ludwig bölkow systemtechnik

WORLD ENERGY COUNCIL | WELTENERGIERAT DEUTSCHLAND

INTERNATIONAL HYDROGEN STRATEGIES

A study commissioned by and in cooperation with

the World Energy Council – Germany

Executive Summary

September 2020

The Weltenergierat – Deutschland, through its members, represents all energy sources and technologies and serves as the independent voice for international energy issues in Germany. Its aim is to bring the global perspective into the national debate and to shape the energy system of the future. As part of the World Energy Council, the Weltenergierat represents the German energy system in the largest international energy network in the world. For almost 100 years, the World Energy Council has been committed to a sustainable energy supply for the benefit of all people worldwide.

The following report is authored by the Ludwig-Bölkow-Systemtechnik GmbH and published on behalf of the Weltenergierat - Deutschland (www.weltenergierat.de/international-hydrogen-strategies/). The study benefits from the support of following members:

- 50Hertz
- DVGW
- EnBW
- E.ON
- Equinor
- EWE
- Gazprom Germania
- Institut für Wärme und Oeltechnik
- Mineralölwirtschaftsverband
- Mittelständische Energiewirtschaft Deutschland
- MunichRe
- Open Grid Europe
- RWE
- Siemens Energy
- TenneT
- TÜV SÜD
- Uniper
- Uniti Bundesverband mittelständischer Mineralölunternehmen
- VDA

as well as from the

International Energy Agency (IEA) and Bundesverband der Deutschen Industrie (BDI)

The report was enhanced with contributions and expert interviews from the World Energy Council network in France, the Netherlands, Australia, Morocco, Germany, Japan, Italy, California, Switzerland, and China.

Authors:
Dr. Uwe Albrecht, Dr. Ulrich Bünger, Dr. Jan Michalski, Tetyana Raksha, Reinhold Wurster, and Jan Zerhusen
Ludwig-Bölkow-Systemtechnik GmbH, www.lbst.de

Introduction

Hydrogen can play a significant role in a future energy system. Based on renewables it can serve as an important link between intermittent wind and solar electricity production and energy consuming sectors traditionally relying on a chemical energy carrier that can be stored in bulk quantities and converted to electricity or heat at the point of use. However, implementing hydrogen at relevant scale including its production, transport, distribution, and use requires governmental support as well as a beneficial policy and regulatory environment allowing for a positive economic outlook for industrial deployment.

As a result, major economies around the globe are currently assessing their position and are discussing, preparing, and agreeing on dedicated hydrogen strategies. Our study analyses government action for hydrogen in 16 countries (United Kingdom (UK), Japan, South Korea, Australia, the Netherlands, France, Italy, Spain, China, Ukraine, Germany, Switzerland, Morocco, California[1], Russia, and Norway) and in the European Union. It focuses on the respective national goals, targeted sectors and infrastructures, current support measures, requirements on the hydrogen used, and achievements so far. The aim of the analysis is to provide an informed factual input to policy discussions and corporate decision-making.

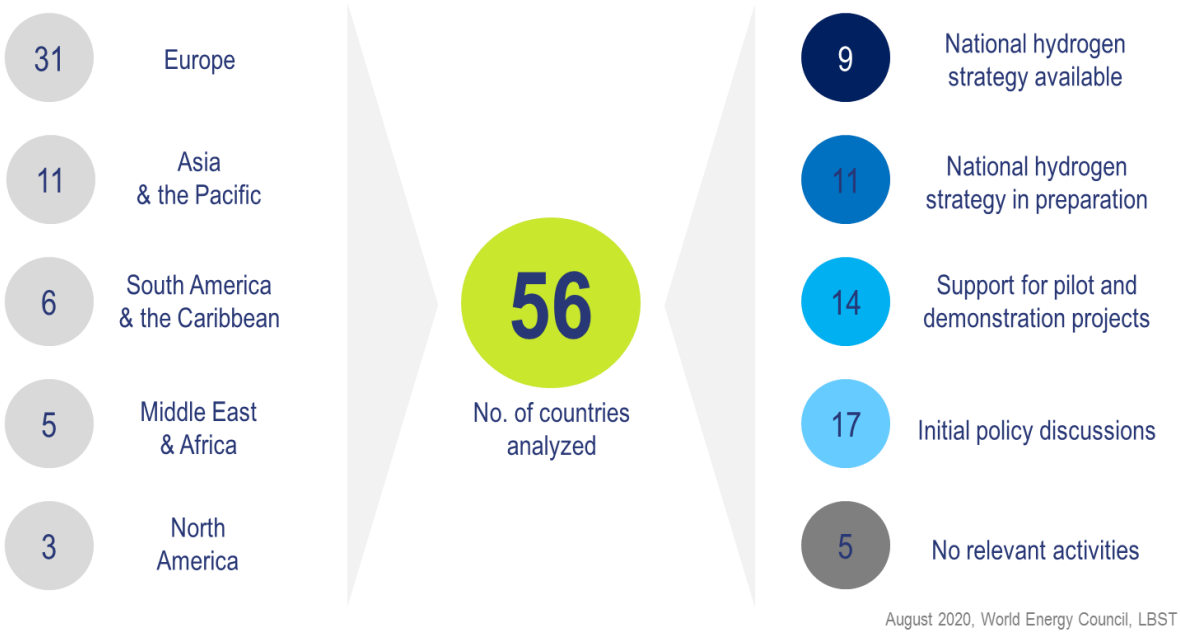
Quickly emerging hydrogen strategies indicate dynamically growing market

