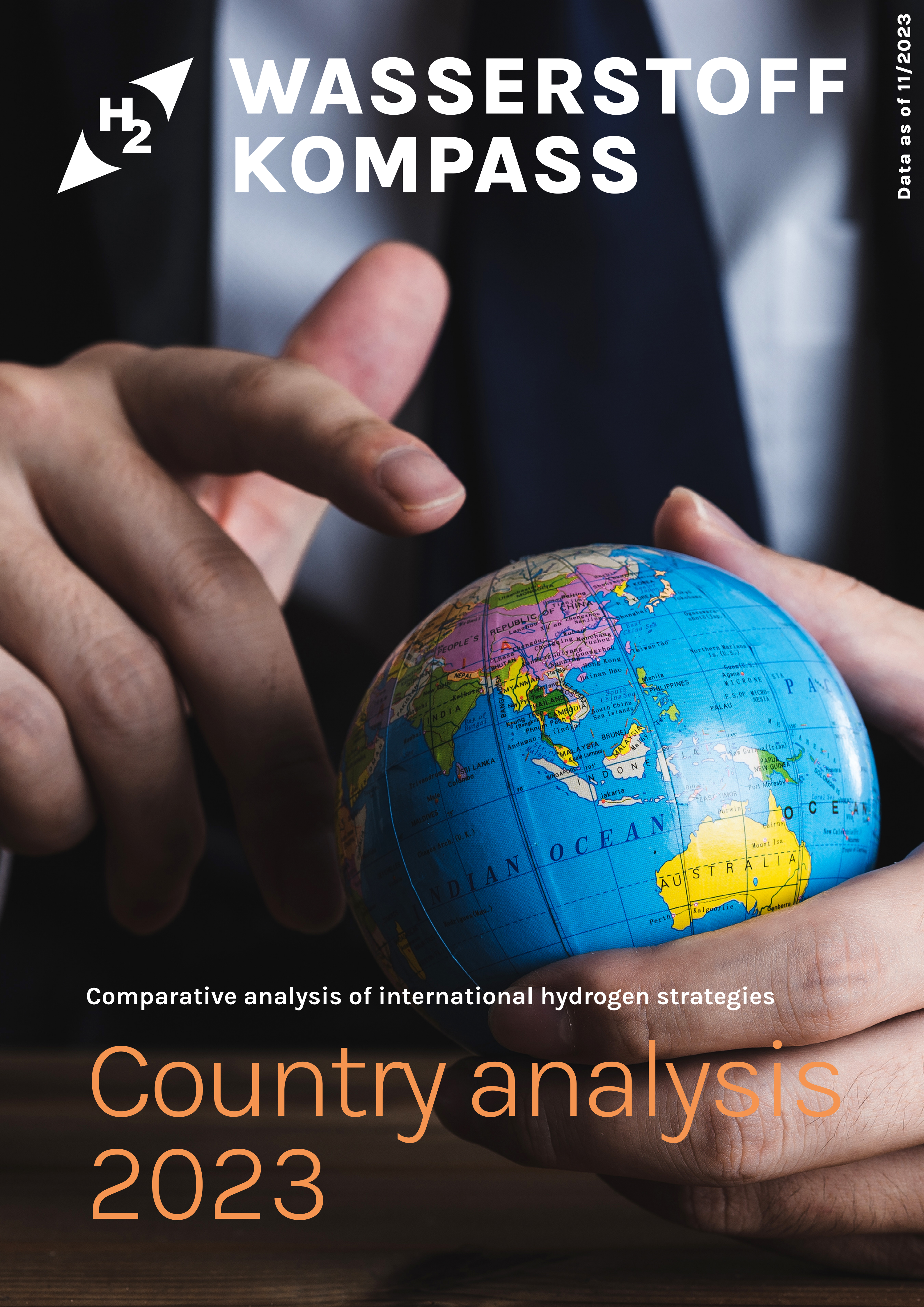


# WASSERSTOFF KOMPASS

Data as of 11/2023

Comparative analysis of international hydrogen strategies

# Country analysis 2023

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# List of abbreviations

| | |
|---|---|
| **CCS** | carbon capture and storage |
| **CCU** | carbon capture and utilisation |
| **CCUS** | carbon capture utilisation and storage |
| **RE** | renewable energy |
| **EU** | European Union |
| **FC** | fuel cell |
| **FCEV** | fuel cell electric vehicle |
| **R&D** | research and development |
| **HD-FCEV** | heavy duty fuel cell electric vehicle |
| **n.s.** | not specified |
| **s.t.** | short-term, in the period until 2030 |
| **LD-FCEV** | light duty fuel cell electric vehicle |
| **lt** | long-term, in the period from 2040 |
| **LOHC** | liquid organic hydrogen carriers |
| **mt** | medium-term, in the period from 2040 |
| **RED** | Renewable Energy Directive |
| **USD** | US dollar |

# Country Codes used

| | |
|---|---|
| **ARE** | United Arab Emirates |
| **AUS** | Australia |
| **AUT** | Austria |
| **BEL** | Belgium |
| **BRA** | Brazil |
| **CAN** | Canada |
| **CHL** | Chile |
| **CHN** | China |
| **COL** | Colombia |
| **CZE** | Czechia |
| **DNK** | Denmark |
| **ESP** | Spain |
| **FIN** | Finland |
| **FRA** | France |
| **GBR** | United Kingdom |
| **GB-SCT** | Scotland |
| **GER** | Germany |
| **HRV** | Croatia |
| **HUN** | Hungary |
| **IND** | India |
| **IRL** | Ireland |
| **ITA** | Italy |
| **JPN** | Japan |
| **KEN** | Kenya |
| **KOR** | South Korea |
| **MAR** | Morocco |
| **NAM** | Namibia |
| **NLD** | Netherlands |
| **NOR** | Norway |
| **NZL** | New Zealand |
| **POL** | Poland |
| **PRT** | Portugal |
| **PRY** | Paraguay |
| **RUS** | Russia |
| **SGP** | Singapore |
| **SVK** | Slovakia |
| **SWE** | Sweden |
| **TUR** | Türkiye |
| **URY** | Uruguay |
| **USA** | United States of America |
| **US-CAL** | California |
| **ZAF** | South Africa |

# Foreword

Hydrogen is an indispensable component of the energy transition. It can be used in a variety of ways to defossilise industry, transport and the energy and building sectors.

The technological supply options and the geographical regions in which hydrogen can be produced are just as diverse as the possible applications. Different countries and regions have different raw material deposits or renewable energy potential and therefore rely on differing hydrogen production technologies, import and/or export strategies.

In December 2022, an initial analysis of international hydrogen strategies and roadmaps was published by $H_2$-Compass. At that time, 22 documents were included in the analysis. Due to the large number of updates (e.g. the update of the German National Hydrogen Strategy in July 2023) and newly published strategies and roadmaps, $H_2$-Compass is now updating its country analysis.

This country analysis now includes 43 national or regional strategies, some of which have set very ambitious targets. As the individual strategies were developed and published at different times, some ostensible contradictions may appear. For example, according to Germany's updated strategy, hydrogen is to be used in air traffic by 2030. Due to the order of publication, corresponding statements are missing in the strategies of the EU and other EU countries. However, the aim reflects the latest EU regulations, which provide for binding blending quotas for sustainable aviation fuels.

We wish you useful and stimulating reading!
Your $H_2$-Compass team

# Abstract

In the strategies reviewed, hydrogen's utilisation is closely tied to the fight against climate change and alignment with the Paris Agreement. Alongside environmental motives, economic factors significantly shape forthcoming hydrogen applications.

Numerous strategies and roadmaps explicitly outline targets. For instance, 16 European nations have outlined electrolysis capacities totaling approximately 50 GW by 2030. Moreover, specific target prices for hydrogen, ranging from €4.50/kg to under €1/kg, are mentioned across certain documents. These figures often differ based on the designated application areas for hydrogen.

State-level support, through funding and investment measures, is pivotal for advancing the hydrogen economy. Collaborative research and development initiatives are highlighted as crucial and infrastructure development is consistently highlighted as fundamental for efficient hydrogen distribution. Above all, achieving cost competitiveness between fossil-based and renewable hydrogen remains a pivotal objective, with $CO_2$ pricing suggested in some cases to achieve parity.

Regarding hydrogen production, more than half of the strategies and roadmaps state the aim to replace fossil-based hydrogen without carbon capture[1]. However, some countries may persist with this type of hydrogen production in the future. Fossil-based hydrogen with carbon capture and storage (or utilisation) is mentioned as a relevant option in more than half of the papers. In some cases, however, it is explicitly mentioned that this should only be a temporary option to enable a ramp-up of the hydrogen economy. There is agreement regarding the goal of using water electrolysis technology, yet the electricity source (grid mix, nuclear, renewable) remains a topic of divergence influenced by local conditions.

This diversity is mirrored in the applications of hydrogen:

- Potential transport sector uses exist in heavy-duty transport and fleet networks. Opinions diverge on the immediate relevance of fuel cell vehicles.
- Industrial consumers, particularly the chemical industry and refineries, stand out due to existing hydrogen demand and expertise. The steel industry is also considered attractive thanks to the role of hydrogen in the transformation of steel production.
- In contrast, the energy sector envisions hydrogen use in the medium to long term. Its relevance lies in applications such as high-temperature process heat, where electrification might be technically infeasible or uneconomical.

There is a common expectation that global hydrogen demand will grow. However, meeting this future demand remains an open question. Many countries aim to become hydrogen exporters, while others acknowledge reliance on imports due to limited production potential. Some nations intend to serve as transit points, importing hydrogen to then distribute it to other countries.

The evolving landscape underscores a varied yet interconnected approach to hydrogen's utilisation, balancing environmental imperatives with economic viability and technical feasibility.

[1] *Also called 'grey hydrogen'*

# Country selection

The following world map shows which hydrogen strategies or roadmaps were included in the updated evaluation. The analysis was expanded from 22 countries or regions (as of 12/2022, blue) to a total of 43 countries and regions (as of 11/2023, green).

The majority of the strategies and roadmaps do not focus on one key topic but take a holistic view of hydrogen use. The papers from China and California are special cases. These are dedicated strategies for the use of fuel cells, primarily in the transport sector, but also in the energy sector. Due to the economic relevance of both regions, these are also included in the analysis where pertinent.

In the case of revised strategies and roadmaps, only the latest version was taken into account. An exception was made for Germany. The update of the National Hydrogen Strategy published by the German government in 2023 was discussed separately from the 2020 strategy, allowing for conclusions to be drawn about changes made since the initial publication.

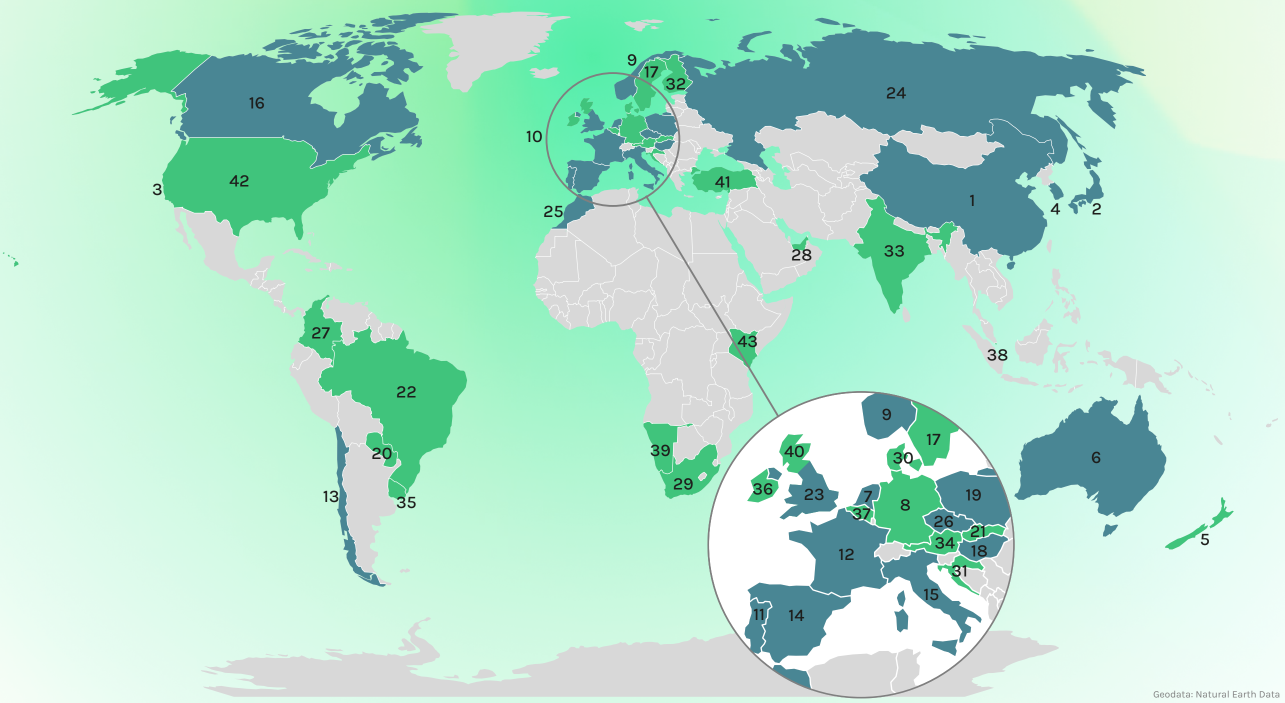



*Figure 1: The marked countries and also the EU are included in the analysis (in blue: countries from the first version; in green: newly added countries),*

**LIST OF ANALYSED DOCUMENTS (CHRONOLOGICAL BY PUBLICATION DATE; INCLUDING COUNTRY CODES:**

1. China (CHN), Fuel Cell Vehicle Roadmap, 11/2017
2. Japan (JPN), Basic Hydrogen Strategy, 12/2017
3. California (US-CAL), The California Fuel Cell Revolution, 07/2018
4. South Korea (KOR), Hydrogen Economy Roadmap of Korea, 01/2019
5. New Zealand (NZL), A Vision for Hydrogen in New Zealand, 09/2019
6. Australia (AUS), Australia's National Hydrogen Strategy, 11/2019
7. Netherlands (NLD), Government Strategy on Hydrogen, 04/2020
8. Germany (GER), Die Nationale Wasserstoffstrategie, 06/2020 & Fortschreibung der Nationalen Wasserstoffstrategie, 07/2023
9. Norway (NOR), The Norwegian Government's Hydrogen Strategy, 06/2020
10. European Union (EU), A Hydrogen Strategy for a Climate-Neutral Europe, 07/2020
11. Portugal (PRT), Portugal National Hydrogen France, 08/2020
12. France (FRA), Stratégie nationale pour le développement de l'hydrogène décarboné en France, 09/2020
13. Chile (CHL), National Green Hydrogen Strategy, 09/2020
14. Spain (ESP), Hoja de Ruta del Hidrogeno, 10/2020
15. Italy (ITA), Strategia Nazionale Idrogeno Linee Guida Preliminari, 11/2020
16. Canada (CAN), Hydrogen Strategy for Canada, 12/2020
17. Sweden (SWE), Strategy for fossil free competitiveness, 01/2021
18. Hungary (HUN), Hungary's National Hydrogen Strategy, 05/2021
19. Poland (POL), Polish Hydrogen Strategy, 05/2021
20. Paraguay (PRY), Towards the Green Hydrogen Roadmap in Paraguay, 06/2021
21. Slovakia (SVK), National Hydrogen Strategy: Ready for the Future, 06/2021
22. Brazil (BRA), Programa Nacional do Hidrogênio, 07/2021
23. United Kingdom (GBR), UK Hydrogen Strategy, 08/2021
24. Russia (RUS), Development of Hydrogen Energy in the Russian Federation, 08/2021
25. Morocco (MAR), Feuille de Route Hydrogène Vert, 08/2021
26. Czechia (CZE), The Czech Republic's Hydrogen Strategy, 09/2021
27. Colombia (COL), Colombia's Hydrogen Roadmap, 09/2021
28. United Arab Emirates (ARE), Hydrogen: From Hype to Reality, 2021
29. South Africa (ZAF), Hydrogen Society Roadmap for South Africa 2021, 2021
30. Denmark (DNK), The Government's Strategy for Power-to-X, 12/2021
31. Croatia (HRV), Hydrogen Strategy of the Republic of Croatia until 2050, 03/2022
32. Finland (FIN), Hydrogen economy – Opportunities and limitations, 05/2022
33. India (IND), Harnessing Green Hydrogen, 06/2022
34. Austria (AUT), Wasserstoffstrategie für Österreich, 06/2022
35. Uruguay (URY), Green Hydrogen Roadmap in Uruguay, 06/2022
36. Ireland (IRL), Consultation on Developing a Hydrogen Strategy for Ireland, 07/2022
37. Belgium (BEL), Vision and strategy, Hydrogen, Update October 2022, 10/2022
38. Singapore (SGP), Singapore's National Hydrogen Strategy, 10/2022
39. Namibia (NAM), Namibia. Green Hydrogen and Derivatives Strategy, 11/2022
40. Scotland (GB-SCT), Hydrogen Action Plan, 12/2022
41. Türkiye (TUR), Türkiye Hidrojen Teknolojileri Stratejisi Ve Yol Haritası, 01/2023
42. United States of America (USA), U.S. National Clean Hydrogen Strategy and Roadmap, 06/2023
43. Kenya (KEN), Green Hydrogen Strategy and Roadmap for Kenya, 09/2023

# Methodology

To create a basis for comparison, all documents were evaluated according to the same criteria:

- **general information** such as the type (strategy, roadmap, concept paper, etc.), title and publisher of the paper, the date of publication and the time horizons considered;
- **targets** recorded, for example, target generation capacities, target prices or hydrogen production volumes;
- frequently addressed, **overarching aspects**, for example, whether the development of a hydrogen economy will create new jobs;
- technologies that the individual countries rely on for domestic **hydrogen production**; and
- the **fields of application** in which hydrogen is to be used in the short, medium or long term.

This information was evaluated quantitatively as far as possible. The evaluation of the individual countries was summarised in fact sheets, which are presented in the appendix.

# Goals and targets of the countries

The reasons for using hydrogen vary. Most strategies (35 out of a total of 41) link the use of hydrogen to achieving the goals of the Paris Agreement. However, there are also countries that are pursuing the use of hydrogen primarily for economic reasons (e.g. AUS, RUS).

More than half of the papers (25/41) define specific production capacities for hydrogen based on renewable electricity (see Figures 2–3). A total of ~52 GW was announced by 17 countries in Europe (DEU, FRA, HUN, ITA, NLD, GBR, POL, PRT, ESP, AUT, HRV, BEL, DNK, SWE, SVK, TUR, FIN) for the year 2030. The EU strategy aims for at least 40 GW of electrolysis capacity by the same date. The strategies of the South American countries Chile, Uruguay and Colombia are aiming for a total of between 27 and 30 GW of electrolysis capacity by 2030. Chile accounts for 25 GW of this. The United States of America is pursuing an electrolysis capacity of 3 GW. The two African countries South Africa and Kenya are aiming for just under 2 GW by 2030. The largest planned electrolysis capacity for a single country was defined in the Indian strategy as between at least 25 and 60 GW in 2030. The strategy noted that capacity by 2030 could be significantly higher still in order to produce hydrogen or hydrogen derivatives for export.

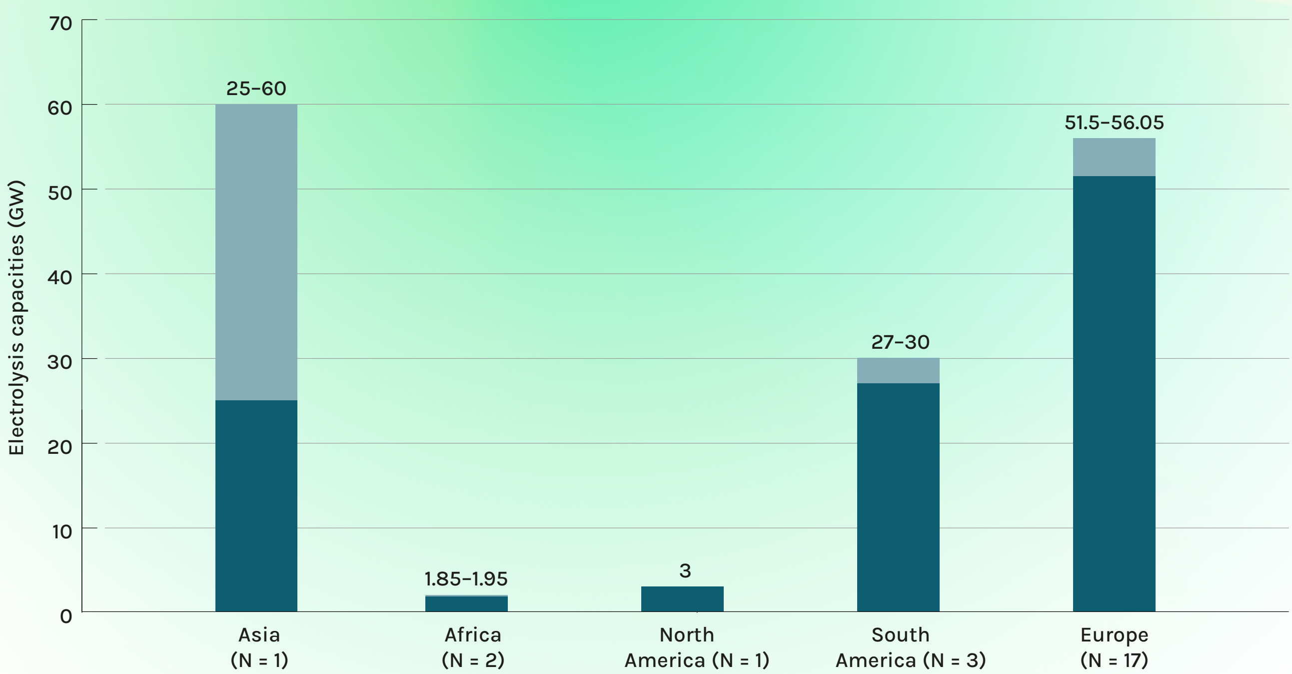



*Figure 2: Global electrolysis capacity in 2030 by continent*

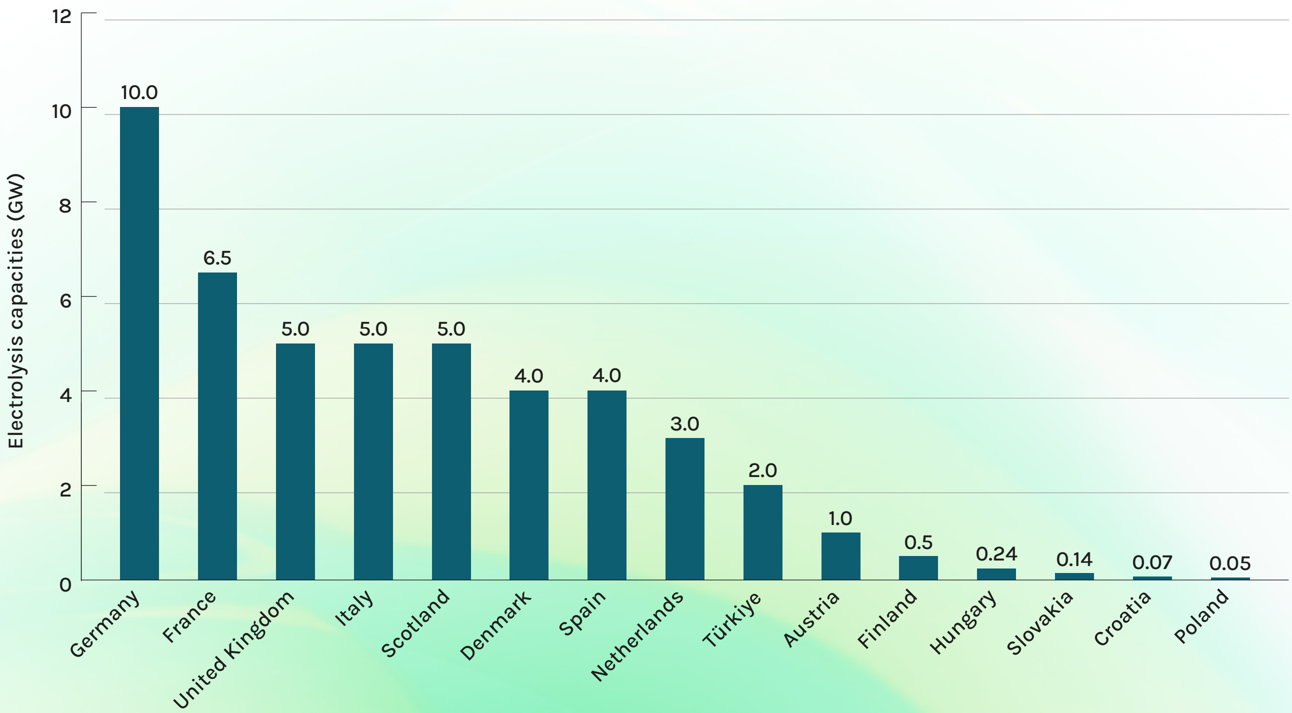



*Figure 3: Country-specific distribution of electrolysis capacity (in GW) in 2030 by continent*

Only a few countries (14/41) provide specific information on the targeted production volumes of hydrogen. Hungary, for example, plans to produce 20 kt/a of low-emission and 16 kt/a of emission-free hydrogen domestically by 2030. For the same target year, Canada plans to produce 3 Mt/a and the EU and the United States of America aim for 10 Mt/a of hydrogen each. However, when comparing such figures, differences in basic conditions such as population densities or land availability must be considered.

