any modification in the CELs allocation methodology affects their business model.

In addition to the above, in order for new investments in clean energy to be contemplated, the acquisition requirements of CELs by developers and investors must be known. In that sense, and as already mentioned above, in the LTE in its Transitional Third Article, it establishes that SENER will set minimum goals for the participation of clean energies in the generation of electrical energy. In this regard, SENER has published in the DOF as indicated below, the "Acquisition Requirements" of CELs, as follows:

Table 3. Publication of CELs addition requirements

Year applicable to the requirement	Date of publication in DOF and requirement				
	31/03/2017	23/03/2018	29/03/2019	2020	2021
2020	7.4%		7.4%		
2021	10.9%	10.9%	10.9%		
2022	13.9%		13.9%		
2023				No publication to date	
2024					No publication to date

Source: Own elaboration

[42] LIE fraction VIII, art. 3, 2021
[43] COFECE, 2021.
[44] SEGOB, 2017.
[45] LIE, Fraction IV, art. 165, subsection c.
[46] LIE, Fraction IV, art. 30. Generator: Holder of one or more permits to generate electricity in Power Plants, or holder of a Market Participant contract representing such plants abroad or, with the authorization of the CRE, Power Plants located abroad;
[47] LIE, Fraction XXV, art.3rd. Exempt Generator: Owner or possessor of one or more Power Plants that do not require or have a permit to generate electrical energy in terms of the LIE.

In accordance with the provisions of Article 124 of the LIE on the publication of CELs requirements by SENER, the requirements for 2023 and 2024, respectively, should have been published no later than March 31, 2020 and 2021. This represents a barrier to the design, development and commissioning of new clean power plants, since the parameters on which the demand for CELs will exist are not known.

Finally, recently in October 2019, SENER modified the criteria for awarding CELs in the sense of awarding certificates to clean power plants that entered into operation before the publication of the LIE (August 11, 2014), a situation that benefits the CFE and that decreases the attractiveness to clean energy generators by decreasing the value of the CELs that emit electricity.[48],[49].

It is important to have these points here exposed to a conception of the challenges that might be faced during the adoption of a system of Guarantees of Origin on the basis of the experience in Mexico of the Certificates of Clean Energy, which, at first, were considered as a means of promoting investment in clean energy, but which, in the current practice, are facing a variety of challenges as discussed in this section.

There is an appetite for Mexican companies to acquiring CELs, as well as the interest of developers of renewable projects in their schemes of business to establish investment models with thresholds of 10 to 30 years, for this reason it is very important to give an order of priorities for the institutional strengthening of the agencies that need to promote its use, as well as the mechanisms that make it up, not only to make this possible, but to maximize its dissemination, nationally and internationally.

Mexican Carbon Platform

In the aspect of green bond markets in Mexico, since the market has not yet been formed spot for the sale of CEL, there are other options such as the Mexican Carbon Platform, whose formation dates to 2014. The platform was born from the brokerage firm financial so-called Services of Financial Integration (SIF Capital), a subsidiary of Mexican Stock Exchange Group with the support of the SEMARNAT, the UK Embassy in Mexico, the National Institute of Ecology and Climate Change (INECC), the National Forestry Commission (CONAFOR) and the United Nations Program for Environment (UNEP)[50].

The mission of the platform is to develop markets in Mexico with an environmental perspective based on the LGCC, the National Climate Change Strategy and the Paris Agreement, generating a reference framework for the design and development of instruments that enhance climate change mitigation and adaptation objectives.

To date, the platform's activities have focused on maintaining communication with its affiliates, offering trainings and education in aspects related to environmental care. The development of a green bond market in Mexico is one of the steps that should be consolidated in the short term given the growing interest of brokerage houses, investment funds and even traditional commercial banking.

Mexican Tax System and Waybill

Electronic taxation is a strength that distinguishes Mexico from other economies where robust models of tax systems have not been established.

With the onset of electronic invoices in 2005, Mexico has achieved significant advances in recent years in the field of digital control by enabling information technologies, aimed at ensuring a high degree of reliability and traceability of commercial operations, reducing inspection costs and increasing the degree of quality and integrity of information through the incorporation, in 2004, of digital tax receipts (CFDis) and to date with the recent implementation of Consignment Note Supplements.

The Ministry of Finance and Public Credit (SHCP), enabling the Tax Administration System (SAT) for its observance and compliance, establishes the obligation on the part of carriers operating in national territory, to have a complementary tax receipt called a Waybill that provides the detail of goods or goods transported, origin locations, intermediate points and destination[51]. This obligation began its validity in January 2022, so it is a good reference point to observe how it evolves and, at a given moment, add it to the tools that can be used for the incorporation of Guarantees of Origin in Mexico.

[48] SENER, 2014.
[49] SENER, 2019.
[50] México CO_2, s.f.
[51] SAT,s.f

4. Guarantees of Origin for Green Hydrogen

Background

Although it is common to hear various classifications for hydrogen (for example, by colours: grey, brown, blue and green hydrogen, among others), in reality there is no difference between the molecules according to the classification. This means that the molecules of hydrogen produced using conventional energies are identical to the molecules of hydrogen produced with renewable energy, which poses a challenge to interested parties for the identification of its origin and production characteristics . Therefore, the need arises to have a system that certifies these characteristics and that allows interested parties to trace the origin of hydrogen. There are several examples of these certification systems in the world, which are often called "Guarantees of Origin" for hydrogen.

The need to certify green hydrogen arises with the aim of assessing the lower GHG emissions compared to a baseline, which allows for the creation of a new market in which there are buyers willing to pay more for the environmental attributes; it can help to justify the cost of production of green hydrogen in comparison with the other types of hydrogen for its production generates higher emissions of GHG. The International Renewable Energy Agency (IRENA) also mentions that the certification "is fundamental for the international trade in which hydrogen and its derivatives would cross borders"[52].

There is no single or global system for the certification of hydrogen, since the various initiatives differ in their characteristics and maturity level. This implies that there may be incompatibilities and inconsistencies between the systems, resulting in a less efficient dynamic.

International Context of Guarantees of Origin for Green Hydrogen

This section provides an overview of the current state of the main hydrogen certification systems in the world, according to their maturity and deployment. The level of detail of each system differs due to the fact that they are at different stages of development and do not have the same amount of publicly available information.

In the European Union, CertifHy stands out, it was initiated at the request of the European Commission and is funded by the Clean Hydrogen Partnership. It aims to facilitate the creation of a system of Guarantees of Origin throughout the EU, and has developed "high quality hydrogen" certification systems for Europe. The project consists of 3 development stages, with the last one currently underway.

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In Germany, the "Green Hydrogen" certification from TÜV SÜD allows interested parties to demonstrate that hydrogen produced from renewable sources has significantly lower levels of GHG emissions than conventional hydrogen or fossil fuels. TÜV SÜD is part of the consortium formed for the creation of CertifHy.

Globally there is the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), established in 2003, whose mission is to facilitate and accelerate the transition to clean energy and mobility systems using hydrogen and fuel cell vehicles (FCEVs) in various industries. In 2019, the IPHE established a task force (Hydrogen Production Analysis Task Force, H2PA TF) to address the need for a reference framework and methodology to address hydrogen production technologies. The objective is to achieve a consensus on the methodology for measuring emissions associated with hydrogen generation among the participating countries, including: Australia, Canada, Costa Rica, the European Union, France, Germany, Japan, Korea, the Netherlands, Norway, South Africa, the United Kingdom and the United States. CertifHy is involved with the IPHE and seeks to contribute knowledge on lessons learned in order to establish a system of Guarantees of Origin for green hydrogen that is internationally compatible.

China recently published a standard on hydrogen with low carbon emissions, which guides the transition of the traditional hydrogen production processes to low-carbon, clean and renewable hydrogen production processes. In Japan, efforts are being made at a regional level through a strategy to Aichi Prefecture and its respective roadmap, the strategy raises the certification of produced hydrogen by means of electrolysis with renewable energy, this certification has been used in projects developed by Toyota. However, these experiences are discussed in some detail because they are more recent initiatives, and there is limited publicly available information.

The international experiences mentioned are discussed in more detail below:

[52] IRENA, 2020.
[53] Air Resources Board, s.f.

4.1 European Union

CertifHy[54]

Overview

CertifHy has developed the CertifHy® GOs, a "high quality hydrogen" certification system in Europe. CertifHy is a consortium led by Hinicio, also integrated by Grexel, Ludwig-Bölkow-Systemtechnik (LBST), the Association of Issuing Bodies (AIB), the Commissariat for Atomic Energy and Renewable Energies (Commissariat à l'énergie atomique et aux énergies Alternatives - CEA) and TÜV SÜD.

The objective of CertifHy is to facilitate the creation of a GO system under the Book & Claim scheme throughout the European Union. By using a CertifHy Guarantee of Origin (GO), the corresponding amount of hydrogen consumed acquires the properties of the hydrogen covered by the certificate. The Guarantee of Origin can be marketed independently of the physical product; the above allows access to green hydrogen to users who are not close to green hydrogen sources . It is an electronic document that proves that a certain amount of hydrogen is produced by a registered production device with a specific quality and production method.

CertifHy is based on the following basic principles:

Basic principle	Description
Singularity	Double counting of GOs will be avoided
Transparency	Objective and publicly disclosed criteria
Immutability	The CertifHy GO data will not change once issued
Property of the GOs	The Account Holder will be treated as the owner of the GOs
Operational reliability	Systems must be reliable and secure, and have adequate capacity
End of useful life	Each GO is subject to a shelf life
Consumption Period	The physical consumption of hydrogen will be between the beginning of the production batch and the date of cancellation of the corresponding GO

Definitions

The CertifHy system includes two different GO tags[56]:

CertifHy Green Hydrogen

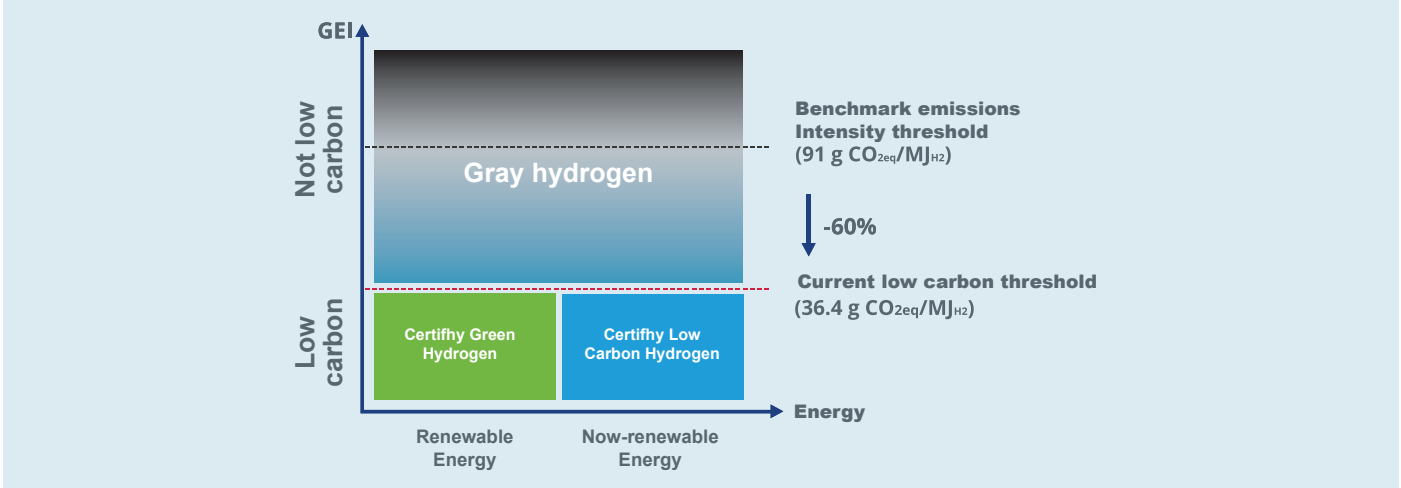
Comes from renewable sources and has a greenhouse gas balance below a defined threshold, which is at least 60% lower than the production of hydrogen by methane reforming with natural gas steam (reference process with a current GHG footprint of 91 g CO_{2eq}/MJ).

CertifHy Low-Carbon Hydrogen

Is produced from non-renewable, nuclear or fossil energy using carbon capture and storage (carbon capture and storage - CCS) and potentially carbon capture and utilization (carbon capture and utilisation - CCU) which is still to be defined in European legislation and that has a greenhouse gas balance below a defined threshold, which is at least 60% below the production of hydrogen by reforming methane with natural gas steam (reference process with a current GHG footprint of 91 g CO_{2eq}/MJ).

CertifHy points out that the GHG intensity indicated in the definitions will be re-evaluated periodically.

Figure 11. Definitions of CertifHy for Hydrogen

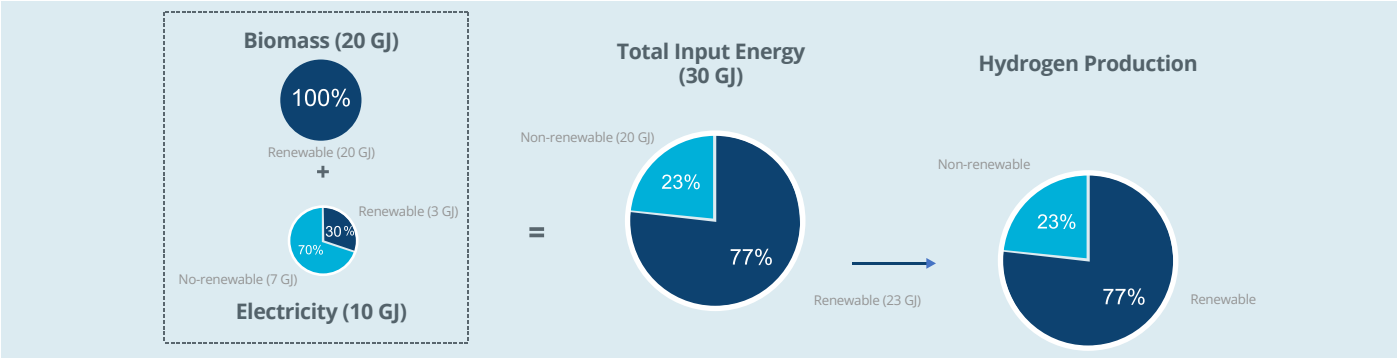


Source: Image taken from CertifHy -Developing the 1st EU-wide Guarantee of Origin Scheme for Premium Hydrogen. (Translation, adapted format)

[54] CertifHy, 2022.
[55] CertifHy, 2017.
[56] CertifHy, 2022. Retrieved from https://www.certifhy.eu/go-labels/
[57] Renewable sources are considered to be: Wind/solar/hydraulic electricity production (these production processes have zero GHG emissions, therefore zero carbon intensity according to the European convention); biomass-based electricity production, which could have GHG emissions according to the definition of GRID II. (CertifHy, 2022, https://www.certifhy.eu/go-labels/)

CertifHy establishes that renewable hydrogen will be as green as the energy used in the production process. This is illustrated in the following example:

Figure 12. Example of percentage of green hydrogen according to energy used



Source: Image taken from CertifHy - Creating the 1st EU-wide Guarantee of Origin for Green Hydrogen - Overview of Certification phase 1 and GO schemes. (Translation, adapted format)

Year of Deployment

By January 2019, CertifHy had emitted more than 75 thousand GOs for hydrogen, after several years of research and design work.

Geographical Scope

CertifHy covers the European Union, the European Economic Area (EEA) , and Switzerland. It is currently not possible to issue CertifHy Guarantees of Origin for hydrogen production outside this geographical scope, and it is also not possible to cancel guarantees for hydrogen used outside of this geography[59].

Certainty

An EU-wide certification system generates trust for end users. CertifHy indicates that, with the two developed labels, unlike the creation of many products or niche labels, it ensures market liquidity for each product[60].

CertifHy endorses that the CertifHy Registration® generates unique GOs for each registered production device and tracks them during their lifecycle, thereby excluding dual use within the registry; said registry is also fraud-resistant and can provide detailed information concentrated in reports[61].

