“Roadmap for the establishment of a well-functioning EU hydrogen GO system”

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“Roadmap for the establishment of a well-functioning EU hydrogen GO system”

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Lead Authors:

Marc Londo, ECN

Karina Veum, ECN

Carolien Kraan, ECN

Contributing Authors:

Wouter Vanhoudt, Hinicio

Frederic Barth, Hinicio

Javier Castro, TÜV SÜD

Matthias Altmann, LBST

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1 Introduction

1.1 Rationale of a Guarantee of Origin scheme for premium hydrogen

Driven by its energy policy objectives (see Box 1), the EU is looking at cost efficient ways to achieve at least 40% cuts in greenhouse gas (GHG) emissions (from 1990 levels) by 2030 and 80 - 95% cuts by 2050. Hydrogen can play a significant role in contributing to the decarbonisation of the transport sector through its direct use as fuel in fuel cell vehicles and through the decarbonisation of conventional fuels (e.g. by replacing conventional hydrogen with low-carbon hydrogen needed in refineries). It can also contribute to significant greenhouse gas emission reductions in the energy-intensive industry, and power-to-hydrogen can play a role in balancing a renewables-based electricity system.

Box 1:The European Union's energy policies are driven by three main objectives:

- Securing energy supplies to ensure the reliable provision of energy whenever and wherever needed
- Ensuring that energy providers operate in a competitive environment that ensures affordable prices for homes, businesses, and industries
- Ensuring a sustainable energy consumption, through the lowering of greenhouse gas emissions, pollution, and fossil fuel dependence.

For hydrogen to be a more climate-friendly alternative, the decrease in emissions will have to take place in its whole life cycle. Furthermore, sustainable ways of producing hydrogen will need to be connected in an infrastructure to support the wide-spread use of hydrogen as a transport fuel and industry feedstock.

Next to conventional hydrogen produced from fossil resources, there is also at present a demand for renewable and/or low-carbon hydrogen (jointly referred to as ‘premium’ in this report), which is projected to increase. In order to allow such premium hydrogen to be traded through conventional infrastructure, evidence of the premium production of hydrogen will need to exist, and a Guarantee of Origins (GO) scheme is an important element to make this possible. This allows for a decoupling of the physical flow of hydrogen and its sustainable attributes in order to allow for an optimized distribution of hydrogen while allowing to differentiate between fossil based hydrogen on the one hand and renewable and low-carbon hydrogen on the other hand.

Against this background, the overall objective of the European project CertifHy is to develop an EU-wide framework for GO for premium hydrogen, based on a widely accepted definition and to propose a roadmap to implement the initiative throughout the EU. This roadmap aims to communicate direction and progress of the high-level initiatives and actions to follow this pathway.

More specifically in this roadmap you will be able to find the following information:

- The essential ingredients of the proposed GO scheme.
- An overview of the required actions that are needed to implement the GO scheme.
- Draft timelines for the proposed actions, including milestones and links among tasks and priorities, and a draft allocation of key responsibilities.

1.2 Guarantees of origin, certificates, definitions, labels: A concise 'who-is-who'

Along the CertifHy project, we ran into several misunderstandings that had to do with terms and definitions. Therefore, a short explanation of the terminology we use in this roadmap:

- A GO is an (electronic) piece of information that reveals characteristics of a product. It contains factual information on e.g. production location and date, feedstocks used and related greenhouse gas emissions. The guarantee of origin can be traded separate from the physical trade of the product, and therefore allows for separate trade of the premium attributes of the product, while the product itself becomes anonymous, e.g. because it is fed into a transport grid. In some countries, guarantees of origin for renewable energy are also named 'green certificates'. This may lead to confusion because the term 'green certificate' is also used in the context of tradable quota obligations for renewable energy and other support schemes, while GOs only serve consumer disclosure.
- Also, any premium H2 producer requesting issuance of a Guarantee of Origin for any production batch will have to be "certified" by an auditor that has been credited to do so. Last but not least, the most common guidelines for the control infrastructure for GOs are the well-established EECS rules. EECS stands European Energy Certificate System; these rules are used for GO schemes (as well as for tradable certificates in the context of quota obligations and other support schemes). The "certification process" and the reference to the EECS are only increasing the confusion between guarantees of origin and other certificates even more.
- The project focusses on hydrogen with 'premium' characteristics. In this context, we propose specific definitions for two premium products (see section 0 for details): CertifHy Green Hydrogen (renewable and low-carbon) and CertifHy Low-Carbon Hydrogen (not renewable, still low-carbon;). Such a definition is also called a label. While the GO collects factual information on the product, the label is merely subjective. A guarantee of origin can also mention whether the product it belongs to meets the requirements of a certain label, by comparing the product characteristics with the label requirements.

A GO scheme, in which guarantees of origin are issued, traded and cancelled, can in principle accommodate several labels, by providing the necessary information to judge whether the definitions of these other labels are met by the product. Essentially, a robust GO scheme should also be able to serve all labels defined for the product.

1.3 Purpose of the Roadmap

A roadmap is essentially a document that matches goals with solutions to achieve these goals, taking into account potential risks and obstacles which may cause the need for 're-routing'. A roadmap must define a clear vision and mission, as well as setting a clear set of future goals or objectives. These are presented in section 1.2.1. Two very important purposes of a roadmap include:

Firstly, to communicate direction and progress, showing high-level initiatives and the planned steps to get there, without including the nitty gritty details. In addition to steps, clearly outlines links among tasks and priorities for action in the near, medium and long term, and includes metrics and milestones to allow regular tracking of progress towards the roadmap's ultimate goals.

Secondly, to engage and align diverse stakeholders in a common course of action, sometimes for the first time. Whilst clearly stating who the audience is (those who have an interest in seeing the roadmap developed and implemented), a roadmap is usually seen as a living document, since the process is often seen to be just as important as the resulting document.

With those two purposes of roadmaps in mind, a vision, mission, and goal have been stated for this roadmap on a GO scheme for premium hydrogen, see box 2.

Box 2:

Vision – the desired end result of the Roadmap is:

A mature market for green and low carbon hydrogen so that the added value of these products can be made monetary.

Mission – the method that will lead to the accomplishment of the vision:

An efficient and effective Guarantee of Origins scheme for hydrogen in the EU that allows for the creation of a green and low carbon hydrogen market.

Goal – the concrete outcome of the Roadmap:

The necessary steps are taken to develop a GO scheme in cooperation with the right stakeholders, such that it can be introduced in 2020.

2 Point of departure

2.1 Current status of hydrogen production and use

Hydrogen has long been known and utilized in the industry, both as feedstock (for example in the oil and gas industry), or produced as a by-product of industrial processes. Additionally, the use of hydrogen as an energy vector has been envisaged for a long time, and it is expected to develop in other sectors of the economy. The global demand for hydrogen in 2010 reached 43 Mton. European demand was slightly lower than 20% of total demand worldwide at 8 Mton of H_2. The hydrogen used can be produced by a variety of processes, primarily by steam methane reforming (SMR) of natural gas, coal gasification and as a result of cracking of hydrocarbons (in refineries).

Figure 1 indicates current hydrogen applications and their market sizes. The most important hydrogen consumer in Europe is the industry, with 90% of the market share (7 Mtons of H_2). Its main sub-segment is the chemical sector with approximately 60% of hydrogen demand (4.3 Mtons of H_2), followed by the refinery sector which accounts for 30% of the market share (2.1 Mtons of H_2). Of the total volume of industrial consumption more than 50% (3.6 Mtons of H_2) is used in ammonia. Most of the hydrogen consumed in the industry is sold within a captive market or produced on-site (64%). 'Fatal hydrogen', which is the name given to hydrogen that is produced as by-product of some industrial processes is also commercialized, and it constitutes 27% of the market. The remaining 9% consists in merchant hydrogen commercialization.

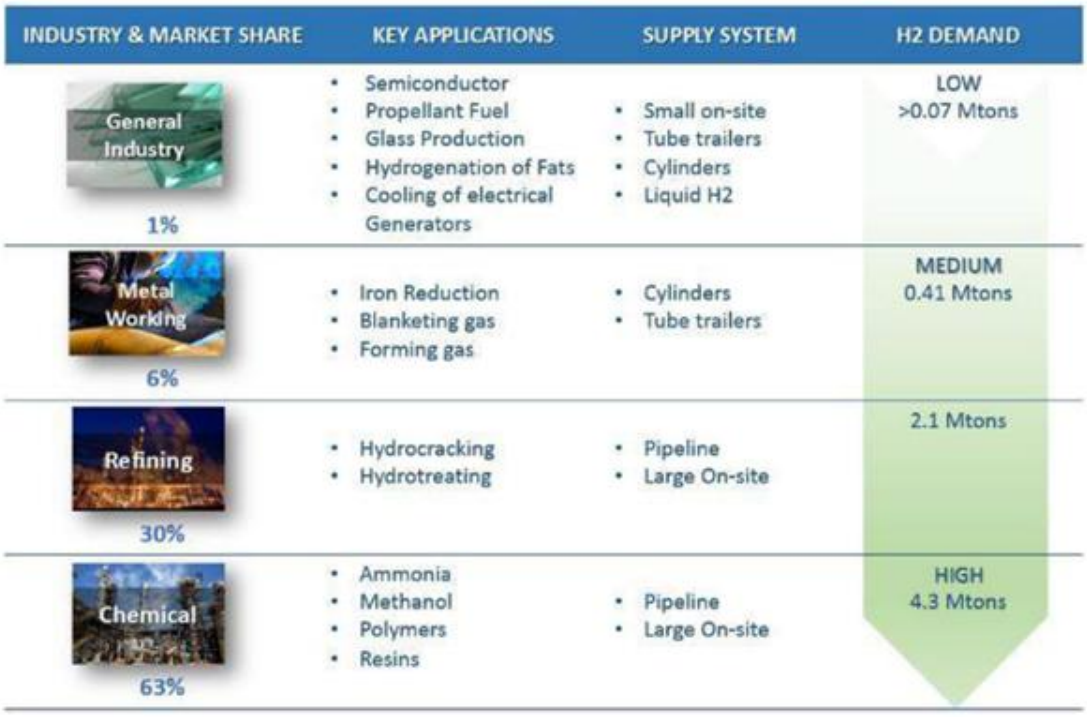

Figure 1: Current demand sectors for hydrogen. Source: CertifHy Deliverable 1.2 (www.certifhy.eu)

2.2 Future hydrogen demand forecast

Global demand for hydrogen is foreseen to reach 50 Mtons by 2025 being used in industry and transport. It is predicted to grow 3,5% per year. Today most hydrogen is produced from fossil resources. For hydrogen being a climate-friendly alternative to fossil fuels, it is necessary to ensure minimal impact on natural resources in the whole life cycle. It is expected that 50-60% of all hydrogen for the growing market of transportation will originate from renewable or low-carbon sources by 2030. This will allow greening the existing industrial market.