Russia has stated planned export quantities of hydrogen. In the corresponding concept paper, a range of 2–12 Mt of hydrogen is targeted for export in 2035. The Indian strategy describes possible ammonia export volumes of between 4.15 and 4.9 Mt.

An explicit target price for electrolysis-based hydrogen is stated in less than half of the cases (14/41). The price ranges from €0.60/kg $H_2$ (IND) to around €4.50 kg $H_2$ (KOR) and varies in some cases depending on the area of application. For example, the United States of America defines different target prices for stationary energy supply (€0.92/kg $H_2$[2]) and for the transport sector (€1.83/kg $H_2$). In contrast, Sweden, Finland and Uruguay only specify production costs (not prices), which according to Uruguay should be in the range of €1.37–2.20/kg $H_2$ in 2025 and €0.92–€1.28/kg $H_2$ in 2050.

15 papers define target numbers for fuel cell vehicles (HUN, NLD, POL, ESP, CAN, JPN, KOR, US-CAL, CHN, COL, URY, ZAF, ARE, IND, SVK). The targets for 2030 range from a few thousand FCEVs to one million (US-CAL). Among the publications, South Korea gives, for 2040, the highest figure with 6.2 million FCEVs. 3.3 million of these are planned for export. The United Arab Emirates do not specify any concrete targets. Instead, they plan to convert half of the public fleet of heavy commercial vehicles to fuel cell technology by 2050.

Twelve of the documents also define a precise number of hydrogen filling stations, the construction of which should promote the use of hydrogen in road transport. A maximum of 1000 filling stations are specified as a 2030 target (US-CAL, CHN).

The countries agree that hydrogen will account for an increasing share of final energy consumption. However, only six strategies define how high this share should be. For example, Italy and Portugal are aiming for hydrogen shares of 2 % and 5 % respectively by 2030. Canada plans to cover 30 % of its final energy demand with hydrogen by 2050.

[2] *At the time of conversion (22 November 2023), 1 USD corresponded to 0.92 EUR*

# Frequently addressed aspects in the strategies

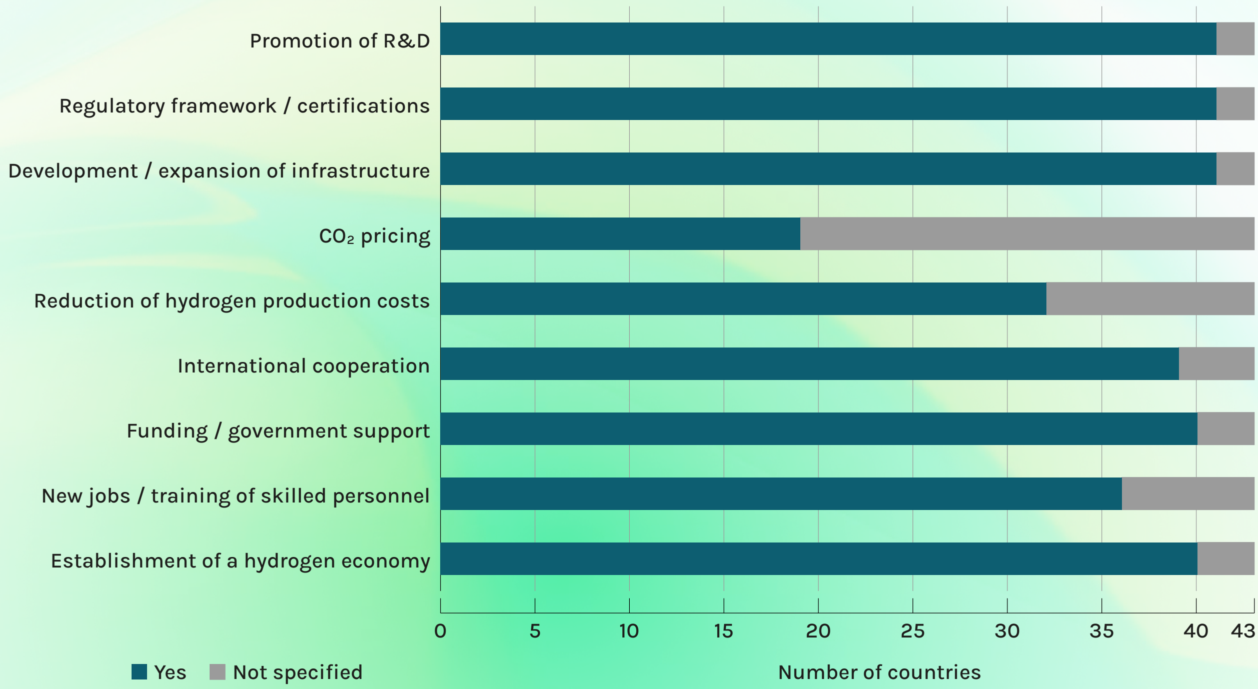
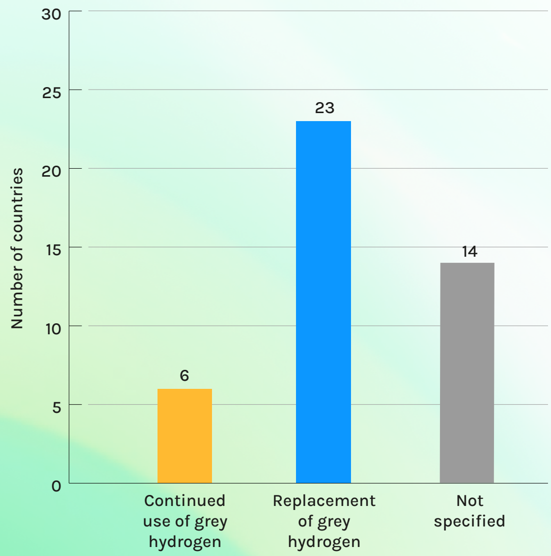



*Figure 4: Overview of various fields of action that play a role in the strategies of the countries (green) or are not explicitly addressed (grey).*

As the general aim is to develop a hydrogen economy (40/43), there is a correspondingly large overlap in the plans presented by the individual countries. However, the details of execution can differ according to local conditions, such as the presence of industrial sectors or raw material deposits. Turkey, for example, is home to more than 70 % of the world's boron deposits. Turkey is correspondingly the only country that mentions boron hydride compounds in its strategy and intends to use sodium borohydride as a hydrogen storage medium for unmanned vehicles, among others. The creation of new jobs is also expected and the need to train skilled workers is emphasised (36/43). 95 % of the studies refer to the provision of state funding (40/43). Another important aspect is the establishment of international cooperation (39/43). This concerns both scientific exchange and the establishment of trade relations.

For a successful ramp-up of the hydrogen economy, many countries are pursuing the goal of reducing production costs (32/43) or achieving cost parity with fossil hydrogen. For the latter, carbon pricing is mentioned as a suitable instrument in around half of the studies (19/43). Most countries see a need for additional action in the development and expansion of infrastructure (41/43). The creation of uniform regulations/certifications (41/43) and the promotion of research and development activities (41/43) are also considered important.

# Use of fossil hydrogen




**HYDROGEN BASED ON FOSSIL FUELS WITHOUT CCS**

Hydrogen production to date has been based primarily on steam reforming or gasification of fossil fuels (natural gas, crude oil, coal) without carbon capture and storage (CCS) or carbon capture and utilisation (CCU). More than half of the strategies (23/43) formulate the need to replace this grey hydrogen. In 14 strategies there is no indication of the future role of grey hydrogen (MAR, SGP, COL, US-CAL, URU, PAR, IRL, HRU, BEL, DNK, SWE, NAM, KEN). Turkey, Russia, South Africa, New Zealand, the United Arab Emirates and the United States of America state that they would continue using grey hydrogen for the time being, given certain prerequisites such as emissions mitigation elsewhere. Turkey, for example, would like to use its lignite coal reserves for hydrogen production.

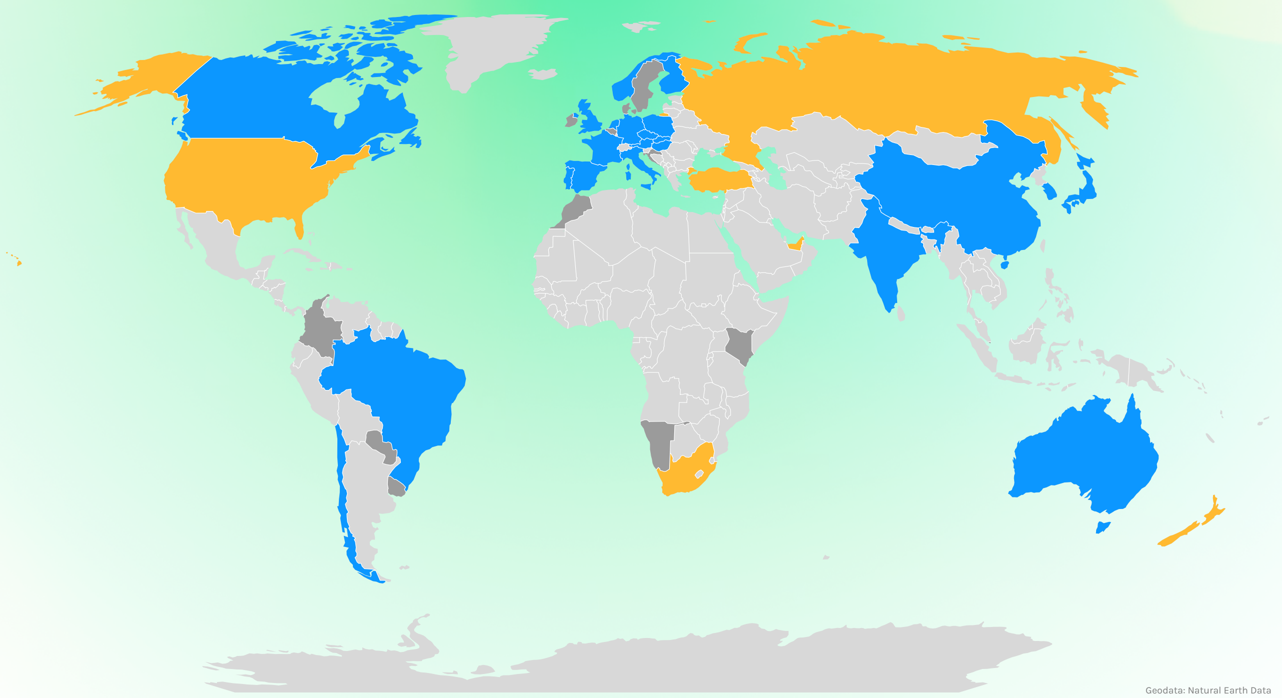
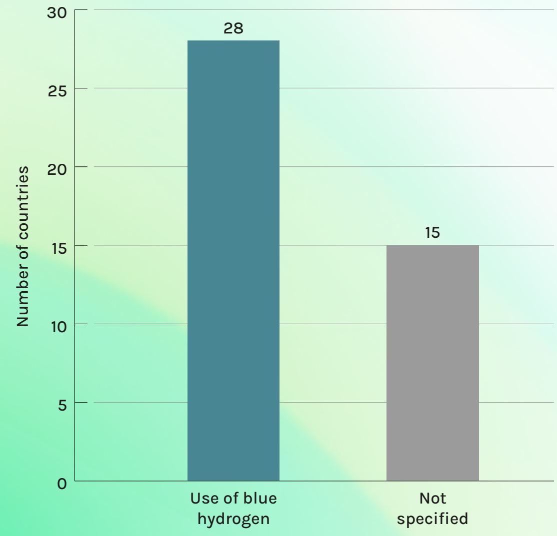



*Figure 5: Overview of countries' positions regarding fossil-based hydrogen: continued use (orange) or replacement with climate-neutral hydrogen (blue).*

**HYDROGEN BASED ON FOSSIL FUELS WITH CCS**

Blue hydrogen is based on the production of hydrogen from fossil resources by capturing and injecting the resulting $CO_2$ (CCS). There are no explicit statements on the use of blue hydrogen in 15 cases. The remaining strategies (28/43) state that they intend to use blue hydrogen. Thirteen of these strategies (AUS, CAN, CZE, EU, GBR, GER, HUN, JPN, KOR, NDL, NOR, NZL, TUR) see it as useful for a limited period of time, as it can enable a (faster) ramp-up of the hydrogen economy. Countries with their own natural gas reserves are also particularly interested in producing blue hydrogen. The Norwegian strategy is the only country strategy to explicitly state the goal of producing blue hydrogen not only for domestic applications, but also for export. In contrast, Finland, for example, has stated that its own production of blue hydrogen is not considered attractive, as Finland has neither suitable natural gas reserves nor geological $CO_2$ storage sites.

When using fossil fuels for hydrogen production, it must be noted that due to the war of aggression against Ukraine, fewer fossil fuels (especially natural gas) are available at low prices, at least in Europe. It is therefore still unclear to what extent natural gas can be used for hydrogen production. Furthermore, it is still not possible to say whether lower levels of natural gas will inhibit the ramp-up of a hydrogen economy or whether this will be compensated for by an accelerated expansion of renewable energies.



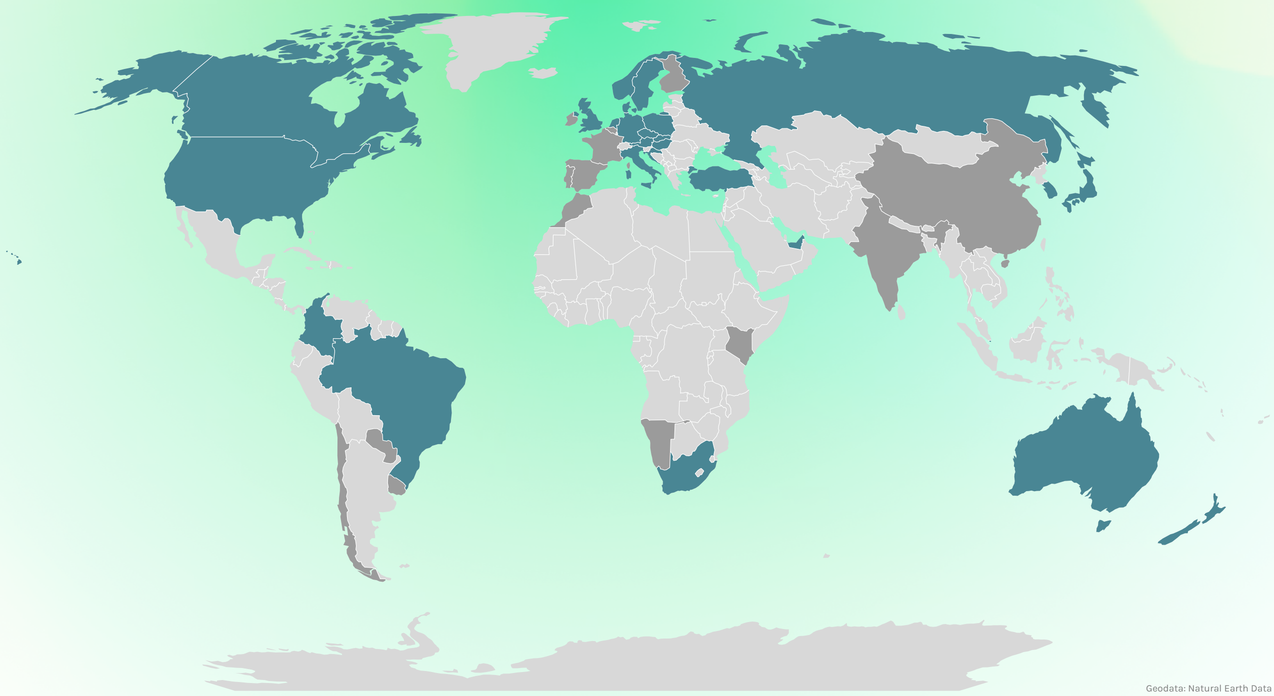
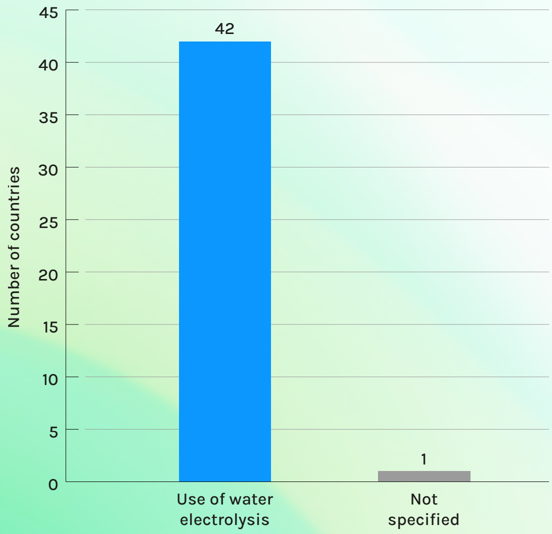




*Figure 6: Countries' positions on fossil-based hydrogen in conjunction with CCS: usage explicitly mentioned (blue) or not (grey).*

# Water electrolysis




**GENERAL APPROVAL**

Almost all the strategies analysed mention that hydrogen production using water electrolysis will play an important role (42/43). Only Singapore makes no statement as to whether water electrolysis should be carried out domestically or if hydrogen produced in this way should be imported. In general, various forms of electricity generation for hydrogen production are discussed.

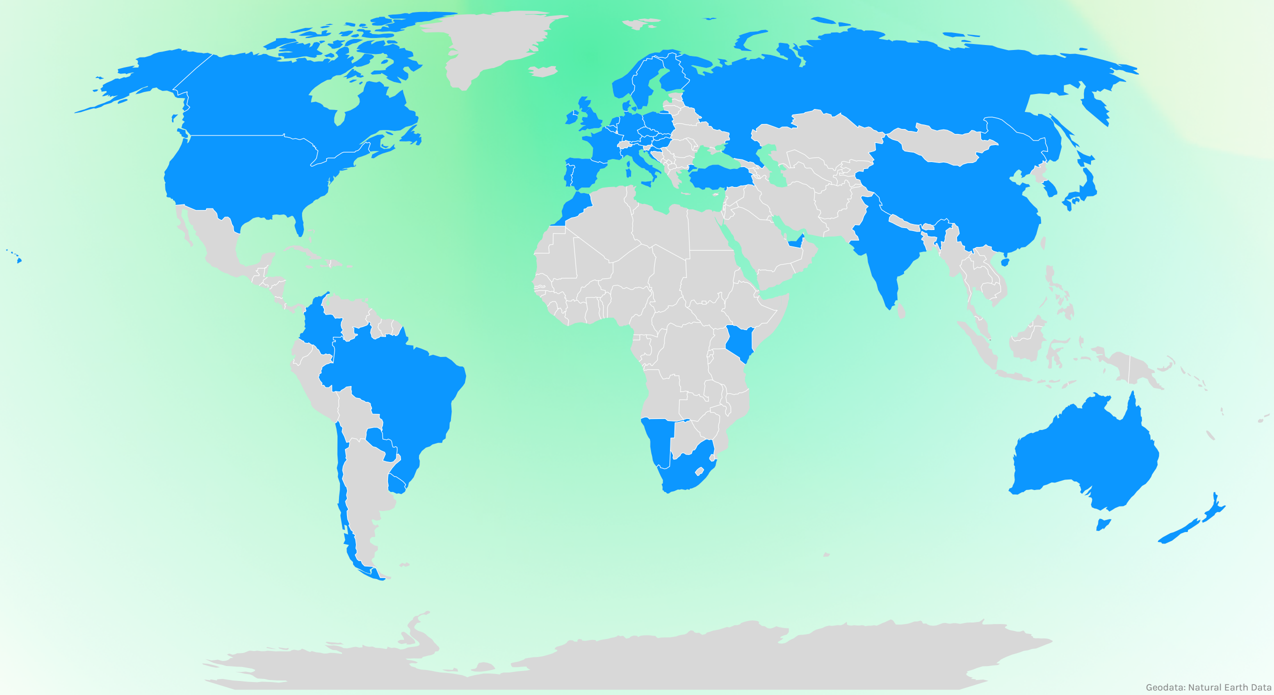
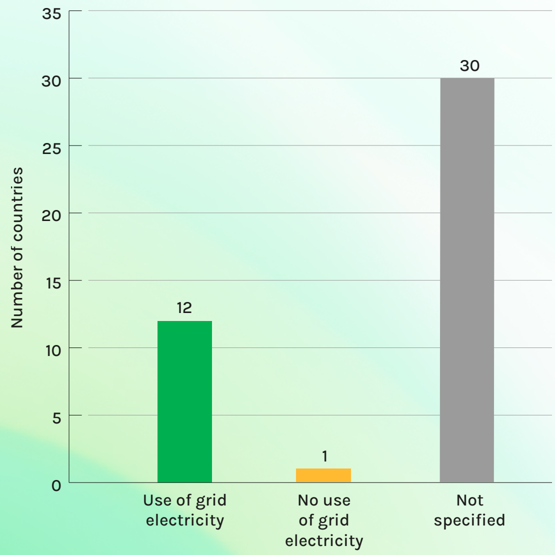



*Figure 7: Countries' positions on hydrogen from water electrolysis.*

**USE OF ELECTRICITY FROM THE GRID**

Electricity for electrolysis could be sourced from a country's power grid. The country-specific electricity mix[3] must be considered, as the type and share of fossil fuels in the mix influences the specific greenhouse gas emissions of the hydrogen produced.

Twelve papers (EU, FRA, HUN, CAN, RUS, MAR, COL, NZL, HRV, DNK, SWE, FIN) discuss the (temporary) use of grid electricity for electrolysis or, in the case of Morocco, are already using it today. Colombia, Croatia and New Zealand state that they only want to use grid electricity if it is climate neutral. The Finnish publication presents the results of a stakeholder survey, according to which the majority of respondents are in favour of using grid electricity if it is "clean". According to Finland's strategy, this includes electricity from renewable energy sources and nuclear power. However, most of the strategies analysed do not comment on the use of grid electricity for water electrolysis (30/43). Only the Czech strategy explicitly excludes grid electricity due to the associated high greenhouse gas emissions.



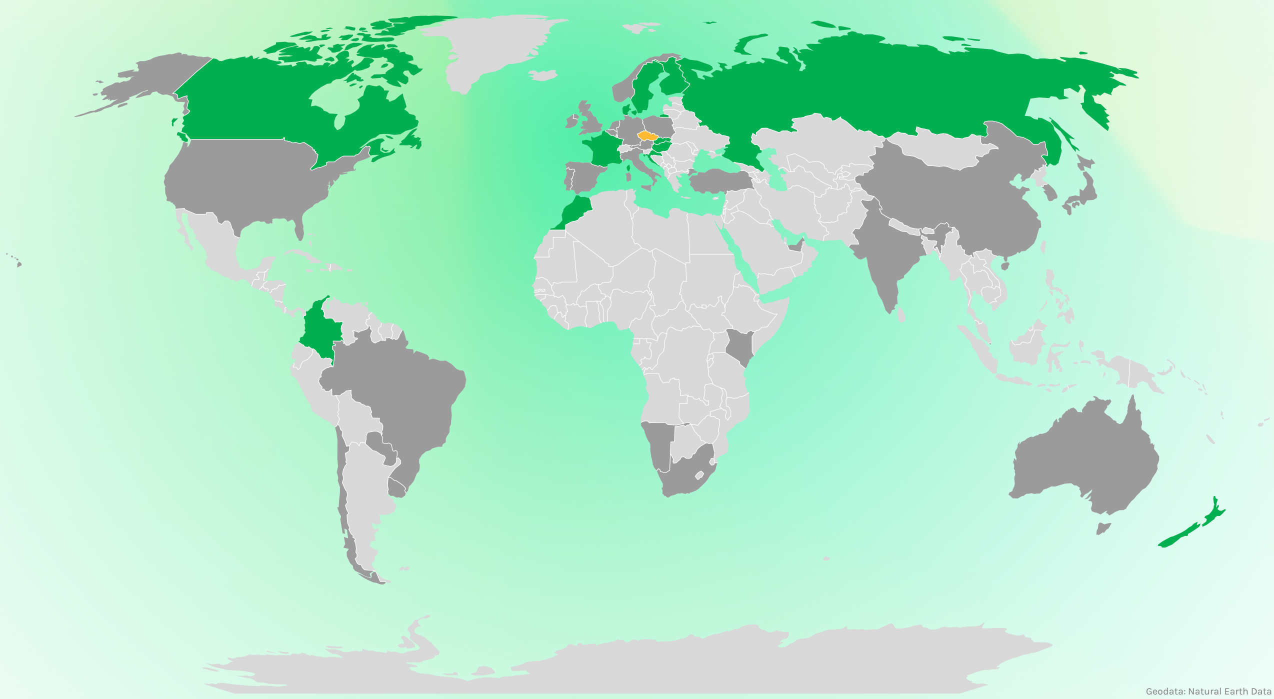
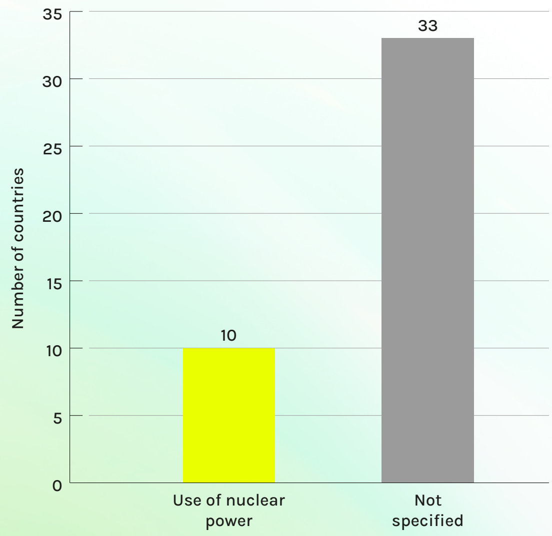




*Figure 8: Countries' positions on grid electricity for hydrogen production: usage (green); no usage (orange); no mention (grey).*

[3] See https://app.electricitymaps.com/map

**USE OF NUCLEAR-GENERATED ELECTRICITY (NUCLEAR POWER)**

The use of electricity from nuclear power to operate the electrolysers is not addressed by most strategies (33/43). In contrast, ten countries (RUS, USA, GBR, BRA, SWE, SVK, TUR, CAN, CZE, HUN) explicitly state that they want to use or are considering using nuclear power, citing the low greenhouse gas emissions associated with its production. The French strategy does not explicitly mention the use of nuclear power either. Instead, this strategy refers to the use of low-carbon French grid electricity, a high proportion of which is of nuclear origin.



