2.3. POLICY PILLAR 3: **GUARANTEE OF ORIGIN SCHEME**

Molecules of green hydrogen are identical to those of grey hydrogen. For this reason, once hydrogen has been produced, a certification system is needed that allows end users and governments to know the origin and quality of the hydrogen.

The schemes used to track origin are usually referred to as providing a "guarantee of origin" (GO).[11] One example in the case of hydrogen is the CertifHy project in the European Union. The scheme issued over 76 000 GOs for green or low-carbon hydrogen, out of which 3 600 were used by 2019.

This was a pilot project covering less than 0.05% of the total EU market and less than 4% of the certificates were actually from renewable energy. Table 2.1 presents this and other examples of GO certification schemes. In particular, such schemes should be used to track CO_2 emissions from the production to the use of hydrogen, in order to recognise when and where the use of hydrogen can be more effective for decarbonisation purposes than direct electrification or the use of bioenergy.

P3
Guarantee of origin scheme

Table 2.1. Examples of guarantee of origin schemes

BODY	REFERENCE	THRESHOLD	QUALIFIED PROCESSES
AFHYPAC	None	100% renewable	All renewable-based solutions
Low Carbon Fuel Standard	Well-to-wheel emissions from new gasoline vehicles	30% lower GHG, 50% lower NO_x	Green hydrogen, catalytic cracking of biomethane or thermochemical conversion of biomass, including waste
CertifHy	Grey hydrogen	60% lower GHG than reference (36.4 gCO_2/MJ)	Two labels: • "Green hydrogen" if the hydrogen is made from renewable energy • "Low carbon hydrogen" otherwise Hydrogen must meet the threshold with 99.5% purity
TÜV SÜD	Grey hydrogen	35-75% lower than reference depending on process	Renewable electrolysis; biomethane steam methane reforming; pyro-reforming of glycerine
Clean Energy Partnership	Grey hydrogen	100% renewable	Renewable electrolysis; biomass
REDII[12]	Transport fuels	70% reduction	Renewable transport fuels of non-biological origin
Technical Expert Group on Sustainable Finance	None	5.8 tCO_2/tH_2 or 100 gCO_2/kWh used as input	Water electrolysis

Notes: REDII = Renewable Energy – Recast to 2030; NO_x = nitrogen oxides; gCO_2/MJ = grams of carbon dioxide per megajoule; gCO_2/kWh = grams of carbon dioxide per kilowatt hour; tCO_2/tH_2 = tonnes of carbon dioxide per tonne of hydrogen.

Sources: Jensterle et al., 2019; Velazquez Abad and Dodds, 2020.

11 For the purpose of this report, GO is used to define all schemes quantifying the GHG emissions of hydrogen or its derivatives.
12 This is applicable to all advanced renewable fuels, including hydrogen and its derived products.

The previous examples show that there is still no single definition for the certification of hydrogen, meaning that schemes may be incompatible. For example, the CO_2 threshold limit below which hydrogen would be considered "green" or "low-carbon" varies widely (35-100%). Some of the schemes cover multiple hydrogen production technologies (e.g. Low Carbon Fuel Standard, CertifHy), while others focus specifically on green hydrogen (e.g. AFHYPAC).

The schemes also vary when it comes to end uses. Some cover all possible sectors (e.g. CertifHy), while others focus on a particular application. For example, the Low Carbon Fuel Standard only applies to use in vehicles. In addition, the references can be different: for example, the TÜV SÜD uses as baseline the production of grey hydrogen, while the REDII compares emissions against the reference values of the incumbent technology (fossil fuels for transport). Finally, it should be noted how some of the schemes presented above are part of a legislative requirement to obtain incentives or to be accounted as renewable energy (e.g. LCFS and REDII – both related to the transport sector), while others are voluntary schemes adopted by producers to guarantee their sustainability.

To be useful for producers, policy makers and end users, all GO schemes should provide a clear label for the hydrogen product to increase consumer awareness and accurately describe the value of the commodity (Veum *et al.*, 2019, Mehmeti *et al.*, 2018). The information provided should clearly differentiate between the various hydrogen production pathways.