- **By 2025 hydrogen strategies can be expected in countries representing over 80% of global GDP**

In a high-level review of countries representing over 90% of global GDP we found that 20 countries representing 44% of global GDP already have a national hydrogen strategy or are on the verge of doing so within the coming months. Additionally, another 31 countries (another 44% of global GDP) are supporting national projects and discussing policy action.

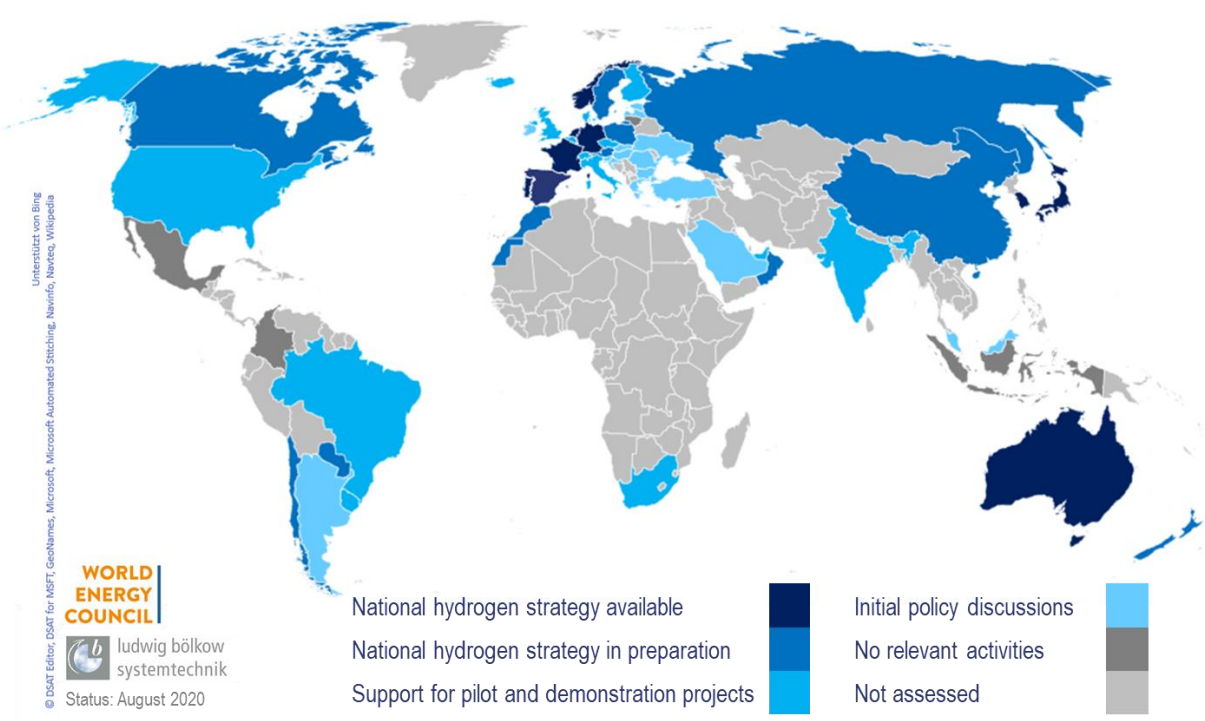
The comprehensive nature of existing and emerging hydrogen strategies, covering relevant application sectors, serving environmental as well as economic goals, is a clear manifestation of the important role the technology is expected to play.