Assuming a similar tendency for Europe for the years 2025 – 2030, this means that the industrial yearly demand would increase from 7 to 8.5 Mton of H_2 (see Figure 2). Production costs of H_2 from steam methane reforming (SMR) are expected to vary little in the future, however, it is important to note that hydrogen costs at the point of use are extremely dependent on volumes and logistics between the point of production and the point of use.

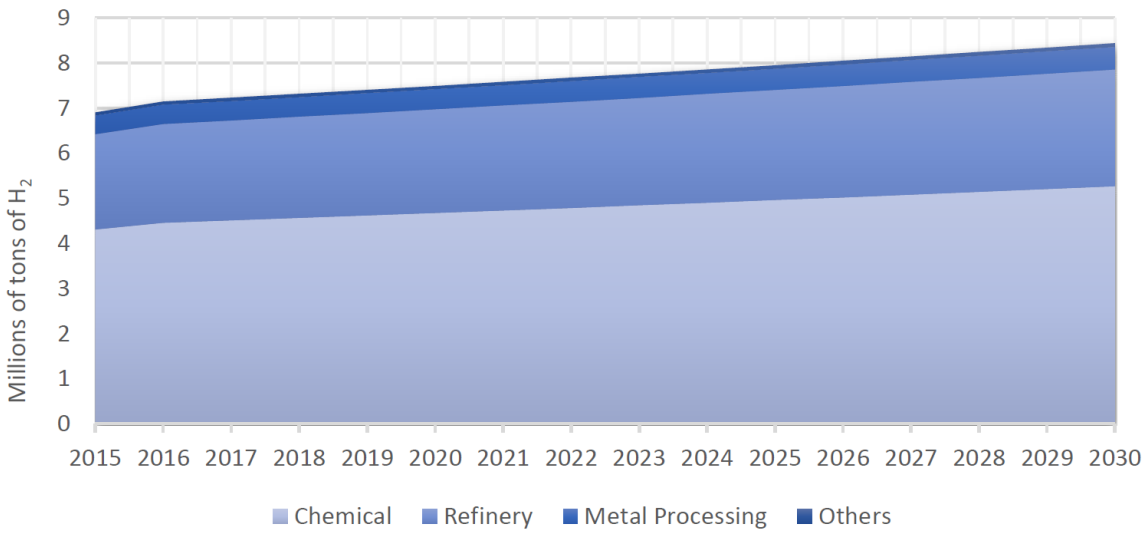

Figure 2: EU Hydrogen demand for the industry sector. Source: CertifHy Deliverable 1.2 (www.certifhy.eu).

Under a policy-driven scenario, green or otherwise premium hydrogen could represent about 15% of all hydrogen demand in Europe by 2030, amounting up to 1.4 Mtons of H_2 (Figure 3). The demand for premium hydrogen will come both from new markets, such as H_2 as a mobility fuel, and from large existing industrial consumers, such as refineries. Generally the substitution rate of conventional hydrogen in the industry sector is small (<9%), but this is varied among subsectors, with a 2% rate in the chemical industry, and 25% in the refineries sector or 40% in the food industry.

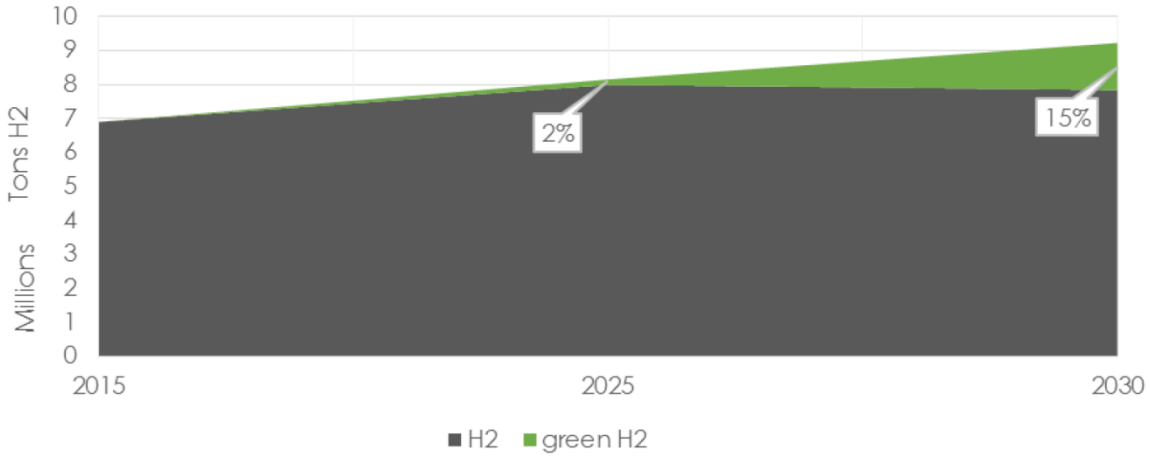

Figure 3: Evolution of hydrogen demand under a CO_2 policy driven scenario for all sectors analysed. Source: CertifHy Deliverable 1.3 (www.certifhy.eu)

With EU agreement on an 80% CO2 emissions cut by 2050, the transport sector requires around 60% reduction, and passenger transport 95%, as it has more options to decarbonise than e.g. aviation and shipping. Transition to hydrogen will have the largest impact in the segment of passenger vehicles, as they comprise the majority of the car fleet, through fuel cell vehicles (FCVs). Fuel cell vehicles (FCV) are at the gates of commercialization, but due to the slow introduction of this technology and the related infrastructure, H_2 mobility is currently limited to a few demonstration projects throughout Europe, which are heavily depending on public subsidies. Hence, the hydrogen demand for the transport sector is today almost negligible. However, it is expected to increase significantly as a larger number of hydrogen vehicles begin to enter the market and the refuelling infrastructure builds up (see also Figure 4). In the EU a penetration rate of FCVs around 9-13% of the total fleet is possible, representing 12-25 million vehicles. The H_2 could be distributed at retail stations similar to today's petrol stations, and in 2030 the number of stations could be as high as 5100, selling 2.6 Mtons of hydrogen, which is expected to create a significant demand for renewable and/or low-carbon hydrogen as well.

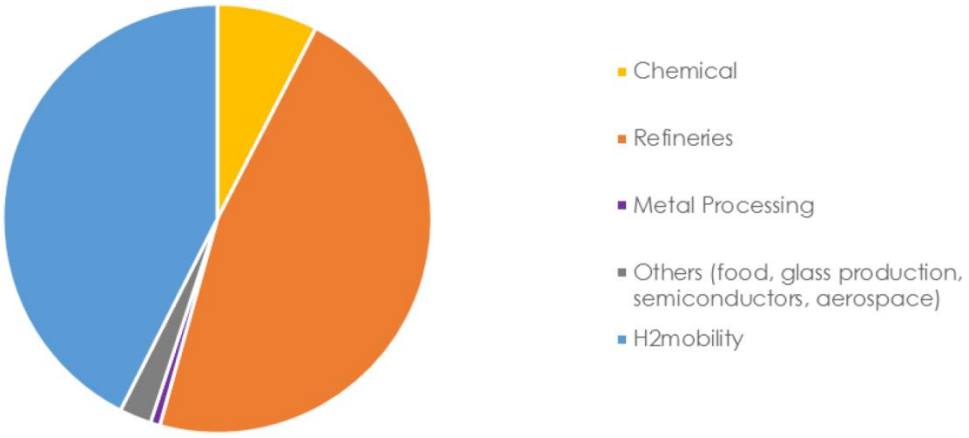

Figure 4: Snapshot of possible green hydrogen demand by 2030, divided by market segments. Source: CertifHy Deliverable 1.3 (www.certifhy.eu).

Another new market for green hydrogen may be found in the power to gas scenario, where renewable electricity is used to create green hydrogen, which in turn can be fed into the gas grid, such that the use of renewable energy through natural gas is facilitated. Volume blending ratios estimate that between 1-15% of hydrogen in the gas grid requires only minor modifications. The bottleneck for higher blending ratios are the appliances installed downstream, but by substituting 1% of the natural gas demand in 2030 by hydrogen already adds 170 ktons of H_2 to the yearly demand for hydrogen.

2.3 Potential market value of premium hydrogen traded through GOs

Experiences with GOs so far indicate that it is difficult to foresee or predict the market value of GOs for energy carriers such as renewable electricity, methane or heat. As GOs serve the purpose of consumer disclosure, it is the balance of demand and supply that sets the price. Also, GO prices are notoriously intransparent: there is no common trading platform for them in which price developments can be monitored easily. Developments in GO production volumes are monitored by several parties, including the Association of Issuing Bodies (AIB).

An important feature of hydrogen is that this energy carrier is usually produced from another energy carrier, such as natural gas (in the case of SMR) or electricity (in the case of electrolysis). This implies that the prices of GOs for CertifHy Green Hydrogen (the renewable and low-carbon option) will probably relate to the prices of GOs for renewable methane and renewable electricity, as (some of these) GOs can be converted into a CertifHy Green Hydrogen GO along with the conversion process (and taking into account the process conversion efficiency).

All in all, the uncertainty in the future price for premium hydrogen GOs makes it difficult to explore business cases for production and purchase of them at this stage. The market will typically need to find this out in practice, which will be part of one of the proposed actions in this roadmap (see Section 6).