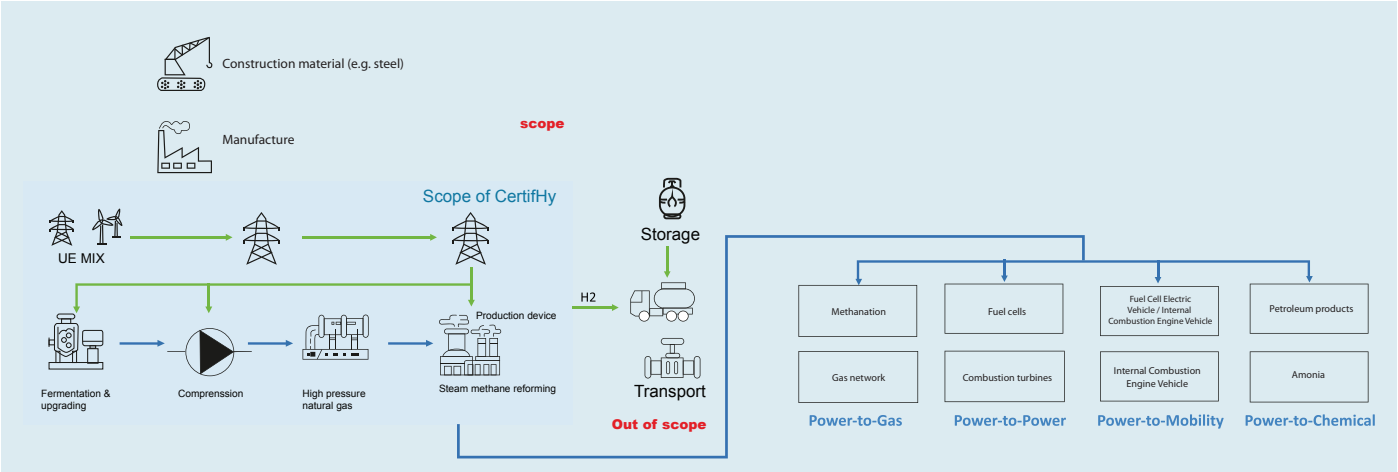
System

The CertifHy system focuses on hydrogen with "premium" characteristics, for which two definitions have been established, specifically for two products: 1) Green Hydrogen (renewable and low-carbon) e 2) Low-Carbon Hydrogen (non-renewable, but low-carbon). These definitions are called labels[62].

CertifHy is neutral in the technology used, that is, any technology that can provide evidence that the defined requirements for the hydrogen produced are met, is included in the scope of the system. In addition, the system will be open to all types of applications, including energy, mobility, chemical conversion, etc.

On the other hand, as can be seen in the following figure, hydrogen GOs and associated GHG emissions cover the generation route to the marketable product, leaving the other activities of the value chain (for example, storage, transport, etc.) out of reach.

Figure 13. Scope of CertifHy



Source: Image taken from CertifHy - Developing the 1st EU-wide Guarantee of Origin for Green Hydrogen - Overview of Certification phase 1 and GO schemes.

[58] The European Economic Area (EEA) brings together the EU Member States and three of the four European Free Trade Association (EFTA) States (Iceland, Liechtenstein and Norway) in an internal market regulated by the same basic rules.

[59] CertifHy, CertifHy Scheme, 2019.
[60] CertifHy, Final Report of Phase 2, 2019.
[61] CertifHy, 2022.
[62] CertifHy, 2016.

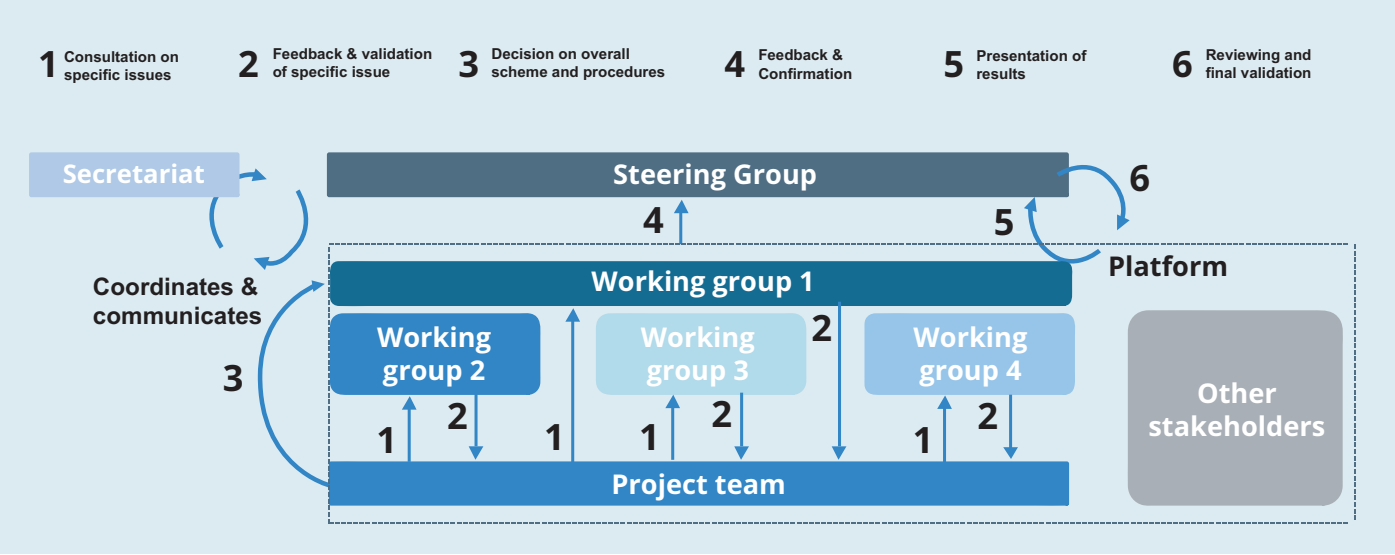
CertifHy indicates that, both in the process of transferring and cancelling a transaction, the commercial part of the transaction/cancellation is outside the scope of CertifHy[63]. As for the transfer of GOs, the commercial agreement between seller and buyer is the sole responsibility of the two parties. Regarding the cancellation of GOs, the commercial settlement (if any) between the holder of the cancelling account and a possible third party is the sole responsibility of both parties.

Guarantees of Origin are aimed at commercial disclosure, so the balance between supply and demand is what sets their price. There is currently no common transaction platform on which the price can be easily monitored.

The generation of the guarantees is monitored by certain actors, including the AIB. An important feature of the hydrogen is generated thanks to other energy vectors such as natural gas or electricity, which means that Guarantees of Origin prices for green hydrogen will be linked to the price of Guarantees of Origin for renewable energy. These Guarantees of Origin may in turn become guarantees for green hydrogen through a specific conversion process, avoiding double counting. The uncertainty of the price of Guarantees of Origin for green hydrogen makes it difficult to explore business cases, for this case pilot projects would be useful[64].

This guarantee has the same mechanism as the Guarantees of Origin of renewable energy that are raised in section 2.2 of the European Union, that is, the guarantee is cancelled when used, either when hydrogen is consumed or converted into another energy carrier, so it can only be used once to claim the consumed hydrogen. The account holder requesting a Cancellation Declaration must inform the Issuing Body about the characteristics of the physical supply of the hydrogen consumed by the end user. The Cancellation Statement is intended to provide reliable information to end customers about the attributes of the hydrogen used. This e-declaration includes a link for online access to the full content of the GO. A GO automatically expires 12 months after the end of the production period.[65].

Figure 14. Schematic Representation of the CertifHy Stakeholder Platform



Source: Image taken from CertifHy - Final Report of Phase 2.

Governance

The governance structure of CertifHy consists of the following bodies: the Stakeholder Platform, the Steering Group, Working Groups and a Secretariat.

The Stakeholder Platform has allowed the views and interests of a large number and a wide range of stakeholders to be considered in the development of the CertifHy system, serving as a discussion forum.

The Steering Group is the decision-making and conflict resolution body of the Platform, which has supported the final design of the CertifHy system, its subsidiary documents and the roadmap.

The Ministry oversees the logistic organization of the Plenary meetings of the Steering Group and the Stakeholders Platform. It has the power to determine whether an organization applying to participate in the platform have enough legitimate interest in the Guarantees of Origin of greenand low-carbon hydrogen.

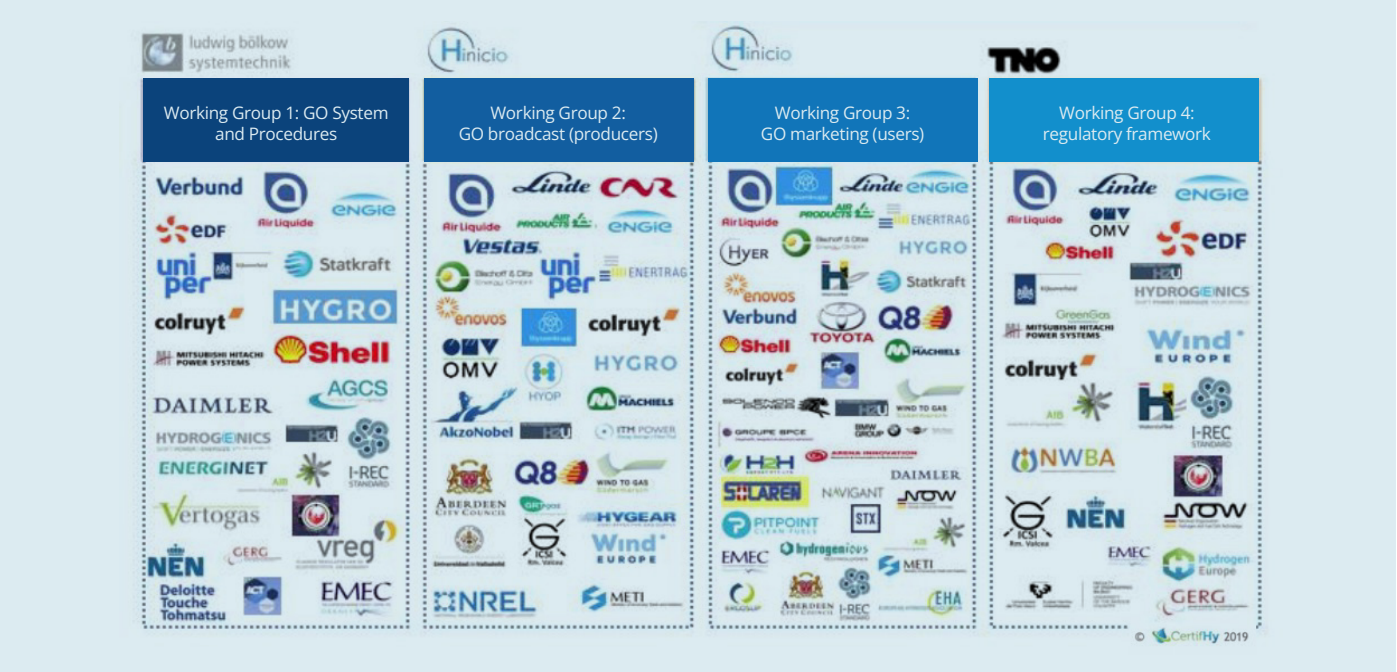
CertifHy has an online form that allows to register applications to be part of the Stakeholder and working group Platform. The Management Group accepts applicants from the online form to create work teams with general and specific activities according to their experience, and with a leader of the Management Group for each work team.

[63] CertifHy, Procedure 1.3: GO cancellation, 2019.
[64] CertifHy, 2016.
[65] CertifHy, Final Report of Phase 2, 2019.

The working groups, with representatives of all the stakeholders of the GO value chain, were consulted on specific topics of their competence:

- Working group 1 contributed to the design of the overall GO system, providing information on other GO systems and drafting all system documents, further adjusting them based on pilot experiences and feedback from other working groups;
- Working group 2 focused on achieving consensus on the requirements to be applied to hydrogen production and on collecting practical information from GO emitters, i.e., hydrogen producers;
- Working group 3 has worked on defining the expectations and requirements of end users for a hydrogen GO system;
- Working group 4 has focused on the identification of alignment issues with current and future regulations, including the evaluation of RED II
- To these four groups one more is added, the working group 5[66], of subsequent creation, prepared for Issuing Bodies, which aims to work on lessons learned.

Figure 15. 2019 Members of the CertifHy Platform Working Groups

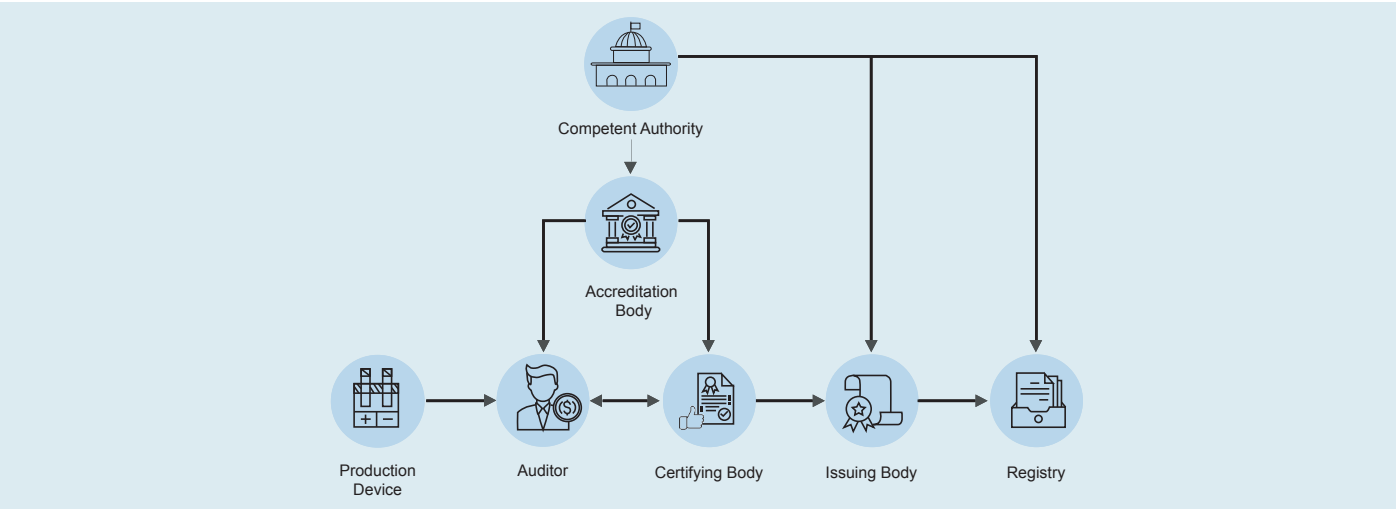


Source: Image taken from CertifHy - Final Report of Phase 2.

Roles and Responsibilities

CertifHy points out that its GOs system has an organization designed in a manner comparable to the European Energy Certificate System (EECS), which is the GOS system of the AIB that manages the electricity GOs.

Figura 16. Roles de CertifHy



Source: Image taken from CertifHy Deliverable No. D.4.2. (Adapted format)

[66] CertifHy, 2020.
[67] CertifHy, Final Report of Phase 2, 2019.

The entities that make up the system are described below:

Competent Authority: The CertifHy Stakeholder Platform assumes this role until such time as the Competent Authority(s) is defined. Among its functions are: (i) to endorse the document of the CertifHy system and all the subsidiary documents of the same; (ii) to decide on the approval of the Certification Bodies; (iii) to designate Issuing Bodies.

Accreditation Body: Entity accepted by the Competent Authority to evaluate and accredit the Certification Body[68]; increases confidence in conformity assessment by ensuring that certification bodies have the technical capacity to perform their functions[69].

Auditor: They are part of a Certification Body and ensure that production devices comply with system requirements[69].

Certification Body: Its activities include (i) verifying the eligibility of production devices through an Audit of Production Devices within the framework of a contract with the Registrant; (ii) verifying the attributes of production lots through an Audit of Production Lots within the framework of a contract with the account holder. During the pilot of the system, and until it is formally implemented, TÜV SÜD has acted as a Certification Body. CertifHy indicates that potential Certification Bodies should be trained to offer certifications and audit procedures harmonized with the CertifHy system, for which TÜV SÜD will provide such training.