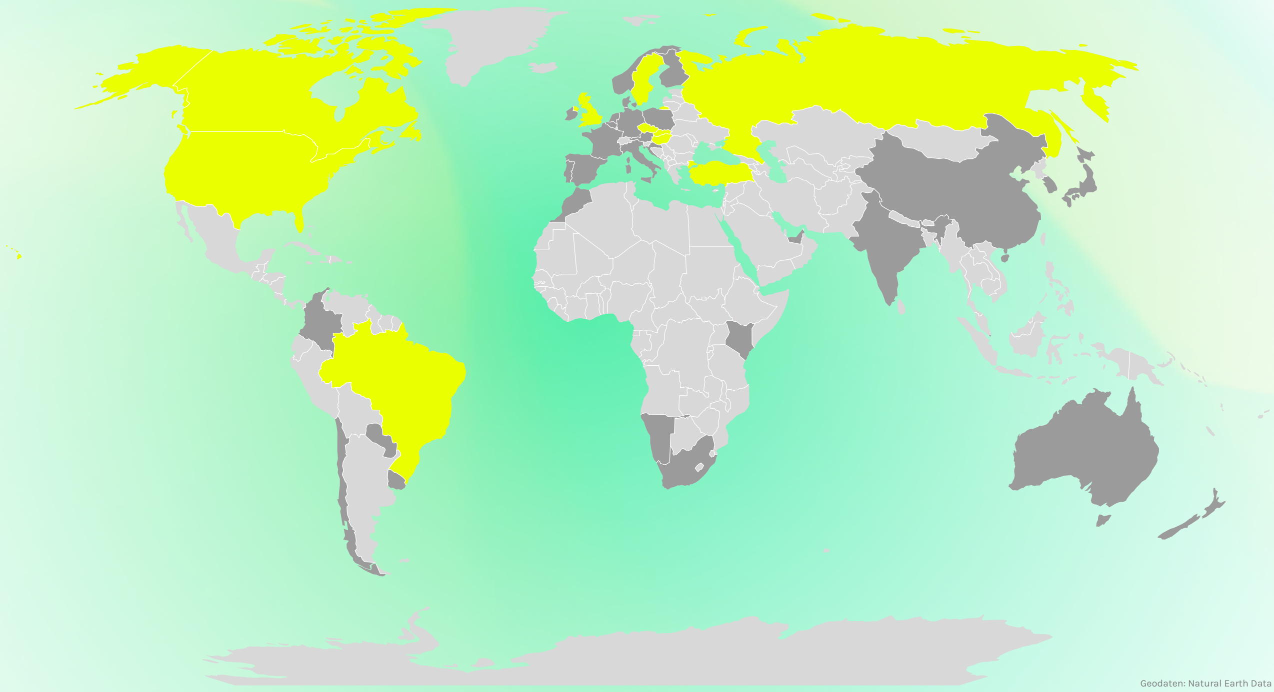
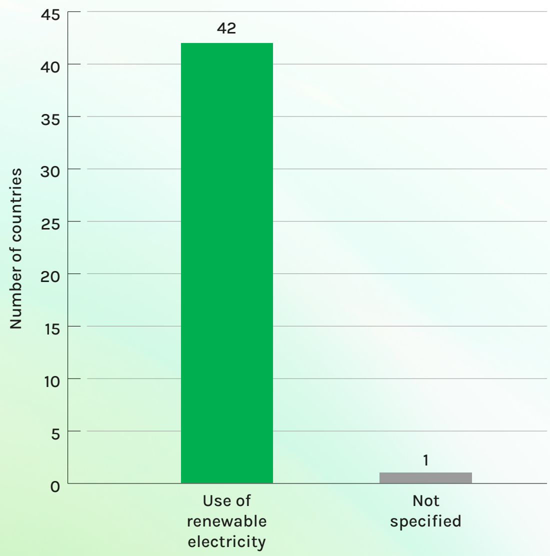




*Figure 9: Countries' positions on electricity from nuclear power for hydrogen production: usage (yellow); no mention (grey).*

**USE OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES**

There is general agreement on the use of renewable electricity as a key option for use in water electrolysis (42/43). However, it is also realistically estimated that a switch to renewable electricity will require a longer transformation process. Canada describes their path to renewables-based electrolysis, including a preceding ramp-up phase, in more detail. During the ramp-up period, the share of renewable energies in the electricity mix is to increase continually.



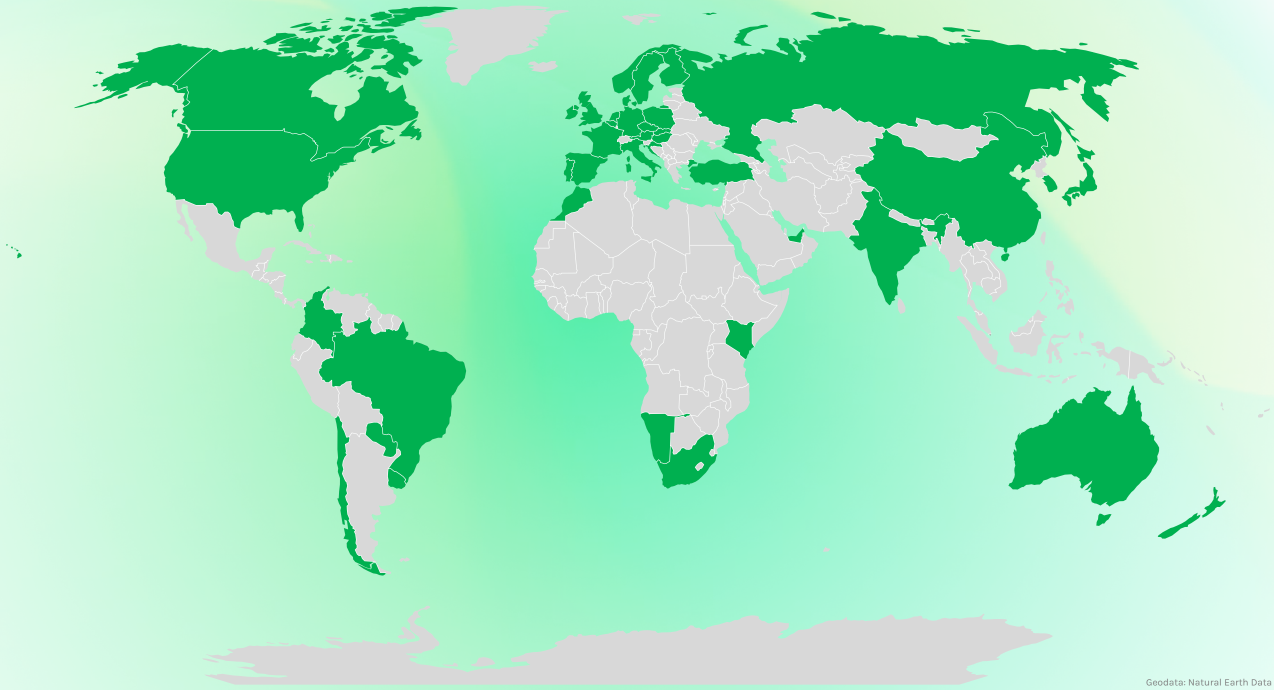




*Figure 10: Countries' positions on producing hydrogen using electricity from renewable energies. .*

# Further options for hydrogen generation/production

Some countries have identified options for producing or extracting hydrogen in addition to the above-mentioned technologies and processes (water electrolysis, steam reforming of natural gas, coal gasification).

For example, the update of the German National Hydrogen Strategy states that the use of hydrogen produced via methane pyrolysis[4], if related emissions remain within greenhouse gas limits, could be promoted as part of the ramp-up of a hydrogen economy.

The use of biomass for hydrogen production[5] is also mentioned in some documents, for example as part of the Austrian or Slovakian strategy. When utilising biomass, fermentation or gasification processes are to be used to produce hydrogen.

(Thermochemical) gasification processes can also be used for (plastic) waste. This approach is mentioned, for example, in the German, Brazilian and US strategies. In addition, the US strategy refers to the use of photoelectrochemical processes[6] for hydrogen production.

Finally, there are also strategies that mention geologically occurring/extractable hydrogen[7] or explicitly aim to search for such deposits. The latter is described in the Moroccan roadmap, for example.

[4] *Also called 'turquoise hydrogen'*

[5] *Also called 'orange hydrogen'*

[6] *Also known as 'artificial photosynthesis'*

[7] *Also called 'white hydrogen'*

# Fields of application

**SELECTED FORM OF PRESENTATION**

Hydrogen can make a significant contribution to the defossilisation of industry, the transport sector and the energy supply.

As part of the country analysis, hydrogen applications are divided into the following categories:

- not explicitly addressed in the country strategy
- categorised as relevant, but with no time horizon specified
- to be implemented in the long term
- to be implemented in the medium term
- to take place in the short term, i.e. in the near future

These categories are based on the time horizons formulated in the country strategies. 'Short term' corresponds to the time period before 2030, 'medium term' to the time from 2030 until 2040 and 'long term' roughly to the period after 2040. However, the papers do not always define clear time horizons, meaning that some applications were categorised more broadly as short to medium term or medium to long term. This classification is summarised in tabular form. If an application was not explicitly mentioned in a strategy, this does not necessarily mean that the application was rejected.

The use of hydrogen was analysed for the transport sector, industry and energy supply. After a general introduction, these three areas are described more specifically.

**GENERAL INTRODUCTION**

The transport, industry and energy sectors are first analysed at an overarching level. The two FCEV strategies of California and China are not included in this general introduction.

All 43 strategies state that hydrogen and/or its derivatives are to be used in transport. In more than half the cases (23/43), usage is already envisaged for the short term. The Czech strategy goes further and explicitly defines the transport sector as a priority for hydrogen. This is due to a prediction that hydrogen will reach cost parity with conventional fuels more quickly.

Many strategies also see the potential to use (renewable) hydrogen for industrial applications. Around 46 % (19/41) state that they intend to already use hydrogen in these areas in the short to medium term. The applications or industries mentioned usually fulfil at least one of the following criteria: They are strongly represented in the respective country or they entail the simple replacement of fossil fuels with low emission or renewable hydrogen in pre-existing uses.

In the case of energy applications, the picture is varied: on the one hand, some strategies (14/41) envisage the use of hydrogen in the short to medium term. On the other hand, there are some countries that only address these applications in the long term or without a defined time scale.

| **Application sector** | **Short-term use** | **Medium-term use** | **Long-term use** | **Application mentioned (no time specified)** | **Not explicitly mentioned** |
|---|---|---|---|---|---|
| **Transport** | Australia, Chile, China, Denmark, Germany (2023), EU, Finland, United Kingdom, Ireland, Italy, Japan, California, Canada, Netherlands, Poland, Singapore, Slovakia, South Korea, Czechia, Türkiye, Hungary, Uruguay, United States of America<br><br>**23/43** | Germany (2020), India, Kenya, Austria, Spain<br><br>**5/43** | France, Morocco<br><br>**2/43** | Belgium, Brazil, Colombia, Croatia, Namibia, New Zealand, Norway, Paraguay, Portugal, Russia, Scotland, Sweden, South Africa, United Arab Emirates<br><br>**14/43** | |
| **Industry** | Australia, Chile, Denmark, Germany (2020), Germany (2023), EU, Finland, India, Italy, Canada, Morocco, Netherlands, Spain, Czechia, Türkiye, Hungary, United States of America<br><br>**16/41** | Japan, Kenya, UK<br><br>**3/41** | France<br><br>**1/41** | Belgium, Brazil, Colombia, Croatia, Namibia, New Zealand, Norway, Austria, Paraguay, Poland, Portugal, Russia, Scotland, Sweden, Singapore, Slovakia, South Africa, Uruguay, United Arab Emirates<br><br>**19/41** | Ireland, South Korea<br><br>**2/41** |
| **Energy** | Australia, Denmark, Germany (2023), United Kingdom, India, South Korea, Czechia, Hungary, United States of America<br><br>**9/41** | EU, Finland, Japan, Canada, Kenya<br><br>**5/41** | Germany (2020), Italy, Morocco, Netherlands, Singapore, Spain<br><br>**5/41** | Belgium, Brazil, Ireland, Colombia, Croatia, Namibia, New Zealand, Norway, Austria, Paraguay, Poland, Portugal, Russia, Scotland, Slovakia, South Africa, Türkiye, Uruguay, United Arab Emirates<br><br>**19/41** | Chile, France, Sweden<br><br>**3/41** |

*Table 1: Overarching analysis for various sectors.*

Specific fields of application within these three areas are described below.

**TRANSPORT SECTOR**

The use of hydrogen in the transport sector is discussed differently in the strategies analysed, for example in relation to fuel cell vehicles. Here there are major differences in the country strategies. On the one hand, 18 strategies do not explicitly address the use of hydrogen in passenger cars. On the other hand, nine strategies (CHN, NLD, KOR, USA, US-CAL, JPN, CAN, SVK, TUR) envisage a short-term rollout of fuel cell cars.

Hydrogen applications in (heavy) goods transport are seen in 19 strategies in the short to medium term, which implies strong potential for the option. The use of hydrogen for vehicles in fleet networks (e.g. taxis and buses) is also seen as very relevant in some documents. For example, 17 strategies classify the use of hydrogen in fleet networks as relevant in the short to medium term, for example, due to the possibility of efficient utilisation of local supply infrastructures.

| Application sector | Short-term use | Medium-term use | Long-term use | Application mentioned (no time specified) | Not explicitly mentioned |
|---|---|---|---|---|---|
| **Passenger cars** | China, Japan, California, Canada, Netherlands, Slovakia, South Korea, Türkiye, United States of America<br><br>**9/43** | Denmark<br><br>**1/43** | Italy<br><br>**1/43** | Australia, Belgium, Ireland, Colombia, Croatia, New Zealand, Austria, Paraguay, Portugal, Russia, Scotland, Sweden, Singapore, Czechia<br><br>**14/43** | Brazil, Chile, Germany (2020), Germany (2023), EU, Finland, France, United Kingdom, India, Kenya, Morocco, Namibia, Norway, Poland, Spain, South Africa, Hungary, Uruguay, United Arab Emirates<br><br>**18/43** |
| **Trucks** | Australia, Chile, Germany (2023), EU, Finland, United Kingdom, Italy, Netherlands, Slovakia, South Korea, Czechia, Hungary, Uruguay<br><br>**13/43** | Denmark, Germany (2020), India, Canada, Kenya, Spain, United States of America<br><br>**6/43** | Morocco<br><br>**1/43** | Belgium, Brazil, France, Ireland, Japan, California, Colombia, Croatia, Namibia, New Zealand, Norway, Austria, Paraguay, Portugal, Scotland, Sweden, South Africa, Türkiye, United Arab Emirates<br><br>**19/43** | China, Poland, Russia, Singapore<br><br>**4/43** |
| **Buses/ Taxis** | Australia, Chile, China, Denmark, EU, United Kingdom, Ireland, Japan, Poland, South Korea, Czechia, Hungary, Uruguay, United States of America<br><br>**14/43** | California, Canada, Spain<br><br>**3/43** | Morocco<br><br>**1/43** | Germany (2020), France, India, Italy, Colombia, Croatia, New Zealand, Austria, Portugal, Russia, Scotland, Sweden, Slovakia, South Africa<br><br>**13/43** | Belgium, Brazil, Germany (2023), Finland, Kenya, Namibia, Netherlands, Norway, Paraguay, Singapore, Türkiye, United Arab Emirates<br><br>**12/43** |

| Application sector | Short-term use | Medium-term use | Long-term use | Application mentioned (no time specified) | Not explicitly mentioned |
|---|---|---|---|---|---|
| **Rail transport** | Australia, Italy, Slovakia, United States of America<br><br>**4/43** | EU, United Kingdom, Canada, Austria, Spain, South Korea, Czechia, Türkiye, Hungary<br><br>**9/43** | | Belgium, Brazil, Denmark, Germany (2020), Germany (2023), France, Ireland, Japan, Croatia, Namibia, New Zealand, Norway, Poland, Scotland, Sweden, South Africa<br><br>**15/43** | Chile, China, Finland, India, California, Kenya, Colombia, Morocco, Nether-lands, Paraguay, Portugal, Russia, Singapore, Uruguay, United Arab Emirates<br><br>**15/43** |
| **Maritime transport** | Australia, Germany (2023), Singapore, Uruguay<br><br>**4/43** | Denmark, United Kingdom, Japan, Canada, Kenya, Spain, South Korea, Hungary, United States of America<br><br>**9/43** | Chile, Germany (2020), EU, France, India, Italy, Türkiye<br><br>**6/43** | Belgium, Brazil, Finland, Ireland, Colombia, Croatia, Namibia, New Zealand, Nether-lands, Norway, Austria, Paraguay, Poland, Scotland, Sweden, Slovakia, United Arab Emirates<br><br>**17/43** | China, California, Morocco, Portugal, Russia, South Africa, Czechia<br><br>**7/43** |
| **Air transport** | Germany (2023), Singapore<br><br>**2/43** | Denmark, United Kingdom, Netherlands, Spain, Uruguay, United States of America<br><br>**6/43** | Chile, Germany (2020), EU, France, India, Italy, Morocco, Türkiye<br><br>**7/43** | Belgium, Brazil, Finland, Ireland, Kenya, Colombia, Croatia, Namibia, New Zealand, Norway, Austria, Paraguay, Poland, Portugal, Scotland, Sweden, Slovakia, South Africa, United Arab Emirates<br><br>**19/43** | Australia, China, Japan, California, Canada, Russia, South Korea, Czechia, Hungary<br><br>**9/43** |

*Table 2: Application-specific evaluation for the transport sector.*

In rail transport, the use of hydrogen is seen as relevant in the medium to short term in 13 cases. It should be noted here that the use of hydrogen is not usually seen across the board, but rather on routes that are difficult or impossible to electrify.

Likewise, 13 countries define the use of hydrogen in shipping on a short to medium-term basis. The Norwegian strategy very specifically describes and promotes the use of hydrogen in maritime transport, for example to power ferries.

In the field of air transport, Singapore assumes that hydrogen will be used in the short term. The update of the German hydrogen strategy also refers to quotas for power-to-liquid kerosene, meaning that higher hydrogen requirements may arise here in the near future. However, most strategies (19/43) do not mention the use of hydrogen in aviation, which may be because they were published before binding quotas were agreed upon, as is the case with the European strategies.

Based on the 'ReFuelEU aviation'[8] initiative, the EU adopted a new legal act on the decarbonisation of aviation in October 2023, in which it defined minimum quotas for the use of sustainable and synthetic kerosene. The minimum quotas for sustainable aviation fuels are 2 % from 2025, 6 % from 2030 and 70 % from 2050. The proportion of synthetic fuels must be 1.2 % from 2030 and increased to 35 % by 2050.

Not listed above are examples of applications that are only mentioned sporadically and/or without time frames, for example the use of synthetic fuels (15/43) or the use of hydrogen in commercial vehicles such as forklift trucks (6/43), mining vehicles (3/43), agricultural machinery (6/43) or military vehicles (4/43). For a complete list, please refer to the fact sheets in the appendix.

[8] *European Council. (9 October 2023). RefuelEU Aviation initiative: Council adopts new legal act to decarbonize the aviation sector [Press release]. Retrieved [05-12-2023], from* [https://www.consilium.europa.eu/de/press/press-releases/2023/10/09/refueleu-aviation-initiative-council-adopts-new-law-to-decarbonise-the-aviation-sector/]

| | SynFuels | Forklifts | Mining | Agricultural machinery | Military |
|---|---|---|---|---|---|
| **AUS** | | | X | | |
| **AUT** | X | | | | |
| **CAN** | | X | | | |
| **CHL** | X | | X | | |
| **DNK** | X | | | | X |
| **EU** | X | | | | |
| **FIN** | X | | | | |
| **GER** | X | | | | X |
| **HRV** | | | | X | |
| **IND** | X | | | | |
| **ITA** | X | | | | |
| **JPN** | | X | | | |
| **KEN** | | | | X | |
| **MAR** | X | | | | |
| **NLD** | X | | | X | |
| **NOR** | | | | | X |
| **NZL** | | X | | | |
| **POR** | X | | | | |
| **PRY** | X | | | | |
| **SGP** | X | | | | |
| **SVK** | X | X | | | |
| **SWE** | | | | X | |
| **TUR** | | X | | | X |
| **URY** | X | | | X | |
| **USA** | | X | X | X | |

*Table 3: Alternative application examples for the transport sector.*

**INDUSTRIAL APPLICATIONS**

Many strategies also see a high potential for reducing greenhouse gas emissions via the use of climate-neutral hydrogen in various industrial sectors. It is often emphasised that the chemical industry or refineries, for example, are potential customers for hydrogen, as they already have the necessary infrastructure, know-how and a high demand for hydrogen.

| Application | Short-term application | Medium-term use | Long-term use | Application mentioned (no time specified) | Not explicitly mentioned |
|---|---|---|---|---|---|
| **Chemical Industry** | Australia, Chile, Germany (2020), Germany (2023), EU, India, Italy, Morocco, Netherlands, Spain, Czechia, Türkiye, Hungary, United States of America<br><br>**13/41** | United Kingdom, Canada<br><br>**2/41** | France<br><br>**1/41** | Belgium, Brazil, Denmark, Finland, Kenya, Colombia, Croatia, Namibia, New Zealand, Norway, Austria, Paraguay, Poland, Portugal, Russia, Scotland, Sweden, Singapore, Slovakia, South Africa, United Arab Emirates<br><br>**21/41** | Ireland, Japan, South Korea, Uruguay<br><br>**4/41** |
| **Refineries** | Chile, Denmark, Germany (2020), Germany (2023), EU, India, Italy, Canada, Netherlands, Spain, Czechia, Hungary, United States of America<br><br>**12/41** | Japan<br><br>**1/41** | Morocco<br><br>**1/41** | Australia, Belgium, Finland, France, United Kingdom, Colombia, Croatia, Namibia, New Zealand, Norway, Poland, Portugal, Russia, Scotland, Slovakia, South Africa, Türkiye, Uruguay, United Arab Emirates<br><br>**19/41** | Brazil, Ireland, Kenya, Austria, Paraguay, Sweden, Singapore, South Korea<br><br>**8/41** |
| **Steel** | Germany (2020), Germany (2023), EU, Finland, India, Czechia, Türkiye<br><br>**6/41** | United Kingdom, Japan, Kenya, Hungary, United States of America<br><br>**5/41** | Canada<br><br>**1/41** | Australia, Belgium, Brazil, Italy, Colombia, Namibia, New Zealand, Norway, Austria, Poland, Portugal, Russia, Scotland, Sweden, Singapore, Slovakia, South Africa, Uruguay, United Arab Emirates<br><br>**19/41** | Chile, Denmark, France, Ireland, Croatia, Morocco, Netherlands, Paraguay, Spain, South Korea<br><br>**10/41** |

*Table 4: Sector-specific analysis for selected industries.*

In the chemical industry, a short to medium-term use of hydrogen is seen in 15 cases, primarily for ammonia, fertiliser and methanol production; these are already the most important areas of application for hydrogen in the chemical industry today. Only six strategies do not explicitly address the chemical industry.

Refineries also already have a high demand for hydrogen, for example, for purification processes such as desulphurisation. Here, 13 strategies mention short to medium-term use of hydrogen, for instance in order for refineries to provide or process renewable/sustainable energy carriers. In contrast, eight strategies do not explicitly mention the use of hydrogen in refinery processes. The use of hydrogen in steel production is of central importance. Eleven countries mention its use in the switch from the existing blast furnace process to direct iron reduction in the short to medium term. Again, this use is not explicitly mentioned in some strategies (ten). A possible reason for such omissions is the lack of primary steel production on a relevant scale in the respective country.