3 Premium hydrogen: Definitions

The definitions of premium hydrogen are among the key outcomes of the project. They have been extensively described in CertifHy deliverable 2.4 (see www.certifhy.eu). The definitions are the outcome of a development process and extensive consultations carried out with a broad set of stakeholders, with a prominent role for the project Affiliate Partners. Three essential requirements were drawn regarding the definitions:

- The scheme needs to support also the commercialisation of low-GHG emissions hydrogen, even when it is not of renewable origin ("dual purpose scheme"); this means there is a need for a definition of renewable (and low-carbon) hydrogen and of non-renewable low-carbon hydrogen.
- If a part of the hydrogen production in a facility meets the requirements of one of the definitions, and another part does not, the greenhouse gas emissions intensity (based on a Life-Cycle Analysis approach) of the part of the production that does not meet the requirements must not be excessively high.
- The approach needs to provide a way for defining the GHG content of hydrogen produced with generation of a GO, but sold without it, and hence belonging to the "residual mix".

3.1 Adopted definition of CertifHy Green Hydrogen

The following definitions for CertifHy premium hydrogen were adopted:

CertifHy Green Hydrogen

CertifHy Green Hydrogen is hydrogen from renewable sources that is also CertifHy Low-Carbon hydrogen (see the definition below).

Hydrogen from renewable sources is hydrogen belonging to the share of production equal to the share of renewable energy (sources as defined in the EU RES directive) in energy consumption for hydrogen production excluding ancillary functions.

CertifHy Low-Carbon Hydrogen

CertifHy Low-Carbon Hydrogen is hydrogen from fossil origin with emissions lower than the defined CertifHy Low-GHG-emissions threshold, i.e. 36.4 gCO_{2eq}/MJ, produced in a plant where the average emissions intensity of the non-"CertifHy Low-Carbon" Hydrogen production since sign-up or in the past 12 months, does not exceed the emissions intensity of the benchmark process (91.0 g CO_{2eq}/MJ, SMR of fossil natural gas).

The relation between hydrogen characteristics and the definitions is illustrated in Figure 5.

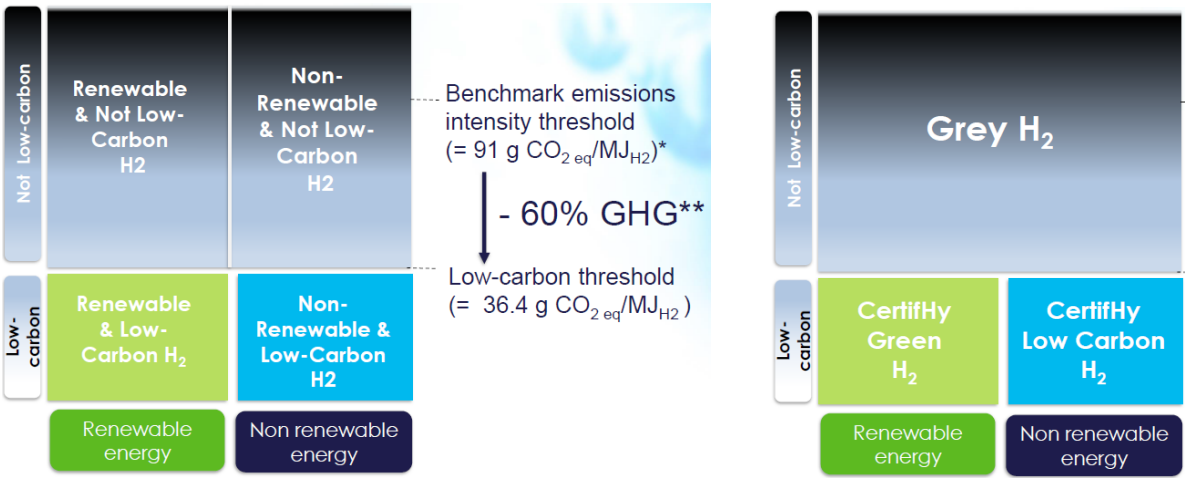

Figure 5: The relation between hydrogen characteristics (viz. their energy origin and their carbon intensity) and the CertifHy definitions.

3.2 Related considerations

The adopted approach was designed to:

1. allow the generation of GOs both for (i) hydrogen from renewable origin with low GHG emissions and for (ii) non-renewable hydrogen that carries the same low level of GHG emissions;
2. structurally ensure that the GHG emissions intensity of any non-certified hydrogen produced by a facility producing CertifHy Green or CertifHy Low-Carbon Hydrogen does not exceed that of the benchmark process, i.e. steam methane reforming (SMR) of natural gas.

To that end, the following conditions for producing CertifHy Low-Carbon and/or CertifHy Green H_2 are defined:

- Only facilities producing H_2 with GHG emissions lower than the benchmark value - 91.0 gCO2eq/MJ1 - since sign up or over the preceding 12 months (or since inclusion in the scheme for a newly included installation) are eligible for producing GOs
- Hydrogen produced over that period by this facility that is neither CertifHy Green nor CertifHy Low-GHG must have emissions lower than the benchmark value.

[1] This value has been calculated within the CertifHy project in: Altmann, M., Weindorf, W.: Extended Life-cycle Analysis of Hydrogen Production, Deliverable No. 2.3, 3 July 2015; the benchmark value should be re-evaluated regularly to accommodate for relevant changes such as e.g. efficiency improvements in the benchmark process.

3.3 Impact of the GHG threshold in both definitions

Obviously, the threshold of a 60% reduction of greenhouse gas emissions compared to the SMR benchmark excludes some production chains from being either CertifHy Green or CertifHy Low/Carbon Hydrogen. Figure 6 shows the greenhouse gas intensities of a wide array of hydrogen production chains, and how they relate to the 60% below SMR threshold. The figure shows that the following chains meet the "60% below SMR threshold":

- Electrolysis using 100% renewable or 100% nuclear electricity,
- SMR onsite using 100% bio-waste or 100% landfill gas,
- Gasification using waste wood or SRF (short-rotation forestry).
- SMR central using NG (natural gas) with CCS (carbon capture and storage).

Other processes/feedstocks will only be able to yield either of the premium types of hydrogen if their processes are more efficient and/or upstream processes entail lower GHG emissions than assumed under these calculations. The figure also shows that electrolysis using the European electricity mix will have a GHG balance significantly higher than the threshold.

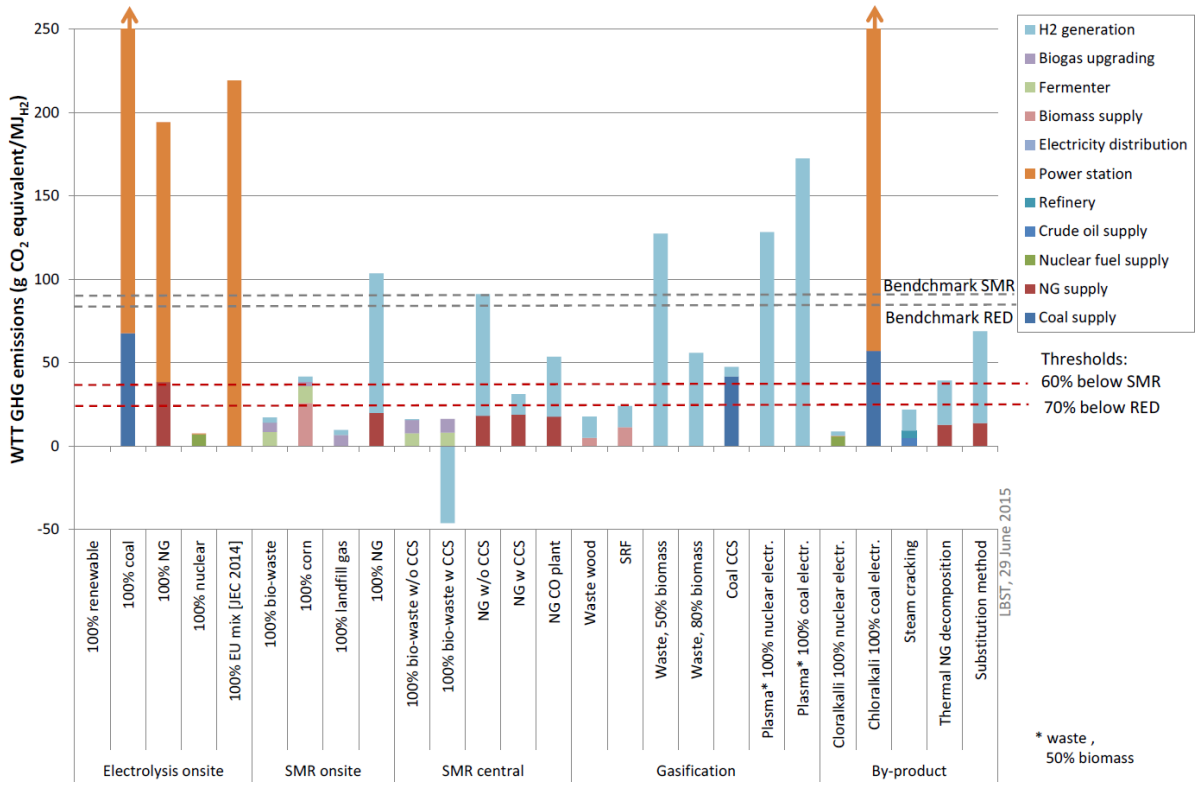

Figure 6: LCA-based greenhouse gas emissions for various hydrogen production chains. Source: CertifHy Deliverable D2.3 (www.certifhy.eu)

3.4 Residual mix considerations

In the CertifHy project, the hydrogen "residual mix" can be understood as the CertifHy Low-GHG hydrogen or CertifHy Green hydrogen sold without generation of associated GOs. The residual mix includes, among others, information on the average carbon dioxide emissions of hydrogen production. Thus, the GHG emissions intensity of the residual mix is the average GHG emissions intensity of the hydrogen produced that has not been sold as CertifHy Low-GHG nor CertifHy Green hydrogen (with GOs).

There are three criteria to evaluate how to deal with the residual mix with regards to the GO scheme:

- Credibility: what are the factors that ensure credibility of GO systems in view of all stakeholders (NGOs, policy makers): e.g. when will the scheme be thought to be allowing "green washing" ? Would the exclusion of some consumers (those not having access to a physical hydrogen source of GHG emissions below the SMR of NG benchmark) be deemed discriminatory?
- Administrative burden: how expensive and burdensome would it be to track all GHG emissions and energy input of all H2 productions plants? What would be the burden to track the physical movement of (above benchmark) physical hydrogen? Is it even possible, considering a part of the hydrogen might be mixed (either in a dedicated pipeline or when sold to a hydrogen distributor, different from the producer)?
- Accessibility: how many consumers would be excluded from the potential of buying green hydrogen (GOs) because there are only above benchmark H2 production sources in their vicinity? What would this mean for the uptake of green hydrogen GO's, being denied from potential customers?