Issuing Body: An Issuing Body shall supervise the issuance, transfer and cancellation of Guarantees of Origin. It is the responsibility of an Issuing Body to ensure that all aspects of the CertifHy system defined in its official documents are complied with, which includes the supervision of the operation of the CertifHy Registry. In addition, it is the function of the Issuing Body to (i) decide on the registration of Account Holders; (ii) decide on the registration of production devices; (iii) decide on the issuance of CertifHy GOs; iv) verify and ensure that the GOs transfer requests of account holders are valid, and that all information in the online form for GOs transfers is accurate; v) decide on the cancellation of CertifHy GOs.

During the pilot of the system, and until it is formally implemented, GREXEL has covered the tasks of the Issuing Body.

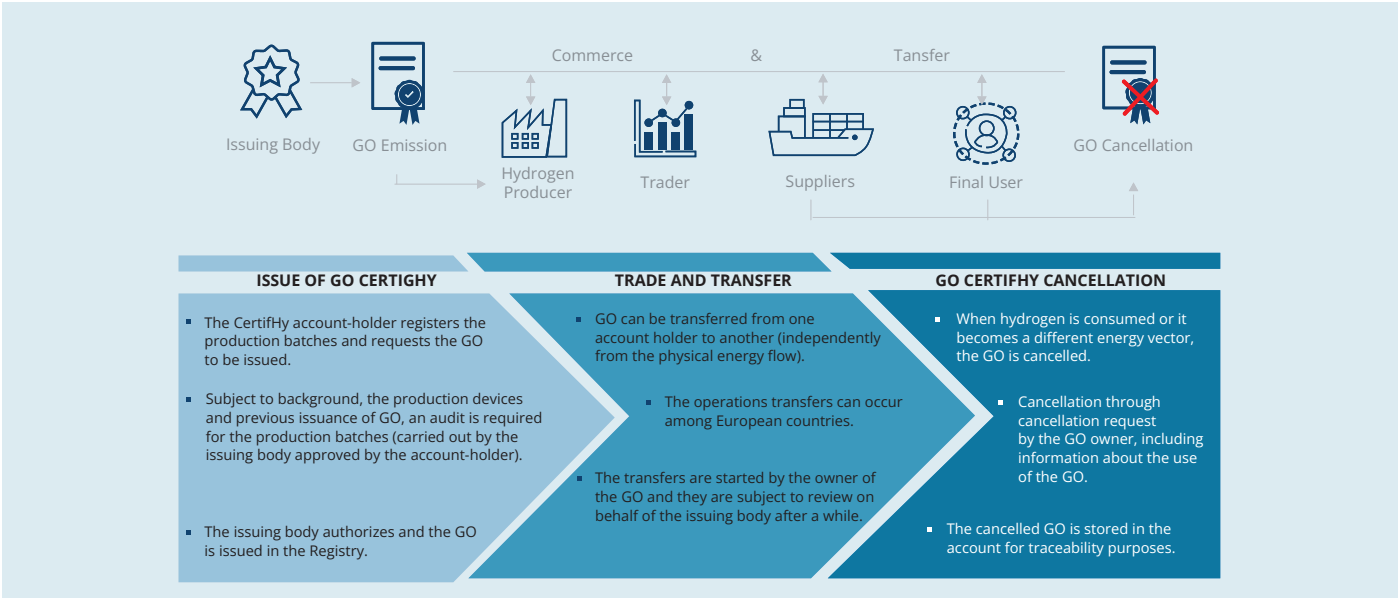
CertifHy Registration: Keeps track of the Guarantees of Origin issued, negotiated and cancelled. This computer system includes the user interfaces for the registration of hydrogen production plants, the opening of accounts, request for issuance, deregistration or transfer of GO, as well as for the holders to consult their account and allow the public to view graphs of general activity in relation to the GOs[73].

During the pilot of the system, and until it is formally implemented, GREXEL[72] has covered the tasks of the Issuing Body.

Account Holder: The Account Holders have in their accounts of the CertifHy Registry production devices and/or GOS CertifHy. It is responsible for the cancellation of the GOs only against the physical consumption of hydrogen which belonging to the scope of the specified GO system is verifiable. May (i) register accounts with the Issuing Body in the Registry CertifHy; (ii) record production devices with the Issuing Body in the Registry CertifHy; (iii) select and hire a Certification Body for the verification of the attributes of the batch of production; (iv) request the issuance of GOs to the Issuing Body; (v) request the transfer of GO from one account to another to the Issuing Body; (vi) request the cancellation of a GO at the Issuing Body.

The following diagram illustrates the operation of a Guarantee of Origin and the users involved:

Figure 17. Operation of the CertifHy GO System



Source: Image made based on CertifHy - Final Report of Phase 2.

[68] CertifHy, 2016.
[69] CertifHy, 2022.
[70] Company of German origin specialized in certification, audits, etc.
[71] CertifHy, 2020.
[72] GREXEL is a leading provider of energy certificate registrations in Europe
[73] CertifHy, Final Report of Phase 2, 2019

On the other hand, CertifHy indicates that four types of users of its system can be distinguished:

Hydrogen producers: They operate registered production devices that issue GOs and make them available for trade and end use.

Traders: They buy and sell GOs on behalf of their customers (suppliers and/or end users).

Provider: Stakeholders who sell hydrogen to their customers and who are obliged, according to RED II, to disclose the energy source and means of production in order to justify and provide green and low-carbon hydrogen to their customers, regardless of physical hydrogen.

End Users: They consume green and low-carbon hydrogen, regardless of their geographical location and the physical hydrogen supplied to them; they can acquire and cancel licenses themselves through the Registry or hydrogen suppliers and/or merchants do it on their behalf.

Content of the Guarantee of Origin

The GO collects objective information about the product; based on this objective information and considering the requirements established in the system at that time, a label is assigned to the product (Green Hydrogen or Low Carbon Hydrogen).

The information contained in a GO CertifHy is listed below[74]:

1. Objective Information:

- Account number.
- Production device identity: Production device identifier; name; country; city; commissioning date; installed production capacity.
- Date and time of hydrogen production: Start and end of the production batch.
- Fuel (or heat source) and technology: Fuel or heat source code(s) (there is room for up to ten fuels); share of the total fuel corresponding to each type of fuel; Technology code.
- Financial support for hydrogen production or input fuel production: investment support; and/or production support; and/or support for a scientific/demonstration/ pilot project; or no support; or no information available.
- Proportion of renewable energy for each input energy carrier to produce the hydrogen (%).
- GHG balance (g CO_{2eq} /MJ_{H2}): Intensity of GHG emissions.
- GO Identity (ID): Identifier (the unique number assigned to the GO); Date of issue; Cancellation/ expiration date.
- Certifying Body: Name.

2. Evaluation based on objective information:

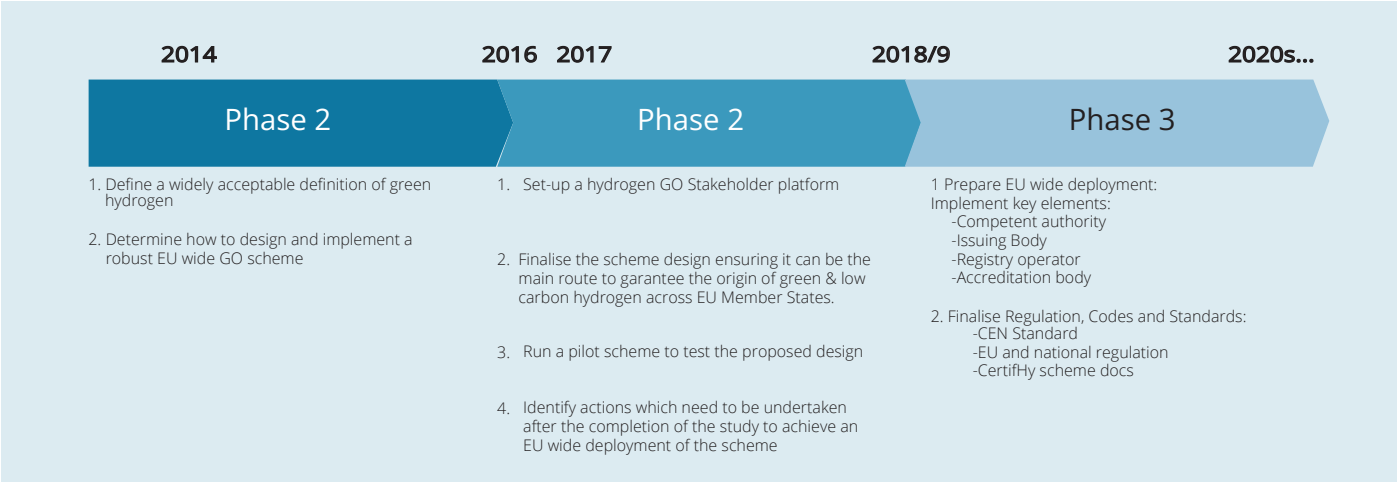
- CertifHy Label: There are two options depending on the objective information, Green Hydrogen or Low Carbon Hydrogen.

The Certification Body issues the Production Batch Audit Report, which is submitted to the Issuing Body and stored in the register together with the GOs covered by the report

Implementation status

CertifHy was designed to work in 3 phases, as described the following figure,:

Figure 18. Phases of the CertifHy System

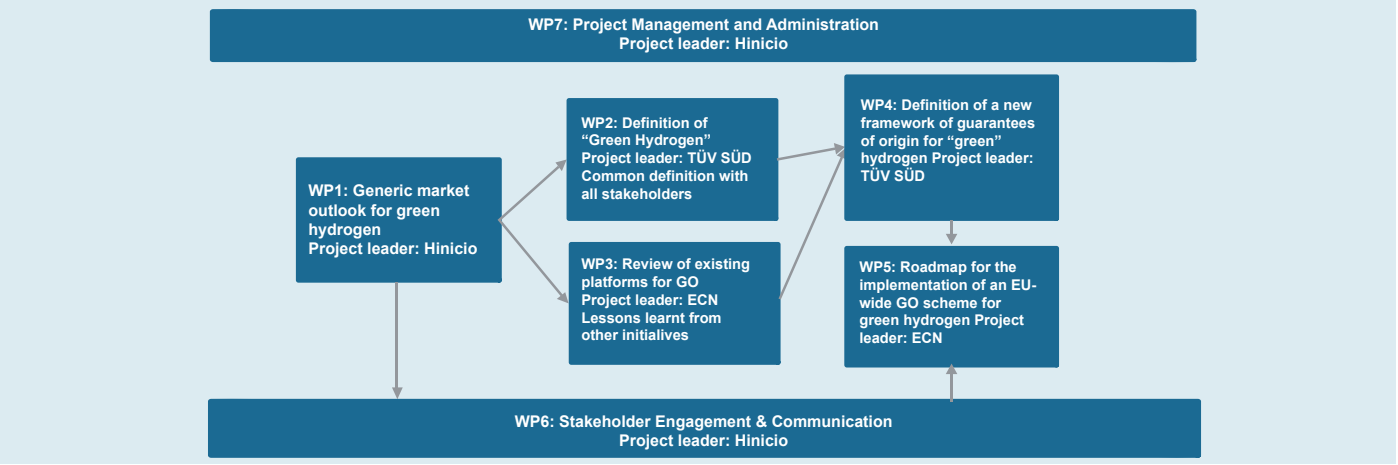


Source: Image taken from CertifHy - Developing the 1st EU-wide Guarantee of Origin for Green Hydrogen - Overview of CertifHy phase 1 and GO schemes. (Adapted format)

[74] CertifHy, Final Report of Phase 2, 2019.

The first phase, CertifHy 1, was developed between 2014 and 2016, in which the CertifHy system was designed, the "Green Hydrogen" and "Low Carbon Hydrogen" labels were established, and a roadmap was developed. The above through a consensus process with industry, policy makers and civil society[75]. The work plan is illustrated below:

Figure 19. Work Plan



Source: Image taken from CertifHy -Developing the 1st EU-wide Guarantee of Origin scheme for Premium Hydrogen. (Translation, adapted format)

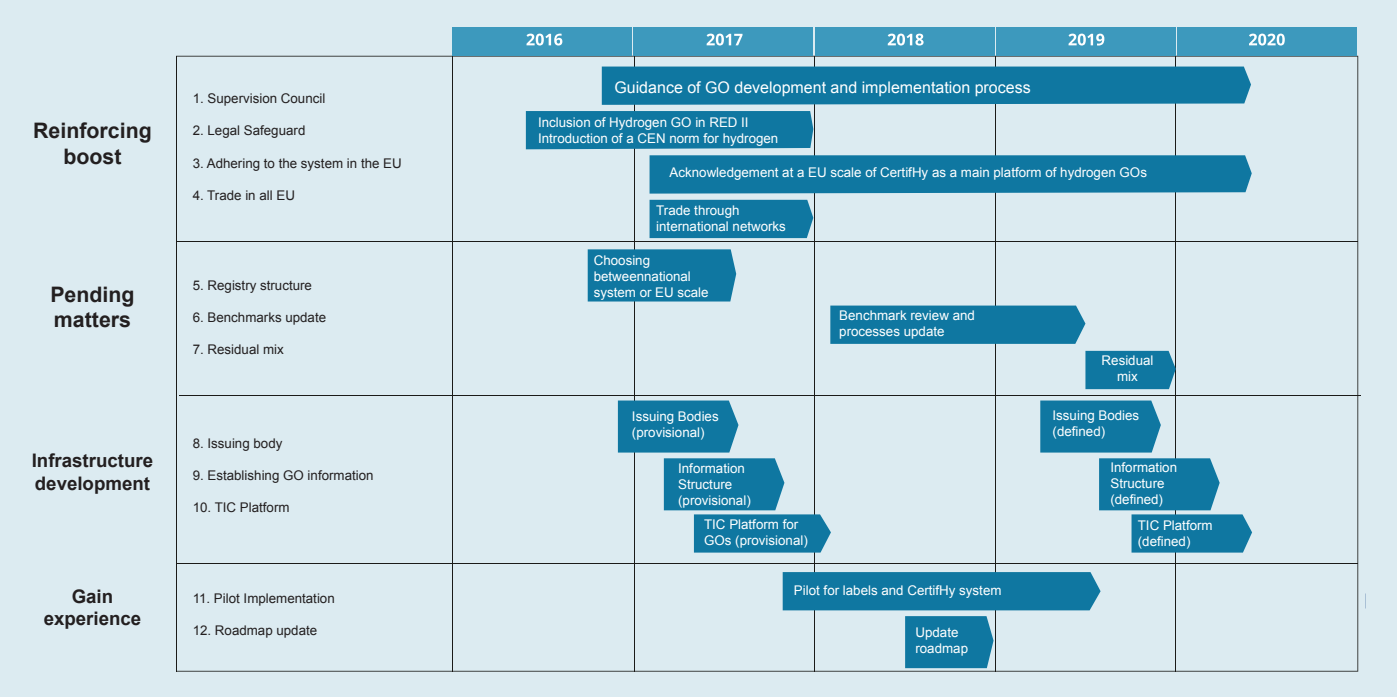
The second phase, CertifHy 2, ran between October 2017 and June 2019, and consisted in elaborating the different procedures of issuance, transfer and cancellation of GOs, the establishment of a Platform of Stakeholders highly inclusive to govern the project, and the implementation with a pilot operating, so as to ensure that the practical problems are identified and addressed; an important component of this phase was to ensure the compatibility of the system with the legislation of the EU, with particular attention to the RED II[76].

The CertifHy 2 pilot project resulted in the issuance of Guarantees of Origin on the market. As of July 2019, 76.6 thousand Hydrogen Certificates of Origin had been issued.[76], equivalent to 2,298 tons of hydrogen; 2.9 thousand GOs (86 tons of hydrogen) corresponded to hydrogen from renewable energy sources and 73.7 thousand (2,212 tons of hydrogen) to hydrogen from fossil sources

For the particular case of direct hydrogen injection into the natural gas network, a simplified procedure for the issuance of Biogas Guarantees of Origin was tested in the German registry operated by the German Energy Agency (Deutsche Energie-Agentur GmbH - DENA); only in the case of direct injection into the gas network, a biogas GO can be created by cancelling a hydrogen GO[77]. The test showed that the DENA can recognize the certification documentation of CertifHy[76].

The CertifHy roadmap is illustrated below:

Figure 20. CertifHy Roadmap.