[1] US federal states follow their own strategies with regard to clean transport and energy supply; the study team has chosen to include California in the analysis as it is the most advanced US state in that respect.



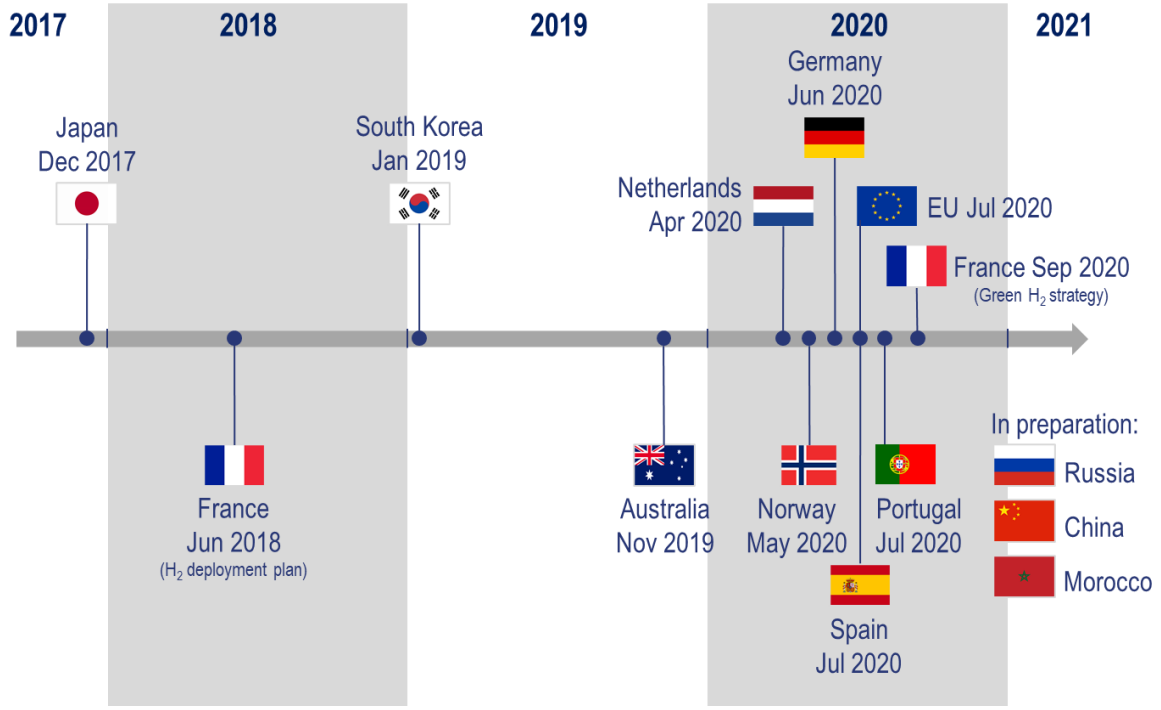
Analysis of 56 countries for their hydrogen activities (August 2020)

Hydrogen activities are well spread around the globe with major interest being located in Europe, in the Asia and Pacific region, as well as in the Americas.



International status of hydrogen activities of national governments (August 2020)

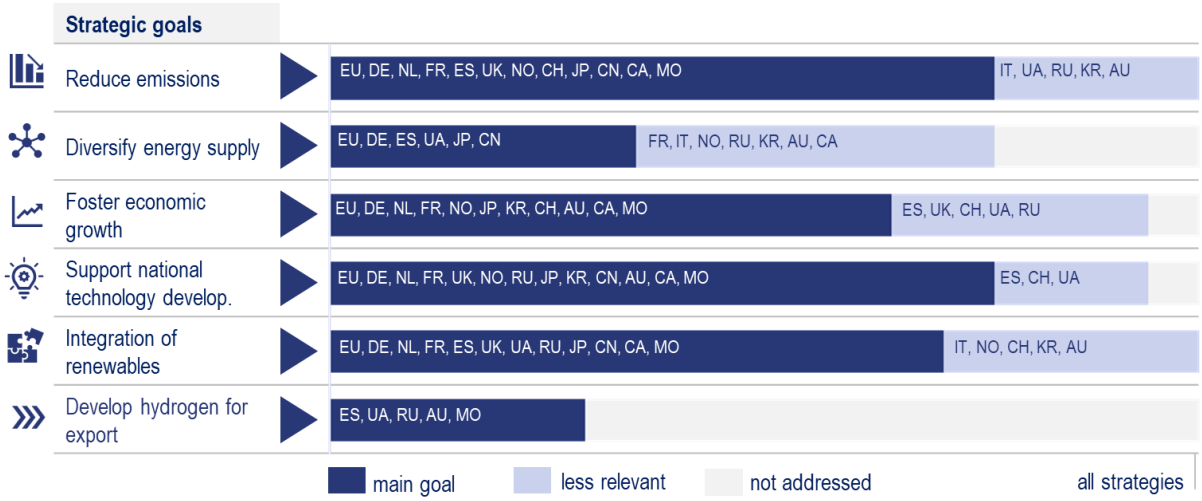
Most strategies have been developed and announced recently, i.e. in 2020 or in late 2019, (AU, NL, NO, DE, EU, ES). Only three of the selected countries have a strategy older than one year (JP, FR, KR).