On the basis of literature survey and consultation of various experts in the field, we concluded that:

- The impact of various residual mix approaches on the credibility of GO systems is still not well understood in general, and not investigated for hydrogen in particular;
- Their impact on administrative burden is difficult to assess ex-ante;
- The approaches will theoretically have different impacts on accessibility; yet the CertifHy project scope does not include options to further assess this, as it would require more detailed identification of hydrogen sources and consumption points.

Therefore, it was decided to actually test various options for residual mix treatment during the pilot deployment of the CertifHy scheme, to better understand needs and to evaluate different options, in order to develop a founded proposal for commercial roll-out. This means that during the pilot deployment, the emissions of the H_2 sources used will need to be made available for the purpose of this evaluation, and the corresponding administrative burden will be investigated, as well the potential market size reduction linked to various options (the 'accessibility' indicator) and the effect on credibility.

4 Outline of a Guarantees of Origin scheme for Green Hydrogen

The GO was first introduced and defined in the 2001 Renewable electricity Directive (2001/77/EC), enabling producers of electricity based on renewable electricity sources to document the source of their electricity generation. Following the 2001 Renewable electricity Directive, additional EU legislation was adopted expanding the GO to other applications such as electricity generated from high-efficient cogeneration of heat and power and heating and cooling based on renewable energy sources. In addition, initiatives in some EU countries have led to several GO systems for methane and heat based on renewable energy sources.

Existing GO schemes represent an important starting point for an EU-wide GO scheme for green hydrogen. In this chapter, we will focus on outlining the key elements and processes for a green hydrogen GO scheme (section 4.2) as well as the key actors and their roles and responsibilities (section 4.3).

4.1 Objective and scope of the GO scheme

The prime objective of the GO schemes is consumer disclosure; this is also how it has been formulated in the Renewable Energy Directive. In the CertifHy case, GOs allow hydrogen users to be informed about the specific sustainability attributes of the hydrogen they consume.

In principle, GOs do not play a direct role in policies. For example:

- Purchase of CertifHy premium hydrogen GOs does not reduce tank-to-wheel greenhouse gas emissions from vehicles; they cannot be used to comply with the EU vehicle emission standards (note that hydrogen fuel cell vehicles count as zero emission under this policy).
- CertifHy premium hydrogen GOs are not identical to green certificates in the context of a quota obligation or other support scheme.
- CertifHy premium hydrogen GOs cannot be used to reduce greenhouse gas emissions under the ETS, as the ETS only considers direct emissions and the use of H_2 does not generate direct CO_2 emissions, whichever way the hydrogen was produced.

Practical experience with GOs for other energy carriers does show some cases in which GOs have been linked policies, but also the related issues. In the Netherlands and Germany, for example, the respective FIP and FIT use GOs as a proof of production volume to base the subsidy payment on. Key difference is that in Germany the related agency want to have the GOs (and effectively cancels them), in the Netherlands the agency CertiQ wants to see them, but producers can still sell them on the market.

And in the Netherlands, GOs for renewable methane fed into the grid can be used in the context of the national policy for renewable energy in transport, designed to meet the binding 10% EU target for this sector. These GOs can be converted into Renewable Fuel Units (RFUs), the tradable certificate in the national quota obligation scheme for transport. However, the EU statistical accounting rules are not entirely clear on the impact of GO trade on the statistics. Some argue that these prescribe that renewable methane fed into the grid is allocated to the different end use types according to the relative shares of these end uses in total grid-based methane consumption, comparable to the rule for renewable electricity. As natural gas is mainly used for heat and power generation in the Netherlands, this means that green gas fed into the grid hardly ends up in the statistics on renewable energy in transport, even when the corresponding GOs are converted into RFUs. In this line of reasoning, conversion of the renewable methane GOs into RFUs, although helping fuel distributors to meet their quota obligation, does not help the Dutch government in meeting the 10% EU target. Others argue that a mass balance approach can be used for distribution in the gas grid. The RED explicitly allows this approach for transporting blends of renewable resources (such as vegetable oils) of which a certain share meets the RED sustainability standards. When also applied to blends of renewable and non-renewable resources in the natural gas grid, this approach allows the allocation of renewable energy to specific sectors, e.g. in line with the way the corresponding GOs go. At the EU level, EBA argues in favour of this approach and pleas for a clearer message on this point in the RED II.

Generally, linking GOs to quota obligations or other support schemes introduces the additionality question. In this context, additionality means that the purchase of a GO leads to an increase in production of the premium product in comparison to the situation without such purchase. For consumer disclosure, additionality is not a prerequisite, although EECS rules allow for transparency on this point. When GOs are used in the context of quota obligations or other support schemes, however, (transparency on) additionality will be vital in order to prevent double stimulation.

In short, it is not impossible to use GOs in the context of support schemes and this can also have its benefits, but such use adds significant complexity and puts additional requirements on the set-up of the GO scheme, which has not been taken into account here.

4.2 Key elements of the GO scheme

An extensive description of the GO scheme can be found in CertifHy deliverable 4.1, and its overview can be found in Figure 8. The most important elements to a GO scheme include:

- Scheme governance
- Eligibility and registration of production plants
- The GO itself (and the information content)
- Issuance, transferability and cancellation of GO
- Registry system and trading platform

We will describe these briefly, highlighting also what these imply for a GO scheme for Green Hydrogen.

Governance of the GO scheme

In this context, the term 'governance' is used to refer to the required rules and regulations, and the continuous monitoring of their proper implementation, in order to ensure a reliable, accurate and verifiable GO scheme. The governance framework includes defining the purpose[2] and core principles of the scheme, which include measurement rules, procedures for admission and expulsion, compliance rules, procedures for review and changes to the scheme, etc. It also includes defining the primary duties of key actors necessary to ensure the functioning and reliability of the scheme.

Eligibility and registration of producers/suppliers of Green hydrogen GO

Before any produced unit of green and/or low carbon hydrogen can be registered, the respective production unit must be registered. The definition of Green Hydrogen and Low GHG Hydrogen determine whether or not production units are eligible for a GO for their production or not. If production plants are not accredited they will not be registered or even eligible for GO issuance. In order to be registered under the GO scheme, the units must comply with rules and requirements under the governance framework. Auditors will typically be involved to ensure that plants fulfil the necessary requirements (see section 5.2 for further details on their roles and responsibilities).

The GO itself (and its information content)

The GO itself is the essence of the GO scheme. Within existing schemes it is usually only available electronically and carries a set of information concerning the production that it represents. Similar to a product label, a GO carries information telling the consumer facts about the product.

Some of the GO information under a GO scheme will be collected during the application and registration phase of a production plant, whereas some information will be collected on a rolling basis, e.g. monthly or quarterly. The latter information usually pertains to the plants generation, in this case the green and/or low carbon hydrogen production and its attributes.

Table 1 on the following page gives an overview of the type of information that would be collected under a GO scheme for green/low carbon hydrogen.

[2] A prime purpose of existing GO schemes has been to increase consumer transparency between renewable-based and non-renewable based energy - be it electricity, heat, gas or other energy carriers. Currently, the prime use of GO has been driven by the fuel mix disclosure obligation under the EU IEM Directive (insert) which requires licensed electricity suppliers to disclose to their customers the mix of fuels (coal, gas, nuclear, renewable and other) used to generate the electricity supplied annually. However, a GO scheme can serve additional purposes, such as proof of compliance of obligations, payment of Feed-in Tariff/Premium, etc.

Table 1: Type of information collected for the issuance of a green/low carbon hydrogen GO

PART 1: Factual information	**Comments**
• Producer (legal entity)	VAT number
• Identity of the originating facility/Production Device ○ Production Device ID; the unique number which has been assigned to the Production Device (see chapter **Error! R eference source not found.**)	
• Date and time of hydrogen production (beginning and end) of the batch • Production year	dd.mm.yyyy

• Energy sources (the level of detail shall be established during the Road map implementation) This is a proposed level of detail:
  ○ Electricity from renewable sources (unsupported, i.e. not supported under public support scheme)
  ▪ Electricity from Wind energy (unsupported)
  ▪ Electricity from Solar energy (unsupported)
  ▪ Electricity from Geothermal Energy (unsupported)
  ▪ Electricity from Ocean Energy (unsupported)
  ▪ Electricity from Hydropower (unsupported)
  ▪ Electricity from Biomass
  • solid sustainable Biomass (unsupported)
  • liquid sustainable Biomass (unsupported)
  • gaseous sustainable Biomass (biomethane) (unsupported)
  • biodegradable fraction of waste (industrial and municipal) (unsupported)
  • residues from biological origin from agriculture, forestry and related industries including fisheries and aquaculture (unsupported)
  ○ Electricity from conventional sources (coal, oil, gas, nuclear, etc.)
	MWh/year

• Type of public support
  ○ investment supported
  ○ production supported
  ○ supported scientific/demo/pilot project
  ○ unsupported	

• Share of renewable energy in total energy input for producing the	%

PART 1: Factual information	Comments
hydrogen (excluding ancillary energy consumption)	
• Raw material sources (the level of detail shall be established during the Road map implementation) This is a proposed level of detail: o Sustainable liquid biomass o Sustainable solid biomass o Sustainable biomethane o Sustainable bionaphta o Waste (biogenic / conventional) o Water o Natural Gas o Fossil Oil o Coal o Peat o Non sustainable biomass o Other	Kg/year // Nm^3/year
• GHG balance (the level of detail shall be established during the Road map implementation). This is a proposed level of detail: o GHG emissions intensity of total hydrogen produced in the production period o Average GHG emissions intensity of the low carbon share o Average GHG emissions intensity of the renewable share o Average GHG emissions intensity of non low carbon share	g $CO2_{eq}$ /MJ_{H2}
• Main or by-product: o Main product o By-product ▪ GHG emissions allocation by input energy share	g $CO2_{eq}$ /MJ_{H2}
• ID of GO	

PART 2: Evaluation of information	Comments
• Type of GO quality: o CertifHy Green hydrogen o CertifHy Low-carbon hydrogen	
• Certification Body	Verifier
• ID of GO	

Issuance, transfer and redemption

The most common guidelines for the control infrastructure for GOs are the well-established EECS rules. EECS stands European Energy Certificate System; these rules are used for GO schemes as well as for tradable certificates in the context of quota obligations and other support schemes. According to the EECS rules, the life cycle of a GO will encompass three phases: issuance, transfer and cancellation. Transition between these three states, is depicted in Figure 7.