Source: Image taken from CertifHy - Creating the 1st EU-wide Guarantee of Origin for Green Hydrogen - Overview of Certification phase 1 and GO schemes. (Adapted format)

[75] CertifHy, Final Report of Phase 2, 2019.
[76] CertifHy, Final Report of Phase 2, 2019.
[77] Both certificates refer to 1 MWh of energy

In a document addressed to the Stakeholder Forum (Stakeholder Forum), of December 2020, it became known that CertifHy 3 would establish harmonized systems of Guarantees of Origin throughout Europe. The Fuel Cell and Hydrogen Joint Undertaking (FCH 2 JU) appointed the consortium to lead this phase, consisting of Hinicio, AIB, CEA, GREXEL, LBST and TÜV SÜD. The previous CertifHy work would be used as pre-normative research to help the AIB in the development of a certification system for renewable hydrogen. The system will be developed within the recently established Gas Scheme Group (GSG), and will comply with: art. 19 of the RED II, the CEN-EN 16325 Standard (which is in the process of being updated), and the general requirements of the AIB for GOs and other energy certificates (AIB EECS standard). With the above, the system is expected to facilitate harmonized implementation and future cross-border transfers and to be recognized by the European Commission. The system will be tested in 3 EU Member States

The document also mentions the initiative for the establishment of a collaboration with the Ministry of Energy, Mines and Environment of Morocco (Moroccan Ministry of Energy, Mines and Environment) to experience a GOs pilot cross-border transaction with the European Union, and it is indicated that CertifHy will lead a working group within the MENA Hydrogen Alliance to work in the region creating a system of Guarantees of Origin harmonized with Europe. The contribution of CertifHy to the hydrogen certification working group of the IPHE is also proposed, to guarantee a harmonization between the EU and the international methodology in process. In addition, it is indicated that Europe is investigating new uses of GOs, for example, in the framework of the ETS MRV reform (Emission Trading System Monitoring, Reporting and Verification).

Finally, the document indicates that CertifHy 3 will create a certification system for renewable fuels for transport that comply with the RED II regulation (RFNBOs). For such certification, a close collaboration with the European Renewable Gas Registry is considered (ERGaR). CertifHy had been issuing only GO type certificates, however, in the current phase 3, CertifHy is expanding its scope of application to create a certification scheme that also covers sustainability certificates for compliance with the legal objectives defined in Articles 25-30 of the RED II. This implies the extension of CertifHy to include both hydrogen and its derivatives (for example ammonia, methanol, synthetic fuels, etc.). In RED II, renewable hydrogen and its derivatives are defined as "renewable liquid and gaseous transport fuels of non-biological origin" (Renewable Fuels of Non-Biological Origin - RFNBO). For certification, the criteria to be covered are those defined in RED II. Depending on the decisions of the CertifHy Stakeholder Platform, the inclusion of other voluntary criteria may be considered in the future[80].

4.2 United States

LCFS

Overview

The Low-Carbon Fuel Standard (Low Carbon Fuel Standard - LCFS) is part of a set of programs in California to reduce GHG emissions and other atmospheric pollutants, this by improving vehicle technology, reducing fuel consumption, and increasing low-carbon and renewable mobility alternatives, which in turn reduce oil dependency and achieve better air quality.

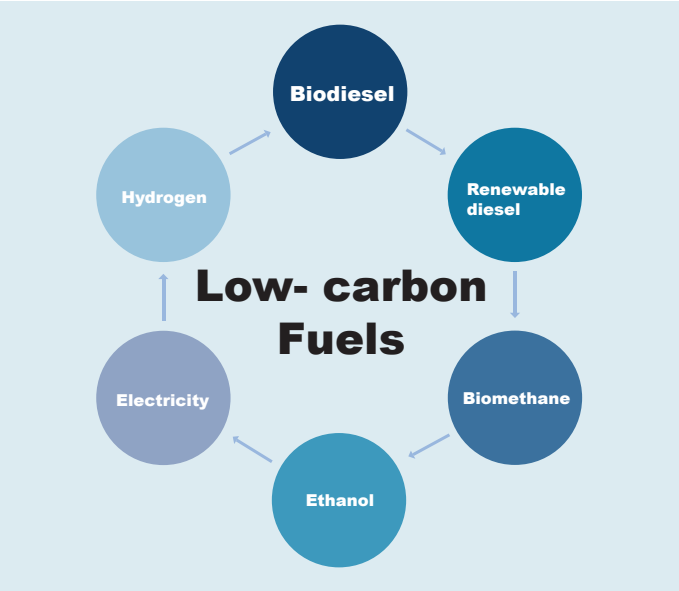
It is a regulatory system that requires fuel suppliers to reduce the carbon footprint of transportation fuels supplied to customers in California. The LCFS is administered by the California Air Resources Board (California Air Resources Board - CARB)[81]; this council sets the carbon intensity each year and publishes the LCFS transactions to ensure the transparency and efficiency of the program.

The carbon intensity (Carbon Intensity - CI) measures greenhouse gas emissions over the lifetime of a type of fuel in grams of carbon dioxide equivalent per mega joule (g CO_{2eq}/MJ). The program is based on the principle that each fuel has greenhouse gas emissions in its life cycle, which include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other GHG contributors. This life cycle assessment examines the GHG emissions associated with the production, transport and use of a given fuel, that is, it considers direct emissions and significant indirect effects on GHG emissions (such as changes in land use for some biofuels).

Through annual targets for reduction by 2030 the LCFS aims to a 20% reduction in the carbon intensity of transport fuels sold in California, so their standards are expressed in terms of carbon intensity of gasoline, diesel, and their respective substitutes such as biofuels, hydrogen and electricity. The CI scores assessed for each fuel are compared to an CI benchmark for each year (this benchmark decreases annually). Low-carbon fuels below the benchmark generate credits, while fuels above the CI benchmark generate deficits. Credits and deficits are expressed in metric tons of GHG emissions.

[78] Association comprising most of the European issuing bodies for renewable electricity GO, and several for gas GO
[79] Middle Eastern – Northern African (MENA) Hydrogen Alliance
[80] GIZ, 2021.
[81] California Air Resources Board, s.f.

Figure 21. LCFS Low Carbon Fuels



Source: Image taken from the document Low Carbon Fuel Standard (LCFS Basics with Notes). (Translation, adapted format)

To ensure that the CI of its fuels meets the annual LCFS target, a regulated entity must reduce the carbon intensity of its fuel pool and/or purchase LCFS credits from other regulated entities. LCFS credits do not expire and any surplus LCFS credits can be saved for future fulfilment[82].

In general, all producers, importers, refiners and wholesalers of petroleum fuel selling fuel in California are subject to the LCFS and must comply with the CI standard of each year established by the CARB.

The annual compliance obligation of a regulated entity is fulfilled when the entity demonstrates how many credits it had and has withdrawn from its account, to compare it with its compliance obligation. This is demonstrated through an annual report

Definitions:

For these purposes, the carbon intensity (CI) is the measure of greenhouse gases in the useful life of a fuel including the gases associated with production, distribution and consumption, measured in g CO_{2eq}/MJ.

In LCFS green hydrogen is defined as hydrogen from (i) electrolysis from renewable energies, (ii) methane reforming with steam from biomethane (iii) or thermochemical conversion of biomass[83].

Year of Deployment

The CARB approved the LCFS regulation in 2009 and it began to be applied from January 1st, 2011. After this, the LCFS was adjusted and modified several times over the following years

Geographical Scope

Some jurisdictions are joining California, as evidenced by the Pacific Coast Collaborative, a regional agreement between California, Oregon, Washington and British Columbia, which seeks to strategically align GHG reduction policies and promote clean energy (California, Oregon and British Columbia have LCFS programs and the Washington legislature is studying a program). CARB has regularly collaborated with these jurisdictions and, over time, these LCFS programs are expected to build an integrated U.S. West Coast market for low-carbon fuels

In addition, the CARB indicates that other regions, such as Canada and Brazil, are observing the success of California and developing performance standards similar to those of the LCFS for transportation fuels.

Certainty

A third-party verification system is necessary to ensure the accuracy of the greenhouse gas data reported.

The LCFS verification program provides confidence and reliability in the data communicated to stakeholders, market participants and the public: the data have financial implications and quality assurance must meet a specific level of rigor. Third-party verification is one of the international best practices for credible greenhouse gas monitoring and reporting. The verification program is based on ISO 14064-3 and 14065 standards. It also provides a systematic, independent and documented process for the evaluation of the reported data with respect to the regulatory requirements of the LCFS and the calculation methods[84].

System

The LCFS follow the Book & Claim certification scheme. The CARB indicates that there are three ways to generate credits, through the accreditation of 1) fuel supplier, 2) projects and 3) capacity (more detail in Annex 1).

Fuel Supplier: Suppliers of low-carbon fuels used for transportation in California generate credits by: (i) obtaining a CI certificate and (ii) reporting transaction amounts on a quarterly basis. Credits are calculated in relation to the annual CI benchmark and are subject to a post-credit generation verification. Under this accreditation, all transportation fuels need a carbon intensity score (CI) to participate in the LCFS, and the type of fuel dictates which process is used to determine such intensity.

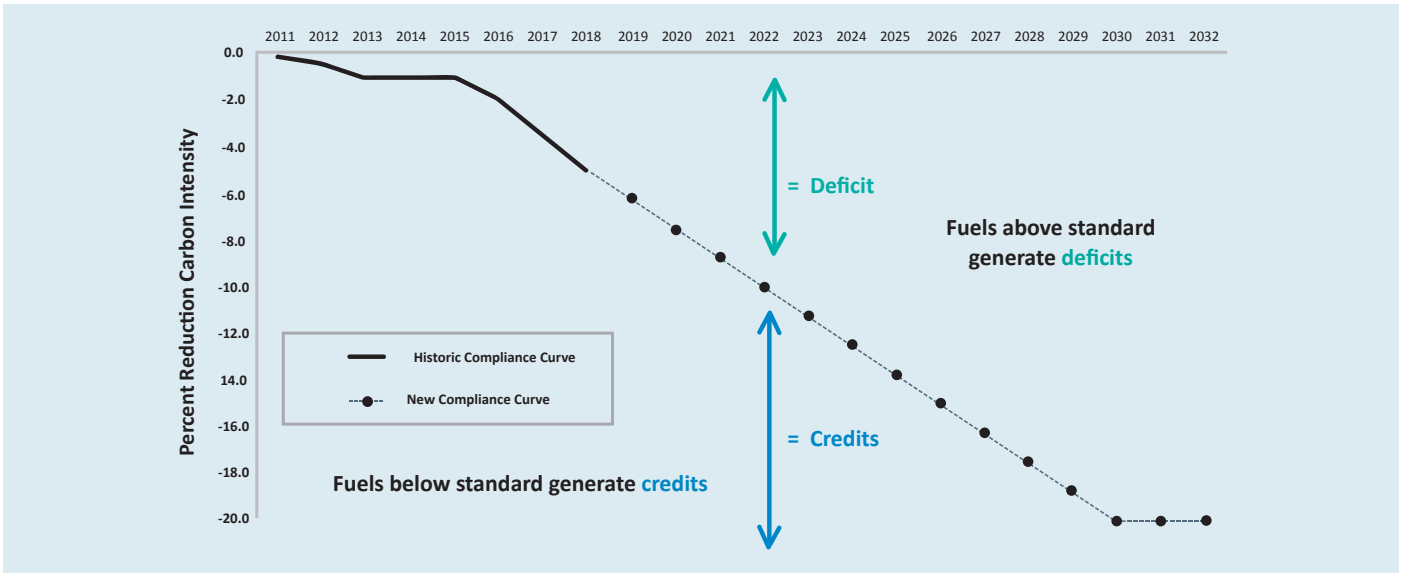
[82] Berkeley Law, 2019.
[83] German Energy Agency, 2022.
[84] California Air Resources Board, Low Carbon Fuel Standard (LCFS Basics with Notes), s.f.

Project: The projects include actions to reduce GHG emissions in the oil supply chain, and also CCS. Project accreditation is based on life-cycle emission reductions. Credits are issued after a verification by the CARB on the reported reductions.

Capacity: This accreditation is designed to support the deployment of zero-emission vehicle infrastructure (Zero Emission Vehicle - ZEV). The accreditation of the ZEV infrastructure is based on the difference between the capacity of the hydrogen station (or the electric vehicle fast charging site) and the actual fuel dispatched. With the above, the number of credits granted for installing hydrogen fuel infrastructure decreases as sales increase . The CARB performs the verification before the credits are issued.

Fuels and fuel mixtures introduced into the California fuel system that have an CI higher than the benchmark generate deficits. Similarly, fuels and fuel mixtures with CI below the benchmark generate credits. Annual compliance is achieved when a regulated subject uses credits to cover its deficits.

Figure 22. Decreasing carbon intensity curve of the LCFS

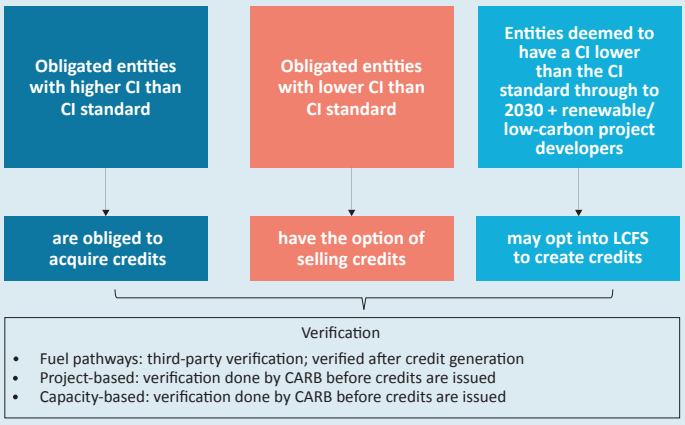


Source: Image taken from the document Low Carbon Fuel Standard (LCFS Basics with Notes).

A deficit fuel producer must have sufficient credits through generation and acquisition to be in annual compliance with the standard. The owners of the credits can only sell their credits to those who have a deficit. Credit trading is allowed only between regulated subjects.

The provisions of the LCFS do not apply in some cases, for example, jet fuel, fuel in some military vehicles, ocean-going vessel, etc., The entities for which the norm is not considered are not restricted necessarily by LCFS, however, to ensure that there are enough credits available, the regulation of LCFS allows them (as well as to developers of renewable energy projects, low carbon fuels, and public utilities) to opt out of the program and become regulated entities, which allows them to produce and sell credits LCFS[86].

Figure 23. LCFS Scheme

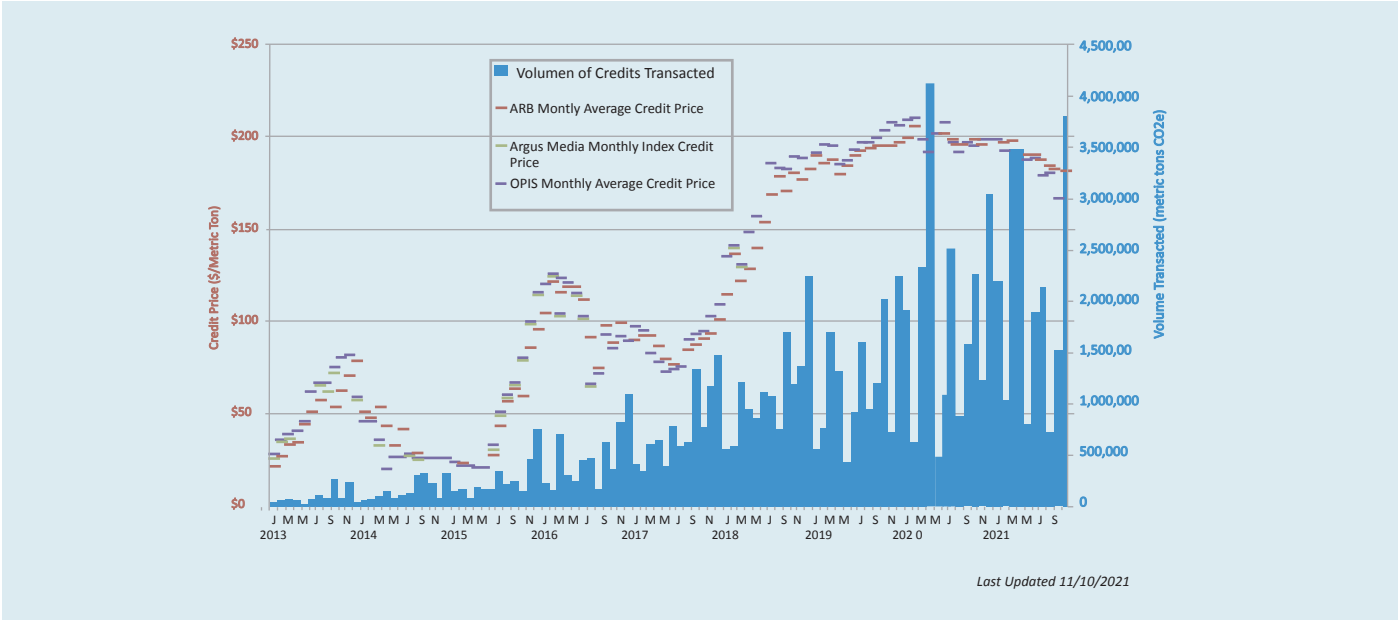


Source: Image taken from Hinicio, "Benchmark of international practices on low-carbon and green H2 certification mechanisms". (Translation, adapted format)

[85] Hinicio, 2021.
[86] Hinicio, 2021.