Timeline of analysed national hydrogen strategies publication

- **Hydrogen is clearly recognised as an essential element of a decarbonised energy system**

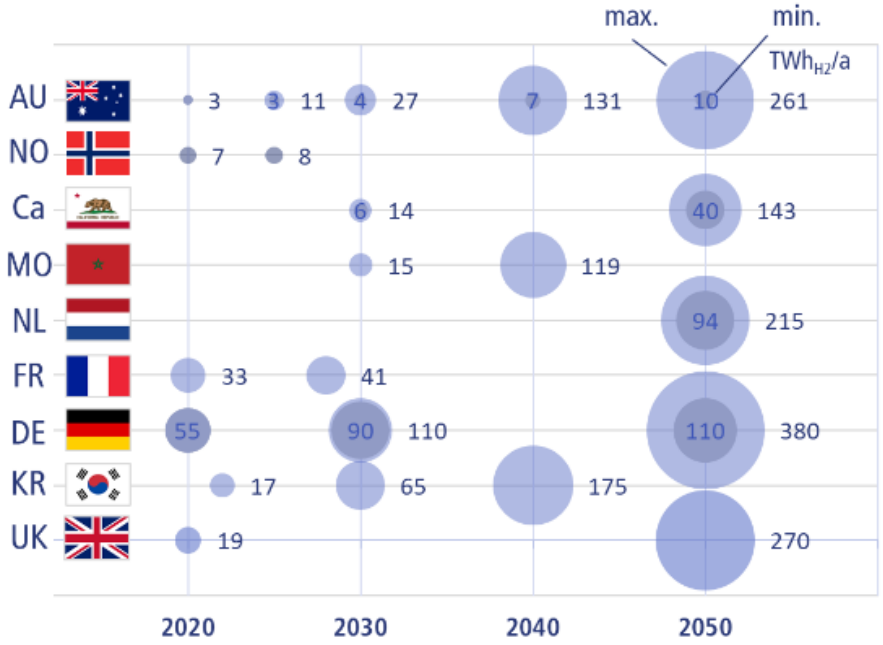
Main drivers for this development are GHG emission reduction goals, the integration of renewables, as well as the opportunity for economic growth. While national strategies differ in detail, reflecting particular country interests and industrial strengths, there is a clear and lasting international momentum behind the universal recognition that hydrogen is an essential and indispensable element of a decarbonised energy system.



Relevance of strategic goals across the selected countries

- **Scaling demand expectations for 2050 indicates a global hydrogen potential of up to 9000 TWh**

Not all countries quantify the expected national hydrogen demand in their strategies, but the ones that do are all in a similar ballpark with respect to the respective size of the economy. Scaling upper hydrogen demand expected for 2050 in national strategies to global level based on GDP indicates a potential of up to 9000 TWh or around 270 million tons of hydrogen per annum. This is an amount as large as the annual primary energy currently provided globally by renewables.



Expected annual hydrogen consumption in TWh$_{H2}$ per year

- **In countries with high energy needs, a substantial share of the H_2 demand will be served by imports, initially on the basis of bilateral agreements**

While hydrogen production from renewable energy offers an opportunity for a higher degree of energy independence, densely populated countries with high energy needs are realising the limits of domestic production capacities. Notably, Japan, South Korea, and Germany expect to develop significant import capacities. As these require large investments in production capacity in the exporting countries as well as in the associated logistics infrastructure along the supply chain on both sides, initial developments will likely build on bilateral agreements, de-risking the capital employed.