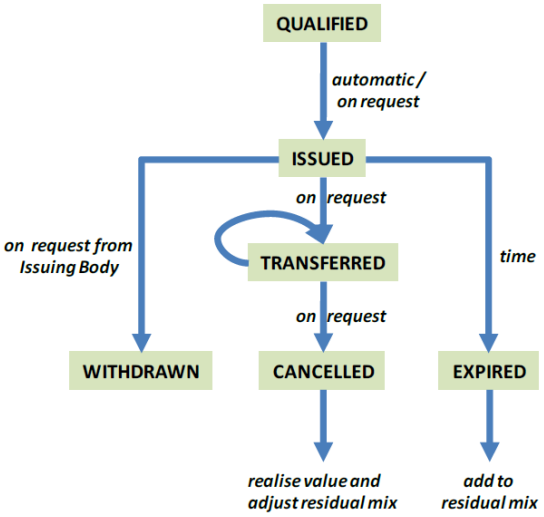

Figure 7: Life cycle of a GO. Source: AIB (2015a)

These 'life cycle' elements will also be applicable for a GO scheme for green hydrogen/low carbon hydrogen. Relevant aspects include:

- A GO is issued by a designated issuing body. The question remains open as to whether there would be one issuing body for the whole EU, or whether there would be national or regional specific issuing bodies. In the latter case, transparent and non-overlapping geographical domains would have to be agreed upon.
- GO may be transferred from the account of the producer to that of a trader, and so on; either within the country of origin or across countries in Europe which form a part the EU-wide scheme.
- Cancellation refers to the GO being removed from circulation. Following the EECS Principle, cancellation occurs at the point at which the value of the GO is realised. This is typically when a consumer pays for the GO in recognition of the qualities it represents. In the practice of hydrogen GOs, logical moments for cancellation would be:
    - The moment at which hydrogen is used in a factory that wants to claim the input to be green
    - The moment hydrogen is supplied to a filling station for FCEVs

Registry system and trading platform

To manage the issue, transfer and cancellation of GOs an electronic register holding all of the GOs and related information should be established and maintained. Each production and/or supplier holding GOs should have an account in such a register. Specifications for the design and functioning of an electronic registry need to be defined. Requirements to the registry have been specified in the CertifHy Deliverable 4.1.

The objective of the register database (registry) is to generate unique GOs (electronic document) for each produced/registered energy unit of green and/or low carbon hydrogen and to track them from generation/issuance till use/cancellation, so that double use or double counting within the registry is excluded. The registry must be fraud-resistant, and should provide reports/statistical data for different kind of purposes (e.g. for the account holder itself, for the competent bodies, for European and national statistics, for the registry administrator).

Overall system control

A GO scheme enables a 'green' value to be accorded to specific types of product; and for this value to be traded. It is therefore essential that a GO scheme is reliable, accurate and verifiable. Among others, controlling the information and the accuracy of the GO is therefore of critical importance. Control will be carried out by different actors, such as the auditors, and the certification and issuing bodies.

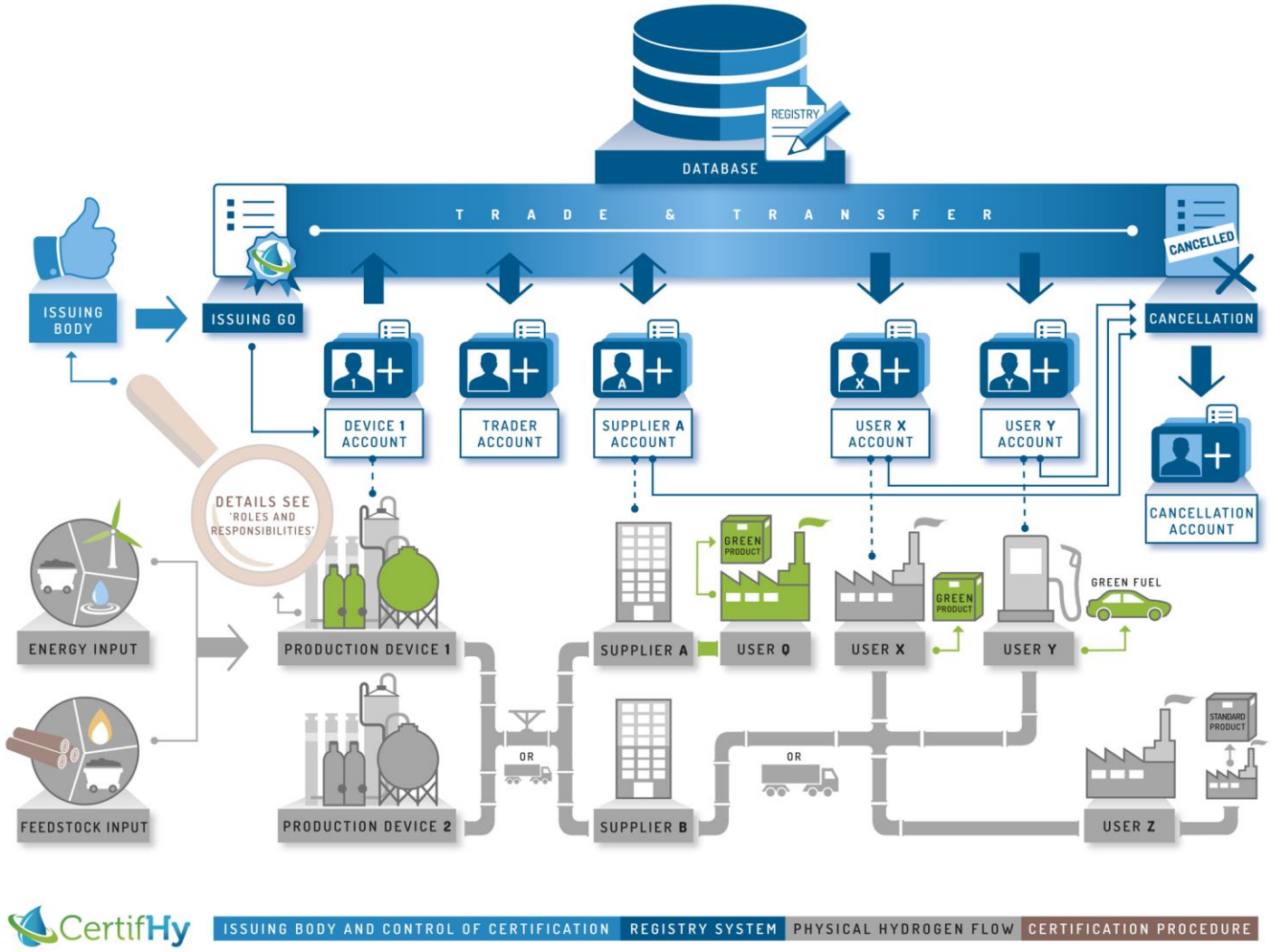

Figure 8: Outline of the CertifHy GO scheme for premium hydrogen. Source: CertifHy Deliverable 4.1 (www.certifhy.eu).

4.3 Roles and responsibilities

A green hydrogen GO scheme will involve a wide number of relevant actors. Their tasks and roles are summarized in Table 2 below.

Table 2: Roles and responsibilities for key actors involved in a GO scheme.

Stakeholder	Definition	Tasks and roles
Competent Authority	In relation to the exercise or discharge of any legislative, governmental, regulatory or administrative function, the body duly authorised under the laws and regulations of the EU to exercise or discharge that function	Managing entity. Governance
Issuing Body	Entity responsible for registering entities, in case of a Production Device, the registration is based on an auditor assessment. Additionally, the entity is responsible for issuing GO	GO issuance
Registry administrator	Entity appointed by the Competent Authority and/or Issuing Body to operate and maintain the registry	Registration transactions
Account Holder	Person in respect of whom an account is maintained on the registry	Producing, supplying or using hydrogen, trading, transferring and cancelling GO
Accreditation Body	Entity accepted by the Competent Authority to assess and accredit the Certification Body	Accreditation
Certification Body	Entity entitled to act as an environmental verifier or environmental verification organisation and approved by an accreditation body	Certification of GO compliance
Auditor	Person who is appointed by a certification body in order to assess the production or conversion against the requirements of the GO scheme	Assessment of GO compliance
Measurement body	Entity responsible for collecting and determining (on behalf of the account holder) measured values of the output of a production device	Assurance of measurement accuracy
IT-Provider	Entity appointed by the Issuing body or competent authority responsible for the IT-System	Develop, establish and maintain the software and the data base
Service provider	Entity who is entitled by the account holder to administer the account	Administration of accounts

4.4 Remaining design elements that still need to be decided on

There are some final details in the GOs scheme that still need to be addressed, and that therefore need to be part of the roadmap. These issues are the following.

The registry structure: one central or various national ones

While there is clear agreement that the CertifHy GO scheme should apply EU-wide, there is still an open point on the establishment of the registry. Should it be a central EU-wide registry from the start, or should it be a network of national, harmonised registries that can trade through a central hub? The latter is current practice in electricity and might also make it easier to have national pilots; the former might be preferable but probably requires more upfront coordination. After further exploration on stakeholders' views, also at national levels, a decision should be made on this. In this light, the set-up of a pilot for premium hydrogen GOs seems valuable: in such a pilot, a limited number of participating countries can start the process. If pilot experiences and lessons learnt point at that direction, the pilot can then pave the way for further roll-out of an EU-wide central registry system.

An update procedure for the benchmark GHG intensities

In the CertifHy definitions of green and/or low-carbon hydrogen, two benchmarks play an important role:

- The 91 g/MJ CO_2 intensity reference for SMR production as a threshold for 'non-CertifHy' hydrogen produced in a hybrid production system that also produces 'CertifHy' hydrogen;
- The -60% compared to the methane SMR reference for the definition of 'low-carbon' hydrogen

As the performance of SMR technology may further develop over time, and policy insights on 'low-carbon' thresholds may do so as well, it seems to make sense to create a simple approach for re-evaluation of these thresholds every once in several years or by the time there are clear signals that there has been significant progress in the reference technology.