The LCFS regulation established the maximum price for traded credits at $200 USD per metric ton of CO_2 being reduced from 2016. This price is adjusted by a deflator of the U.S. Consumer Price Index (Consumer Price Index in the United States - CPI) in all years after 2016. This mechanism is providing more certainty in the long-term value of the LCFS credit. Approximately since the beginning of 2019, the monthly credit price has remained stable at around $200 USD per metric ton of CO_{2eq} reduced. The following graph with CARB data shows the evolution of certificate prices over time and the volume of credits negotiated.

Figure 24. LCFS monthly credit price and transaction volume (historical)



Source: Image taken from Data Dashboard from CARB

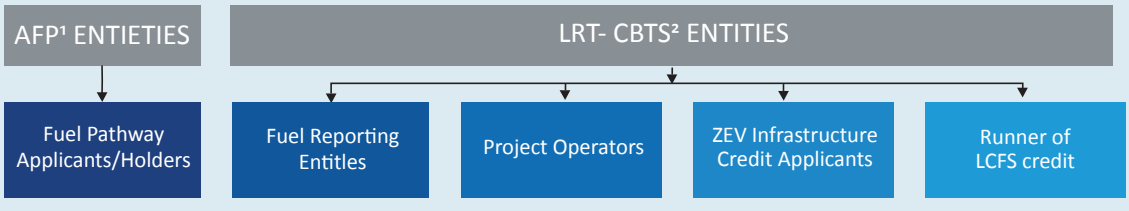
Governance

CARB applies and enforces California's LCFS, consistent with the broad emissions reduction mandate that the state legislature established in Assembly Bill 32 (Health and Safety Code § 38500 et seq.)[87]. The CARB is the one who establishes the CI reductions for each year and who publishes the operations of the LCFS.

On the other hand, the CARB considers that a third-party verification system is necessary to guarantee the accuracy of the greenhouse gas data reported, as of 2019, this third-party verification is possible, where verifiers apply for CARB accreditation and carry out the necessary training and exams. The CARB publishes on the LCFS website the list of verification bodies accredited to perform LCFS verification services.

The organization of the LCFS system is illustrated below:

Figure 25. Overview of LCFS Entities



1) Alternative Fuels Portal (AFP)
2) LCFS Credit Banking and Transfer System

Source: Prepared based on the document Low Carbon Fuel Standard (LCFS Basics with Notes)

The Alternative Fuels Portal (AFP) and the Credit Banking and Transfer System (LCFS LRT-CBTS) are two of the platforms that make up the LCFS database management system[88].

AFP: The AFP facilitates the application process to obtain a certified CI score. Applicants who rely on site-specific data use this portal to submit their CI calculator and supplemental information.

LRT-CBTS: The LRT-CBTS is specifically designed to facilitate reporting and credit transfers.

[87] Berkeley Law, 2019.
[88] The Verification Module is not shown here, which will provide access to participant data for LCFS Accredited Verification Bodies

The entities' requirements and responsibilities are defined according to the role played by each of them. An entity can have multiple functions in the LCFS, for example, a producer of liquid alternative fuel can be an applicant for fuel supplier accreditation, but since this entity also reports and generates credits, it is also a fuel reporting entity. An owner of a hydrogen station that generates infrastructure credits must also be a fuel reporting entity (to report the amount of fuel dispensed); this entity may also hold a fuel supplier accreditation, or another entity could have assumed the responsibilities of applying for and maintaining accreditation.

All applicants for the fuel supplier accreditation become holders once their CI is certified; they must demonstrate annually that the accreditation is still valid.

Implementation status

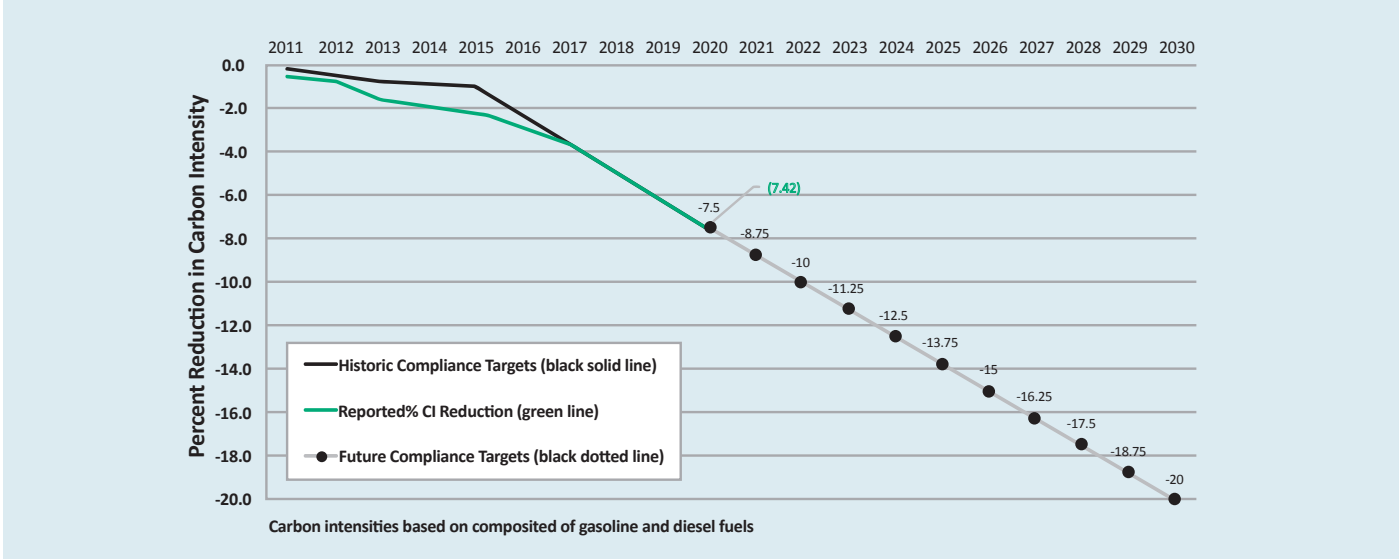
In 2013, amendments were implemented that allowed refineries to receive credits for the deployment of innovative crude oil production technologies, such as solar steam generation or carbon capture. Subsequently, in 2016, the process deficiencies in the original regulation were addressed.

Finally, in 2018, amendments were passed that included softening the carbon intensity benchmarks for California's GHG emission reduction by 2030 enacted through Senate Bill 32, adding new credit opportunities to promote the adoption of zero-emission vehicles, alternative jet fuel, carbon capture, and advanced technologies to achieve deep decarbonization in the transportation sector

The CARB mentions that the use of low-carbon fuels has increased since the regulation came into force. The total value of credit transactions exceeded $2 billion in 2018. An LCFS data dashboard was created to show current and historical information about the program, in which you can find information such as the volume of fuels and credits generated under the LCFS, the compliance curve, the percentage of carbon intensity reduction to date, the volumes of credits negotiated and the average prices of credits per month, among others.

In a 2019 press release, the CARB reported that from 2011 to 2018 nearly 3.3 billion gallons of petroleum diesel have been displaced by clean, low-carbon alternatives[89].

Figure 26. LCFS Performance 2011-2020



Source: Image taken from Data Dashboard, LCFS, CARB.

4.3 Germany

TÜV SÜD CMS70[90]

With the Green Hydrogen certification (TÜV SÜD CMS 70 Standard[91]), TÜV SÜD allows interested parties to provide evidence that hydrogen produced from renewable sources has significantly lower greenhouse gas (GHG) emission levels, compared to conventional hydrogen or fossil fuels

The green hydrogen produced by electrolysis must have a GHG reduction potential of 75% including the compression, liquefaction and transportation phases . This certification system gives the option to choose the Book & Claim system (book & claim) or the Mass Balance (mass balance) one; it could be applied globally in the future, for now it is focused on Germany and the EU.

On the other hand, the standard also includes additional criteria that go beyond legal requirements, such as the use of electricity from renewable energy sources and the use of biomethane. The holders of the Green Hydrogen certificates

[89] Congressional Research Service, 2021.
[90] TÜV SÜD, 2022.
[91] Version 01/2020 "Generation of Green Hydrogen"
[92] The comparison is based on the current reference values established in the Renewable Energy Directive II (RED II) and on the values of conventional hydrogen produced by natural gas reforming

must have a robust control system in place to ensure compliance with certified quality and supply commitments. The audit is carried out by TÜV SÜD, but it also enables qualified third parties to carry it out.

On the other hand, the standard also includes additional criteria that go beyond legal requirements, such as the use of electricity from renewable energy sources and the use of biomethane. The holders of the Green Hydrogen certificates must have a robust control system in place to ensure compliance with certified quality and supply commitments. The audit is carried out by TÜV SÜD, but it also enables qualified third parties to carry it out.

One of the requirements for the TÜV SÜD certification for green hydrogen generation is the additionality of the renewable energy used in the electrolysis process, three alternatives are proposed:

1. Proportion of new installations: 30% of renewable electricity must come from plants that have started operating no more than 36 months ago.
2. Technology Mix: Renewable energy must consist of at least 15% hydroelectric plants or 30% wind plants or 5% solar, geothermal or biogas.
3. The energy must come from plants built no earlier than January 1, 2020.
4. Financing: 0.2-euro cents/kWh of the electricity used in the production of green hydrogen is allocated to a fund for projects promoting renewable energy, efficiency, innovation and compensation.

TÜV Rheinland

TÜV Rheinland announced in July 2021 that it offers hydrogen-related certification services based on patented labels, and further announced that they cover a verification of compliance with RED II requirements . On its web portal (www.tuv.com) offer the industry, market players and actors a new practice-oriented specification for the certification of green hydrogen: the TÜV Rheinland H2.21 standard for carbon-neutral hydrogen. It is possible to certify the following criteria: green hydrogen, blue hydrogen, turquoise hydrogen, hydrogen that meets the RED II standard. However, there is not much public information available regarding this certification[94].

H2 Global[95]

In addition to these certifications, Germany has the H2 Global Foundation (a concept developed by GIZ), which seeks to comply with Germany's National Strategy by promoting environmental protection through the production and use of green hydrogen.

This foundation provides financing for high-volume green hydrogen production projects in other countries seeking to export hydrogen to Germany. To achieve this, auctions of purchase contracts are held abroad, consisting of fixed quantities of hydrogen at fixed prices for 10 years. Hydrogen imported via Global H2 will be eligible to enter the European Union Emissions Trading System (EU Emissions Trading System—EU ETS). The foundation establishes certain economic, social and environmental requirements that must be met in order to be accredited for financing

4.4 IPHE

The International Partnership for Hydrogen and Fuel Cell in Economics (IPHE), seeks to facilitate and accelerate the transition to clean energy and mobility systems using hydrogen and fuel cell vehicles (FCEVs) in various industries. Some of the participating countries are Australia, Canada, Costa Rica, the European Union, France, Germany, Japan, Korea, the Netherlands, Norway, South Africa, the United Kingdom and the United States. This association does not have a certification as such, but they seek to harmonize measurement and trade standards to make the hydrogen market more dynamic, accessible and international.

The IPHE built two working groups: (i) IPHE Hydrogen Trade Rules Task Force (H2TR TF), and (ii) IPHE Hydrogen Production Analysis Task Force (H2PA TF).

The H2TF seeks to facilitate the hydrogen trade by identifying tariff and non-tariff barriers in international hydrogen transactions. This working group seeks to understand the rules of trade at the international level between the affiliated countries, including multilateral agreements, to identify what are the rules of hydrogen trade (tariffs, technical security requirements, customs processes) and possible barriers.

On the other hand, the H2PA TF aims to facilitate an international hydrogen market. It establishes that the hydrogen trade will benefit from internationally agreed standards for the transport, storage, tracking and measurement of low-carbon hydrogen emissions. This working group developed a methodology to determine the GHGs associated with the production of a hydrogen unit. This methodology can serve as the basis of a certification system; however, it will not provide guidance in the definition of the intensity of GHG emissions that the certification system should adopt. This will remain the responsibility of each country, even if terminologies and defined emission intensity values for a common certification would facilitate international hydrogen trade. This methodology is based on the principles of inclusion, flexibility, transparency, comparability and practicality.

The working group published a draft of the methodology, which establishes that the origin and GHG intensity of hydrogen are important parameters. In order to facilitate international trade and allow consumers to choose their preferences, a harmonized international classification framework for hydrogen is needed that includes information on sustainability criteria (e.g., origin, CO2 intensity, other emissions),) throughout the entire life cycle, usually called de "cradle to grave", and that ensures the traceability of the attributes. IPHE's future guidance may address additional aspects of the complete life cycle, such as emissions associated with the distribution of hydrogen and with the manufacture of goods. The framework will provide a mutually agreed approach to certificates of origin covering greenhouse gases in hydrogen-based fuels and raw materials. After the launch of this methodology, the IPHE will carry out a series of activities linked to the publication as:

[93] GIZ, 2021.
[94] TÜV Rheinland, 2022.
[95] H_2 Global, s.f.
[96] Dena, 2022.
[97] IPHE, 2021.

- Apply the chosen approach to various case studies as examples
- Prepare documentation for engagement and socialization to actors (government, industry associations, environmental organizations) to build a broad understanding and potential agreement.
- Identify and specify the necessary content in any technical report based on the agreed approach.
- Technical report describing the agreed approach.

Currently, the IPHE is working on making a compendium of hydrogen safety standards and codes, fostering interest and understanding of the technology through a scholarship program for students/postdocs and monitoring the progress of IPHE members in relation to the commitments agreed in the Global Action Agenda, principle that guides actions towards a hydrogen-based society and mobilizes efforts to expand hydrogen research and development composed of 6 pillars:

- Formulation of Strategies and Road Map;
- Use of Fuel Cells Between Applications;
- Hydrogen Supply Chains;
- Sector coupling;
- Study and Assessment of the Hydrogen Potential, and
- Communication, Education and Outreach.

The objective of this agenda is to reach 10 million mobility systems and 10 thousand hydrogen charging stations among the affiliated countries in 10 years.

4.5 China

China Hydrogen Alliance standard[98]

The China Hydrogen Alliance published a low-carbon hydrogen standard at the end of 2020, of which limited details are currently available. The standard applies to the production, storage and transportation of hydrogen at production facilities. The standard guides the transition from traditional hydrogen production processes to low-carbon, clean and renewable hydrogen production processes through certification

Three types of hydrogen are defined:

1. Low-carbon hydrogen: hydrogen with a greenhouse gas emission value equal to or less than 14,51 kg CO_{2e}/kg_{H2} (120.9 gCO_{2e}/MJ_{LHV}) in the production process
2. Clean hydrogen: hydrogen with a greenhouse gas emission value equal to or less than 4,90 kg CO_{2e}/kg_{H2} (40.8 gCO_{2e}/MJ_{LHV}) in the production process.
3. Renewable hydrogen: hydrogen whose greenhouse gas emissions are the same as those of clean hydrogen, but the energy consumed is renewable[99].

The limit of the life cycle assessment system (LCA) covers the procurement and transportation of raw materials, hydrogen production, storage on-site and transportation.