A GO scheme should also be based on life cycle GHG emissions, from upstream activities such as electricity generation to transport (see Figure 2.5). That would ensure consistency and compatibility with GHG emission certification schemes for other commodities, such as electricity or fossil gas.

Green hydrogen solutions could then be compared with other hydrogen shades, fossil fuels, direct electrification and use of bioenergy.

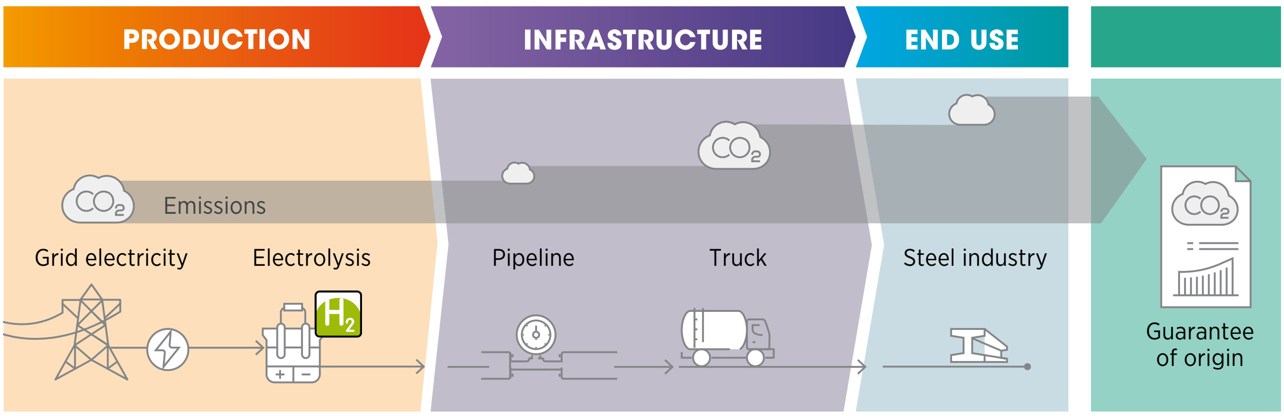
Biofuel certification schemes offer lessons on how to track and certify hydrogen. In biofuel certification schemes, some parts of the production chain can have default CO_2 reference values. In this way, the process of certification is accelerated for new applications. The default values are regularly updated to reflect technological changes. Producers may still apply for specific audited values, if they believe they have achieved better values than the reference ones.

The transport of biofuels is also accounted for in biofuel certification schemes by considering how and how far feedstocks and biofuels have been transported. Hydrogen GO schemes need to do this as well, since hydrogen produced from a dedicated wind farm and then transported with diesel trucks may have a greater carbon footprint then hydrogen produced with grid electricity that is transported in a pipeline.

Lastly, GO schemes should be designed to allow the international trading of green hydrogen, helping to create a global market. An example of international collaboration is the Hydrogen Production Analysis Task Force from the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE, 2020). The task force is aiming to develop a harmonised methodology and terminology to define and standardise clean hydrogen across different countries and to facilitate the creation of a common scheme for GO.

GO schemes will be a key element of a green hydrogen system, at least until carbon-intensive hydrogen is no longer produced. Other enabling policies will still be needed, however, to drive growth in green hydrogen.

FIGURE 2.5. Guarantees of origin lifecycle emissions (Illustrative)



2.4. POLICY PILLAR 4: **GOVERNANCE SYSTEM AND ENABLING POLICIES**

As green hydrogen transitions from niche to mainstream, the policies that drive the transition must not only cover the deployment of green hydrogen (presented in Chapter 3), but also its integration into the broader energy system. It is economy-wide policies that affect the sustainability and pace of the transition. Civil society and industry must be involved in this new sector in order to reap its benefits.