For the final GO scheme, a decision is needed on how to deal with residual mix issues

An important remaining discussion point relates to the GHG emissions of the residual mix (see section 3.4). One of the objectives of the pilot projects with the CertifHy definitions and GO scheme shall be to gain experience with the different approaches suggested, and the impact they have on GO credibility, administrative burden and accessibility. On the basis of the outcomes of the pilots, a final decision will have to be made on this issue before the GO scheme will be fully implemented.

5 Challenges of establishing an EU-wide GoO scheme for hydrogen

Creating an EU-wide Green Hydrogen GoO scheme faces a number of challenges. These also take into account lessons learned from the ongoing process of establishing an EU-wide scheme renewable electricity GoO. These challenges will be translated into actions in section 1. Essentially, there are three key challenges to be met:

5.1 The momentum for implementation should be strengthened further

The analyses and stakeholder interactions along the CertifHy project have clearly confirmed the relevance of a GO scheme for premium hydrogen, and the interest by various stakeholders to realise it. For the implementation of the scheme however, both strengthening and broadening of the commitment will be necessary and top priority. Strengthening commitment is important because its establishment will require coordination and guidance from the involved stakeholders, and broadening commitment is relevant because the interest so far has mainly come from industry (both hydrogen producers and consumers) and EU policy makers; for implementation of the GO scheme, also support from national policy makers, end consumers (think of future hydrogen in transport) and NGOs will be important. In the next phase, involvement of all these parties will need to be formalised and put into concrete steps towards implementation. This will need to include ongoing activities in broadening the support for the scheme, and consolidating it into legislation and other institutional settings. This will also need to include the condition that hydrogen consumption can only be claimed to be 'green' or 'low-carbon' with the cancellation of a GO.

In this respect, cross-border trade also deserves attention. Current EU regulations for gaseous fuels differ from regulations for electricity in one respect: Today, renewable gaseous fuels and their GOs cannot be transported internationally through a grid. They can be injected and transported physically but in the border crossing the renewable attributes are not transferred. This seems mainly due to a lack of attention for gaseous fuels in the renewable energy directive, which laid out extensive rules and regulations for liquid biofuels but does not cover specific issues related to gaseous biofuels traded through a grid.

5.2 Remaining issues and open points need to be settled

As section 4.4 shows, the CertifHy team and its involved stakeholders have left some remaining issues for further exploration and final decision-making. These are:

- The structure of the registry: one EU-wide registry or a set of harmonised national registries in combination with an EU-wide hub;
- An update procedure for the two benchmarks in the scheme.
- A final decision on residual mix issues;

As these points need to be solved before full implementation of the GO scheme can start, the roadmap will need to accommodate actions and deadlines to settle these issues, as they vary in the degree of urgency.

5.3 The required GO infrastructure needs to be developed

After the remaining open points have been settled, the practical aspects of the GO scheme can be further shaped. A functioning GO scheme requires a formalised organisational setting, in which the different roles and responsibilities identified in the GO outline have been assigned to specific parties (see also Figure 9). The key party in this is the Issuing Body, but also certification bodies, auditor and accreditation bodies will need to be identified. Besides, the ICT systems to allow for issuing, trade and cancellation of the GOs needs to be set up. While these matters are not 'issues' in the sense that they require further consensus building, these activities will need to be done after settling of the remaining issues identified in the second challenge.

5.4 Practical experience needs to be gained

So in support of the development of a full-blown EU-wide GO system for premium hydrogen, one or more pilots seem useful in which a limited number of countries, producers and consumers participate. These pilots allow the various actors to gain experience, and provide useful insights on the practical implications of the choices made in defining the premium labels and setting up the GO scheme.

Pilots will essentially serve three purposes:

- The exploration of the value of CertifHy premium hydrogen product labels. The uncertainty of the market value of GOs with a premium label is an important point on which practical experience will be useful. Therefore, the pilots are important to allow stakeholders to get a flavour of the potential market size and value of GOs, relevant for a business case.
- Gaining experience with the technical and administrative aspects of the GO scheme and the actual trade in GOs. The network that has by now been formed in the CertifHy project provides a good basis for this, and should be open for other entrants.
- As mentioned in Section 3.4, the pilots will also need to gain experience in the impact of various approached to deal with the residual mix.

Generally ,the pilots should have clear objectives in terms of the lessons that need to be learnt, monitoring activities that are needed for this, and possibly how the pilots should generate insights in the implications of the choices made in setting up the premium labels and the GO scheme.

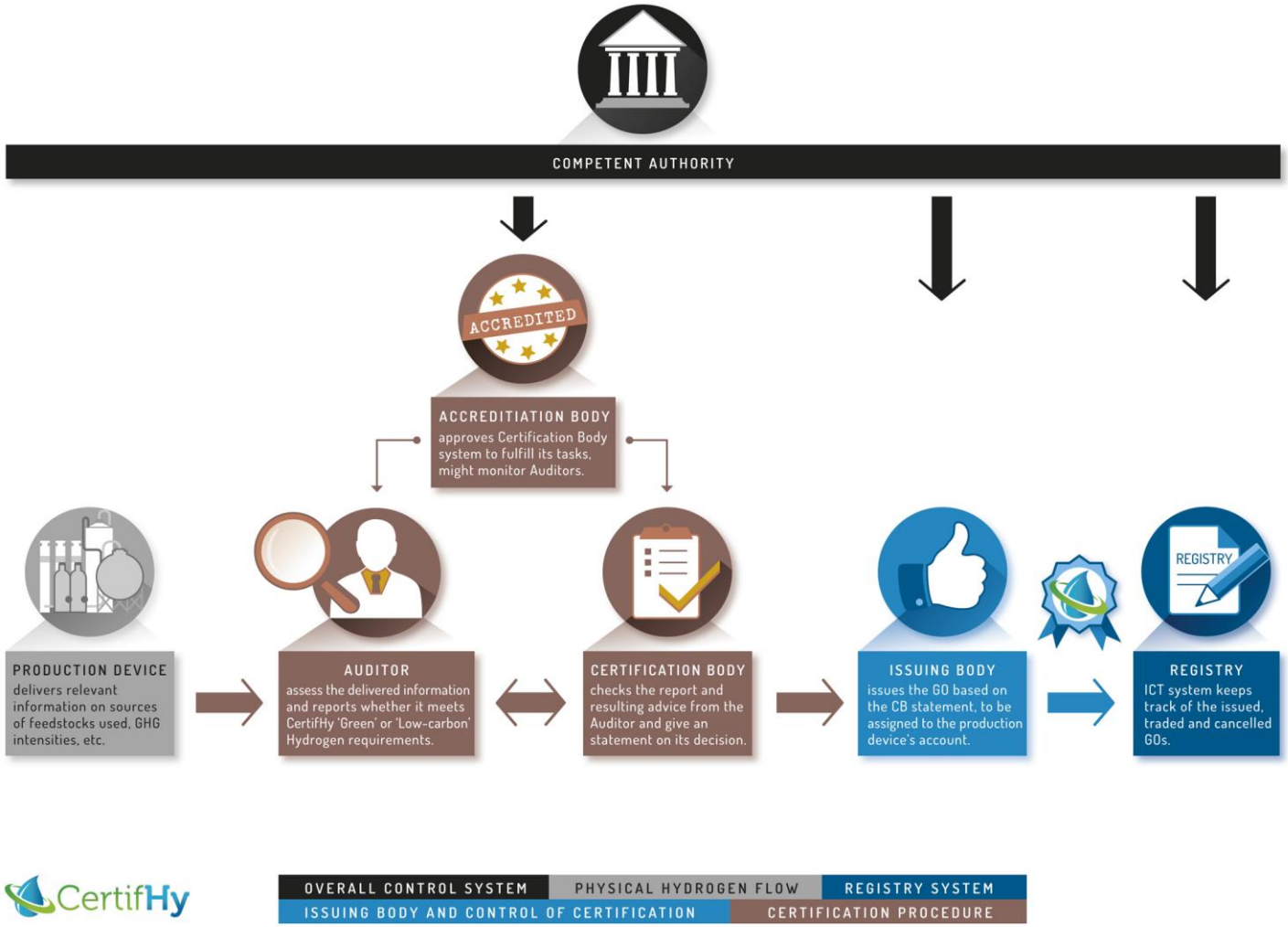

Figure 9: Roles and responsibilities in the GO scheme. Source: CertifHy deliverable 4.1 (www.certifHy.eu).

6 Key actions for realisation of the CertifHy GO scheme

The introduction of the CertifHy GO scheme and the premium labels will not come on its own. Concrete actions will need to be taken in the next 5 – 10 years. This section describes the key actions that we foresee, elaborating on the key challenges identified in section 5. The complete set of actions provides a balanced between political actions bringing the initiative further and actions related to implementation and market development. In section 7, we will put these actions into a coherent picture.

The first challenge:

Strengthening momentum for a Premium Hydrogen GO scheme

To address this challenge, we propose the following actions:

1. Creation of a Supervisory Board to drive the GO building and rollout process
2. Creation of a legal safeguard to relate consumer claims to the GO
3. Creation of EU-wide buy-in for one GO system and for the CertifHy label definitions
4. Create the opportunity for EU-wide trade in hydrogen GOs

Action 1: Creation of a Supervisory Board to drive the GO building and rollout process

Most importantly, a party or platform will need to take up the responsibility for the further development and implementation of the GO scheme for hydrogen and the related CertifHy labels for green and for low-carbon hydrogen. This 'Supervisory Board' would:

- Commit to the execution of the roadmap;
- Assign and supervise subgroups for the execution of the various other actions;
- Discuss any new opportunities or challenges as they come up along the way.

As the scheme will need to be credible for all related parties, we propose to introduce a CertifHy Supervisory Board for this, consisting of:

- Policy makers (EU and national);
- Industry stakeholders (from hydrogen producing, trading and consuming sectors);
- NGOs (both private consumers' and environmental ones)
- GO and label experts, such as the AIB and CEN.