The rule indicates that the applicant has to submit a formal verification application form to the utility platform recognized by the national energy authority. A third party, which must be recognized by the service platform, will carry out the audit on-site to demonstrate that the submitted documents comply with the requirements of the standard. Certification is carried out annually. The producer has to inform the auditor if the production process changes, and in that case the auditor will decide whether additional audits are required.

4.6 Japan

Aichi Municipality

Japan has made efforts for the certification of green hydrogen at the regional level. The Aichi Low-Carbon Hydrogen Supply Chain Promotion Association, a body that includes the Aichi prefectural government, companies operating within the prefecture, municipal authorities and experts, developed the Aichi Low-Carbon Hydrogen Supply Chain Vision 2030 and its roadmap in 2018. The goal is the realization of a hydrogen-based society encompassing the entire region through mutual coordination and inclusive efforts.

This strategy is based on three pillars: (i) sustained development of a regional low-carbon hydrogen supply chain; (ii) carbon reduction in the various fields of electricity, transport, heating and industrial processes; and (iii) elimination of dependence on fossil fuels through the expansion of hydrogen distribution volumes in a wider area.[100]

The strategy includes implementing a certification system for hydrogen produced by renewable energy as "low carbon hydrogen" with the aim of promoting the popularization of low carbon hydrogen in accordance with the roadmap. The system defines renewable hydrogen as hydrogen from the electrolysis of water using renewable electricity sources or steam reforming using biomass . Currently, four projects of the Toyota automotive company use these certificates.

[98] DENA, 2022.
[99] Renewable energy is defined in the "Renewable Energy Law of the People's Republic of China
[100] Toyota, ,2018.
[101] Dena, 2022.

5. Potential benefits for the Implementation of a Guarantees of Origin System for Green H2 in Mexico

There is a great potential for the countries that implement systems of Guarantees of Origin; in this section, we will address the potential benefits to Mexico by the adoption of Guarantees of Origin, which were identified by (i) the international experiences with certification of renewable described in section 2, (ii)the national experiences in certification, (iii)the current and most anticipated trends in accordance with international organizations leaders in research and impetus to the green hydrogen, and its certification, and (iv) the perspectives of key actors[102] in the hydrogen industry in Mexico. The benefits were segmented into three key sectors: economic, social and environmental.

Among the identified benefits, data and projections that are related to the scope of each of them are mentioned; these data and projections correspond to the study "Green Hydrogen in Mexico: towards a decarbonization of the economy"[103], which presents two scenarios for its projections: the first Nationally Determined Contributions (NDC), which assumes that Mexico will meet its climate commitments to comply with the Paris Agreement, and the second "Hydrogen Breakthrough" (H2B), with more optimistic assumptions aligned with the projections of the Hydrogen Council. Some data from these scenarios are mentioned in this section to illustrate certain points within the identified benefits, however, they are not data completely dependent on the Guarantees of Origin system.

5.1 Economic

Pushing for a new green hydrogen market

The certification of green hydrogen is a critical element that provides credibility on the sustainability and quality of the product being marketed, serving as a basis for determining the price of this type of hydrogen against that of other types of hydrogen and fuels, which enables its economic viability.

In addition, the certifications for green hydrogen enable national and international trade in a transparent way. With its implementation, new uses for hydrogen would be promoted, which would growth the market size through incentives aimed at increasing its supply and demand.

It is expected that by 2050, the national electrolysis capacity could reach 38.7 GW; this capacity would be accompanied by a demand of almost one million tons of green hydrogen per year, which would be equivalent to the creation of a Mexican green hydrogen market valued at 5.7 billion dollars per year .It should be mentioned that the promotion of this market would bring benefits both for private companies that participate as producers of green hydrogen, and for State Productive Enterprises (EPE). By boosting the production of ammonia and synthetic fuels, as well as refining, the proposed scenarios establish that PEMEX will be able to count on a supply of green hydrogen of 800 million dollars per year in 2050 (under the optimistic scenario). Similarly, for CFE a market of 380 million dollars per year (2050) is projected, with thermal power plants as the greatest opportunities for green hydrogen. These scenarios help to have a better idea about the potential of green hydrogen in Mexico, which in turn confirms the need to certify the production of such green hydrogen.

Pushing for investment in green hydrogen projects

With the Guarantees of Origin, representing an additional source of revenue for the sale of hydrogen and ensuring secure and transparent transactions, Mexico would have the chance of becoming an attractive market for a nascent market that promotes lower-carbon fuels and technologies, both for foreign and Mexican companies.

To illustrate this aspect, an example of investment is certainly Chile, which performed a round of capital raising of $ 50 million dollars to promote green hydrogen projects, in support of forming a functioning market as part of one of the four action lines of its national strategy, in which the country proposed the upcoming certification for the hydrogen green.

Enabling the export of green hydrogen to importing countries

By having a system of Guarantees of Origin compatible with other countries, Mexico's competitive advantages could be exploited by making international transactions and traceability possible. Mexico has the potential to become an exporter of green hydrogen to markets such as Europe and Asia thanks to the projected low cost of production. In addition, Mexico has a privileged geographical position, which allows it to compete against other potential exporting countries.

A great opportunity for Mexico would be to position itself as an exporter of green hydrogen to the United States, where there is currently a great interest from the private sector to adopt hydrogen as an energy vector, which was reflected in the hydrogen roadmap prepared by this sector. Mexico could take advantage of the proximity to the US territory, its already installed transport infrastructure, and the growing interest in low-carbon alternatives (for example, in the state of California), among others.

[102] The key players interviewed include actors from the academia and industry sector
[103] GIZ, 2021.
[104] GIZ, 2021.

Improvement in the reputation of the companies involved

Guarantees of Origin undoubtedly improve the image and environmental reputation of any organization that invests in them, making it more attractive to informed and environmentally concerned consumers, and increasing competition among potential suppliers. The business culture could direct its investments to countries that have established certification systems to be able to achieve its environmental objectives, increasing brand credibility through an internationally recognized initiative.

5.2 Social

Greater energy security (resilience and flexibility)

With Guarantees of Origin, the industry would be strengthened and stabilized, in addition, production costs could become more competitive. This would provide an energy vector free of fossil fuels produced locally, positively impacting the supply of renewable energies by increasing their demand and national production, improving the Mexican energy balance by decreasing fossil fuel imports. This would reduce the risk of interruptions to the electricity supply generated by external causes that hinder the processes and profitability of energy suppliers. In addition, it would reduce the impact on the Mexican energy market due to cost fluctuations of international fossil fuel markets and would provide benefits to EPEs, contributing to the energy security of the country

In a scenario of integrating green hydrogen into the isolated Mulegé system, the installed capacity would be increased by approximately 11% due to hydrogen energy storage, which would also lead to a reduction in the cost of storage[105].

Job creation in the domestic market

As there is a greater aggregate demand for green hydrogen with a Guarantee of Origin system, the need arises for new specialized jobs that help the local economy in the regions in which the investments are located. At the same time, as there is a greater demand for spaces for the construction of production plants, income from land managers could increase.

In addition, green hydrogen could boost the development of new manufacturing industries in the country. Mexico has the potential to position itself as a leading manufacturer of FCEVs and to be competitive in the manufacture of power turbines, transport and hydrogen storage equipment[106]. By 2050, 90,000 people in Mexico could work in green hydrogen infrastructure and FCEV production. 67% of the jobs created would be in hydrogen production, 20% in hydrogen refuelling stations (HRS), and 13% in the automotive industry in the manufacture of hydrogen FCEVs[106].

Green hydrogen accompanied by Guarantees of Origin can boost the economy and job creation while meeting the national energy supply

Consumer and community empowerment

The objective of the Guarantees of Origin in the European Union according to CertifHy is to empower consumers by allowing them to choose the origin of their energy contributing to the energy transition. In Mexico, the guarantees would help to create greater awareness among users. In the future, it could be considered to include issues related to hydrogen and its certification in educational systems at the national level. Additionally, there would be an empowerment of communities by having their participation in the development of local projects that boost the industry in the country to position it as a key producer, consumer and exporter.

5.3 Environmental

Boosting Decarbonization

By building a green hydrogen industry at scale, in parallel to a system of Guarantees of Origin, leveraged in international systems, decarbonization will be promoted in different industries and the reduction of emissions, contributing to the current or possible environmental objectives set by the government and companies. The Guarantees of Origin will serve as an incentive for companies to implement and acquire new green hydrogen technologies. By 2050, the introduction of green hydrogen technologies could reduce more than 40 $MtCO_2$ of emissions each year[106].

The transportation sector is the sector that generates the most GHG emissions, accounting for a quarter of national emissions. The electrification of the vehicle fleet is one of the measures to comply with the NDCs to reduce 19% of the sector's emissions. A promising zero-carbon alternative consists of heavy-duty hydrogen fuel cell (FCEV) trucks and buses focused on the long-haul cargo segment and public transport. By 2050, half a million units are expected in Mexico, which could reduce by up to 26.7 $MtCO_{2e}$ emissions in the transportation sector. The introduction of these vehicles would represent a hydrogen fuel market worth 3.6 billion dollars per year.

Other environmental benefits that green hydrogen could bring are presented in the mining, steel, cement and chemical industries, by replacing processed materials with fossil fuels, for example iron, and making them with green hydrogen or generating thermal energy.

By 2050 the introduction of green hydrogen technologies could reduce 3.2 $MtCO_{2e}$ in PEMEX operations and up to 7.6 $MtCO_{2e}$ in energy storage, thermal uses and other industrial applications.[107]

[105] GIZ, 2021.
[106] GIZ, 2021.
[107] GIZ, 2021.

The use of green hydrogen in these industries should be accompanied by Guarantees of Origin to ensure that the inputs that are being handled for the production of other products, or what is being used in certain industrial processes, really has the characteristics attributable to the guarantee. This will be necessary to encourage the consumption of green hydrogen to be promoted and have a positive effect towards the energy transition and sustainability.

Control over the environmental impact on water and land

An opportunity to implement Guarantees of Origin for green hydrogen would be to include information on the sustainable use of the water and land for the generation of hydrogen in the issuance of the Guarantee of Origin. An analysis of the hydrogen potential shows that, in theory, up to 22 TW of electrolysis capacity could be installed throughout the country, producing around 1,400 Mton of hydrogen per year driven mainly by low-cost photovoltaics. The amount of water needed annually for the production of this potential would be 116.8 hm3, which represents 0.13% of the country's water consumption in 2017; that is, less than 1% of the water used in the country would be compromised for these purposes.[106]

A similar analysis applied to the use of land for the construction of green hydrogen generation plants would give a good idea of what could be achieved without affecting natural resources; this could be done through an Environmental Impact Assessment . The results of this technical study that indicates the effects that an activity may cause on the environment could be reflected as an attribute within the guarantee of origin, informing the consumer that these factors were evaluated prior to the generation of hydrogen.

Boosting Renewable Energies

The incentive of Guarantees of Origin and the ramp up of the green hydrogen market, would promote investment in renewable energy generation, since it is an input for hydrogen generation. While governments are looking for models with the least possible investment to support renewable energies, Guarantees of Origin help by decreasing the cost of these models, providing an additional source of income. The integration of green hydrogen with Guarantees of Origin in different industries will allow a greater expansion and adoption of renewable energies. In the national electricity system, energy storage with green hydrogen could allow an increase in renewable energy generation of 2% in the energy matrix by 2050[106]. The main benefit of the integration is that it will allow a greater use of lower-cost photovoltaic solar energy, decreasing the total cost of the system.

In summary, Mexico has a privileged position being next to the United States, which coupled with the country's renewable potential positions it as a potential exporter of green hydrogen to the United States, and potentially also to other countries within the European Union and Asia. Therefore, it is important to be aligned in terms of certification and regulation developed by these importing countries to comply with the requirements that are set internationally and thus be in a position to exploit the potential of green hydrogen production in thecountry

It should be noted that the investment risk is from the developer, whether from the public or private sector. The Guarantees of Origin represent a guarantee of the marketed product, but also a guarantee of the market that can be unlocked by having an internationally compatible guarantee system implemented in the country. This system could give certainty to business cases with expected long-term returns, which would enable financing for developers of green hydrogen generation plants. Financing is necessary to be able to boost the national market, to trigger studies, pilot tests and to be able to count on green hydrogen at a competitive cost. Guarantees function as proof of an additional source of income to the hydrogen trade and can help to scale this market, attracting profits, as mentioned in this section, in various sectors.

6. Roadmap and Recommendations for the Adoption of Guarantees of Origin for Green Hydrogen in Mexico

Guarantees of Origin systems for hydrogen are in constant development, mainly in Europe, where CertifHy has been working on developing a system since 2014. The international green hydrogen certification efforts provide access to lessons learned that can accelerate the adoption of Guarantees of Origin and help map out a high-level roadmap for Mexico.

There are specific activities that contribute to Mexico achieving a system of Guarantees of Origin of green hydrogen. These activities were identified and segmented into six phases, which, together, form an applicable roadmap for the Mexican case.

In addition, some risks and general recommendations for each of the particular phases of the roadmap are included in this analysis. The above, is carried out based on (i) an analysis of the international experiences on certification of renewable energy discussed in section 2; (ii) an analysis of the relevant international experiences in certification of green hydrogen, identifying the key points of their systems and the lessons learned; (iii) a review of national experiences in renewable energy certification, with special attention to the challenges that have been presented in the country; (iv) a review of the recommendations and points of view on green hydrogen certification of renowned international bodies and research leaders in green hydrogen and its certification; and (v) interviews and a survey of key players in the industry of hydrogen in Mexico, to learn about their perspectives on the implementation of Guarantees of Origin in Mexico.

Furthermore, we considered three scenarios for theimplementation of a system of Guarantees of Origin in Mexico, based on the international experiences analysed, and considered the development of a roadmap, implementation and deployment.

Scenario	Years
Optimistic	4
Baseline	5 a 7
Pessimistic	more than 8

General Recommendations

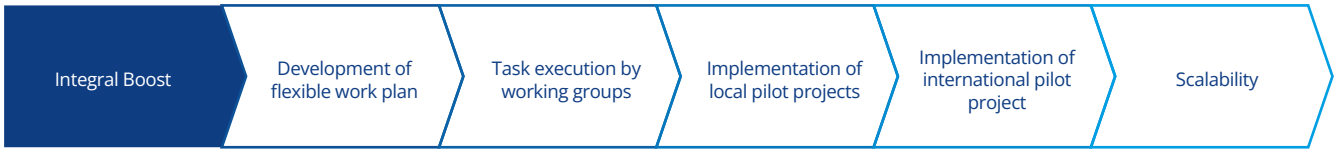
- It is recommended to adopt of a system of Guarantees of Origin with international recognition that is already used by the main target countries of Mexico, that is to say, the countries to which Mexico potentially would export its production of green hydrogen that is not locally consumed consumption, as this is the most appropriate approach to achieve the interoperability of systems between Mexico and the target countries. In addition, it is considered that the adoption of an advanced international system is more agile compared to the design, development and implementation of a national system.
- There is general consensus that it would be ideal that the efforts to have a system of Guarantees of Origin in Mexico is generated in the short term and in an agile way, that is to say, which are aligned with the overall efforts of the adoption and use of hydrogen, without having to wait on to a stage of greater maturity of the industry and of the market in the country, taking into account the time required to count with a system of Guarantees of Origin of hydrogen green is considerable.

General Risks

- The possible lack of interest and commitment of key actors to promote the Guarantees of Origin system is considered as a risk, especially the absence of any relevant sector, for example, of the government (including public sector, regulators and EPEs). Intersectoral participation is necessary throughout the proposed roadmap, that is, to have at least the involvement, participation and commitment of both the public sector, private sector and research centres.
- A potential risk in place during all phases of the roadmap is the lack of coordination and direction of individual efforts by actors.

Below, the key activities and main actors within each of the phases of the roadmap are described, as well as their corresponding threats and recommendations:

6.1 Integral Boost



First of all, it is advisable to generate a comprehensive boost to green hydrogen and a system of Guarantees of Origin. To achieve the required momentum, it is important to organize and establish a working consortium on green hydrogen dedicated especially to the efforts of a system of Guarantees of Origin in Mexico, whose leader is ideally aligned with a mission to promote green hydrogen and who has demonstrated interest, initiative and involvement in other previous efforts to promote green hydrogen in the country. In addition to this leadership, within the consortium it would be ideal to have leading actors from industry, the public sector, non-profit organizations and academia, with the aim of having a balanced vision that allows considering key aspects of the different areas of a Guarantees of Origin system. Broadly speaking, the main objective of this working consortium would be to coordinate any effort related to the Guarantees of Origin system in Mexico.