A broad base of support can create an enabling environment for green hydrogen actors to provide their value to the whole energy and social system. With these goals in mind, concrete actions that policy makers can take include:

- **Seeking advice from civil society and industry.** Civil society and industry can provide advice to policy makers on proposals, actions and amendments to the strategy depending on progress. An advisory council of experts who can provide high-quality input to government could be created. The council should include a diverse range of actors from academia, business and civil society to ensure that all interests are considered. The council could use sectoral or thematic tables to gather input from a broader range of stakeholders. Outcomes of the tables would be summarised and used as inputs for the council's recommendations to government. Italy's "Hydrogen Table" is an example of this policy. It involves companies and other stakeholders operating in the institutional and research world, with the objective of keeping the government updated on technological progress, identifying possible projects in the hydrogen value chain and their potential socio-economic effects, and maintaining international collaboration (MISE, 2020).

- **Implementing measures to maintain industrial competitiveness and create export opportunities.** Policy makers can assess which elements of the green hydrogen value chain can be manufactured domestically. This would include an assessment in each country of its existing national capacity compared to other countries and the actions needed to achieve leadership. In some cases, as in Canada, Germany and South Korea, the strategy could also set a national goal of becoming a first mover to develop a domestic industry, thus enabling exports of the technologies to other regions. Countries (such as Australia, Chile, Portugal and some members of the Gulf Cooperation Council region) may also focus on using their vast domestic renewable resources to establish an exporting hydrogen sector and promote domestic economic growth.

- **Identifying economic growth and job creation opportunities.** As part of a strategy, policy makers should assess the value that the hydrogen sector would add to the economy and its effect on associated industries, quantifying the number of jobs generated in equipment manufacturing, construction and operation, and indirectly in the supply chain and supporting industries. Examples of analyses of the employment impact of green hydrogen within an economy are common across first-mover countries, and they are used to inform national strategies. This was the case, for example, in the Netherlands (CE Delft, 2018; Government of the Netherlands, 2020). In addition, the local workforce needs to be able to perform the new jobs that will be created in these activities, and even in regulating the industry. Countries will therefore need education and training programmes to ensure a match between the skills needed and those currently available.

P4

Governance system and enabling policies

P4

Governance system and enabling policies

- **Introducing hydrogen as a part of energy security.** Not all countries enjoy the presence of large reserves of fossil fuels, meaning that the continuity of supply is governed by ever-changing political and economic factors. The production of green hydrogen can ease the demand for fossil fuels, in particular for industry and hard-to-abate sectors, increasing the energy security of a country.

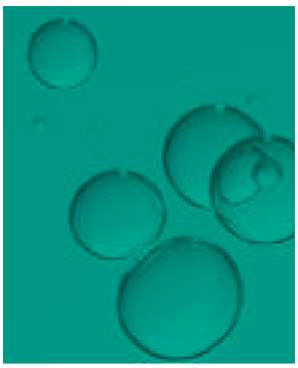
- **Setting international codes and standards.** International standards make it possible not only to execute cross-border projects, but also to reap the benefits of learning-by-doing from foreign companies that design and construct the equipment. This will enable costs to decrease more rapidly and will enhance safety as a result of applying best practices, among other benefits for end consumers.

- **Building or repurposing infrastructure.** Policy makers should assess the potential for repurposing existing natural gas pipelines to transport hydrogen, and thus decrease overall costs. They also need to guide the development of the hydrogen network by considering the locations of potential demand clusters and supply centres. Transparent plans and timelines for hydrogen network backbones, storage, fuelling stations and port infrastructure can be useful at the early stages to indicate the future routes and identify possible hurdles. Plans to repurpose grid infrastructure can be found in the EU hydrogen strategy (European Commission, 2020).

- **Ensuring access to financing.** Policy makers can provide direct dedicated funding from state budgets, or assist access to private capital by creating guidelines or new facilitating mechanisms. Public support may be needed for initial investments, in order to attract private capital. Given the versatility of hydrogen, there are multiple ways to expand existing funding programmes to cover its development.