There are also other industrial sectors that are less in focus. These include the glass industry (5/41), the cement industry (11/41), the food industry (5/41) and mining (4/41). A complete list can be found in the appendix.

| | Glass | Cement | Food | Mining |
|---|---|---|---|---|
| ARE | | X | | |
| AUT | X | X | | |
| BEL | X | X | | |
| BRA | | | | X |
| CAN | | | | X |
| CHL | | | | X |
| COL | X | | X | |
| FIN | X | | X | |
| HRV | | X | | |
| HUN | | X | | |
| IND | | | X | |
| ITA | | X | | |
| PRY | | | X | |
| SGP | | X | | |
| SVK | | X | | |
| TUR | X | X | | |
| USA | | X | | |
| ZAF | | X | | X |

*Table 5: Further application examples in the industrial sector.*

**POWER SYSTEM**

The use of hydrogen for heat or electricity generation was only named as a short to medium-term measure in a few cases, mainly in European and Anglo-Saxon countries. This is due to a multitude of unresolved issues e.g. regarding the necessary infrastructure.

| Application | Short-term application | Medium-term use | Long-term use | Application mentioned (no time specified) | Not explicitly mentioned |
|---|---|---|---|---|---|
| **(High-temperature) process heat** | Denmark, Germany (2023), India<br><br>**3/41** | United Kingdom, Czechia, United States of America<br><br>**3/41** | Germany (2020), Italy, Morocco, Spain<br><br>**3/41** | Australia, Belgium, Finland, Ireland, Japan, Colombia, Croatia, Namibia, New Zealand, Netherlands, Norway, Austria, Paraguay, Scotland, Singapore, Slovakia, South Africa, Türkiye, Uruguay<br><br>**19/41** | Brazil, Chile, EU, France, Canada, Kenya, Poland, Portugal, Russia, Sweden, South Korea, Hungary, United Arab Emirates<br><br>**13/41** |
| **Building heating** | Australia, Denmark, United Kingdom, South Korea<br><br>**4/41** | Germany (2023), Japan, Canada, Czechia, United States of America<br><br>**5/41** | Germany (2020), Italy, Morocco, Netherlands, Spain<br><br>**4/41** | Belgium, EU, Finland, India, Ireland, Colombia, Croatia, New Zealand, Austria, Russia, Scotland, Slovakia, South Africa, Türkiye<br><br>**14/41** | Brazil, Chile, France, Kenya, Namibia, Norway, Paraguay, Poland, Portugal, Sweden, Singapore, Hungary, Uruguay, United Arab Emirates<br><br>**14/41** |
| **Electricity/ Energy storage** | Germany (2023), United Kingdom, Hungary, United States of America<br><br>**4/40** | EU, Finland, Canada, Kenya<br><br>**4/40** | Germany (2020), India, Italy, Japan, Singapore, Spain<br><br>**5/40** | Australia, Belgium, Brazil, Denmark, Ireland, Colombia, Croatia, Namibia, New Zealand, Netherlands, Austria, Paraguay, Poland, Portugal, Russia, Scotland, Slovakia, South Africa, Türkiye, Uruguay, United Arab Emirates<br><br>**21/40** | Chile, France, Morocco, Sweden, South Korea, Czechia<br><br>**6/40** |

*Table 6: Application-specific evaluation of use in the energy sector.*

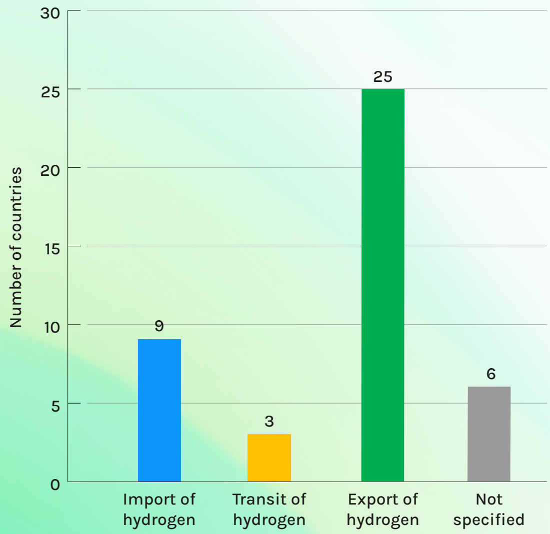
The provision of (high temperature) heat for industrial processes using hydrogen or hydrogen downstream products is discussed as a short to medium-term option only in six cases. Most strategies do not mention a timeframe for this area of application (19/41) and 13 of 41 strategies do not explicitly mention it at all.

Nine strategies envisage the short to medium term use of hydrogen in building heating. Examples of suitable technology options are fuel cells or boiler for hydrogen or synthetic natural gas.

The use of hydrogen or hydrogen downstream products for storing electrical energy and thus to compensate for fluctuations in a renewables-based electricity supply is discussed often. The use of power plants based on hydrogen or its downstream products is also addressed. This is described in eight strategies on a short to medium-term time scale. On the other hand, the use of hydrogen for these fields of application is not explicitly addressed in six strategies. Norway is a special case. Here, no need is seen for the use of hydrogen to store electrical energy, as reference is made to domestic capacities for storage using hydropower.

# Import and export of hydrogen

To supply the abovementioned applications with low-emission or emission-free hydrogen, renewable energy capacities must be expanded worldwide. At the same time, hydrogen production capacities must also increase. Due to different local conditions, there is varying potential to produce hydrogen. This influences a country's ambitions to act as an importer, exporter or transit country for hydrogen and its downstream products.



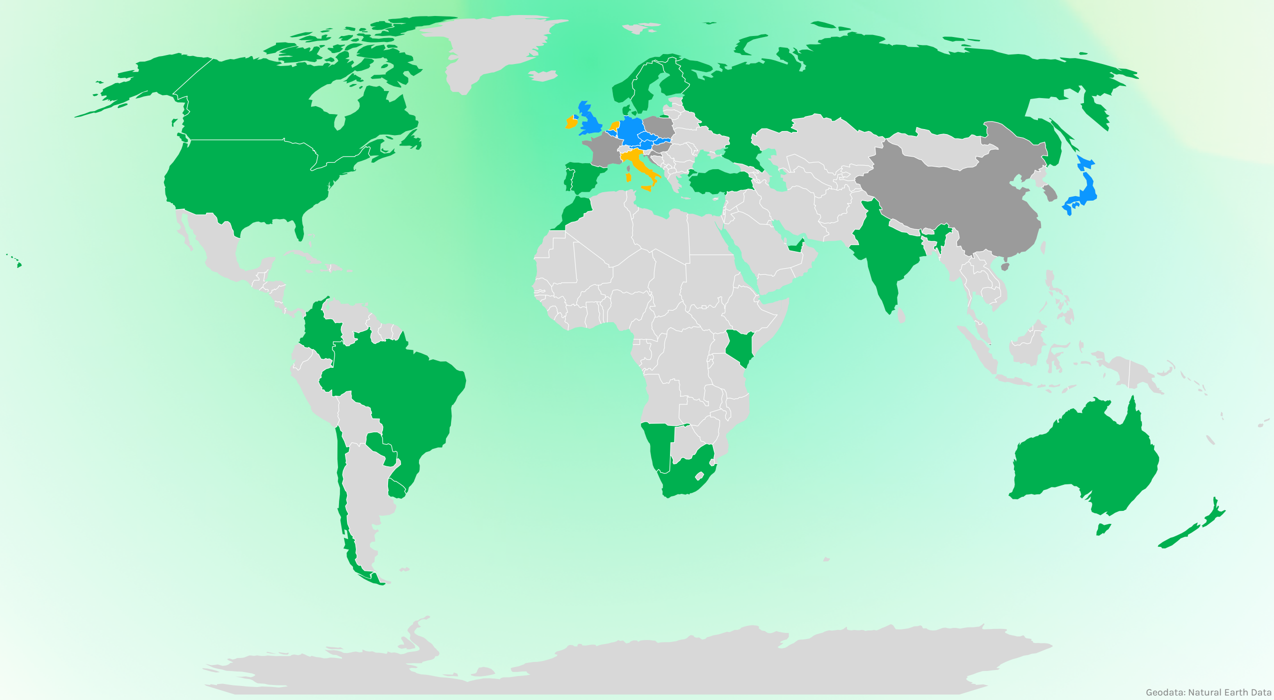




*Figure 11: Countries' positions on exporting, importing or acting as a transit point for hydrogen.*

Nations with favourable conditions for renewable energy production and thus also renewable hydrogen have often expressed a desire to export hydrogen. Due to the high potential for photovoltaics and/or wind power, countries such as Chile, Spain, Portugal and Morocco intend to export hydrogen. In addition, some countries wish to position themselves as exporters of hydrogen based on fossil fuels (AUS, CAN, NOR). A total of 25 countries have formulated the ambition to export the hydrogen they produce themselves. Uruguay, for example, has declared it has identified profit opportunities worth 93 million dollars and 1.3 billion dollars for 2030 and 2040 respectively. The Netherlands, Italy and Ireland play a special role as potential transit countries. They aim to position themselves by importing hydrogen and then distributing it to other European countries, in addition to meeting their own needs.

Table 7 lists exporting nations (including transit countries) and the export goods named. 24 countries explicitly mention the export or forwarding of hydrogen. Only Namibia states that it intends to rely solely on hydrogen derivatives or hydrogen-based products due to their lower transportation costs.

A total of 17 countries indicated their intention to export hydrogen derivatives. Ammonia was mentioned most frequently (14×) and in some cases reference was made to existing logistics structures. Methanol (7×) as well as synthetic fuels such as kerosene (6×) are also attractive cases. The export of methane was only mentioned once. In addition to hydrogen and its derivatives, hydrogen-based products such as iron/steel (3×) or plastics (1×) were also named as potential export goods. In addition, some countries intend to use their technological expertise (7×) to export (components for) fuel cells, electrolysers and more. Not shown in Table 7 is an additional good that Paraguay lists for export: oxygen.

| **Country** | **Addressed export goods** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Hydrogen derivatives** | | | | **Others** | | |
| | **Hydrogen** | **Ammonia/ Fertiliser** | **Methanol** | **SynFuels (e.g. kerosene)** | **Methane** | **Iron / Steel** | **Plastics** | **Power-to-X Technologies** |
| **ARE** | **X** | | | | | | | |
| **AUS** | **X** | **X** | | | | | | |
| **BRA** | **X** | **X** | **X** | | | | | |
| **CAN** | **X** | | | | | | | **X** |
| **CHL** | **X** | **X** | **X** | **X** | | | | |
| **COL** | **X** | **X** | | | | | | |
| **DNK** | **X** | | | **X** | | | | **X** |
| **ESP** | **X** | | | | | | | |
| **FIN** | **X** | | | **X** | | | | |
| **GB-SCT** | **X** | **not specified** | | | | | | |
| **HRV** | **X** | | | | | | | |

| **Country** | **Addressed export goods** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Hydrogen** | **Hydrogen derivatives** | | | | **Others** | | |
| | | **Ammo-nia/ Fertiliser** | **Methanol** | **SynFuels (e.g. ker-osene)** | **Methane** | **Iron / Steel** | **Plastics** | **Power-to-X Tech-nologies** |
| **IND** | **X** | **X** | | | | **X** | | |
| **IRL** | **X** | **X** | **X** | **X** | | | **X** | |
| **ITA** | **X** | | | | | | | |
| **KEN** | | **not specified** | | | | | | |
| **MAR** | **X** | **X** | | | **X** | | | |
| **NAM** | | **X** | **X** | **X** | | **X** | | |
| **NLD** | **X** | | | | | | | |
| **NOR** | **X** | | | | | | | **X** |
| **NZL** | **X** | **X** | **X** | | | | | |
| **PRT** | **X** | | | | | | | **X** |
| **PRY** | **X** | **X** | **X** | | | | | |
| **RUS** | **X** | | | | | | | **X** |
| **SWE** | | | | | | **X** | | **X** |
| **TUR** | **X** | **X** | | | | | | **X** |
| **URY** | **X** | **X** | | **X** | | | | |
| **USA** | **X** | **X** | **X** | | | | | |
| **ZAF** | **X** | **X** | | | | | | |

*Table 7: Overview of named export goods related to hydrogen.*

In contrast, nine countries/regions state that they will be dependent on hydrogen imports to develop a hydrogen economy (GER, EU, CZE, GBR, JPN, SGP, AUT, BEL, SVK). This is because their own local conditions are inadequate for achieving a self-sufficient supply of hydrogen or hydrogen derivatives. The type of import is not restricted here. Usually only the various existing options are named, for example pipeline transport, import of derivatives such as ammonia or hydrogen transport with LOHC (liquid organic hydrogen carriers).

In the remaining six strategies, it was not explicitly stated whether hydrogen should be exported or whether a need for hydrogen imports is seen.

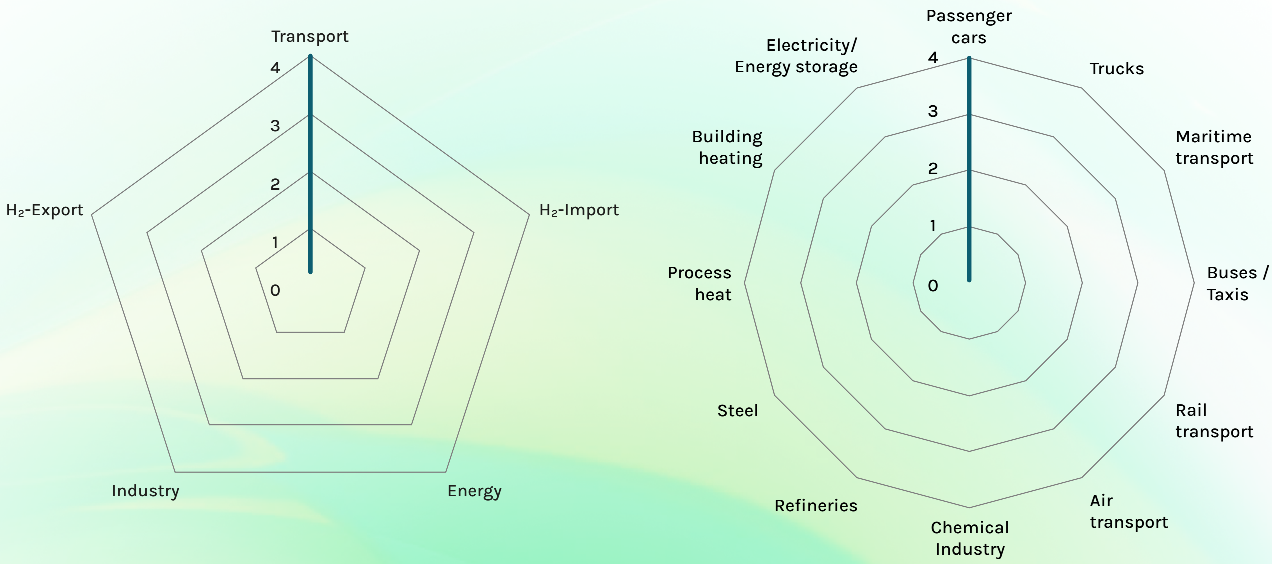
# Appendix

1. United Arab Emirates (ARE), Hydrogen: From Hype to Reality, 2021
2. Australia (AUS), Australia's National Hydrogen Strategy, 11/2019
3. Austria (AUT), Wasserstoffstrategie für Österreich, 06/2022
4. Belgium (BEL), Vision and strategy, Hydrogen, Update October 2022, 10/2022
5. Brazil (BRA), Programa Nacional do Hidrogênio, 07/2021
6. Canada (CAN), Hydrogen Strategy for Canada, 12/2020
7. Chile (CHL), National Green Hydrogen Strategy, 09/2020
8. China (CHN), Fuel Cell Vehicle Roadmap, 11/2017
9. Colombia (COL), Colombia's Hydrogen Roadmap, 09/2021
10. Czechia (CZE), The Czech Republic's Hydrogen Strategy, 09/2021
11. Denmark (DNK), The Government's Strategy for Power-to-X, 12/2021
12. Spain (ESP), Hoja de Ruta del Hidrogeno, 10/2020
13. European Union (EU), A Hydrogen Strategy for a Climate-Neutral Europe, 07/2020
14. Finland (FIN), Hydrogen economy – Opportunities and limitations, 05/2022
15. France (FRA), Stratégie nationale pour le développement de l'hydrogène décarboné en France, 09/2020
16. United Kingdom (GBR), UK Hydrogen Strategy, 08/2021
17. Scotland (GB-SCT), Hydrogen Action Plan, 12/2022
18. Germany (GER), Die Nationale Wasserstoffstrategie, 06/2020 & Fortschreibung der Nationalen Wasserstoffstrategie, 07/2023
19. Croatia (HRV), Hydrogen Strategy of the Republic of Croatia until 2050, 03/2022
20. Hungary (HUN), Hungary's National Hydrogen Strategy, 05/2021
21. India (IND), Harnessing Green Hydrogen, 06/2022
22. Ireland (IRL), Consultation on Developing a Hydrogen Strategy for Ireland, 07/2022
23. Italy (ITA), Strategia Nazionale Idrogeno Linee Guida Preliminari, 11/2020
24. Japan (JPN), Basic Hydrogen Strategy, 12/2017
25. Kenya (KEN), Green Hydrogen Strategy and Roadmap for Kenya, 09/2023
26. South Korea (KOR), Hydrogen Economy Roadmap of Korea, 01/2019
27. Morocco (MAR), Feuille de Route Hydrogène Vert, 08/2021
28. Namibia (NAM), Namibia. Green Hydrogen and Derivatives Strategy, 11/2022
29. Netherlands (NLD), Government Strategy on Hydrogen, 04/2020
30. Norway (NOR), The Norwegian Government's Hydrogen Strategy, 06/2020
31. New Zealand (NZL), A Vision for Hydrogen in New Zealand, 09/2019
32. Poland (POL), Polish Hydrogen Strategy, 05/2021
33. Portugal (PRT), Portugal National Hydrogen Strategy, 08/2020
34. Paraguay (PRY), Towards the Green Hydrogen Roadmap in Paraguay, 06/2021
35. Russia (RUS), Development of Hydrogen Energy in the Russian Federation, 08/2021

36. Singapore (SGP), Singapore's National Hydrogen Strategy, 10/2022
37. Slovakia (SVK), National Hydrogen Strategy: Ready for the Future, 06/2021
38. Sweden (SWE), Strategy for fossil free competitiveness, 01/2021
39. Türkiye (TUR), Türkiye Hidrojen Teknolojileri Stratejisi Ve Yol Haritası, 01/2023
40. Uruguay (URY), Green Hydrogen Roadmap in Uruguay, 06/2022
41. United States of America (USA), U.S. National Clean Hydrogen Strategy and Roadmap, 06/2023
42. California (US-CAL), The California Fuel Cell Revolution, 07/2018
43. South Africa (ZAF), Hydrogen Society Roadmap for South Africa 2021, 2021

## MODE OF PRESENTATION

We employ a radar chart to compare the hydrogen applications addressed by the different countries and their prioritisation:




4 = application should take place in the short term, i.e. promptly

3 = application should take place in the medium term

2 = application is seen on a long-term basis

1 = application was classified as relevant, but no time horizon was specified

0 = application was not explicitly addressed in the strategy

*Figure 11: Example of results visualised as radar charts..*

The applications are divided into the following time categories (0–4):

0 = an application was not explicitly addressed in the strategy
1 = an application was classified as relevant, but no time horizon was specified
2 = an application is seen on a long-term basis
3 = an application is to take place in the medium term
4 = an application should take place in the short term, i.e. promptly

The time categories are based on the time horizons formulated in the country strategies. The classification 'short-term' ('s.t.') corresponds to the time period before 2030, 'medium-term' ('m.t.') to the time period from 2030 until 2040 and 'long-term' ('l.t.') roughly to the period after 2040. However, the papers do not always define clear time horizons, so applications were sometimes classified on a short to medium-term basis (3.5) or medium to long-term basis (2.5). This classification is presented in the form of radar charts to show where and whenindividual countries plan to use hydrogen. It is important to note that category 0 (not specifically mentioned, 'n.s.') should not be equated with a negative attitude towards a particular application!

**UNITED ARAB EMIRATES (ARE)**

Hydrogen: From Hype to Reality

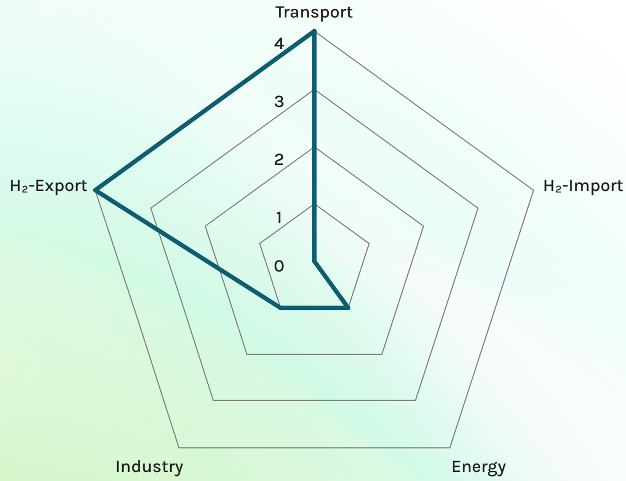
1. General information
   - Strategy
   - Publisher: Ministry of Energy and Infrastructure, Ministry of Climate Change and Environment – ARE
   - Published: 2021
   - Time horizons: 2030, 2050

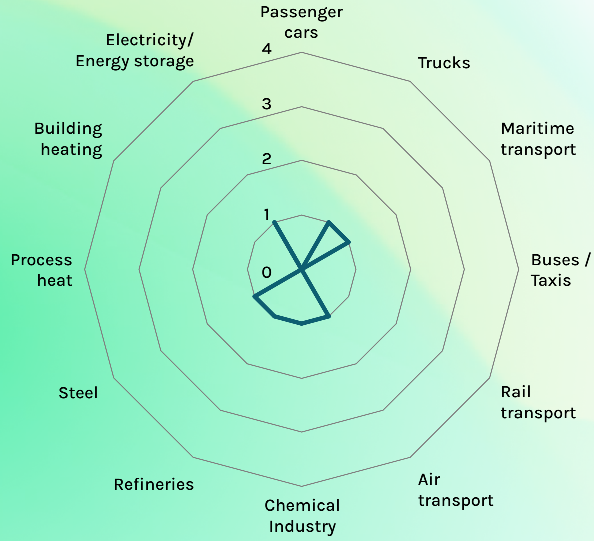
2. Targets
   - Climate neutrality by 2050
   - Dedicated vehicle volume: conversion of by 50 % of all public heavy goods vehicle fleets by 2050
   - Dedicated filling stations: 100 by 2050

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✓
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Hydrogen production based on fossil fuels without CCUS
   - Hydrogen production based on fossil fuels with CCUS
   - Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Industry:
  > cement (n.s.)

## AUSTRALIA

Australia's National Hydrogen Strategy

### 1. General information

- Strategy
- Publisher: COAG Energy Council Hydrogen Working Group commissioned by the Australian government
- Published: 11/2019
- Time horizons: 2030, 2045/2050

### 2. Targets

- No explicit targets

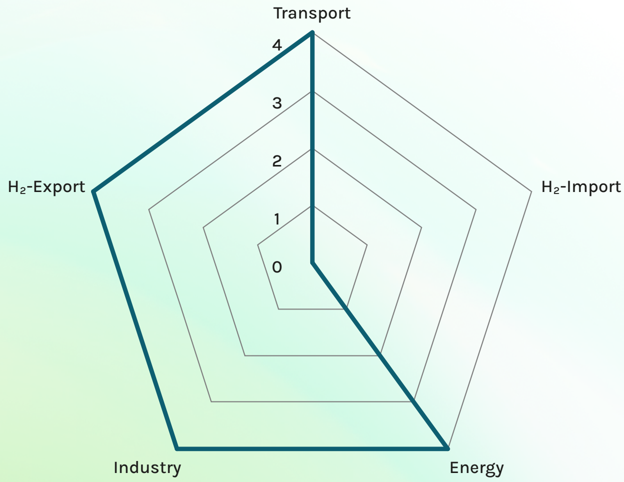
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

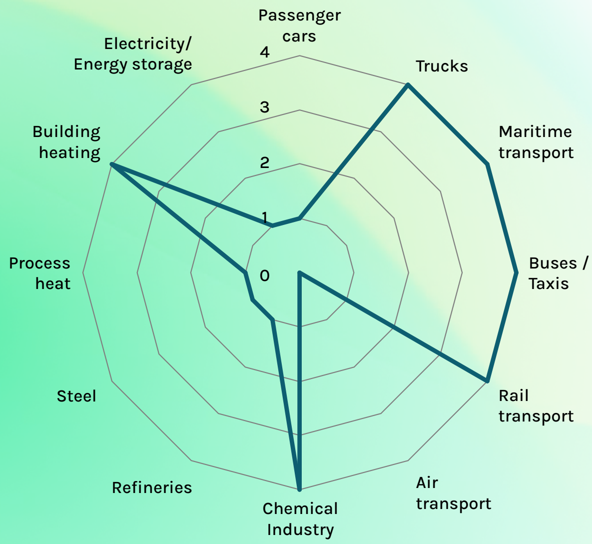
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Transitional use of hydrogen based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Transport:
  > mining vehicles (s.t.)