Among the first tasks of the consortium of work, you could consider the creation of a stakeholder forum that brings together a large number of relevant actors, national and international in various fields, including: industry, public sector, academia, consumers, NGOs, etc. These actors could provide relevant information in their areas of specialty, to transmit their expectations and concerns, and to support the validation of the work that the consortium of work carried out. It would be convenient for the working consortium to design a governance system for the stakeholder forum in advance, and subsequently open a call to add those interested in participating; in addition, the working consortium could leverage the previous efforts of current associations that already have a representative number of actors, to accelerate the integration and growth of the stakeholder forum.

The convergence of various actors in the stakeholder forum could facilitate the development of new joint green hydrogen studies with a focus on Guarantees of Origin; the above with the aim of improving the understanding of the systems, within the consortium and the forum, in terms of Guarantees of Origin systems for green hydrogen. These studies can cover in greater detail the potential of green hydrogen exports from Mexico, identifying the main target importing countries. The studies could also cover the safety standards necessary for the production, handling and consumption of green hydrogen, which will boost the industry and, consequently, the system of Guarantees of Origin.

It is important to take advantage of this joint effort to disseminate the information reviewd, supporting the knowledge, acceptance and adoption of green hydrogen in society in general, as well as to socialize international experiences in green hydrogen certification.

The working consortium could seek to participate in international initiatives to adopt Guarantees of Origin so that Mexico is present in the discussions and advances that are being carried out globally. Among these global initiatives, it would be a priority to seek the participation of Mexico in the IPHE, especially for the collaboration with CertifHy on hydrogen certification to guarantee harmonization between the EU and the international methodology that is being configured. For this activity, the participation and commitment of the public sector is important, since the IPHE is open to national government entities committed to advancing hydrogen and fuel cell technologies.

Recommendations:

- In the creation of the consortium, it is important to consider that government institutions have a very relevant role in ensuring the reliability, transparency and market acceptance of certification systems. Therefore, it is recommended that government institutions are involved in the efforts carried out around the Guarantees of Origin system in Mexico and that they have an allocated budget for its completion.

- To create greater interest, it is highly recommended that the government institutions of the hydrogen producing and exporting countries, in this case the Mexican institutions be in direct contact with the government institutions of the potential green hydrogen importing countries (these target countries could be defined with subsequent studies).

- Within the public institutions to be involved in the efforts for the Guarantees of Origin system, it would be advisable to seek the participation mainly of SENER, SE, SCHP, SEMARNAT, CRE and CENACE, among others.

- There is a consensus among the key actors interviewed that the development of a National Green Hydrogen Strategy by the public sector is required; it is recommended that this strategy reflects the commitment to establish a system of Guarantees of Origin.

- Mexico could adopt and implement international safety standards in the production and management of green hydrogen, with a process of adaptation to the context and situation of the country, for those specific activities where there are not yet sufficient regulations. The key actors interviewed agree that Mexico could leverage international safety standards and adapt them for cases where required, in order to enable the development of projects. This could motivate the adoption of green hydrogen, which in turn would imply a growing need for a certification system with international scope and validity

- It is important that Mexico seeks to consolidate agreements with green hydrogen importing countries from this initial phase. This will give a clearer vision of the approach that the next steps should have, and therefore, set initial monetary values that will guide the development of the Guarantees of Origin system.

Main Risks:

- Potential lack of representation and participation of some specific area of key actors, for example, the public sector, which affects the possibility of having a comprehensive vision and consensus.

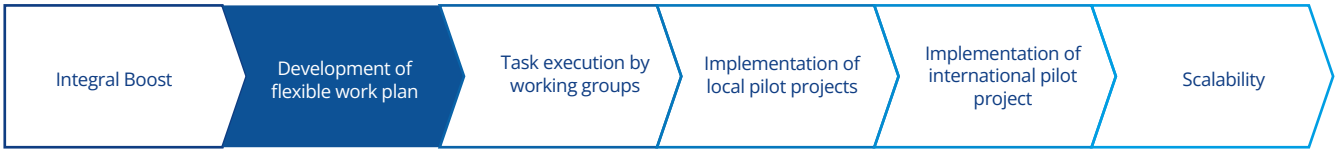
- Not having the budget or allocation of resources by the government or key actors involved.

- Lack of harmonization of certification systems at an international level, this would limit the number of countries to which green hydrogen could be exported according to the requirements that each country establishes, translating into higher costs and a segmented market.

- Not to seek or achieve international agreements in the short-term with importing countries that give certainty to investments in green hydrogen and its certification.

The sponsorship of private stakeholder, could be considered as an alternate measure. However, being the energy sectoran economic activity regulated by the State, that scenario would not be possible since there would not be a synergy for enabling spaces, permits and coordination of different authorities, which due to their attributions should be informed.

6.2 Development of Flexible Work Plan



It is advisable to draw up a work plan for the adoption of the system. To achieve this, it would first be necessary for the working consortium, also considering the comments of the stakeholder platform, to define the international system of Guarantees of Origin that would be best adapted in Mexico, based on the studies, information and recommendations available up to that moment. The system to be adopted must be marketable, transparent and traceable.

After the selection of the international system, the next step is to develop a work plan to achieve the successful adoption of such a system. It is important that the work plan is flexible, that it allows subsequent updates according to the progress of the proposed activities, and that it clearly includes the mission, vision, general and specific objectives, required time frames and actors.

Considering that various guiding documents in the country's energy planning are updated annually (p. e.g., PRODESEN), it is necessary to revise and update the proposed work plan on an annual basis to take account of the significant changes introduced by the governing documents in public policy; moreover, it is highly advisable to carry out a quarterly progress follow-up according to the budget allocated and exercised for these effects.

The objective of the development of this plan would be to engage and align the actors involved towards the same objective; thus, the consortium could validate the work plan with the stakeholder's forum to create a general consensus and at the same time, the necessary commitments for a successful implementation.

During this work plan phase, it would also be important to define working groups with designated tasks to achieve the specific objectives of the plan. The consortium could define which work teams would be needed, and what their general and specific activities would be, and designate a leader for each work team, ideally from the members of the consortium.

The working groups and their main objectives could be in line with the following proposal:

- Working Group 1: Facilitate the adoption of definitions, methodologies and requirements established in the selected system of Guarantees of Origin in Mexico, through: review, training and communication of these. To study the potential of implementing additional attributes to the adopted system, with a focus on sustainability, that allow differentiating Mexico's products.

- Working Group 2: To achieve the practical adoption of the system of Guarantees of Origin through: review and adoption of the international system, development and adjustment of the necessary documentation for the system based on the international system, review of information systems required, identification and solution of practical problems, and identification, implementation, and communication of lessons learned. To study the practical feasibility of the additional sustainability attributes proposed by working group 1.

- Working Group 3: Identify possible conflicts between the adopted system and the Mexican regulations and institutions, as well as find the best solution to these conflicts. To study the possibility of establishing penalties for fraudulent use of the Guarantees of Origin system (for example, disqualification of the producer or marketer). Review the current available documentation related to green hydrogen, to detect possible requirements for updating documents (for example, review the "General Administrative Provisions containing the efficiency criteria and establishing the calculation methodology to determine the percentage of fuel-free energy in energy sources and electric power generation processes").

- Working Group 4: Design local pilot projects to test the adopted system; provide support in the development of the selected and executed pilot projects; detect and share lessons learned and possible improvements for the system based on the developed projects.

- Working Group 5: Design an international pilot project to test the compatibility of the adopted system with countries that have a potential green hydrogen import strategy; provide support in the development of the pilot project; detect and share lessons learned and possible improvements for the system based on the developed pilots.

Recommendations:

For the selection of a system of Guarantees of Origin in this second phase of the proposed roadmap, the following recommendations can be considered:

- Governance is essential for the success of the implementation of a Guarantees of Origin system, therefore, there must be decision-making capacity and strict compliance with the deadlines that are established. It is valid to have the participation of different actors, but that does not mean that the initiative should be immobilized to several decision makers that could generate a "bottleneck".

- It is important that the system has the ability to separate on the one hand the complete information about the origin of green hydrogen and, on the other hand, the label of compliance with certain requirements. The complete information is objective and neutral, while the label may change with the evolution of international requirements over time.

- It is important that the Guarantees of Origin system considers the "renewable" quality of the energy provided and the associated carbon footprint, as both are essential key criteria according to international experiences; in addition, these attributes are in line with the existing certification systems in international markets.

- Information on carbon intensity and definitions within the Guarantees of Origin system should have clarity, transparency and a scientific methodological basis; in addition, it is important to have generally accepted definitions, based on GHG reduction thresholds.

- Minimum criteria and optional criteria can be considered, as well as non-negotiable criteria or thresholds. The criteria of the system could evolve according to the maturity of the industry and market, seeking not to restrict the market too much in its early stages.

- The system of Guarantees of Origin should provide a clear label for the knowledge of consumers and the transparent differentiation between the different routes of hydrogen production.

- The Guarantees of Origin system should allow international trade of green hydrogen, enabling exports in Mexico and helping to create an international market.

- The system must be open to all hydrogen end uses, although initially the industrial sector may be the main end user, the system should already be prepared for the entry of hydrogen distributors.

- The Guarantees of Origin system must use a solid and as simple as possible methodology, developed in a step-by-step procedure; that is also resistant to fraud and incorruptible. Correct accounting and documentation (registration) is essential, as this would help to generate consumer confidence and avoid double accounting (double registration). It is advisable to have a single register of generating plants (plant census) and controls of emission, trade and cancellation of guarantees in order to generate unique guarantees and avoid double counting. The registry should be fraud resistant and should provide reports for different purposes. Leveraging an existing registry internationally, would help reduce connection costs between different registry bases.

- It is advisable that the guarantee of origin is not only informative, but that it allows to have market value.

- Finally, it is essential to consider which are the potential countries to which Mexico will export green hydrogen, since the design of the certification system must follow the target market. Since there are currently no generally accepted definitions at the international level (for example, there is no consensus on the definition of "green hydrogen"), these definitions are usually established by the importing market based on its priority sustainability criteria. Therefore, in Mexico, the definitions applicable in the destination markets and the applicable regulation must be clearly understood.

Considering the points listed above, the adoption of the CertifHy system represents a viable route for Mexico's case. CertifHy has positioned itself as the most advanced hydrogen Guarantees of Origin system, and it is considered a potential model by the IPHE for a unified global system. Therefore, being aligned to this system, or to the global system where the IPHE leverages the advances of CertifHy, is for now the most resilient way both to guarantee compatibility with the largest number of countries, and to take advantage of good practices and lessons learned at the international level. Likewise, it is recommended to consider affiliation with the IBA to facilitate the transaction and cancellation of guarantees between the affiliated countries and Mexico. It is important to keep an eye on new developments in certification systems, especially the efforts of the IPHE.

Another point to consider is to be aware of the innovations and updates in the use of digital platforms to know their evolution and potential application in the energy transition. The blockchain technology could be the basis for the establishment of a system of Guarantees of Origin; this information system is a data registry organized in a decentralized way that is characterized by its specific properties of security, immutability, transparency, robustness and collective validity. This opens up the opportunity to skip individual stages of technological development and position itself as an innovative model for other industries. With blockchain, information can be assigned a value, transmitted and used in a traceable, authentic, automated and self-executing manner. Once a piece of data is stored in blockchain, it is linked to all other registries; in other words, it adapts to tasks such as Guarantees of Origin.

In the particular case of green hydrogen, blockchain acts as a "digital licensee" that guarantees the authenticity of the registry that endorses that the green hydrogen obtained by a company is produced with renewable energy. Once implemented, the platform based on blockchain it will be possible to collect generation data from renewable energy plants, then verify the part that is injected into an electrolyser and the amount of hydrogen produced in the process, all so that finally, the monitoring of the green hydrogen delivery is enabled.

Thanks to the audit trail in blockchain, all information shared on the platform is reliable, transparent and tamper-proof. These types of platforms could reduce costs and other barriers to participation in the global market for small producers[108]. Two examples of international initiatives in this area are mentioned below:

As an example of coordinated work between blockchain and energy certificates, there is the National Renewable Energy Registry (RENOVA) of Chile, which seeks to be the only registry of production and consumption of renewable energies in Chile, based on technology blockchain. The system, according to information from the National Electricity Coordinator (CEN), is the result of public-private expert tables, whose design considers avoiding double accounting of the sale and use of renewable energies, as well as an issuance of certifications under international standards[109].

Specifically speaking of green hydrogen, ACCIONA has developed GreenH2chain®, the world's first blockchain technology-based platform which guarantees the renewable origin of green hydrogen. This new tool will also allow customers to verify the process of transportation and delivery of this type of clean energy. In the future, GreenH2chain® will be complementary to any official system dedicated to certify the renewable origin of hydrogen, once the system is established. The ACCIONA platform will offer its service to these systems both at European level and in each country individually[110].

In terms of IT development, Australia and the China Hydrogen Alliance are actively considering the use of blockchain technology for certification platforms, due to transparency and cost factors. It is expected that the use of blockchain assist with the collection and processing of data in the hydrogen Guarantees of Origin systems. This would allow aggregation of small producer lots and further automation of manager functions, along with other benefits. However, this does not necessarily avoid the need for GHG calculations and measurement systems to provide the necessary data, which can still be complex and must be audited.[111]

Main Risks:

- Lack of consensus and eventually a lack of leadership among the consortium actors, or interested actors, in the selection of an international Guarantees of Origin system for green hydrogen.

- That a realistic work plan is not developed to guide the actors involved in the efforts of the Guarantees of Origin system, or that the work plan does not consider all the key aspects due to a lack of comprehensive vision or of participation of a specific area of key actors.

[108] Flexidao, 2021.
[109] Hinicio, 2021.
[110] ACCIONA, 2021.
[111] BEIS, 2021.

6.3 Task Execution by Working Groups

The work consortium could bring together the members of each working group using open call to the public, where actors from different sectors (public, private, academia, etc) apply to be part of the working group according to their skills, experience and interest, as did CertifHy. The working groups, as mentioned in the previous stage, could be led by a member of the consortium, who would be responsible for the working group to follow the work plan and that the efforts made are in compliance with general and specific objectives.

At this stage, the consortium could rely on the working groups to kick off and implement the work plan. Each of the groups would carry out the activities defined in the plan with the aim that, at the end of this stage, it can be in a position to start implementing local pilot projects (which are integrated in the next phase).

Recommendations:

- Efforts can go beyond the adoption of the international system as it is. It is possible to deepen and cover other important aspects to measure impact, such as environmental criteria, water supply and consumption, social and local economic development, as well as community and working conditions. Adding additional criteria to Mexico's Guarantees of Origin could make exported products more attractive to specific buyers and markets. The working groups, in this proposal groups 1 and 2, could analyse additional criteria to add value to the Mexican system, preferably the following: additionality of input energy, social aspects, the non-conflicting use of water and the non-conflicting use of land. However, the aforementioned criteria are only a proposal based on international experiences, and it will be necessary to carry out specialized studies to define and study them in detail.

Main Risks:

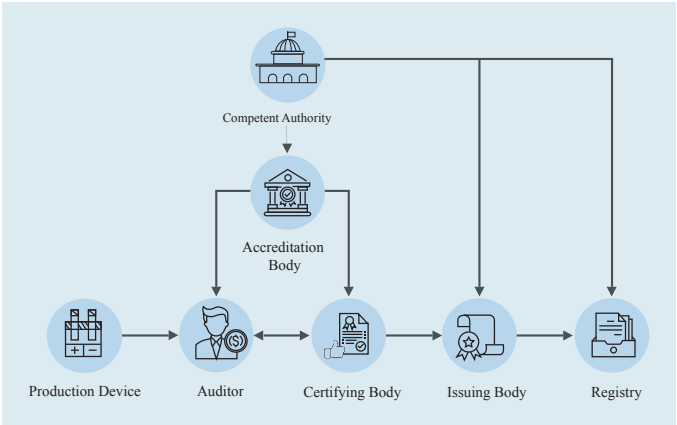
- That there is no interest to attract and maintain the participation of the members of the working group.
- Lack of leadership in the working groups that affects the fulfilment of established tasks and objectives.
- Little or no alignment with the developed work plan, which results in delays in the phases, and eventually the abandonment of the initiative.