- **Initial applications focus on the transport and industry sectors**

Target sectors of national strategies notably include transport and industry, the latter particularly in countries with a strong industrial sector and a high priority on greenhouse gas reduction.

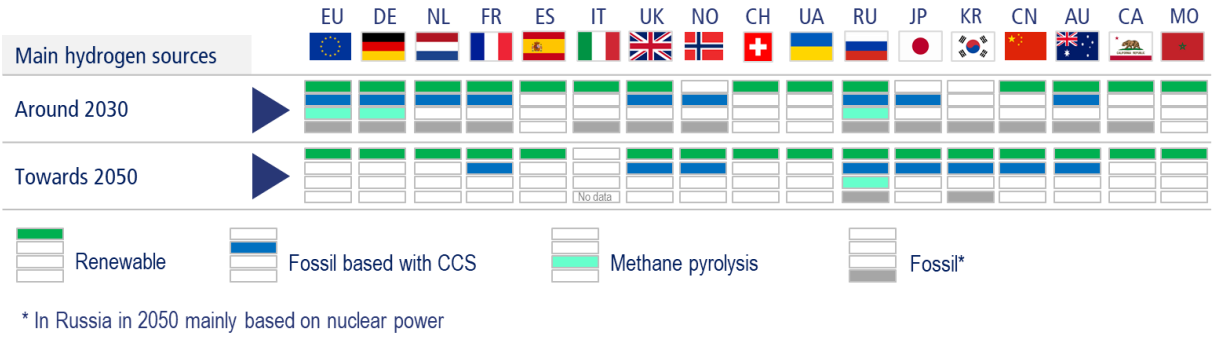
The range of applications addressed by a strategy often depends on the time when it was conceived as well as on the ambitions for GHG emission reduction. Typically, newer and more ambitious strategies are characterised by higher and more prominent GHG emission reduction

targets, leading to a higher relevance of the industry, building, and power sectors as significant hydrogen consumers.

Main target sectors of analysed H_2 strategies per country

- **Green hydrogen is central to all strategies**

In the long run, with a view towards a largely decarbonised world by 2050, over half of the countries analysed focus on using green hydrogen sourced from renewable energy only; the emphasis on green hydrogen is particularly pronounced in the EU. However, in the interim other types of low carbon hydrogen are seen as an effective and pragmatic way to ramp up volumes and to get the associated hydrogen economies started.



Considered medium-and long-term hydrogen production options by country

Emerging opportunities and areas to watch for industry

- **Large cumulative market of over 40 B€ for green hydrogen production equipment will develop within the EU until 2030**

Several countries are stating clear and massive targets for ramping up green hydrogen production. The move from the currently installed base of electrolysers in the lower Megawatt range to Gigawatt-size capacities within less than a decade points towards a massive growth path in the coming years and the targeted large hydrogen production capacities translate into a sizeable market. The EU target alone indicates a cumulative market size for electrolysers and balance of plant of more than 40 B€ within the EU until 2030.

- **Large industrial partnerships will be formed for production and export/import**

Initial export/import relationships are expected to build on bilateral agreements. Corresponding supply chains will benefit from a tight integration, resulting in partnerships between relevant major stakeholders covering production, infrastructure, and logistics. Such partnerships are already being formed and industry players should start to engage now.

- **Refineries and chemical industry to become the first important large-scale hydrogen markets in the mid-term**

Green hydrogen is seen as one of the main levers to decarbonize the industry sector. Refineries and the chemical industry are large hydrogen users already today, and gradually replacing the fossil-based 'grey' hydrogen by green or low carbon hydrogen is an element in several strategies. In addition, the EU Renewable Energy Directive recast (RED II) allows green hydrogen used in refineries to count towards the mandatory transport sector target of a 14% renewable energy share, creating a strong regulatory incentive. As a result, already now large-scale electrolysers are being planned in and around European refineries.

- **Road transport and fuel cell market is currently stronger in Asia than in Europe**

While the transport sector is a relevant application segment in all countries, when comparing countries with relevant automotive original equipment manufacturers (OEMs), the expected use of hydrogen in fuel cell passenger vehicles and trucks is stronger in Asia than in Europe. While Japanese, South Korean, and Chinese plans foresee a relevant role of fuel cell electric vehicles in all road transport sectors, European strategies mainly focus on heavy goods vehicles. Similarly, fuel cells in the building and power sector have a pronounced role in Asia while playing only a limited or no role in Europe.