## AUSTRIA (AUT)

Wasserstoffstrategie für Österreich

### 1. General information

- Strategy
- Publisher: Federal Ministry Republic of Austria: Climate Action, Environment, Energy, Mobility, Innovation and Technology and Ministry of Labour and Economy
- Published: 2022
- Time horizons: 2022, 2030, 2040

### 2. Targets

- Electrolysis capacity: 1 GW by 2030
  > Climate neutrality by 2040

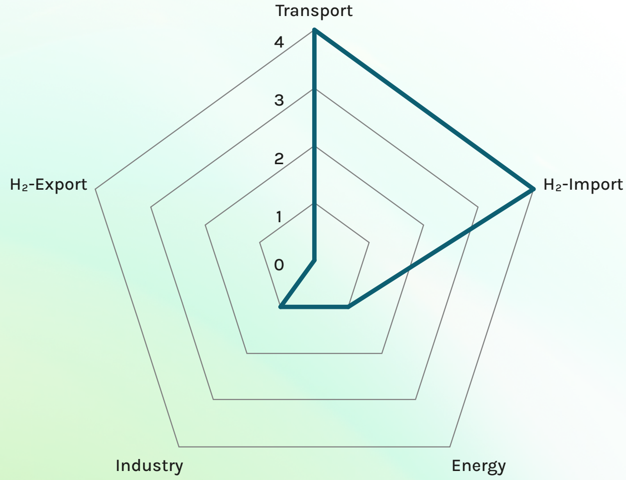
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

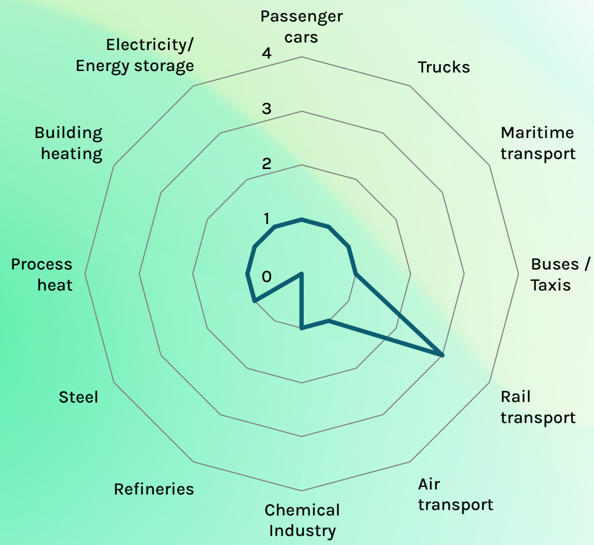
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity
- Use of gasification processes and gasification of biomass to produce biomethane and hydrogen
- Hydrogen production with methane pyrolysis

### 5. Application fields




### Other application fields:

- Transport:
  > synthetic fuels (m.t.)
- Industry:
  > cement, construction, refractory materials, glass, non-ferrous metals, paper (n.s.)

**BELGIUM (BEL)**

Vision and strategy, Hydrogen

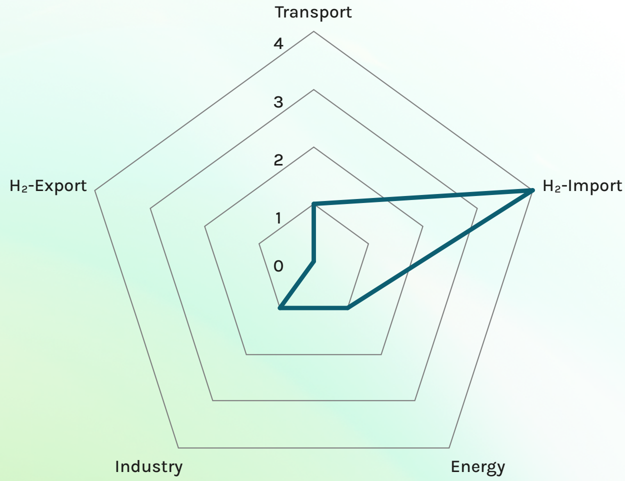
1. General information
- Strategy
- Publisher: Belgian Government
- Published: 10/2022
- Time horizons: until 2026, 2030, 2050

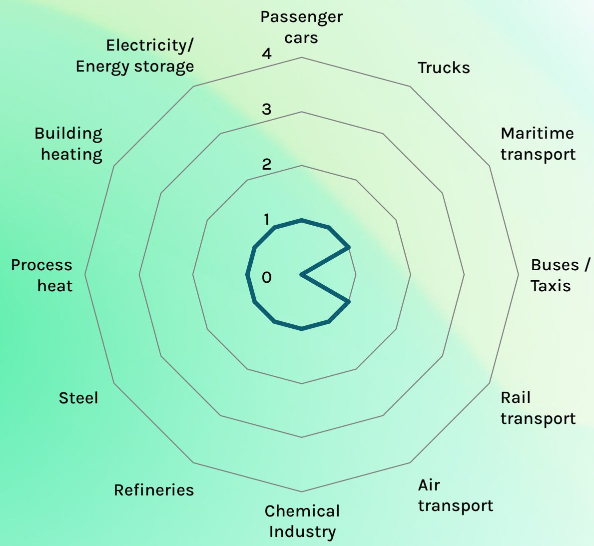
2. Targets
- Electrolysis capacity: 150 MW by 2026
- Climate neutrality by 2050

3. Strategic approach (✓ = addressed; ✗ = not addressed)
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

4. Hydrogen production
- Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Transport:
  - > two and three-wheelers, ammonia, methanol (n.s.)
- Industry:
  - > cement, aluminium, ceramics, glass, plastics recycling (n.s.)

6. Comments / Remarks
- Import volumes: 20 TWh in 2030, 200–350 TWh in 2050
- The Belgian government is essentially focussing on electrification as the most effective way to harness and consume renewable electricity

## BRAZIL (BRA)

Programa Nacional do Hidrogênio

### 1. General information

- Basis for a strategy
- Publisher: Ministry for Mining and Energy – Brazil
- Published: 07/2021

### 2. Targets

- Climate neutrality by 2050
- ...

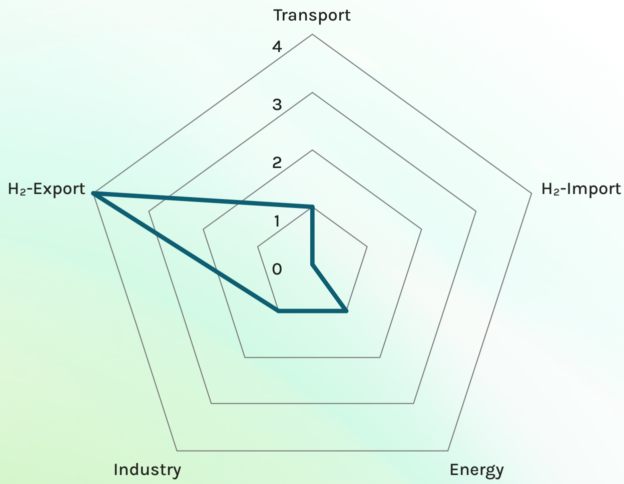
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

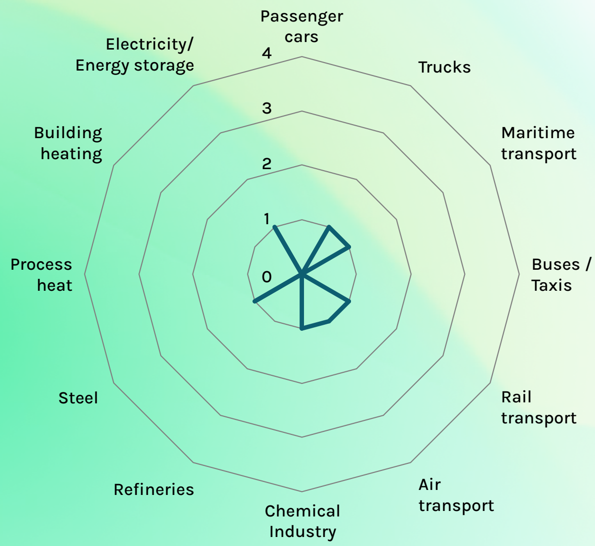
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✗
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS.
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity
- Use of electrolysis based on nuclear energy.
- Extraction of geological hydrogen
- Hydrogen production based on plastics

### 5. Application fields




Other application fields:

- Industry:
  > mining, fertilisers (n.s.)

**CANADA (CAN)**

Hydrogen Strategy for Canada

1. General information

- Strategy
- Publisher: Canadian government
- Published: 12/2020
- Time horizons: 2020–2025, 2025–2030

2. Targets

- $H_2$ target price 1.50–3.50 CAD/kg $H_2$
- $H_2$ production: 3 Mt $H_2$/a (2020s and 2030); 4 Mt $H_2$/a (2040); 20 Mt $H_2$/a (2050)
- FC buses: 5000 (2025)
- 30 % share of $H_2$ in final energy consumption (2050)

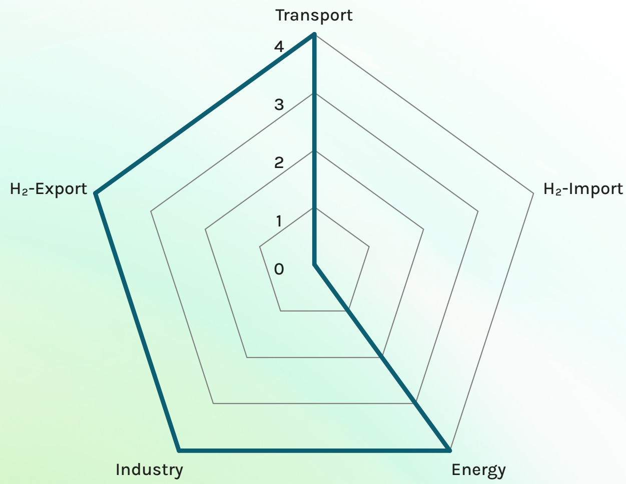
3. Strategic approach (✓ = addressed; ✗ = not addressed)

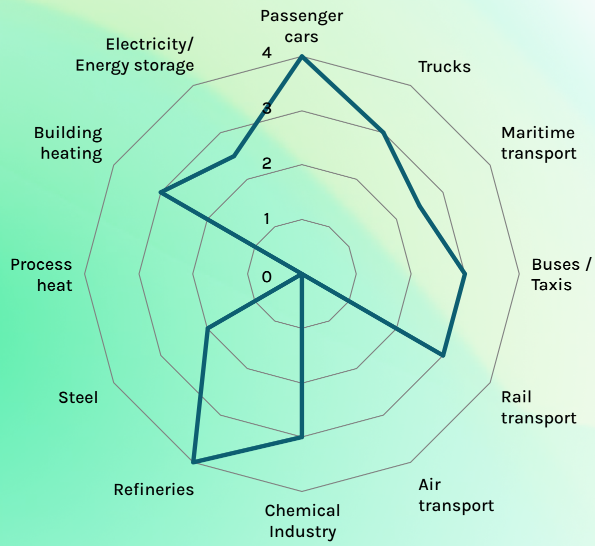
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on nuclear energy
- Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:

- Transport:
  > forklifts (s.t.), port devices (m.t.–l.t.)
- Industry:
  > mining (m.t.)

**CHILE (CHL)**

National Green Hydrogen Strategy

### 1. General information

- Strategy
- Publisher: Chilean Ministry of Energy
- Published: 09/2020
- Time horizons: 2023–2028, 2028–2033, 2033 onwards

### 2. Targets

- Electrolysis capacity: 5 GW operational or commissioned (2025); 25 GW (2030)
- $H_2$ target price < 1.50 USD/kg $H_2$

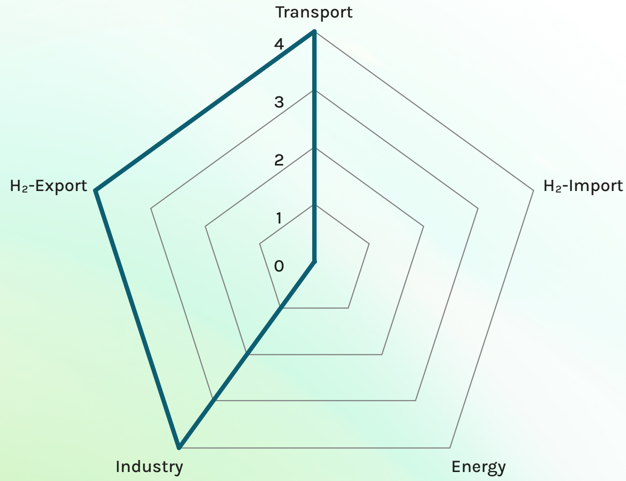
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

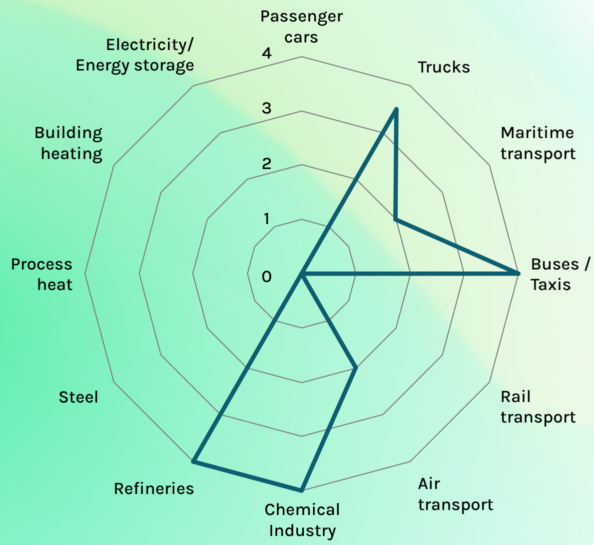
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Transport:
  - > mining vehicles (m.t.),
  - > synthetic fuels for maritime and air transport (l.t.)
- Industry:
  - > mining (l.t.)
  - > admixture into the gas grid (l.t.)

**CHINA (CHN)**

Fuel Cell Vehicle Roadmap

### 1. General information

- Roadmap
- Publisher: Strategy Advisory Committee of the Technology Roadmap for Energy Saving and New Energy Vehicles – China
- Published: 11/2017
- Time horizons: 2020, 2025, 2030

### 2. Targets

- FCEVs: 50 000 (2025); 1 000 000 (2030)
- $H_2$ filling stations: 100 (2020); 350 (2025); 1000 (2030)

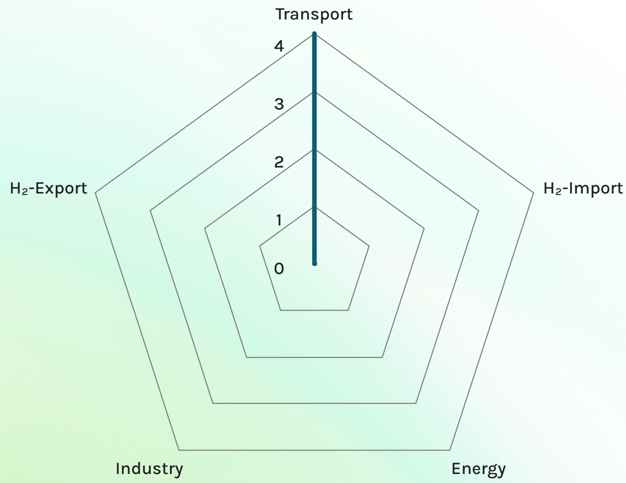
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

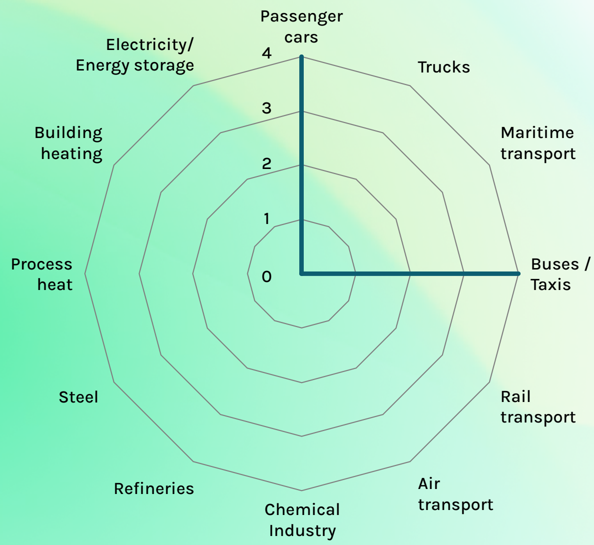
- Establishing the $H_2$ economy ✗
- New jobs/training of specialised staff ✗
- Subsidies/government support ✗
- International cooperation ✗
- Reduction of $H_2$ costs ✗
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✗
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Use of electrolysis based on renewable electricity

### 5. Application fields




### 6. Comments / Remarks

- In this roadmap, the focus was purely on FCEVs and other transport options were not discussed.

**COLOMBIA (COL)**

Colombia's Hydrogen Roadmap

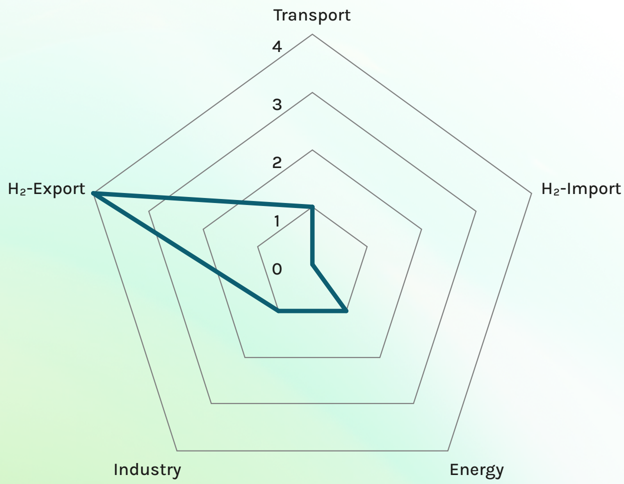
1. General information
- Roadmap
- Publisher: Colombian Ministry of Mines and Energy, Inter-American Development Bank, UK government
- Published: 2022
- Time horizons: 2030, 2050

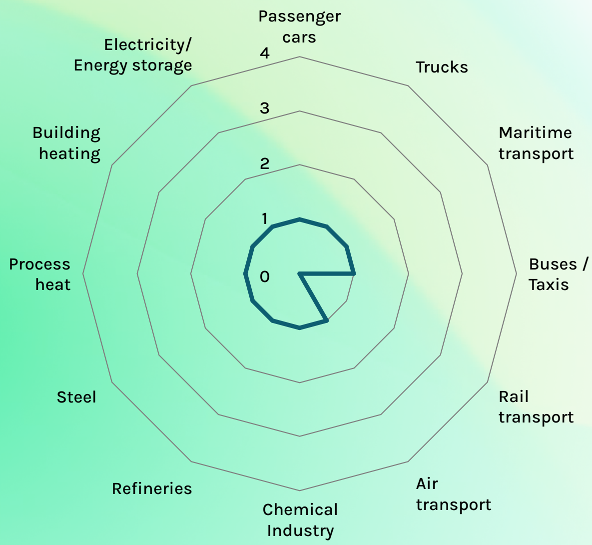
2. Targets
- Electrolysis capacity: 1–3 GW by 2030
- Climate neutrality by 2050
- Target price: 1.70 USD/kg $H_2$
- Dedicated production volume: 50 kt of blue hydrogen
- Dedicated fuel cell fleets: 2500–3500 vehicles by 2030
- Dedicated filling stations: 50–100 by 2030
- 40 % share of green and blue hydrogen in the industrial sector

3. Strategic approach (✓ = addressed; ✗ = not addressed)
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

4. Hydrogen production
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity
- Use of electrolysis based on grid power once grid electricity is renewable

5. Application fields




Other application fields:
- Industry:
  > iron, fertilisers, float glass, fat and oil processing (n.s.)

**CZECHIA (CZE)**

The Czech Republic's Hydrogen Strategy

### 1. General information

- Strategy
- Publisher: Ministry of Industry and Trade of the Czech Republic
- Published: 09/2021
- Time horizons: 2021–2025, 2026–2030, 2031–2050

### 2. Targets

- $H_2$ target price 1.00–1.50 Euro/kg $H_2$

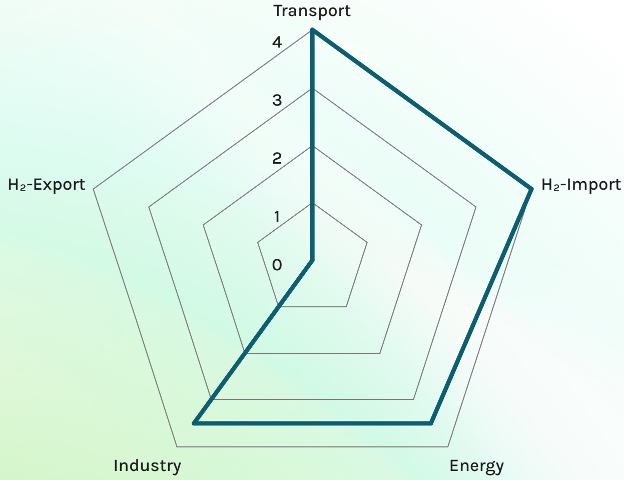
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

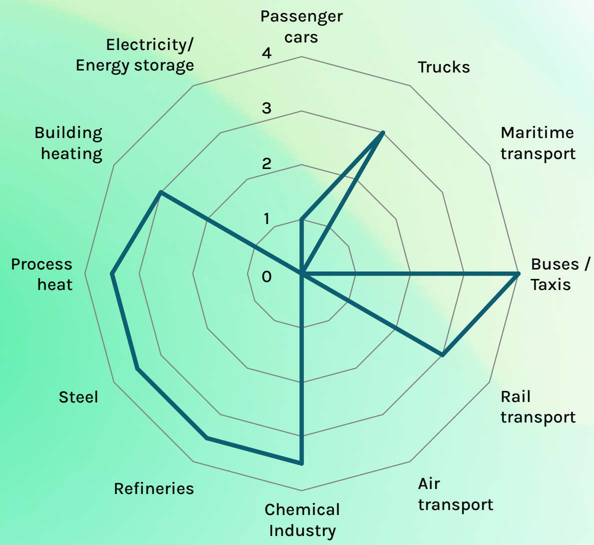
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS during a transitional period
- No use of electrolysis based on grid power
- Use of electrolysis based on renewable electricity

### 5. Application fields



**DENMARK (DNK)**

The Government's Strategy for Power-to-X

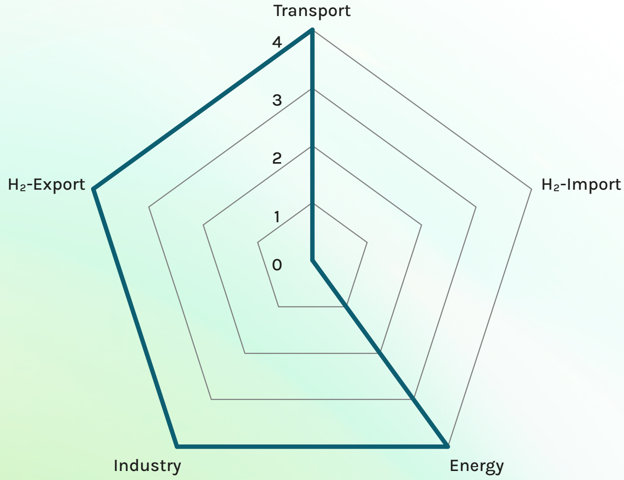
1. General information
- PtX Strategy
- Publisher: Danish Ministry of Climate, Energy and Utilities
- Published: 12/2021
- Time horizons: 2030, 2050

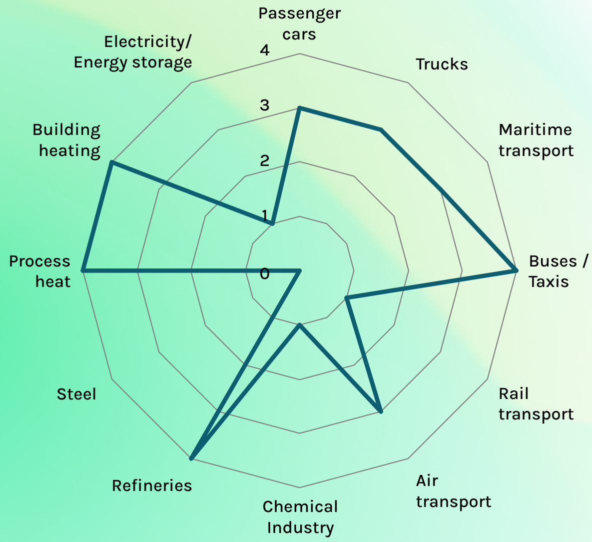
2. Targets
- Electrolysis capacity: 4–6 GW (7 GW projects) by 2030
- Climate neutrality by 2050
- Target prices:
- $H_2$: 125 DKK [€16.76], Ammonia: 225 DKK [€30.16], Methanol: 245 DKK [€32.84], SAF: 345 DKK/GJ [€46.25 /GJ] (in the next decade)
- long term: $H_2$: 60 DKK [€8.04], Ammonia: 145 DKK [€19.44], Methanol: 175 DKK [€23.6], SAF: 240 DKK/GJ [€32.17 per GJ, currency conversion rate on 15 Nov. 2023, 10:58 UTC]

3. Strategic approach (✓ = addressed; ✗ = not addressed)
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

4. Hydrogen production
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity
- Use of electrolysis based on grid power
- Hydrogen production by pyrolysis

5. Application fields




Other application fields:
- Transport:
  > defence industry, synthetic fuels (methanol, e-gasoline, e-diesel, e-kerosene) (s.t.)
- Industry:
  > plastics, fertilisers (n.s.)