In order to keep the number of participants manageable, it might be useful to make the supervisory board a 'platform of platforms', in which e.g. national policy makers, industry stakeholders and NGOs are represented through their EU federations or umbrella

organisations. Also within the European Commission, a limited number of persons should effectively represent all relevant DGs.

Possibly, this board would be linked to the FCH JU, the key existing body in which stakeholders cooperate on the development of a hydrogen economy. The board could also be held accountable to the FCH JU Stakeholder Forum. Participants in the Supervisory Board would participate in their own time but it would have profession secretarial support.

The board would need to be established as soon as possible, as it would also coordinate other actions. Its relevance could be reconsidered by the time a full-blown GO scheme is in place.

Action 2: Creation of a legal safeguard to relate consumer claims to the GO

It has become common practice for other GO schemes that any consumer claims related to the environmental performance of energy carriers is accompanied by the cancellation of a related GO. For hydrogen, it would be important to introduce this practice as well. It could be safeguarded by several actions:

- Inclusion of a hydrogen GO scheme in EU legislation, like was previously done for GOs for renewable power and heat in the RED. The new RED II would be a logical place for this. As the RED II is in preparation now, it is important to bring this point under the attention of the Commission already early 2016, and remain attentive on this point until final establishment of the RED II. Given the foreseen co-decision process, this can be expected late 2017.
- Implementation of the CertifHy premium labels through a CEN standard; this could be done in coordination with the new CEN Project Committee on Fuel labelling, CEN/TC 441. This process could also be start early and could be finalised late 2017.

Within the Supervisory Board, these activities can be coordinated and interaction can be sought with e.g. DG-ENER regarding the RED II preparations. These actions can strongly improve legal embedding of the CertifHy labels and GO scheme. However, they are not essential to the scheme: even if the RED finally would not mention GOs for premium hydrogen, the scheme should still be implemented.

Action 3: Creation of EU-wide buy-in for the GO system and the CertifHy labels

CertifHy findings confirm that an EU-wide GO system for green hydrogen from the start is preferable to the establishment of national schemes that later need to be harmonised or integrated. While this is clearly recognised at EU level, additional efforts may be needed to create buy-in for this strategy at member state level. This could be done by coordinated activities in the key member states in which the demand for green hydrogen will arise. It is also of vital importance that other programs developing other definitions of renewable, low-

carbon or otherwise 'premium' hydrogen make use of the same GO scheme; think of e.g. the Clean Energy Program in Germany. Concretely, activities could consist of:

- In the framework of the Concerted Action on Renewables (CA-RES), specific attention could be paid to the hydrogen GO scheme to explore and improve policy makers' support for an EU-wide scheme.
- It might be worthwhile joining forces with the various issuing bodies currently responsible for (trade in) GOs for other energy carriers such as electricity and renewable methane, and it will be vital to maintain open lines with the AIB.
- Wider communication with key target groups, such as policy makers (including their national energy agencies), industry actors (including e.g. vehicle manufacturers) and NGOs. This can be coordinated by the various representatives of these target groups in the Supervisory Board, and could focus on the benefits various actors would have from a functioning GO scheme for premium labels, and the role they would need to play in implementing it.
- Close communication with relevant federations such as Hydrogen Europe, the European Biogas Association, Eurelectric and Eurogas.
- Outreaching contacts with other initiatives on premium hydrogen will also be important.

Next to buy-in for the GO scheme, EU-wide acceptance of the CertifHy definitions of Green Hydrogen and Low-Carbon Hydrogen is also important. Although this is not essential for the GO scheme itself (which should essentially be open for other definitions as well) it seems worthwhile to strive for one, broadly accepted pair of definitions for renewable hydrogen and for hydrogen with low GHG impacts. The CertifHy project provides a good starting point for this, with a pair of definitions that has been widely discussed and agreed upon. It will be vital to have communication with other initiatives currently developing label definitions, including some national hydrogen associations and NOW in Germany.

These activities can be ongoing throughout the lifetime of the Supervisory Board, and can be carried out by various coalitions of its members. Their attention should be focussed on opportunities and challenges that are relevant at the time.

Action 4: Create the opportunity for EU-wide trade in hydrogen GOs

For the long-term perspectives of a premium hydrogen GO, the possibility of international trade for these GOs will be important to increase market size and liquidity. The biogas sector, with the European Biogas Association (EBA) as an important representative has already proposed an approach to change this and responsibly allow for international trade. Although this issue is not most urgent for hydrogen, the initiators of a renewable hydrogen GO scheme could join in this proposal, particularly in the context of the current preparation of the RED II.

Given the current preparation of the RED II, in which these issues can also be settled, it would be logical to focus these activities in 2017.

The second challenge:

Settling remaining issues and open points

On this challenge, which directly related to the issues and open points identified in section 4.4, we propose the following actions:

5. Decide on the registry structure: one central or various national ones
6. Set up update procedure for the benchmark GHG intensities
7. Make a final decision on the residual mix, based on experiences in the pilots

Action 5: Decide on the registry structure: one central or various national ones

After further exploration on stakeholders views, also at national levels, on the pros and cons of both identified options (an entirely EU-wide scheme or a system of harmonised national schemes and an EU-hub) a decision should be made on this within the supervisory board. If a structure with national schemes and registries is opted for, it should be safeguarded that these structures are harmonised across member states in order to facilitate international trade.

It will be important for the Supervisory Board to make a decision on this point before the GO pilots are started (action 12). Therefore, it would be logical to decide on this by mid-2017.

Action 6: Set up update procedure for the benchmark GHG intensities

As the performance of SMR technology may further develop over time, and policy insights on 'low-carbon' thresholds may do so as well, it makes sense to create a simple approach for re-evaluation of these thresholds every once in several years. Concretely, this holds for the now proposed value of 91 g CO_2/MJ hydrogen as well as the to take -60% as the required reduction. This updating process can be organised alongside the other activities, and the Supervisory Board secretariat can come up with a proposal for this.

Action 7: Make a final decision on the residual mix, based on experiences in the pilots

The CertifHy project identified several approaches to deal with the residual mix issue, and their pros and cons in practice will need to be further explored (see actions 11 and 12). On the basis of the further insights gained in these pilots, and possibly after some further negotiation, a final decision on this matter will need to be taken. The Supervisory Board will be an appropriate platform to guide this.

The third challenge:

Developing required GO infrastructure

On this challenge, we propose the following actions:

8. Identification of the issuing body as the key party in the scheme
9. Settle the information on the GO
10. Set-up of the ICT system and registry platform to implement the scheme

Action 8: Identification of the issuing body as the key party in the scheme

The issuing body is at the heart of the GO scheme. It issues the GOs and is responsible for the proper inclusion of information regarding the environmental characteristics, thereby allowing GOs to be labelled 'CertifHy Green Hydrogen' or "CertifHy Low-carbon Hydrogen'. The issuing body is also the commissioner and key owner of the ICT systems in which GOs are created, traded and cancelled. At a certain point in the development process, the issuing body responsibility should be assigned. This can be done to an existing or newly set up organisation. Depending on the final decision on Action 6 (the registry structure), the central issuing body will either be managing the central registry or coordinating national issuing bodies and managing the central hub. Logically, the (new or existing) organisation would also become a member of the AIB, the Association of Issuing Bodies.

In terms of timing, a provisional Issuing Body (or set of national ones) should be identified relatively early, as this is vital for the GO pilots (action 12). A decision should be made on this by mid-2017. After the pilots have been finalised and the GO scheme is ready for full implementation, it will be time for identifying the definite Issuing Body/ies.

Action 9: Settle the information on the GO

As mentioned before, the CertifHy project has specified the requirements of a GO scheme (as a carrier of factual information on hydrogen attributes), and has proposed definitions for

two premium labels: CertifHy Green and CertifHy Low-Carbon. In principle, the GO scheme could also be used for other labels, and depending on their requirements additional information may be needed in the GO registry. Therefore, before finalising the ICT system that will carry the GO scheme, it seems sensible to explore what other information needs may live with other potential users of the GO scheme and include this.

A provisional version of the GO information should be available before the GO pilots, and should therefore be created relatively soon. As the Issuing Body/ies will also have a say in it, this will probably be in the second half of 2017. Again, the definite version of the information structure can be decided upon after the pilots.

Action 10: Set-up of the ICT system and registry platform to implement the scheme

A full-blown GO scheme requires a relatively extensive ICT platform. This could be built from scratch, which would require considerable capacity and efforts. However, some existing platforms might be useful to copy from, particularly the ones available for renewable methane. This would improve the perspective for keeping the system cost effective. The fact that schemes for renewable methane already deal with a gaseous energy carrier with some diversity in production routes will probably make these a better basis than the systems for renewable electricity. These systems should include some specific methodologies, e.g. for:

- Clarifying renewable attributes and GHG intensity of the production systems, also in installations with combined renewable and non-renewable inputs;
- GO conversion for installations that use grid-connected inputs and claim their renewable nature through GO (e.g. from green power or green methane).

Given the dependency of this action on actions 8 and 9, and its relevance for action 12, it should be started by mid-2017 and deliver a provisional version for the pilots by the end of 2017. The definite version of the system can then be delivered in 2020, after taking up lessons learnt from the pilots.

The fourth challenge:

Gaining practical experience

On this challenge, we propose the following actions:

11. Pilot implementation of premium hydrogen GOs in practice
12. Update the roadmap on the basis of experiences gained and external developments

Action 11: Pilot implementation of premium hydrogen GOs in practice

As mentioned earlier, the pilot should provide practical experience with the value of the CertifHy premium labels and the operation of the GO scheme, and it should bring up relevant knowledge on how to deal with the residual mix issue. The pilot should include all the functions that are needed to prepare the deployment of an EU-wide GO scheme.

In principle, some pilot activities could already start even when the initial GO infrastructure is not yet fully operational. In situations in which there is a direct physical link between producer and consumer of the premium hydrogen, only parts of the GO scheme will be needed as there is no infrastructure involved that should allow separation of the physical flow of the hydrogen from the trade of its GO. The demand for such initial, simplified activities as part of the pilot will need to be explored first. In any case, the GO scheme should be used to verify compliance with the CertifHy premium hydrogen definitions, and to administer GO issuance and cancellation.