6.4 Implementation of Local Pilot Projects

Once the system of Guarantees of Origin is adopted, it would be useful to implement one or more pilots at the regional level to test the functionality of the system with a limited number of producers and consumers; these pilots would be in line with the design developed in the previous phase by one of the working groups (working group 4 according to this proposal).

In this scenario, where Mexico would opt for adoption of a system recognized internationally (CertifHy or equivalent at the time), it would define who would be involved in the operation of the system of Guarantees of Origin; taking CertifHy as a reference, it would be required to designate a competent national authority, an issuing body or bodies, as well as an accreditation agency that accredits certification bodies, auditors, and the registration may be leveraging with the defined international system. Below, the CertifHy system is shown again for reference:

Figure 27. CertifHy Roles



Source: Image taken from CertifHy Deliverable No. D.4.2. (Adapted format)

The definition of the actors for this structure may be developed provisionally to later state the definitive actors, or it could be defined during the pilot test phase, this will depend on the actors and their faculties.

Working group 4 could provide the necessary accompaniment for the pilot to be carried out as planned. These pilots would make it possible to gain practical experience in technical and administrative aspects to the different actors involved (for example, producer, certifier, consumer) and identify key information about the practical complications of the implemented system.

The working group corresponding to the local pilots would have the important task of supporting the implementation of the necessary adjustments for the better functioning of the system. In addition, as the level of maturity of the adoption of the system increases, new pilots can be planned and developed at different scales depending on the task to be tested.

Another activity that is important in this phase is to keep a documented control of the results of the pilot projects, in order to disseminate and socialize the benefits and progress achieved. This activity would boost the acceptance and adoption of green hydrogen in Mexico, and could arouse greater interest in the use of the adopted Guarantees of Origin system.

Recommendations:

- Starting the pilot phase with small projects, and testing some initial processes instead of trying to get the whole system fully up and running

.

- To train the Mexican institutions involved in the Guarantees of Origin system, with the working consortium (or its equivalent) leading this activity , since the institutions (regulators and authorities) would need to expand their technical capacities with respect to the use and exploitation of green hydrogen, as well as the Guarantees of Origin system.

Main Risks:

- Possible lack of installed capacity for generation.
- Possible lack of social license.
- Possible lack of investment for pilot projects.
- Possible lack or paralysis in the delivery of generation permits for pilot projects.
- In case the implemented system presents many regulatory conditions and is very strict, generators could be discouraged from entering such a system.
- Possible changes in regulation that hinder the development of pilot plans or changes in regulation after the execution of the pilots, which would change the results obtained and the lessons learned for their application at scale.

6.5 Implementation of international local pilot project

After the operation of the system in Mexico has been optimized thanks to the lessons learned from the local pilots, the next step is to conduct an international pilot project, this with the aim of testing the international compatibility of the system. This pilot (or pilots) would ideally be in line with the design developed by the corresponding working group (working group 5 in this proposal); this same working group could give the required accompaniment so that the pilot can be successfully executed.

Like the local pilot phase, this international phase would allow gaining practical experience in technical and administrative aspects, and timely identify relevant information on practical complications to achieve system compatibility and enable green hydrogen exports from Mexico. Efforts for this international pilot or pilots can form the basis for the negotiation of international trade agreements with the counterparty (for example, European Union, Asia-Pacific Economic Cooperation - APEC and Brazil, Russia, India and China - BRIC), as well as to promote and review the green hydrogen Guarantees of Origin integration within the current international trade agreements of Mexico (for example, USMCA, FTA EU-MX).

As in the local pilots, it is important to keep a documented control of the benefits and achievements of this phase; this will give signals to other countries of Mexico's commitment to green hydrogen certification and the country's export potential.

Recommendations:

- It is important that during the previous phases' actions have been carried out to consolidate agreements with hydrogen importing countries, which enables the development of one or several pilot projects , without starting from scratch from this stage.

Risks:

- There may be a situation in which the maturity level of the national pilot is not as expected according to the schedule, because there are still unresolved problems in the adoption of the system, causing delays in a potential international pilot project.
- Any trade restrictions in the form of physical transport obligations between individual countries could lead to separate and less flexible regional markets, which could further divide the market into small submarketss.
- Lack of international agreements to carry out the pilot tests with other countries.

6.6 Scalability

This stage considers that, thanks to local and international pilots, Mexico can deploy the system of Guarantees of Origin in the national territory and enable exports with importing countries of green hydrogen. The previous work carried out by the work consortium is key to reaching this stage.

The flexibility of the work plan could be used to adjust to the conditions that arise at this stage, which would be difficult to define exactly from the early stages of the roadmap.

It would be important that for the next steps towards the implementation of the system an additional set of cost competitiveness studies, projection of market demands and diplomatic exchanges regarding the establishment of cooperation agreements with other countries could be required.

Recommendations:

- Developers of green hydrogen projects should study and consider the certification requirements, both those required by law and those requested by the market, as early as possible in the project development process (to design it properly), since subsequent adjustments can be expensive and time-consuming for implementation.
- It is relevant that a constant and transparent review and update of the adopted and deployed system is carried out, taking into account that the international environment is constantly evolving, and it is possible that the attributes, definitions and other elements of the system will be updated.
- The government could define clear guidelines for certifying companies and create a public framework that allows public traceability in all senses, one way to achieve this is by implementing the internationally defined methodologies for emission reporting in green hydrogen generation, guaranteeing a transparent and simple system.
- In addition to leveraging the registration of the international certification system, there could be a national registry where all the relevant information is centralized (unified databases).
- Consider alignment between different types of existing certification systems (e.g., CELs) and the future Guarantees of Origin system for hydrogen.
- It is recommended that the production and export of hydrogen should not be done at the expense of the benefit of renewable energies in Mexico and its energy security, that is, not to risk the supply of renewable energy in the country to export green hydrogen.

Risks:

- A potential threat is that green hydrogen producers and the public sector focus more on exports than on the domestic market, which could compromise the potential consumption of renewable energies in the country, leaving it in the background.
- Changes in regulation that could mean an obstacle to the maturity of the Guarantees of Origin market in the country.
- That the final process defined to bring the guarantee market to scale is very expensive and bureaucratic, which would disincentive generators to seek to enter this system.

7.Conclusions

Guarantees of Origin represent an opportunity to assure the generation attributes of green hydrogen, and the quality and validity of clean energy origin sources that produce it. It is an important tool that allows actors to access green hydrogen despite its location, helping them to comply with national and international environmental targets; it is, in itself, a system that serves to communicate to the end users the origin of the clean energy harnessed for the production of green hydrogen, enabling them to make more informed decisions.

Through international experiences, it is observed how certification systems for renewable energy have been successfully implemented in some countries and how suppliers, governments and consumers have benefited. These experiences have left lessons learned and good practices to follow for the current and soon to be developed green hydrogen certification system.

This mechanism that allows the traceability, trade, use and cancellation of certificates with the energy source information, is an enabler for the international trade of green hydrogen, promoting alignment and compatibility between systems from different countries. International trade would help boost the market by reaching economies of scale that could provide an alternative energy vector at a competitive cost of production.

There are some international certification systems for green hydrogen, however, the most developed so far, with greater maturity and openness is the European system of Guarantees of Origin for hydrogen from CertifHy. This system considers green and low-carbon hydrogen for its certifications, and is in the last phase of deployment seeking to cover fuels produced with hydrogen and aligning the issuing bodies. CertifHy is working hand in hand with the IPHE to develop and define measurement methodologies, definitions and clear international trade rules, in order to boost the green hydrogen market internationally.

According to this study, the most feasible recommendation for Mexico to have a system of Guarantees of Origin for green hydrogen is the adoption of an international system in the short term, leveraging the knowledge developed in terms of definitions, methodologies, processes, governance structure, documentation and pilot tests. The international system to adopt that is recommended is CertifHy, coupled with the search for Mexico's participation in the IPHE to always be informed, updated and aligned to one of the future international hydrogen trade networks.

Adopting an international system of guarantees such as CertifHy would have great benefits for the country in the economic sphere: boosting a new green hydrogen market, investment in green hydrogen projects, enabling the export of green hydrogen to importing countries, improving the reputation of companies; in the social sphere: greater security (resilience and flexibility) and energy diversity, job creation in the domestic market, empowerment of consumers and communities; and in the environmental sphere: boosting decarbonisation, control over the environmental impact on water and land, and ramping up renewable energies.

Although Guarantees of Origin represent multiple benefits for the country, we must consider where Mexico currently stands regarding renewable energies and certifications of these. It represents a great challenge to meet the Nationally Determined Contribution by 2024 to achieve 35% clean energy generation. In addition, the country has few instruments for the promotion of clean energy, one of them being the Clean Energy Certificates scheme, and which in recent years has faced resistance in terms of the completion of regulatory instruments for its enablement in short-term markets, as well as changes in its regulation. In addition to being seen as barriers to the development of a system of Guarantees of Origin in Mexico, they also represent valuable lessons learned that can be capitalised on in a positive way for a system of Guarantees of Origin that is appropriate to the characteristics of the country.

Guarantees of Origin can be a great tool to boost the generation of green hydrogen and increase the market. They serve as a guarantor of certainty of a future trade of this energy vector, which could enable financing for infrastructure and research projects. Today there is a positive national attitude around green hydrogen, there is a conviction by several that it can be an alternative for the planet and for the country.

It is important to seek the participation of the government with a pronouncement regarding the opportunities represented by green hydrogen, for example, through a national hydrogen strategy, and that the necessary mechanisms be raised to ensure that an investment in the country with expected long-term returns can operate under a stable regulatory scheme that protects investment and the growth of the industry. Failure to guarantee this would cause Mexico to lag behind in this potential world market, which, as stated in the document, is being adopted and implemented by world economic powers.

Once there is a clear direction at the national level on the future of green hydrogen, the adoption of the recommended Guarantees of Origin system could be considered, for this a roadmap is proposed in this study. This roadmap was developed based on the experience of other countries and has 6 phases: Integral boost of hydrogen as an energy vector,

development of a flexible work plan, execution of tasks by working groups, implementation of local and international pilot projects and scalability of generation and transactions. This roadmap proposes that Mexico could implement a certification system between 4 and 8 years. Each phase of the roadmap has recommendations and identified risks. However, an indispensable factor to be able to carry out this roadmap is the collaboration between the public, academic and private sectors. With the knowledge and skills of each of these sectors, Mexico could become an exporter, consumer and generator of green hydrogen; being one of the largest players in this new market.

The incorporation of green hydrogen into the national energy balance as an alternative energy represents a great opportunity for Mexico. To take advantage of it, the country must join actions that accelerate its incorporation into this new world market, and it is there that the Guarantees of Origin represent the base instrument for an unprecedented export potential, which will help consolidate a value generation that goes beyond the strictly economic and that positively permeates society and care for the environment.

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9. Summary of interviews

A brief survey of key actors was carried out to find out their perspective on the issue of green hydrogen in Mexico, the vision of the state and Guarantees of Origin. After the survey, an analysis was carried out to identify the main findings, which are presented below:

- The majority of respondents consider that Mexico has the necessary experience and technical capabilities for the phased adoption of hydrogen as an energy vector, although a National Green Hydrogen Strategy by the public sector is necessary to boost the industry in the country.

- It is considered that the adoption of an international system of Guarantees of Origin (GO) could give impetus to the adoption of green hydrogen. This certification system should be implemented in the short term along with efforts in general hydrogen regulation, however, respondents consider that additional technical capabilities are necessary in current institutions in Mexico for the implementation of a certification system. The institutions that most consider should be involved in the development and implementation of the guarantee system are: SENER, SHCP, SE, SRE and CRE.

- There is a consensus among the interviewees that Mexico could adopt and adapt international safety standards for specific activities in the hydrogen value chain that are not currently covered, with the aim of enabling the value chain and thus allowing the development of projects, which promotes the adoption and deployment of hydrogen in the country.

The findings of the actors' opinions were included in the document as part of the recommendations for the implementation of the roadmap.

10. Annex

ANEXO 1
Additional details LCFS
Accreditation Fuel Supplier

All transportation fuels require an CI score to participate in the LCFS; the type of fuel dictates which process is used to determine such an CI. The following diagram shows the basic process for generating credits, which, in this type of accreditation, are calculated based on 1) the CI score that is determined in the initial application, 2) the Energy Efficiency Index (EER) for the type of vehicle in which the fuel is used and 3) the amount of fuel reported in the application. Credits are issued quarterly..

The diagram shows the basic process for generating credits. Fuel Supplier credits are calculated based on the CI score that is determined on the initial application, the energy economy ratio or EER for the type of vehicle in which the fuel is used, and the amount of fuel reported. Credits are issued quarterly; they are checked every year.

Project-based credit opportunities

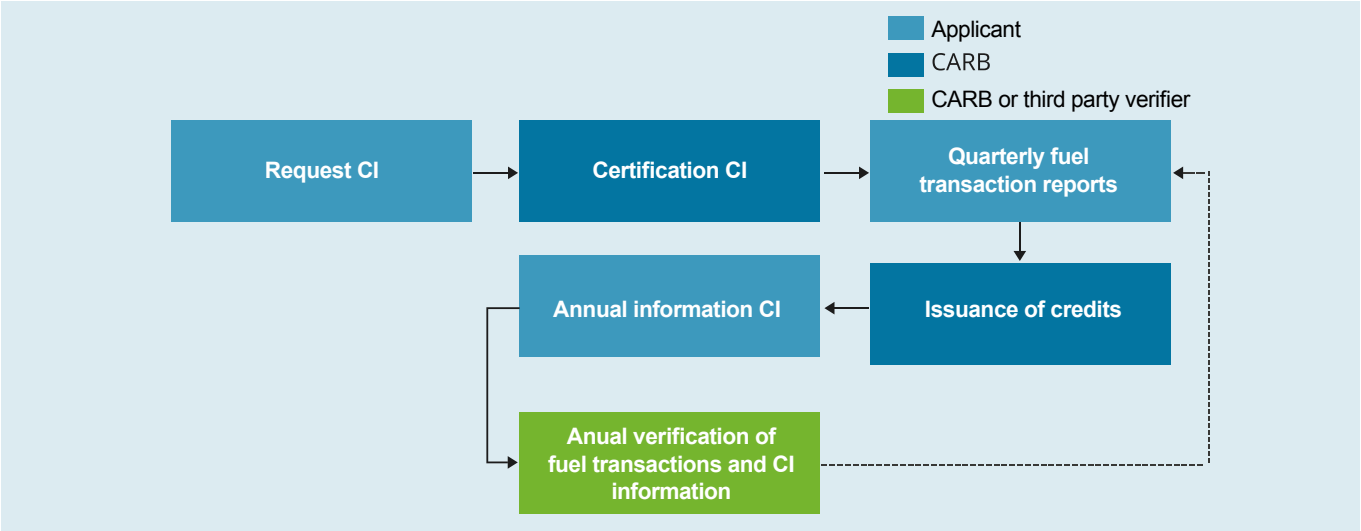
The LCFS contains two credit provisions for refineries, a credit opportunity for crude oil production, and carbon capture.

The provision of credits for renewable hydrogen refineries allows refineries to generate credits by using renewable hydrogen to produce gasoline and diesel. Renewable hydrogen can be produced by SMR of renewable natural gas or by electrolysis using renewable electricity.

The provision of refinery investment credits allows them to generate credits for GHG reduction projects at the refinery, such as the use of renewable energy sources, the conversion of combustion energy sources into electricity, the use of carbon capture and process improvement projects.

The provision of credits for crude oil production supports innovative technologies for steam or solar heat generation, electricity based on solar or wind energy, renewable energy from natural gas or biogas, and carbon capture and sequestration.

Figure 28. Basic credit generation process



Source: Image taken from the document Low Carbon Fuel Standard (LCFS Basics with Notes). (Translation, adapted format)

[112] Steam Methane Reforming.

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