6. Comments / Remarks
- PtX Strategy

**SPAIN (ESP)**

Hoja de Ruta del Hidrogeno

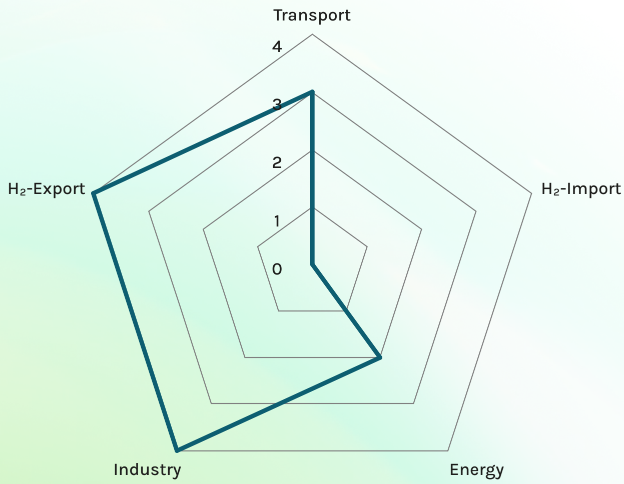
1. General information
   - Strategy
   - Publisher: Spanish Ministry for Ecological Transition and the Demographic Challenge
   - Published: 10/2020
   - Time horizons: 2024, 2030, 2050

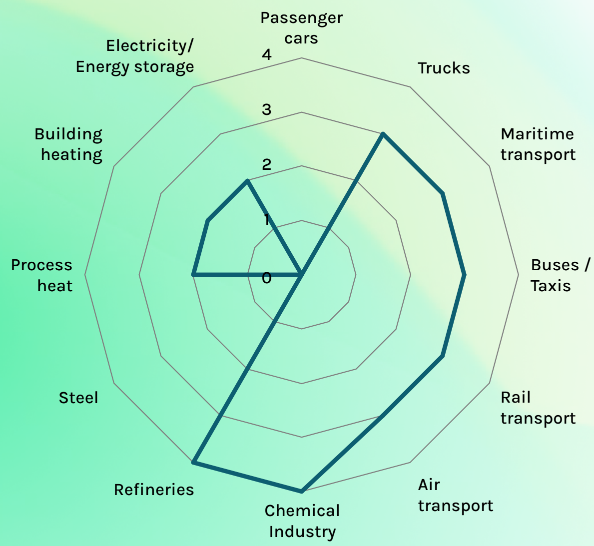
2. Targets
   - Electrolysis capacity: 300–600 MW (2020s); 4 GW (2030)
   - 150–200 FC buses (2030)
   - 5 000–7 500 LD and HD FCEVs (2030)
   - 100–150 $H_2$ filling stations (2030)

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✓
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Replacing of hydrogen based on fossil fuels without CCUS
   - Use of electrolysis based on renewable electricity

5. Application fields



## EUROPEAN UNION (EU)

A hydrogen strategy for a climate-neutral Europe

### 1. General information

- Strategy
- Publisher: European Commission
- Published: 07/2020
- Time horizons: 2024–2030, 2050

### 2. Targets

- Electrolysis capacity: 6 GW (2020s); 40 GW + 40 GW in neighbouring countries (by 2030)
- Production levels: 1 Mt renewable $H_2$ (2020s) and 10 Mt renewable $H_2$ (2030)

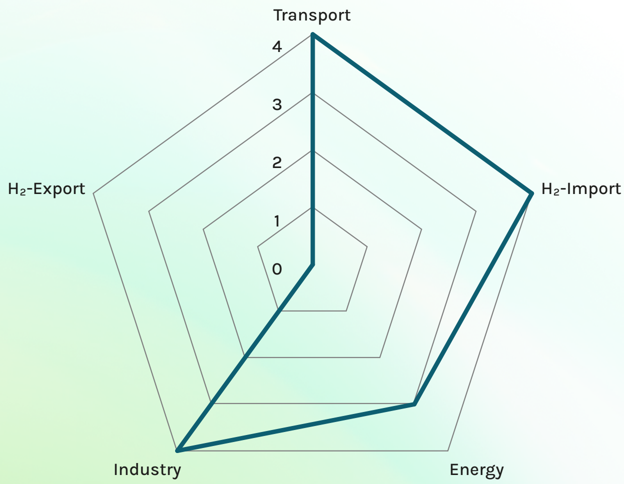
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

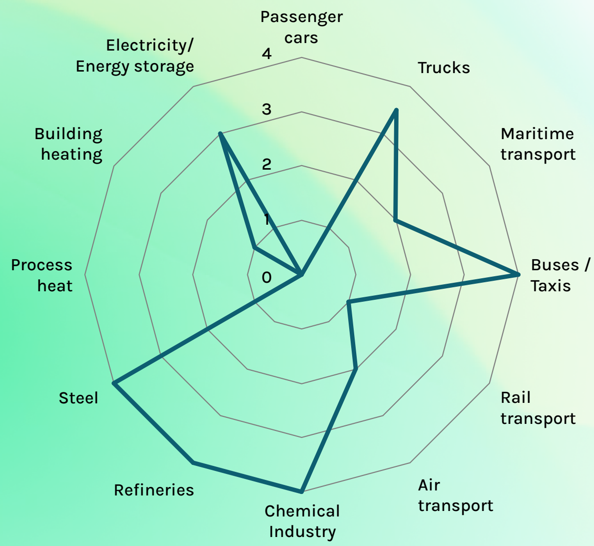
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS during a transitional period
- Use of electrolysis based on grid power allowed during a transitional period
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Transport:
  > synthetic fuels (l.t.)

## FINLAND (FIN)

Hydrogen economy – Opportunities and limitations

### 1. General information

- Report
- Publisher: Finnish government
- Published: 05/2022
- Time horizons: 2022, 2025, 2030, 2050

### 2. Targets

- Electrolysis capacity: 0.5–1.3 GW by 2030, 4.5–11 GW by 2040, 12–27 GW by 2050
- Climate neutrality by 2035
- Target price (production cost): €2.60/kg
- Dedicated production volume: 3.7–7.9 TWh by 2030, ca. 5–57 TWh by 2040, 6.4–132.9 TWh by 2050

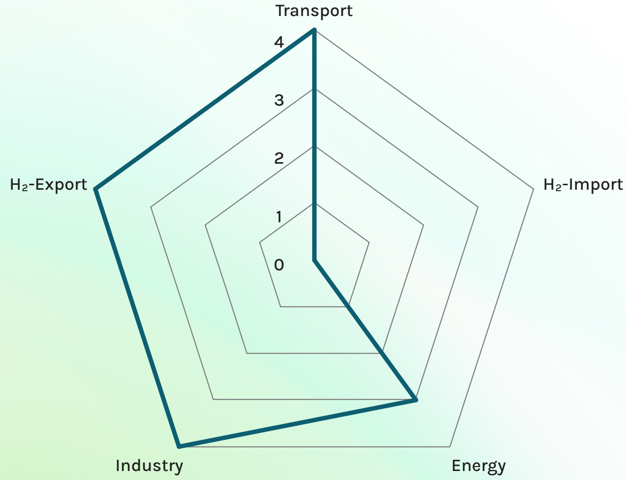
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

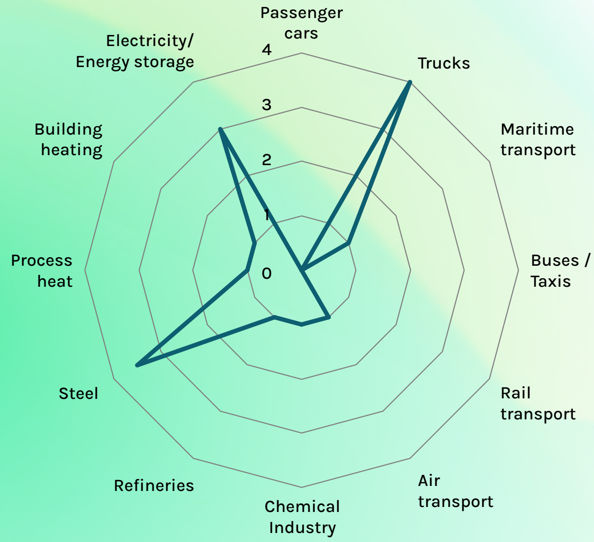
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Transport:
  - > synthetic fuels (ammonia, methanol, methane, kerosene, diesel, gasoline) (n.s.)
- Industry:
  - > other metals, electrical industry, forestry (paper), manufacturing industry, hydrogen peroxide, food, ceramics and glass (n.s.)

## FRANCE (FRA)

Stratégie nationale pour le développement de l'hydrogène décarboné en France

### 1. General information

- Strategy
- Publisher: French government
- Published: 09/2020
- Time horizons: 2030, 2050

### 2. Targets

- Electrolysis capacity: 6.5 GW (2030)

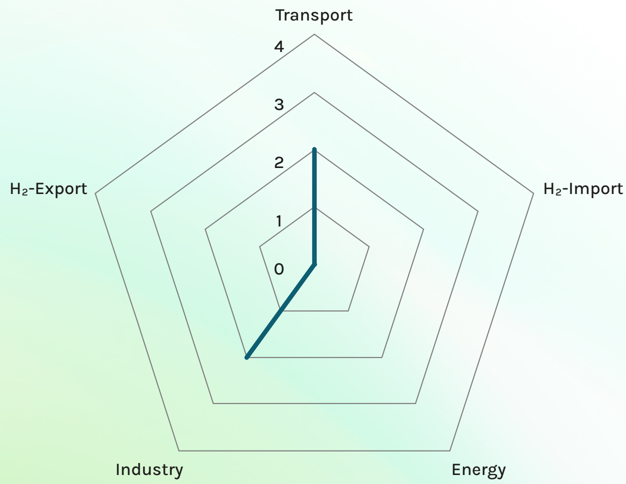
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

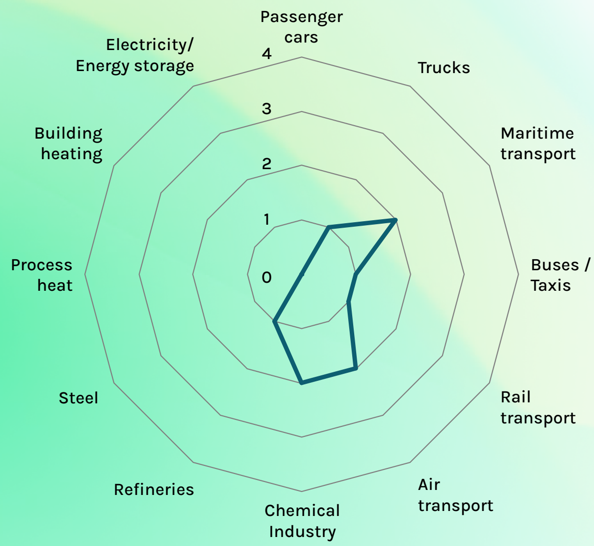
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✗
- Carbon pricing ✗
- Infrastructure development ✗
- Regulatory framework/certifications ✗
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Use of electrolysis based on grid power, as the nuclear power-dominated French electricity mix is very low carbon
- Use of electrolysis based on renewable electricity

### 5. Application fields



## UNITED KINGDOM (GBR)

UK Hydrogen Strategy

### 1. General information

- Strategy
- Publisher: Secretary of State for Business, Energy & Industrial Strategy
- Published: 08/2021
- Time horizons: 2025, 2030, 2040

### 2. Targets

- Electrolysis capacity: 1 GW (2025); 5 GW (2030)

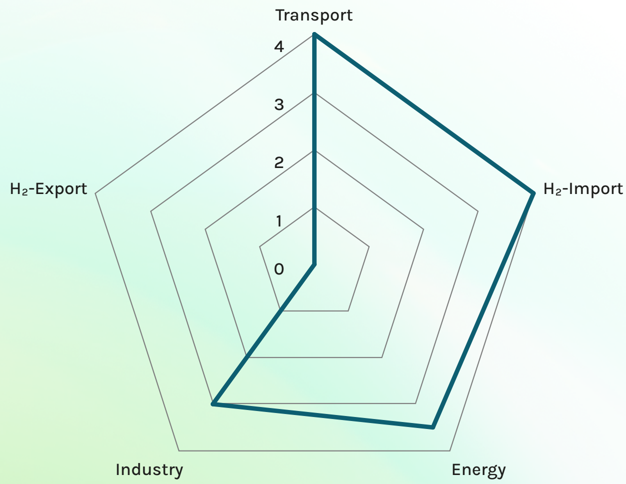
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

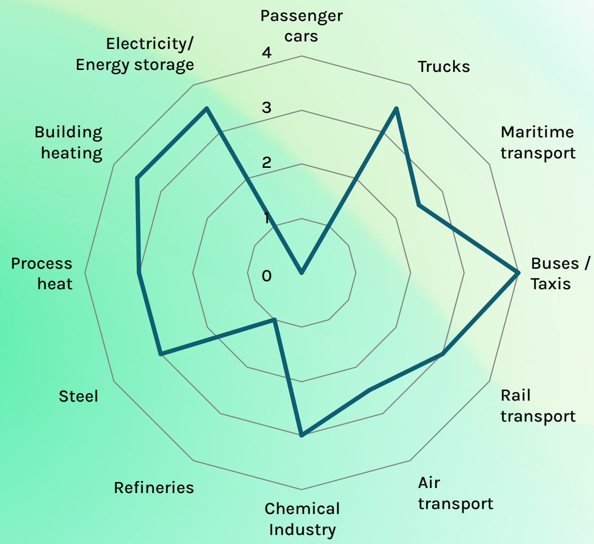
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS during a transitional period
- Use of electrolysis based on nuclear energy
- Use of electrolysis based on renewable electricity

### 5. Application fields



**SCOTLAND (GB-SCT)**

Hydrogen Action Plan

### 1. General information

- Strategy
- Publisher: Scottish government
- Published: 2022
- Time horizons: 2030, 2045

### 2. Targets

- Electrolysis capacity: 5 GW by 2030, 25 GW by 2045
- Climate neutrality by 2050
- Dedicated production volume: 450 kt (renewable & low carbon) by 2030,
- 3.3 Mt by 2045

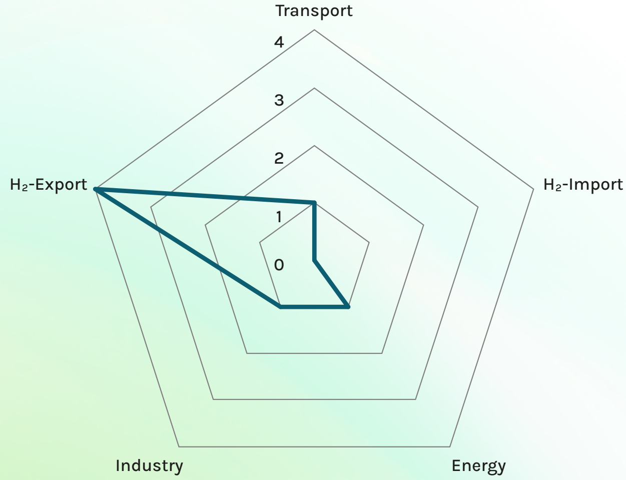
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

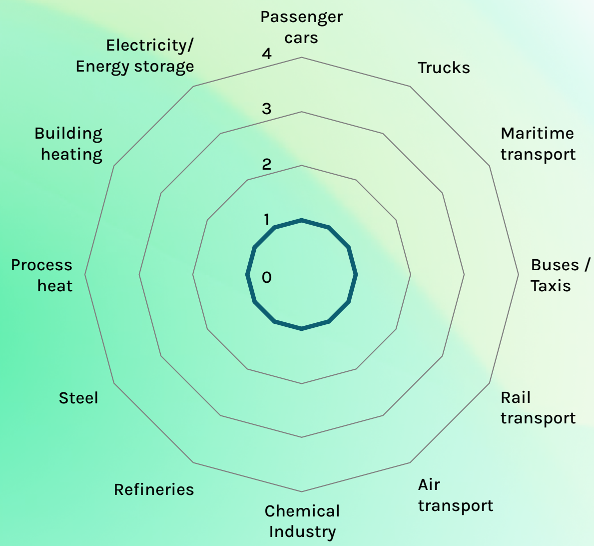
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✗
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Transport:
  > off-road (n.s.)
- Industry:
  > fertilisers, distilleries (n.s.)

### 6. Comments / Remarks

- Scotland's strategy does not define any explicit targets and instead refers largely to possibilities, e.g. "…hydrogen could [emphasis added] play a wider role…"

## GERMANY (GER)

Die Nationale Wasserstoffstrategie + Fortschreibung der Nationalen Wasserstoffstrategie

### 1. General information

- Strategy
- Publisher: prev. Federal Ministry for Economic Affairs and Energy (BMWi), currently: Federal Ministry for Economic Affairs and Climate Action (BMWK)
- Published: 06/2020 (07/2023)
- Time horizons: 2020, 2030, 2050 (2023, 2024–25, 2026–30)

### 2. Targets

- Electrolysis capacity: 5 GW by 2030 and additional 5 GW by 2040 (10 GW by 2030)
- Climate neutrality by 2050 (by 2045)

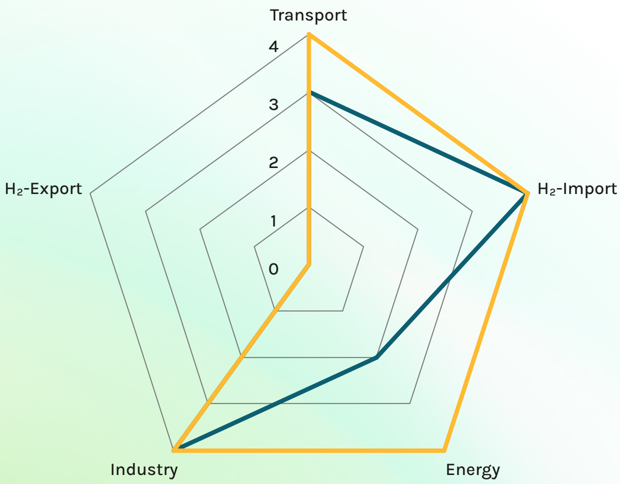
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

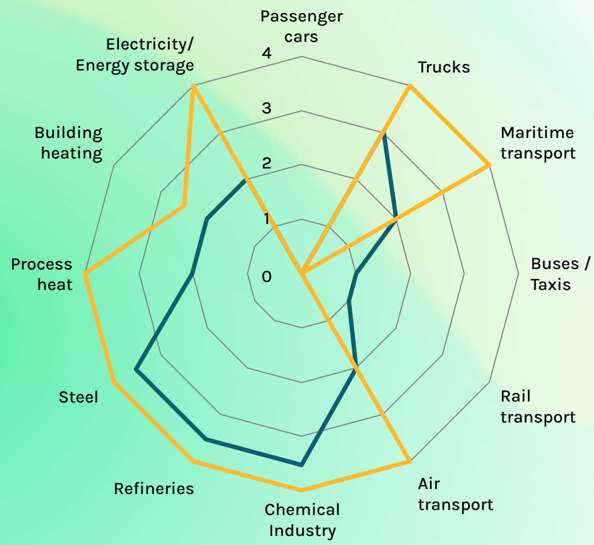
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS during a transitional period
- Use of electrolysis based on renewable electricity
- Hydrogen production by methane pyrolysis
- Hydrogen production from waste and residual materials

### 5. Application fields




Other application fields:

- Transport:
  - > synthetic fuels (m.t.)
  - > defence sector (l.t.)

### 6. Comments / Remarks

- Additions in orange are taken from the updated national hydrogen strategy

## CROATIA (HRV)

Hydrogen Strategy of the Republic of Croatia until 2050

### 1. General information

- Strategy
- Publisher: Croatian Ministry of Economy and Sustainable Development
- Published: 03/2022
- Time horizons: 2022–2026, 2027–2030, 2031–2050

### 2. Targets

- Electrolysis capacity: 70 MW by 2030, 2750 MW by 2050
- GHG reduction of 74 % by 2050 compared to 1990
- Dedicated filling stations: 15 by 2030, 100 by 2050
- Share of hydrogen in energy consumption: 0.2 % by 2030, 11 % by 2050

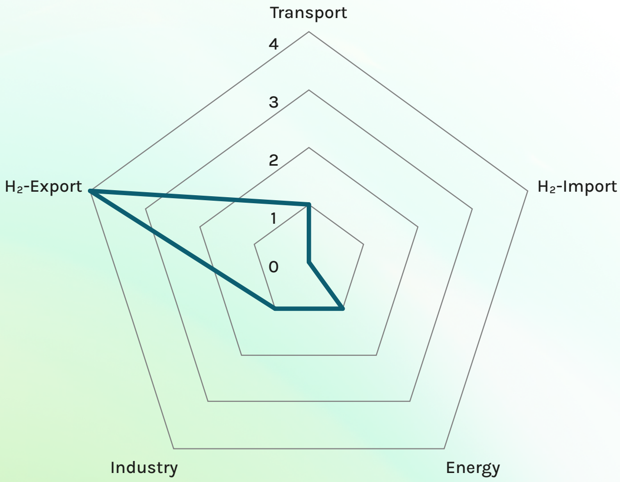
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

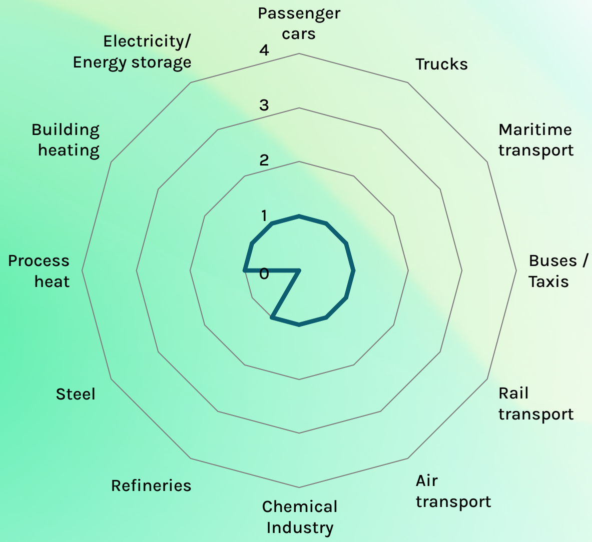
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Hydrogen production based on fossil fuels
- Use of electrolysis based on renewable electricity
- Use of electrolysis based on grid power once grid electricity is renewable

### 5. Application fields




Other application fields:

- Industry:
  - > cement, agriculture (n.s.)
- Energy/Heat:
  - > subsector: heating and cooling (n.s.)

## HUNGARY (HUN)

Hungary's National Hydrogen Strategy

### 1. General information

- Strategy
- Publisher: Hungarian government
- Published: 05/2021
- Time horizons: 2030, 2040, 2050

### 2. Targets

- Electrolysis capacity: 240 MW (2030)
- $H_2$ production: 20 kt low carbon $H_2$ and 16 kt renewable $H_2$ (2030)
- 4 800 vehicles
- 60 $H_2$ filling stations (2030)

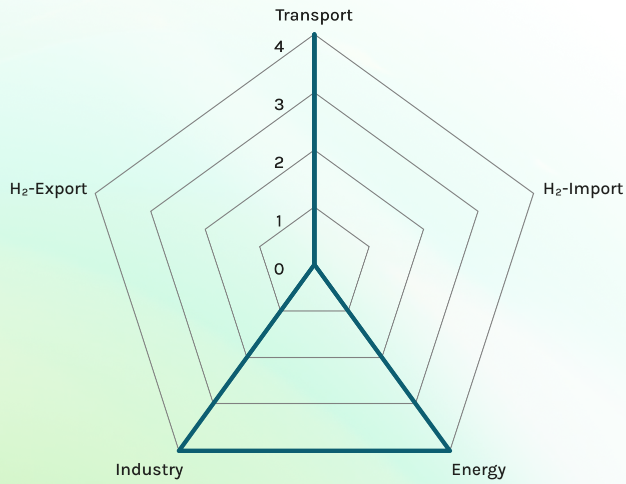
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

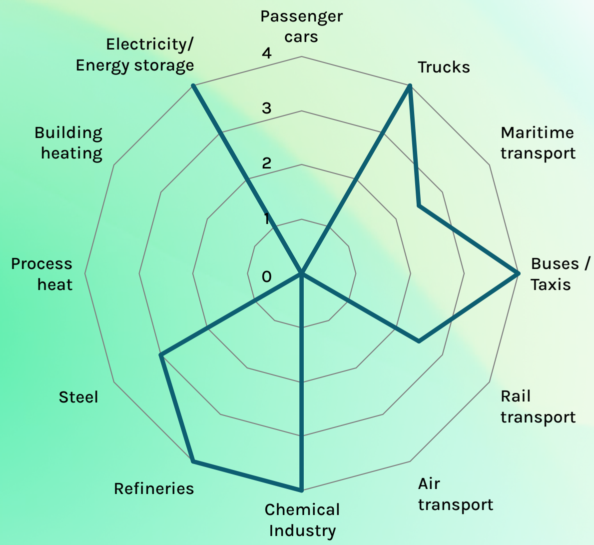
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✗
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS during a transitional period
- Use of electrolysis based on grid power
- Use of electrolysis based on nuclear energy
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Industry:
  > cement (m.t.)