- **Green synthetic liquid e-fuels (PtL) can grow into an interesting opportunity, particularly in the aviation and/or maritime sector**

In a few strategies, green synthetic fuels are mentioned as an option for aviation and maritime shipping. Being able to be used in the existing engines without major modification, they provide a perspective for decarbonisation in the short term, whereas a direct hydrogen use is seen as a potential longer term solution, requiring a more profound technology development and longer lead time. A possible introduction of quota in the aviation sector is discussed in the German and Dutch strategies, which would lead to an opportunity for significant volume demand. Likewise, existing emission reduction targets in the maritime sector and international pressure to accelerate the path towards them can help to further enlarge the market.

New policies needed to achieve strategic aims

- **Current measures are insufficient to catalyse envisaged strong growth**

Most strategies focus on targets for green hydrogen production and technology deployment rather than on measures supporting these targets. Many policies in place concentrate on R&D-oriented action, which remains relevant but less important than fostering commercialisation.

Support measure type	EU	DE	NL	FR	ES	IT	UK	NO	CH	UA	RU	JP	KR	CN	AU	CA	MO
R&D support	++	++	++	++	++	+	++	+	o	+	++	++	++	++	++	+	++
Regulatory measures	++	+	++	+	++	+	+	+	+	o	+	++	++	++	++	+	+
Financial support	++	++	++	+	++	+	+	+	+	o	+	++	++	++	++	++	+
Acceptance and training	+	+	o	+	+	o	o	+	o	o	o	+	+	o	++	++	o
Governance and other	+	++	+	+	+	+	o	o	o	o	+	++	++	o	++	++	o

++ Strong focus + Less pronounced o Not mentioned

Existing and planned hydrogen support measures by country

In most cases, policy development is lagging behind the strategic ambitions. Current measures are insufficient to catalyse the envisaged strong growth. New policies required to achieve these targets are still in the making and are only starting to emerge. The time for policy discussions is now and policymakers will likely be open to sensible approaches and good arguments.

- **Building on earlier successes, policies should focus on commercialisation**

Many countries have already been supporting hydrogen and its applications for quite some time and successful deployment examples can be traced back to a few triggers, which help in discussing policy options. The following measures appear particularly suitable.

- Mandatory quota or emission limits have been employed successfully in the past to help creating a market for low carbon or more efficient technology. **Well-designed sectoral quota for green feedstock and fuels in industry and transport can stimulate large scale demand.**
- Moving from R&D support, which has been the dominant public support mechanism in the past, to supporting commercialisation and the demonstration of entire value chains in e.g. Germany (‘Reallabore’) and Europe (‘hydrogen valleys’) has kicked off large projects and a flurry of activity even in regions not receiving funding. **Targeted support for establishing comprehensive value chains will provide nuclei for sustainable business.**
- While public funding towards project investments lowers the entry hurdle for participants, it usually does not create a green hydrogen business case due to the high cost of green

electricity. **Moving from CAPEX to OPEX support will help to establish sustainable business cases for operators.** Measures may range from reducing green electricity costs to the carbon contracts for difference (CCfD) instrument, which is currently discussed in the European and German strategies as a possible future instrument.

- Greenhouse gas reduction is one of the primary goals behind all hydrogen strategies and carbon pricing is a well-established instrument in many world regions. While current carbon prices in most countries and regions are too low to enable sustainable green hydrogen business cases, aiming for **globally high CO_2 prices will help to further reduce the cost gap and create a level playing field.**
- When it comes to commercial deployment, any policy instrument needs to provide a **long-term perspective and security of investment** in line with typical investment lifetimes.

- **A green hydrogen certification needs to be put in place**

A green hydrogen producer needs to be able to verifiably prove the green quality of its product. A broadly agreed green or low carbon hydrogen certification mechanism is crucial for a successful market development.

- **Infrastructure development requires central coordination and financial support**

A reliable and accessible infrastructure is a necessary prerequisite for retail and SME applications and has to precede market development. This holds similarly for hydrogen pipelines, where existing infrastructure for gas transport and distribution can be converted to transport pure hydrogen, and for refuelling stations. **Comprehensive infrastructure development requires public financing, central coordination for planning and harmonisation, and the appropriate regulatory environment**.

- **Public acceptance is key**

Public acceptance is crucial to any new technology deployment and suitable **measures supporting public acceptance need to complement any policy development.** Examples include education campaigns, training programmes, and community engagement.