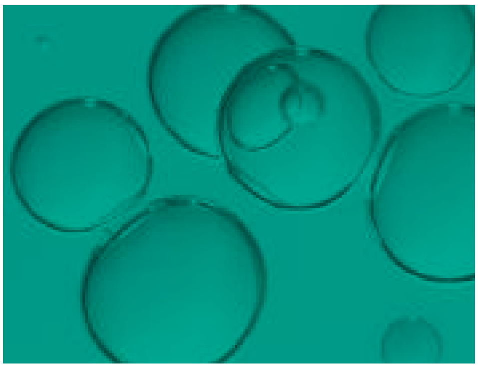
- **Collecting statistics.** Hydrogen is not currently included in national energy balances, because it is considered to be a chemical product. Including hydrogen supply and demand as a separate category in national energy balances (similar to electricity, fossil fuels or bioenergy) will allow better identification of energy flows and provide a solid basis for further analysis. Maintaining a central repository of data on hydrogen deployment across different sectors (such as MW of electrolysis or number of FCEVs) can make market information (such as prices, traded volumes and share of green and low-carbon hydrogen) openly available to promote transparency. This action will also require international co-operation to align the methodology and ensure mutual comprehension.

- **Setting research priorities.** By identifying technology needs, policy makers can prioritise the actions needed to close innovation gaps. A regular review of funding, progress and priorities should be part of the process. Since many of the hydrogen pathways needed over the long term are still in their early stages, policy makers should ensure the research agenda includes key demonstration projects to bridge the gap to commercialisation.



- **Implementing carbon pricing.** Green hydrogen will bring major GHG emission reductions when used to replace fossil fuels for many end uses. However, in many cases this benefit is not reflected in commodity prices, reducing the economic incentive to produce green hydrogen. By internalising the externalities (such as the impacts of extreme weather events, including damage to crops and other assets) in the form of either a carbon tax (i.e. a predetermined price path) or a trading system (i.e. a predetermined limit on emissions with a variable price), policy makers will contribute to valuing this benefit and closing the economic gap with fossil fuel pathways.
- **Phasing out fossil fuel subsidies.** Fossil fuel subsidies are responsible for various fiscal, social and environmental problems. These problems include harmful impacts on energy markets and greater fiscal burdens on governments, as well as environmental impacts. By phasing out fossil fuel subsidies, policy makers will help to close the economic gap with green hydrogen, while reducing market distortions and making the real price of fossil fuels clearer. When energy subsidies are used to assist energy-vulnerable populations or to guarantee competitiveness of national companies, careful planning of their phase-out should include measures to avoid energy price spikes or excessive burdens on family and company budgets.

While the measures described here can facilitate the deployment of green hydrogen, supporting mechanisms may still need to be put in place. The next chapter provides examples of such measures.



3 SUPPORTING POLICIES FOR GREEN HYDROGEN

This chapter will present insights and recommendations for policy makers who are considering kickstarting the green hydrogen sector in their jurisdictions. Green hydrogen is at an early stage in most applications and needs policy support to advance from niche to mainstream and be part of the energy transition. Some barriers to the deployment of green hydrogen in various sectors are relatively consistent across end uses (as discussed in Section 1.3), the cost barrier being the main one.

Other barriers are more sector-specific and call for a tailored approach (Figure 3.1).

Once priorities are set, policy makers need to address the barriers specific to the sectors where green hydrogen is expected to be deployed. In this chapter, specific policies and measures are presented for selected segments of the hydrogen value chain. The policy briefs that are due to follow this publication will delve in greater detail for each of the mentioned elements.

FIGURE 3.1 Selected barriers and policies for segments of the hydrogen value chain

	ELECTROLYSIS	INFRASTRUCTURE	INDUSTRY	AVIATION	SHIPPING
BARRIERS	- Capital cost - Electricity cost - Lack of hydrogen market - Barriers to power market	- Limited existing infrastructure - Technical limitations of users - Lack of investment	- High cost - Lack of demand for green products - Global competition and carbon leakage	- High cost - Procurement of sustainable CO_2 - Policy focus on biofuels	- High cost - Technical barriers
POLICY OPTIONS	+ Set capacity targets + Offer loans + Introduce feed-in premium + Allow participation in ancillary markets	+ Collaborate on global trading of hydrogen + Identify priorities for conversion + Align blending targets + Provide financing	+ Offer dedicated loans + Develop public procurement of green products + Phase out high-emission technologies	+ Set targets + Review policy focus + Expand emissions trading system	+ Introduce fiscal incentives + Set targets for zero-emission vessels + Support infrastructure development