## INDIA (IND)

Harnessing Green Hydrogen

### 1. General information

- Strategy and Roadmap
- Publisher: NITI Aayog, Government of India, RMI (India)
- Published: 06/2022
- Time horizons: 2020, 2030, 2040, 2050, 2070

### 2. Targets

- Electrolysis capacity: 25 GW by 2028, 60 GW by 2030
- Climate neutrality by 2070
- Target price: 1.70–2.40 USD/kg by 2030, 0.60–1.20 USD/kg by 2050
- Dedicated production volume: 5 Mt by 2030
- Dedicated fleet size: 1000 trucks, 50 boats, 10 aircraft by 2030

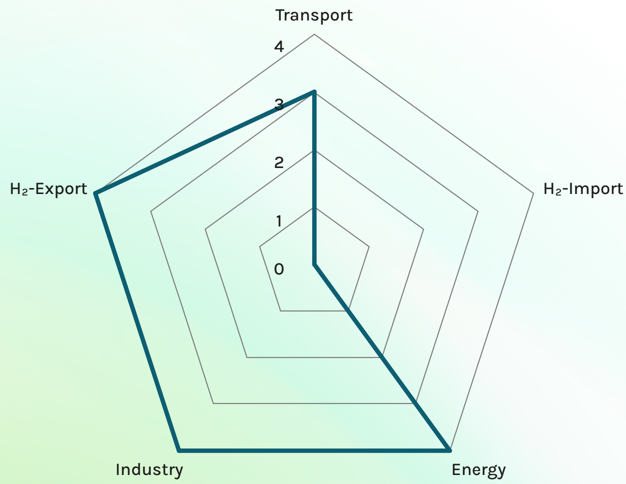
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

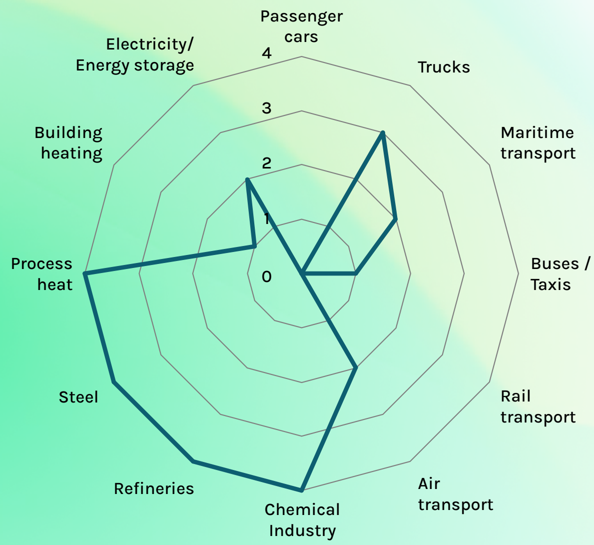
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Use of electrolysis based on renewable electricity
- Use of biomass

### 5. Application fields




Other application fields:

- Transport:
  > synthetic fuels e.g. ammonia (s.t.)
- Industry:
  > ammonia as fertiliser (s.t.), food (n.s.)

**IRELAND (IRL)**

Consultation on Developing a Hydrogen Strategy for Ireland

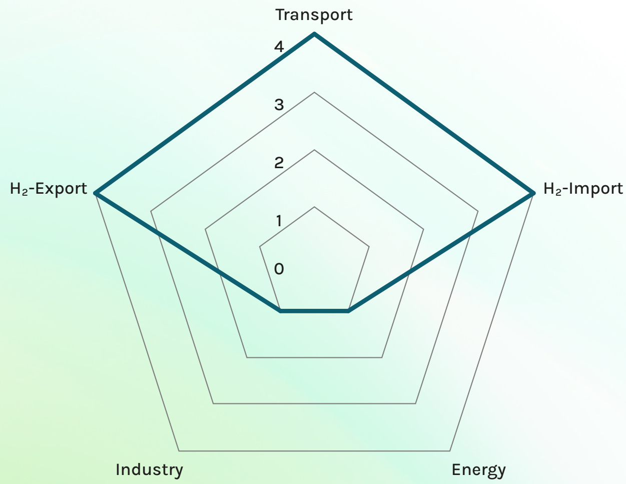
1. General information
   - Consultation paper
   - Publisher: Irish Department of the Environment, Climate and Communications
   - Published: 07/2022

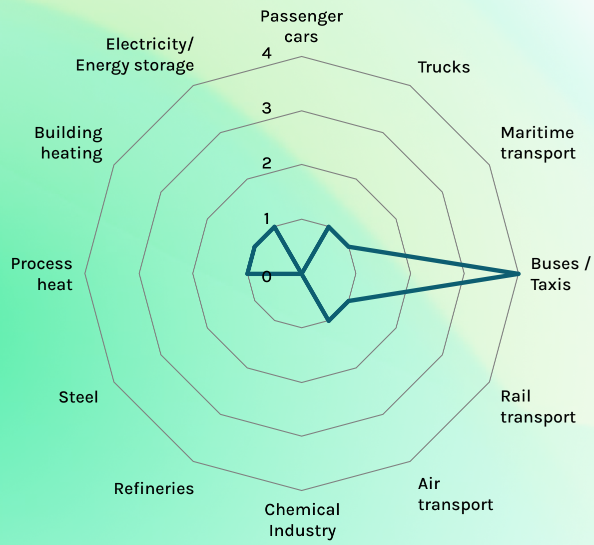
2. Targets
   - Climate neutrality by 2050

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✗
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✗
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Industry:
  > pharmaceutical, heavy industry (n.s.)

6. Comments / Remarks
   - This is a consultation, not a specific strategy. Its purpose was to gather the views of stakeholders and other interest groups to inform the development of a hydrogen strategy for Ireland. It contains no concrete/absolute statements.
   - Submissions for the consultation were possible from 12 Jul. – 02 Sept. 2022.

## ITALY (ITA)

Strategia Nazionale Idrogeno Linee Guida Preliminari

### 1. General information

- Strategy
- Publisher: Italian Ministry of Economic Development (currently: Italian Ministry of Enterprises and Made in Italy)
- Published: 11/2020
- Time horizons: 2030/2050

### 2. Targets

- Electrolysis capacity: 5 GW (2030)
- $H_2$ production: 0.7 Mt $H_2$/a (2030)
- 2 % share of $H_2$ in final energy consumption (2030)

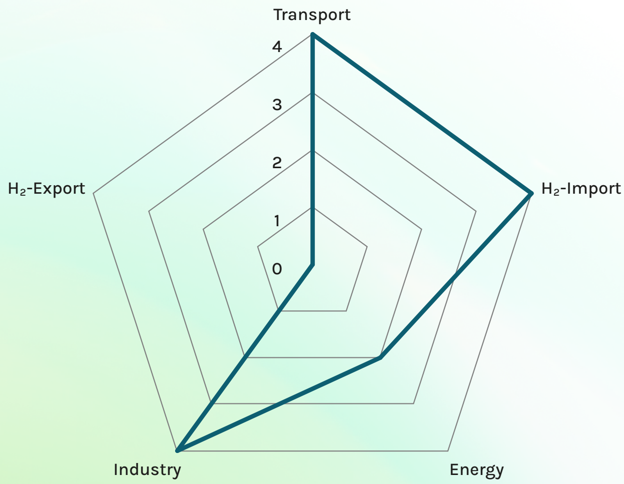
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

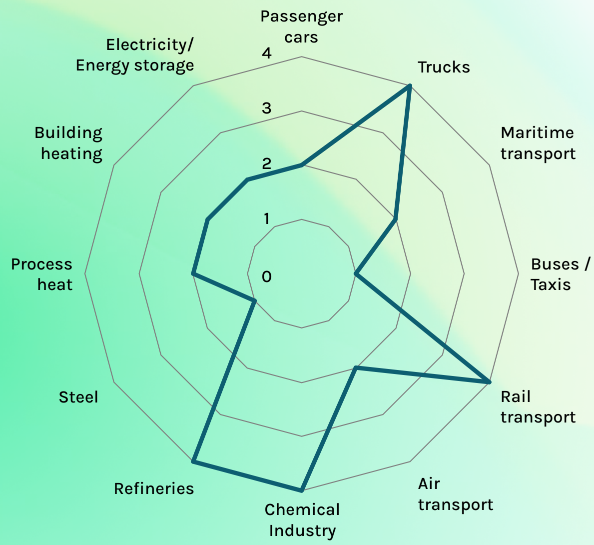
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Transport:
  - > synthetic fuels (n.s.)
- Industry
  - > cement (n.s.)

**JAPAN (JPN)**

Basic Hydrogen Strategy

### 1. General information

- Strategy
- Publisher: Japanese Ministerial Council on Renewable Energy, Hydrogen and Related Issues
- Published: 12/2017
- Time horizons: 2030, 2050

### 2. Targets

- Target price: 2.50 Euro/kg $H_2$ (by 2030) and 1.80 Euro/kg $H_2$ (as of 2030)
- Production level: 300 kt $H_2$/a (2030)
- FCEVs: 200 000 (by 2025), 800 000 (by 2030)
- FC Buses: 1200 (2030)
- FC Forklifts: 10 000 (2030)

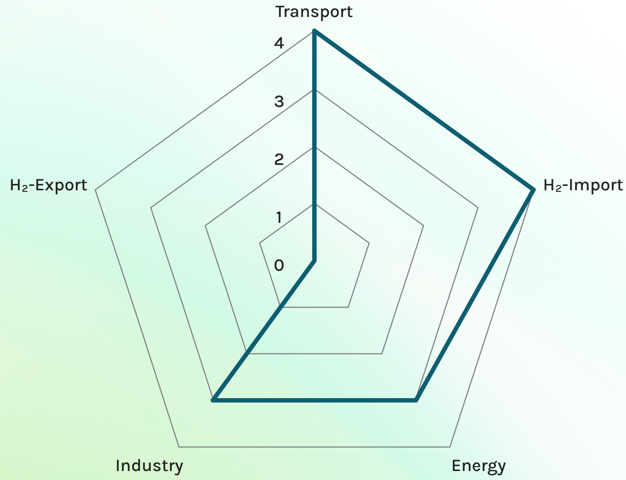
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

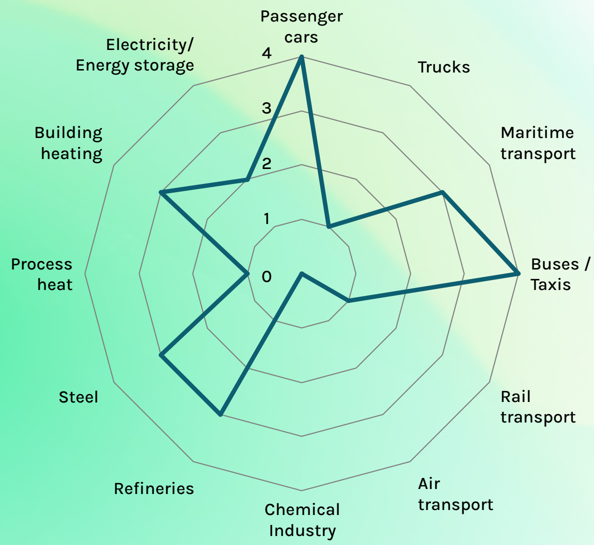
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS during a transitional period

### 5. Application fields




Other application fields:

- Transport:
  - > Transport:
  - > miscellaneous: forklifts (s.t.), waste collection (n.s.) and towing vehicles (n.s.)

**KENYA (KEN)**

Green Hydrogen Strategy and Roadmap for Kenya

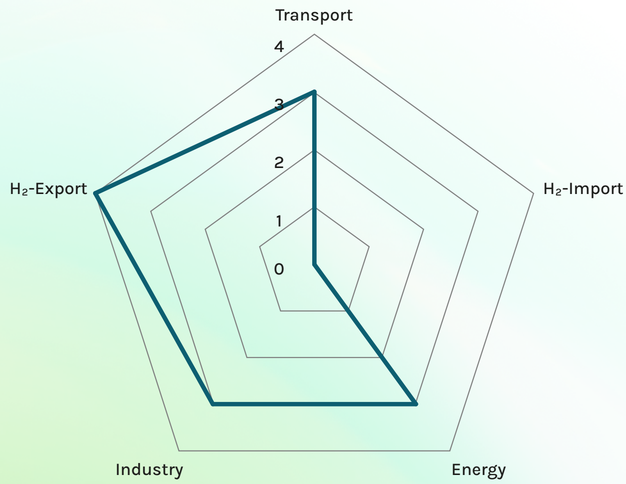
1. General information
   - Strategy and Roadmap
   - Publisher: Kenyan Ministry of Energy and Petroleum
   - Published: 09/2023
   - Time horizons: 2023–2027, 2028–2032, 2032 onwards

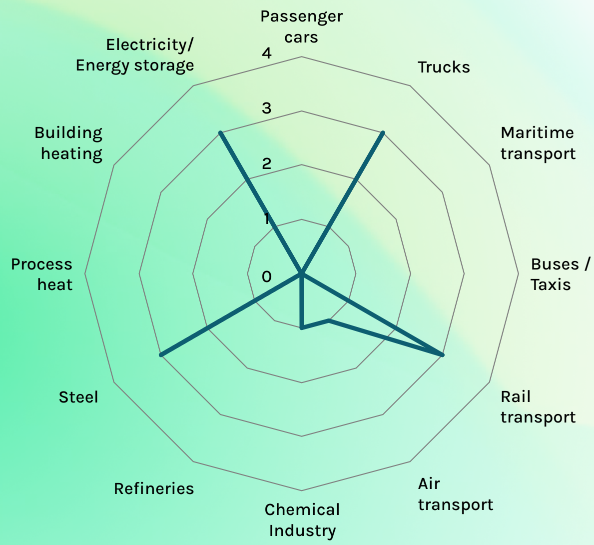
2. Targets
   - Electrolysis capacity: 100 MW by 2027, 150–250 MW by 2030
   - Climate neutrality by 2050

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✗
   - Carbon pricing ✗
   - Infrastructure development ✗
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Use of electrolysis based on renewable electricity
   - Hydrogen production based on geothermal energy

5. Application fields




Other application fields:
- Industry:
  > agriculture (fertilisers) (s.t.), ammonia, methanol

**SOUTH KOREA (KOR)**

Hydrogen Economy Roadmap of Korea

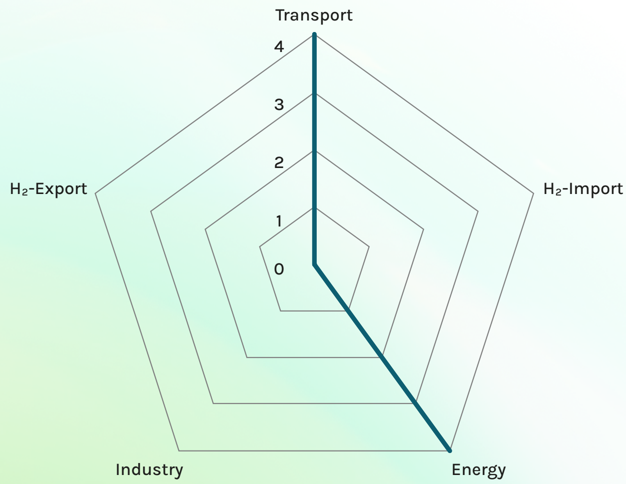
1. General information
   - Roadmap
   - Publisher: South Korean Government
   - Published: 01/2019
   - Time horizons: 2018, 2030, 2050

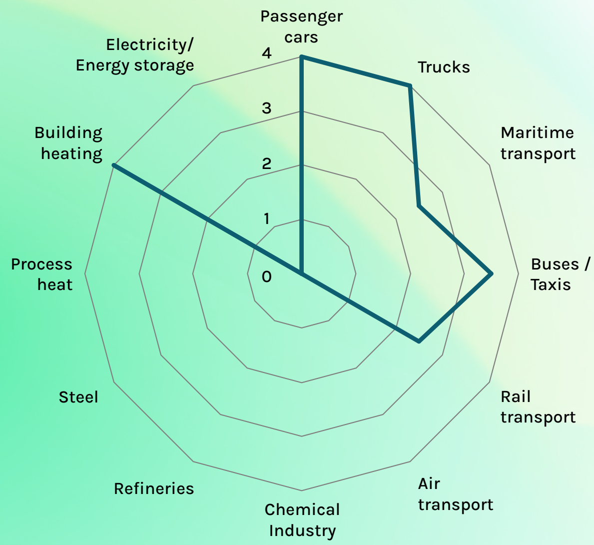
2. Targets
   - Target price: €4.40/kg $H_2$ (2022) and €2.20/kg $H_2$ (as of 2040)
   - FCEVs: 6.2 million (3.3 million for the export market) in 2040

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✓
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Replacing of hydrogen based on fossil fuels without CCUS
   - Hydrogen production based on fossil fuels with CCUS during a transitional period
   - Supplementary use of hydrogen obtained as a by-product
   - Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Transport:
  > drones (m.t.)

**MOROCCO (MAR)**

Feuille de Route Hydrogène Vert

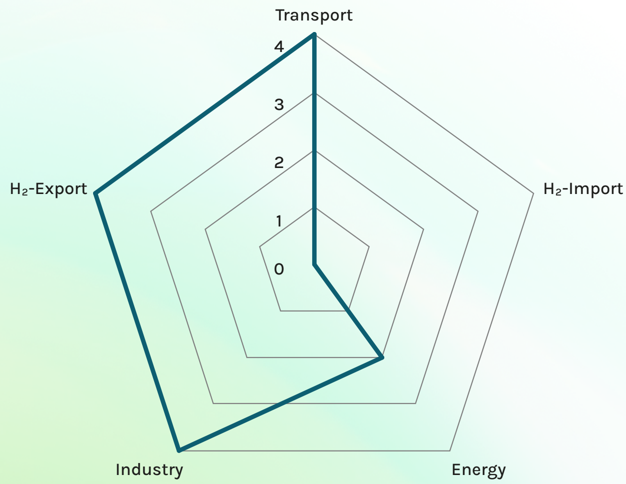
1. General information
   - Roadmap
   - Publisher: Moroccan Ministry of Energy, Mining and Environment
   - Published: 01/2021
   - Time horizons: 2030, 2040, 2050

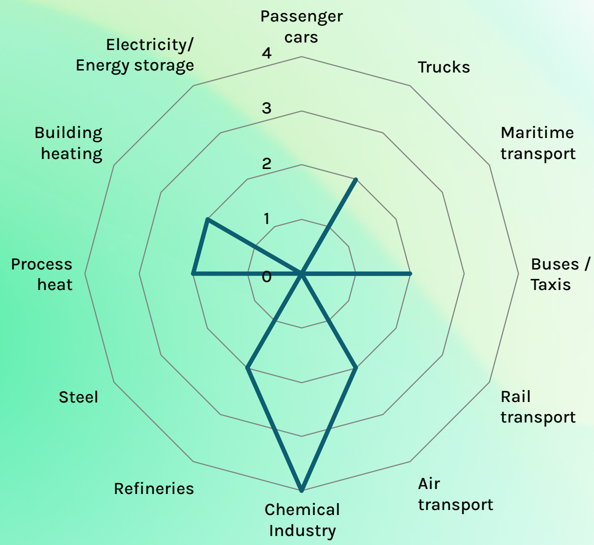
2. Targets
   - No explicit data

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Use of electrolysis based on grid power
   - Use of electrolysis based on renewable electricity
   - Search for white hydrogen

5. Application fields




Other application fields:
- Transport:
  > synthetic fuels (s.t.)

## NAMIBIA (NAM)

Namibia. Green Hydrogen and Derivatives Strategy

### 1. General information

- Strategy
- Publisher: $GH_2$ Namibia, Harambee Prosperity Plan II, with support from: SASSCAL and BMBF
- Published: 11/2022
- Time horizons: 2030, 2040, 2050

### 2. Targets

- Target price: LCOH 1.20–1.30 USD/kg 2030, if no specified firmness level is required. LCOH of derivatives (e.g., ammonia or methanol) 1.50–1.60 USD/kg hydrogen in 2030
- Dedicated production volumes: 1–2 Mt/a by 2030, 5–7 Mt/a by 2040, 10–15 Mt/a by 2050 $H_2$ equivalent

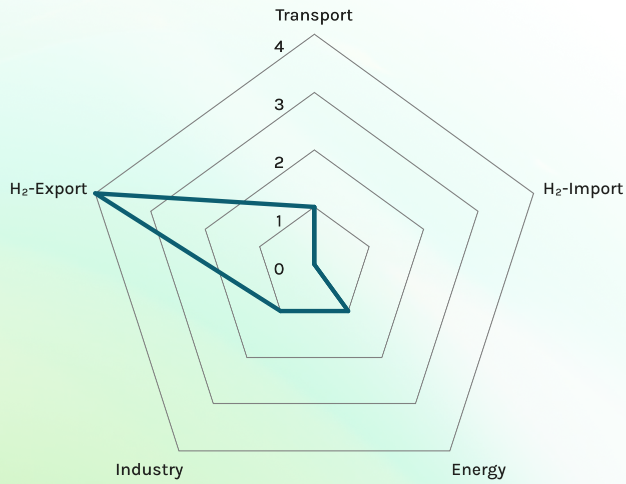
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

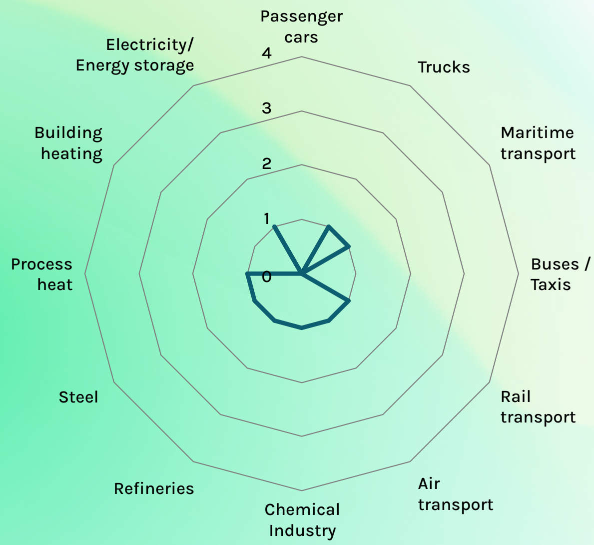
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✗
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Industry:
  - > ammonia for fertilisers, zinc, synthetic methanol (n.s.)

**NETHERLANDS (NLD)**

Government Strategy on Hydrogen

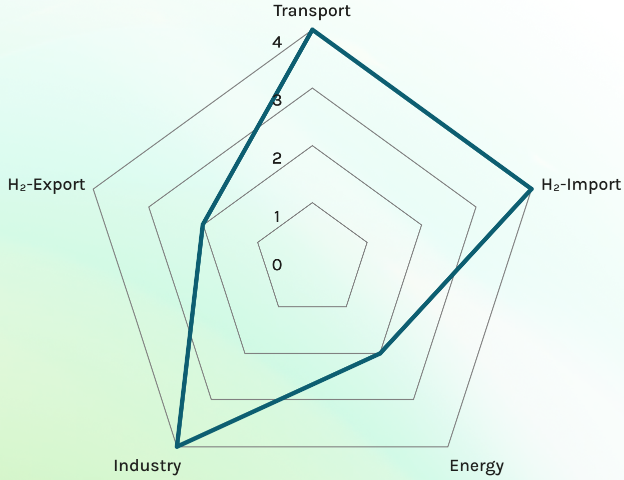
1. General information
   - Strategy
   - Publisher: Dutch Government
   - Published: 04/2020
   - Time horizons: 2025, 2030, 2050

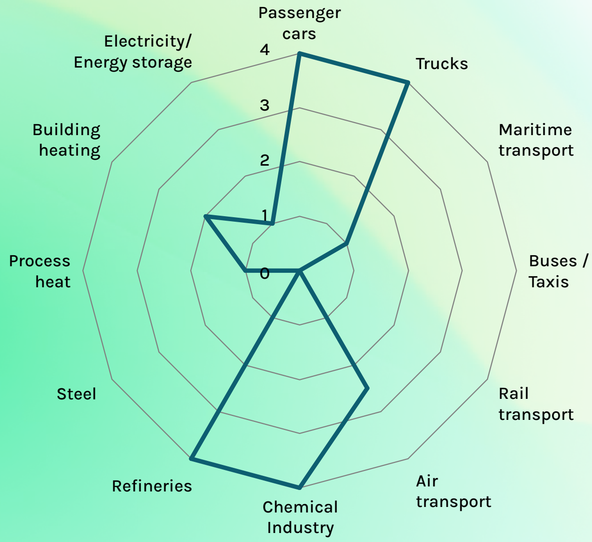
2. Targets
   - Electrolysis capacity: 500 MW (2025) and 3–4 GW (by 2030)
   - FCEVs: 15 000 (2025) and 300 000 (2030)
   - HD FCEVs: 3000 (2025)
   - 50 $H_2$ filling stations (2025)

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Replacing of hydrogen based on fossil fuels without CCUS
   - Hydrogen production based on fossil fuels with CCUS during a transitional period
   - Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Transport:
  > synthetic fuels in aviation (n.s.)
  > agricultural vehicles (n.s.)