Under guidance of the supervisory board, details on the pilot implementation should be worked out, including its scope, appointments to be made to make it possible, and key lessons to be learnt. Key parties to be involved are producers, traders and users of the GOs, but also all actors identified in the GO handling process: the issuing body/ies, auditors, certification and accreditation body (see Figure 9). It seems worthwhile to engage ongoing FCH-JU projects bringing in concrete cases.

For pilot activities to start operating under the GO scheme, the required infrastructure will first need to be set up provisionally, Given the planning of these actions, the pilot implementation of the GO scheme will be able to start late 2017 or early 2018. The simplified activities that only make use of part of the GO infrastructure may start slightly earlier

Experiences from the pilot implementation will feed into As mentioned in Section 3.4, it will also gain experience in the impact of various approaches to deal with the residual mix, feeding these results into action 7 (a final decision on this matter).

Action 12: Update the roadmap on the basis of experiences gained and external developments

In a dynamic environment such as the hydrogen economy, any roadmap or other strategic document should be reviewed and updated on a regular basis. This should relate to the roadmap objectives, tasks identified, and responsible parties and timing related to them.

We propose to make this updating a responsibility of the Supervisory Board, and to update the roadmap every two years.

7 The Roadmap: Coherent actions, responsibilities and timing

On the basis of the outcomes of the project, we propose to aim for a full-blown GO scheme being operational by 2020. This is relatively early for the hydrogen market for transport, as it will take until circa 2030 until hydrogen-fuelled fuel cell vehicles will play of role of significance. However, both for the existing hydrogen market (e.g. refineries and other chemical companies) and for early adopters in transport it is probably important to have a GO scheme in place on the relatively short term.

As mentioned earlier, some actions need to be done before others can take place. Essentially, the order is:

- First, the Supervisory Board needs to be set up, coordinating the other actions;
- Second, the remaining issues and open points need to be settled under guidance of the Supervisory Board;
- Third, the GO infrastructure (issuing body, GO info structure and ICT) can be developed provisionally, taking up the decisions on the remaining open points;
- Fourth, the pilots with the GO scheme can start, making use of the provisional GO infrastructure
- In contrast to the GO scheme pilots, the pilots marketing the premium labels directly (action 11) can start relatively early;

In Table 3, the actions identified, their execution period and the key parties to be involved have been summarised, and related to the key results to be delivered. This allocation of roles was first elaborated as a draft and then discussed as part of the CertifHy stakeholder meeting on June 17. Feedback from that session has been processed in this version.

The coherent set of activities, including proposed timing and responsibilities, has also been summarised in Figure 10.

Table 3: Proposed actions, timeline involved partners and key results to be delivered for the CertifHy GO scheme.

Action		Start	Completion	Involved parties	Key results to be delivered
First challenge: Strengthening momentum					
1	Supervisory Board	Late 2016	2020, at scheme implementation	Policy makers (EU and MS), industry (full-chain), NGOs, GO and label experts	Guidance on the further GO development and implementation process
2	Legal safeguard	Mid- 2016	End 2017	CertifHy consortium, EC DG ENER and other relvant DGs	Inclusion of a hydrogen GO in the RED II
3	Buy-in for EU scheme	Early 2017	2020, and beyond	Supervisory Board, active role for all board members	EU-wide recognition of the CertifHy scheme as the prime platform for hydrogen GOs
4	EU-wide trade	Early 2017	End 2017	EC DG ENER, Supervisory Board	Possibility to trade hydrogen GOs through international grids
Second challenge: Settling remaining issues and open points					
5	Registry structure	End 2016	Mid-2017	Supervisory Board	Decision on EU versus national registries
6	Benchmark updates	Early 2018	Mid-2019	Supervisory Board, issuing body	Process for review and update of benchmarks
7	Residual mix	Mid-2019	End-2019	Supervisory Board	Final decision on the approach to be taken on this matter, on the basis of pilot outcomes.
Third challenge: Developing required GO infrastructure					
8	Issuing body	End 2016 (p) Early 2019 (d)	Mid-2017 (p) End 2019 (d)	Supervisory Board, AIB	Appointment of a hydrogen GO issuing body
9	Settle GO information	Early 2017(p) Mid-2019 (d)	End 2017 (p) Early 2020 (d)	Issuing body, Supervisory Board	Final GO information structure
10	ICT platform	Mid-2017 (p) Late 2019 (d)	End 2017 (p) Mid-2020 (d)	Issuing body, Supervisory Board	An operating ICT platform for GOs
Fourth challenge: Gaining practical experience					
11	Pilot implementation	End 2017	Mid-2019	Supervisory Board, participants	Lessons on label value, GO scheme, res. mix
12	Roadmap update	Mid-2018	End 2018	Supervisory Board	Actualisation of the roadmap

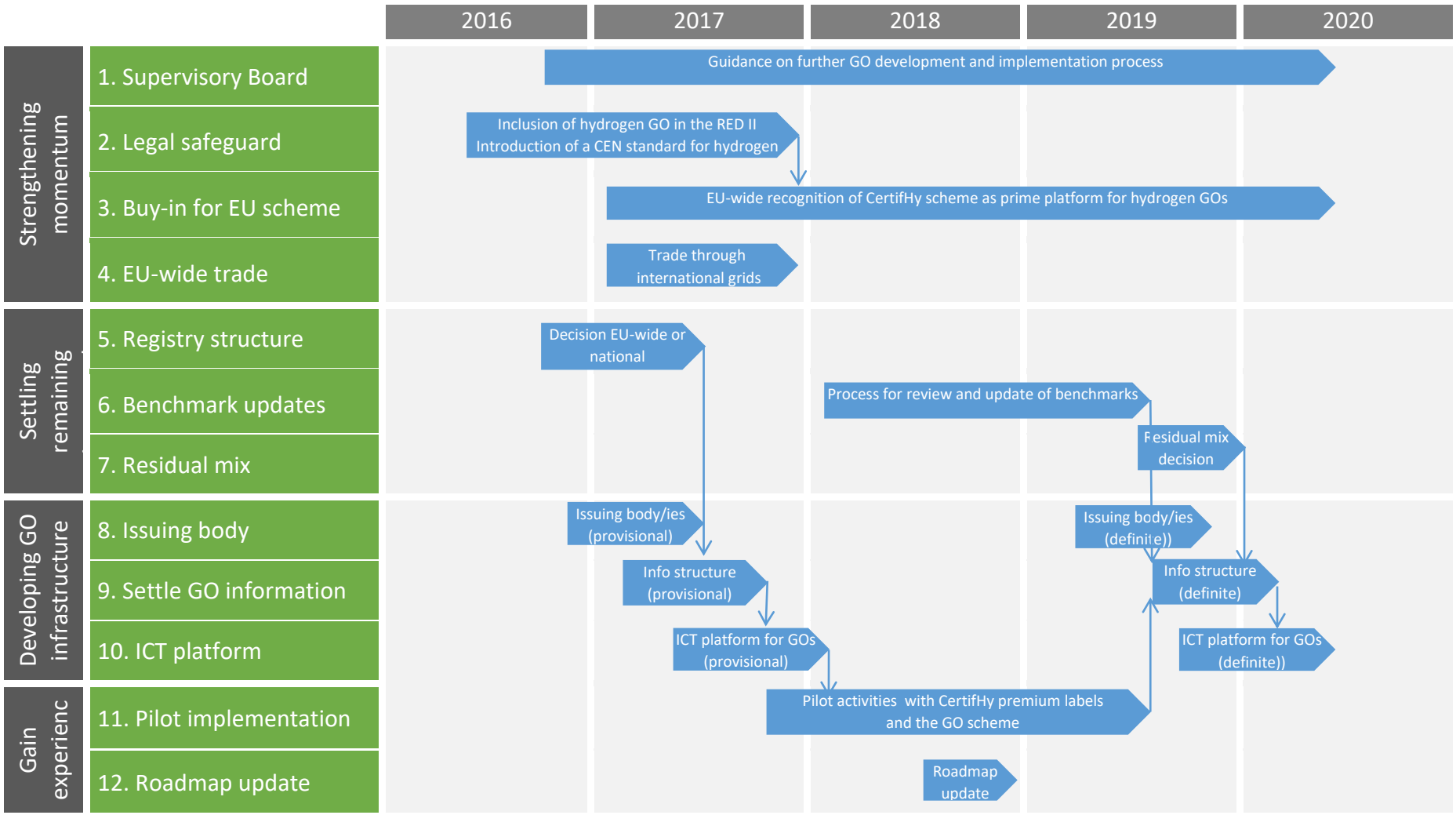

Figure 10: Roadmap activities and their timing.

8 How did we produce this roadmap

This roadmap has been based on earlier CertifHy deliverables, earlier stakeholder feedback during the project, and specific consultation activities for this roadmap.

Results from the earlier CertifHy work packages 1-4

Particularly sections 2 and 3 merely summarise the key findings of earlier work packages: particularly WPs 1 and 4, respectively. The results from work package 2 and 3 were key input to the key challenges and actions.

Earlier stakeholder feedback

Along with the preparation of the WP 2-4 reports, several stakeholder interactions were carried out in which roadmap elements were discussed. Written feedback was provided on:

- An extensive questionnaire on the WP2 material (definitions of premium hydrogen), carried out early 2015;
- A request for written feedback (and some related telephone or face-to-face interviews) on the draft WP3 material, on lessons learnt from earlier GO schemes, carried out late 2015;
- A request for written feedback (and several related telephone interviews) on the draft WP4 material, carried out early 2016.

Physical stakeholder consultation meetings on these WPs were held at:

- April 23 2015, launching the project and discussing general and specific WP2 points;
- July 7 2015, on key discussion points related to WP2;
- May 4 2016, on key discussion points related to WP4;
- June 17 2016, on a draft version of this roadmap (WP5).

Specific consultation activities for the roadmap

This roadmap was prepared as follows:

- A first outline was prepared by ECN and shared within the CertifHy consortium for feedback in April 2016;
- The outline and first draft set of key actions was presented and discussed with stakeholders in a specific time slot on the WP4 event on May 4 2016
- A first full draft of the roadmap was shared with the affiliated partners for comments on May 19 2016
- The second draft roadmap was then presented and discussed in the WP5 stakeholder event on June 17 2016.

After each step and before the next, comments were processed.