## NORWAY (NOR)

The Norwegian Government's Hydrogen Strategy

### 1. General information

- Strategy
- Publisher:
- Norwegian Ministry of Petroleum and Energy & Norwegian Ministry of Climate and Environment
- Published: 06/2020
- Time horizons: 2030, 2050

### 2. Targets

- No explicit targets

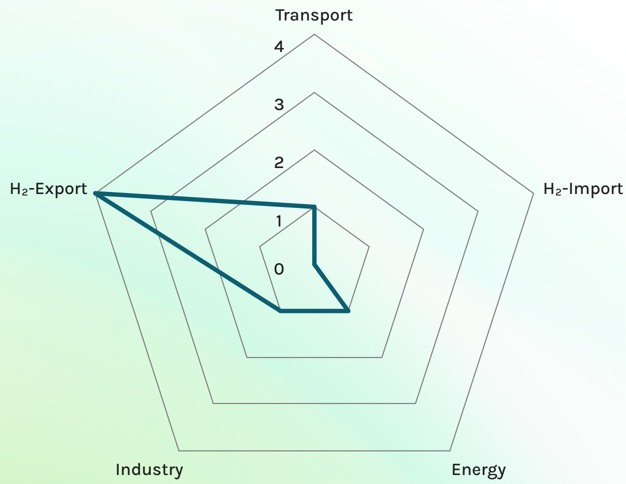
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

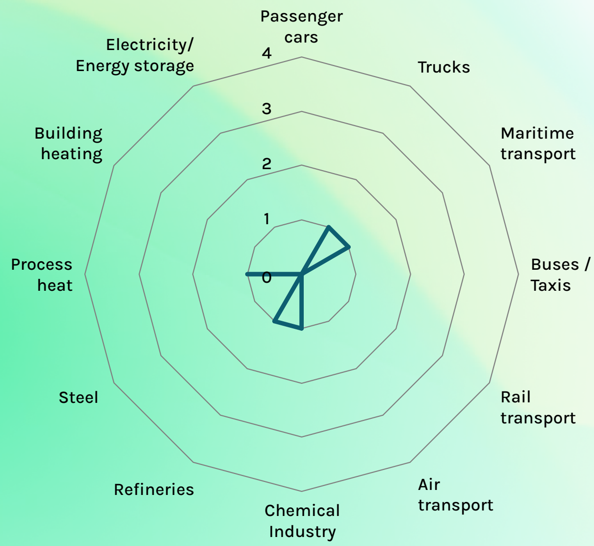
- Establishing the $H_2$ economy ✗
- New jobs/training of specialised staff ✗
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS during a transitional period
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- defence sector (n.s.)

**NEW ZEALAND (NZL)**

A vision for hydrogen in New Zealand (Green Paper)

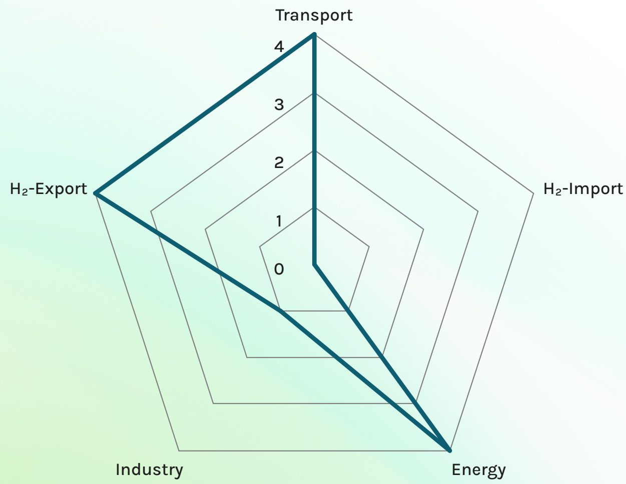
1. General information
   - Green Paper on development of hydrogen economy
   - Publisher: New Zealand Ministry of Business, Innovation & Employment
   - Published: 09/2019
   - Time horizons: by 2020, 2020–2025

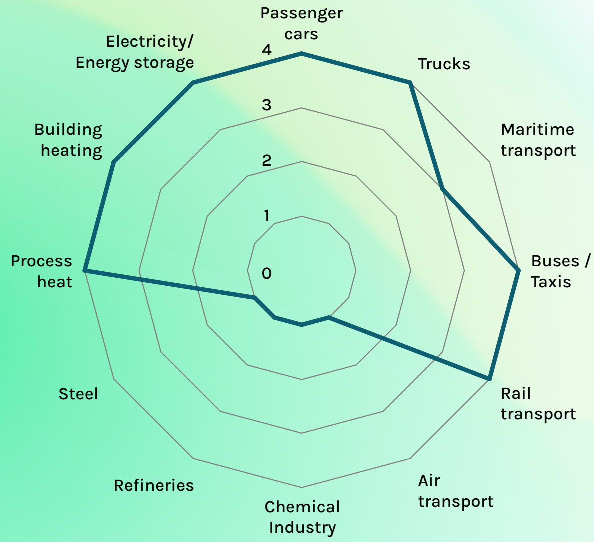
2. Targets
   - Climate neutrality by 2050
   - Dedicated production volume: 10–12 Mt/a hydrogen equivalent by 2050

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✗
   - International cooperation ✓
   - Reduction of $H_2$ costs ✗
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Hydrogen production based on fossil fuels without CCUS during a transitional period
   - Hydrogen production based on fossil fuels with CCUS during a transitional period
   - Use of electrolysis based on renewable electricity
   - Use of electrolysis based on grid power (renewable as of 2035)

5. Application fields




Other application fields:
- Transport:
  > forklifts, off-road motorcycles
- Industry:
  > agriculture, metal production

6. Comments / Remarks
   - The Green Paper was published by the New Zealand Ministry of Business, Innovation & Employment (MBIE) as the basis for a public consultation. The aim was to gather feedback on the challenges and opportunities of building a hydrogen economy in New Zealand.

**POLAND (POL)**

Polish Hydrogen Strategy

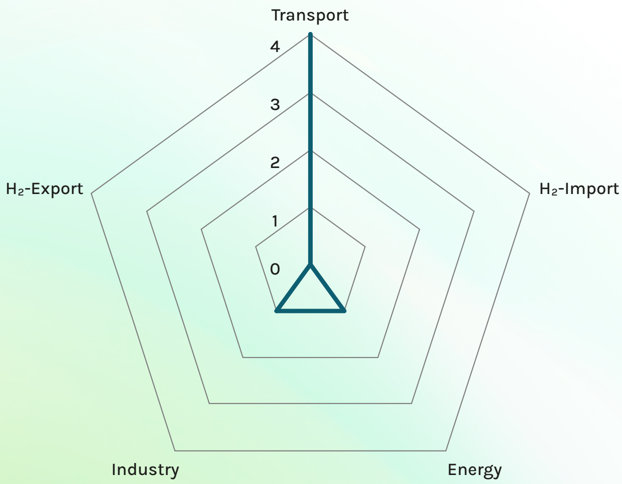
1. General information
   - Strategy
   - Publisher: Polish Ministry of Climate and Environment
   - Published: 05/2021
   - Time horizons: 2030, 2040

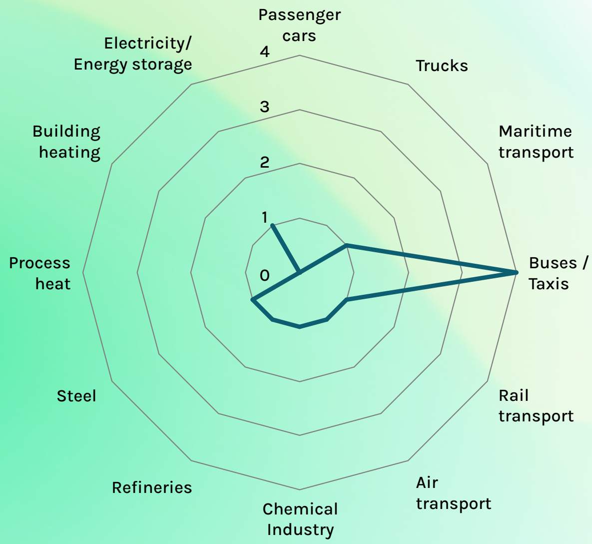
2. Targets
   - Electrolysis capacity: 50 MW (2030); 2 GW (2040)
   - FC buses: 100–250 (2025); 800–1000 (2030)
   - 32 $H_2$ filling stations

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✗
   - Subsidies/government support ✓
   - International cooperation ✗
   - Reduction of $H_2$ costs ✗
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Replacing of hydrogen based on fossil fuels without CCUS
   - Hydrogen production based on fossil fuels with CCUS
   - Use of electrolysis based on renewable electricity

5. Application fields



**PORTUGAL (PRT)**

Portugal National Hydrogen Strategy

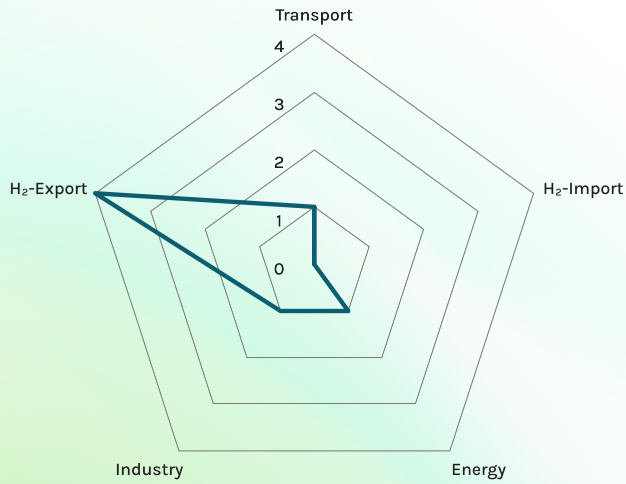
1. General information
- Strategy
- Publisher: Portuguese Government
- Published: 08/2020
- Time horizons: 2030/2050

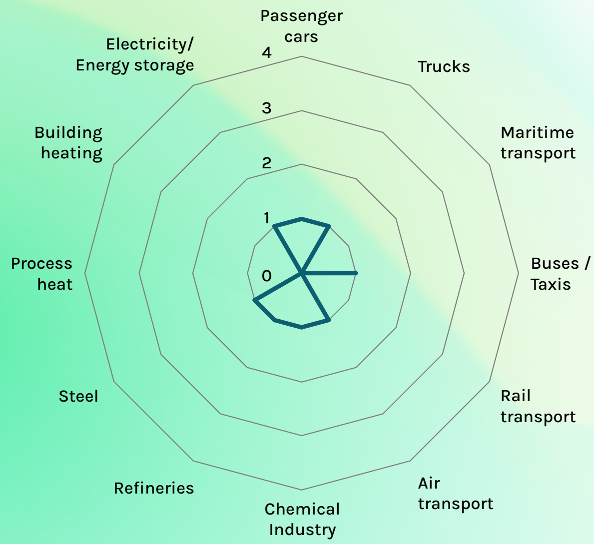
2. Targets
- 50–100 $H_2$ filling stations (2030)
- 5 % share of $H_2$ in final energy consumption (2030)

3. Strategic approach (✓ = addressed; ✗ = not addressed)
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

4. Hydrogen production
- Replacing of hydrogen based on fossil fuels without CCUS
- Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Transport:
  > synthetic fuels (n.s.)

**PARAGUAY (PRY)**

Towards the Green Hydrogen Roadmap in Paraguay

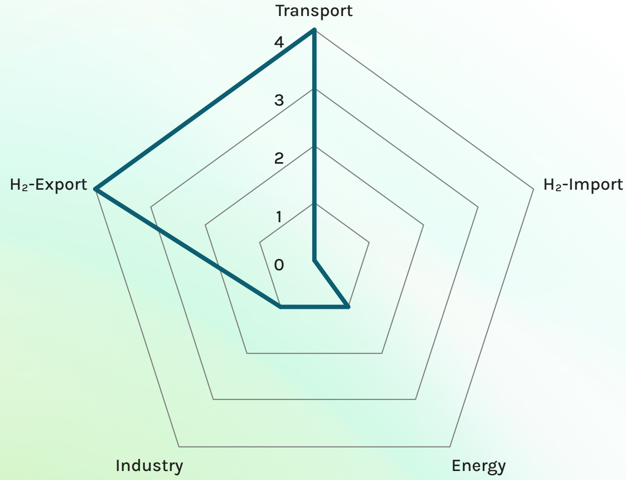
1. General information
   - Roadmap
   - Publisher: Vice-Ministry of Mines and Energy
   - Published: 06/2021
   - Time horizons: n.s.

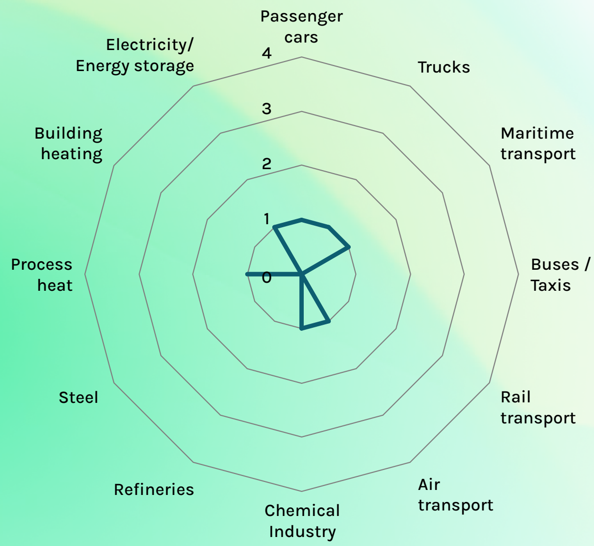
2. Targets
   - Climate neutrality: decarbonisation mentioned but without a target year or reference to Paris Agreement
   - Target price: under 3 USD/kg
   - Dedicated production volume: 1168 t by 2030

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Transport:
  > freight and passenger transport, synthetic fuels (n.s.)
- Industry:
  > pharmaceutical, food, metallurgy (n.s.)

6. Comments / Remarks
   - A strategy is to be developed in the next few years

**RUSSIA (RUS)**

Development of Hydrogen Energy in the Russian Federation

### 1. General information

- Concept
- Publisher: Russian Government
- Published: 08/2021
- Time horizons: 2024, 2035, 2050

### 2. Targets

- $H_2$ export volume: 0.2 Mt (2024); Mt (2035); 15–50 Mt (2050)

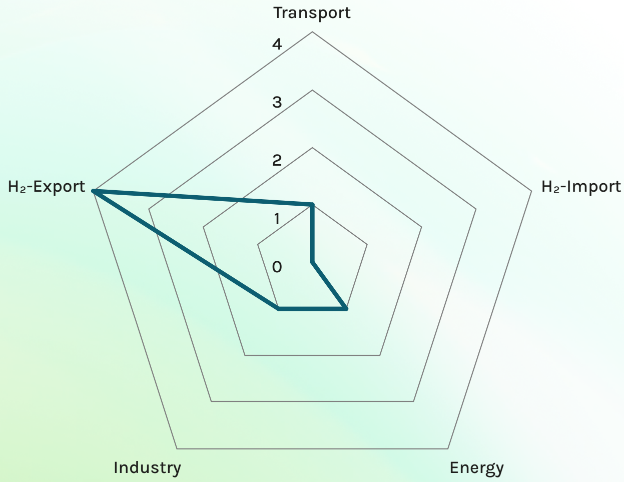
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

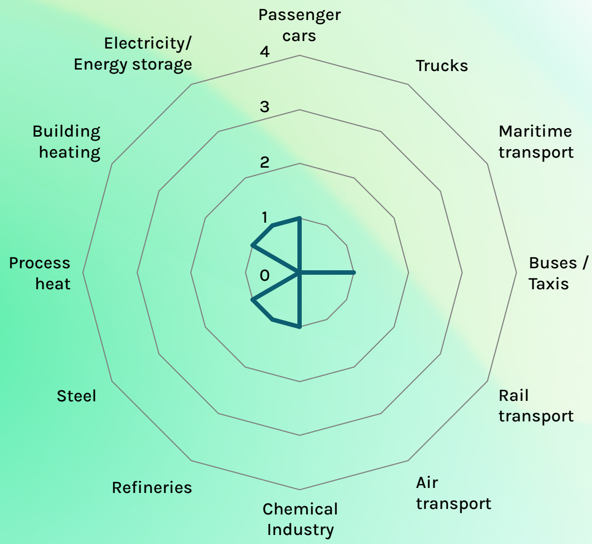
- Establishing the $H_2$ economy ✗
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Hydrogen production based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on grid power
- Use of electrolysis based on nuclear energy
- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Industry:
  > robotics (n.s.)

### 6. Comments / Remarks

- According to Russia, it is low-emission $H_2$ if the production is based on fossil fuels with CCUS; using pyrolysis; using steam reforming of natural gas with thermal energy from nuclear power and the use of CCUS; using electrolysis with electricity from nuclear power plants, hydroelectric power plants, RE sources or from the power grid, or if the $CO_2$ emissions are offset by climate projects.

## SINGAPORE (SGP)

Singapore's National Hydrogen Strategy

### 1. General information

- Strategy
- Publisher: Ministry of Trade and Industry – Singapore
- Published: 10/2022
- Time horizons: 2040, 2050

### 2. Targets

- Climate neutrality by 2050

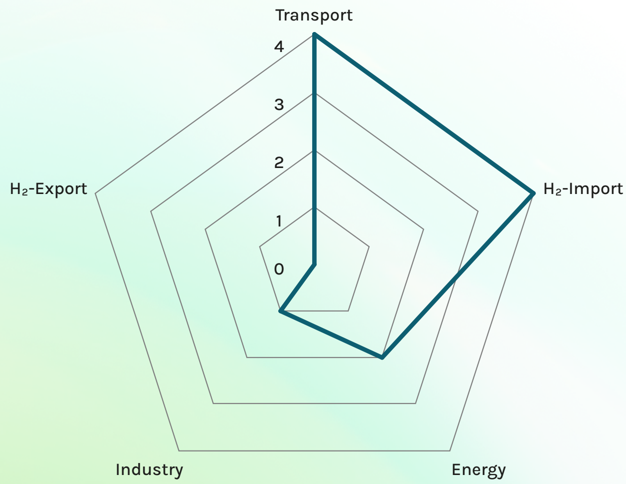
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

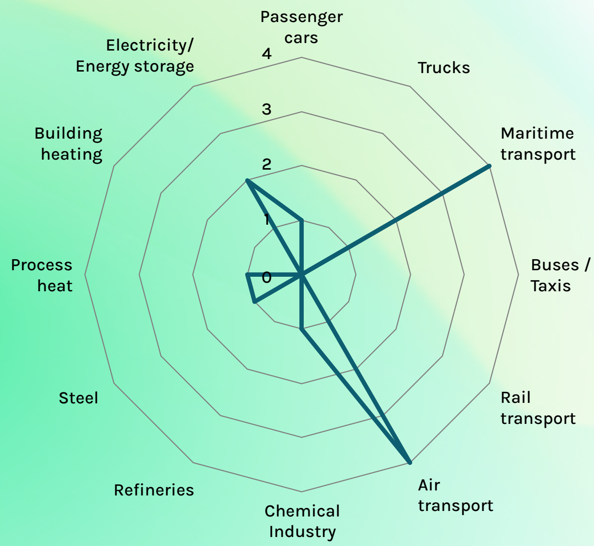
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Hydrogen production based on fossil fuels with CCUS
- Hydrogen production based on methane
- Hydrogen production based on ammonia

### 5. Application fields




Other application fields

- Transport:
  - > biofuels, synthetic fuels (n.s.)
- Industry:
  - > cement (n.s.)

### 6. Comments / Remarks

- Singapore is considering the use of hydrogen derivatives and downstream products in aviation and shipping.

**SLOVAKIA (SVK)**

National Hydrogen Strategy: Ready for the Future

### 1. General information

- Strategy
- Publisher: Slovak Ministry of Economy
- Published: 23/06/2021
- Time horizons: 2030, 2050

### 2. Targets

- Electrolysis capacity: 140–390 MW by 2030
- Climate neutrality by 2050
- Dedicated vehicle volume: 5000–15 000 passenger cars, 100–300 buses, 12–20 trains, 500–2000 utility vehicles by 2030
- Dedicated filling stations: 15–40 by 2030

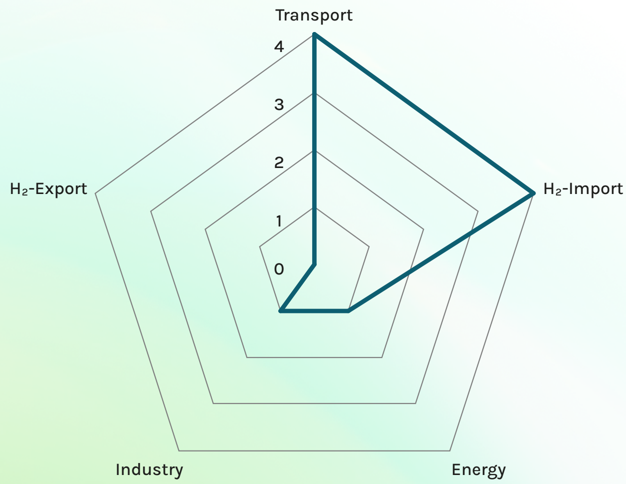
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

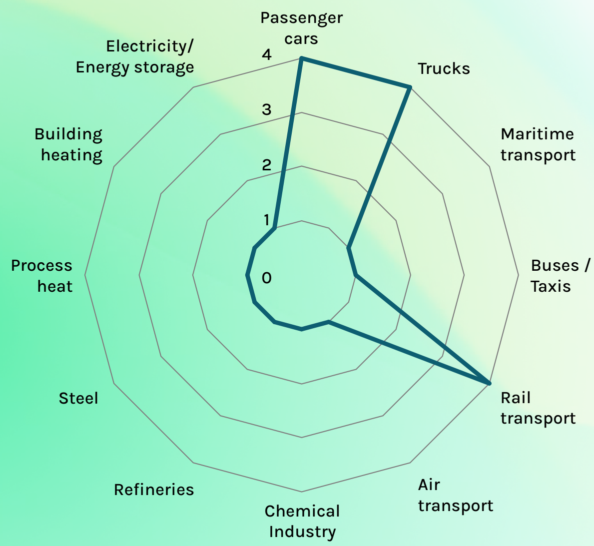
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✓
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Replacing of hydrogen based on fossil fuels without CCUS
- Hydrogen production based on fossil fuels with CCUS
- Use of electrolysis based on renewable electricity
- Use of electrolysis based on nuclear energy
- Hydrogen production based on biomass
- Hydrogen production based on waste
- Hydrogen production based on fermentation

### 5. Application fields




Other application fields:

- Transport:
  - > bicycles and scooters (n.s.), utility vehicles (s.t.), synthetic fuels (n.s.), forklifts (n.s.)
- Industry:
  - > metals, cement, synthetic fuels (n.s.)

**SWEDEN (SWE)**

Strategy for fossil free competitiveness

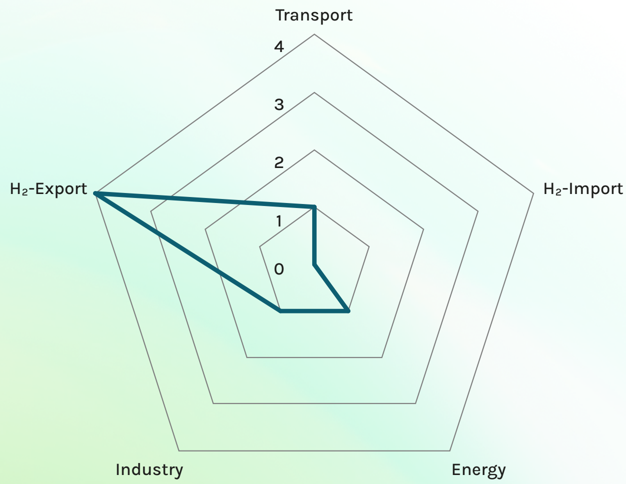
1. General information
   - Strategy
   - Publisher: 'Fossil Free Sweden' government initiative
   - Published: 01/2021

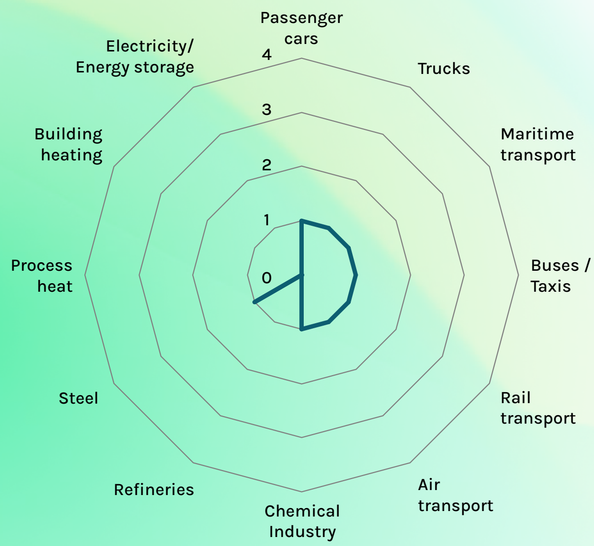
2. Targets
   - Electrolysis capacity: 3 GW by 2030, 8 GW by 2050
   - Climate neutrality by 2050

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Hydrogen production based on fossil fuels with CCUS
   - Use of electrolysis based on renewable electricity
   - Use of electrolysis based on grid power
   - Use of electrolysis based on nuclear power (through the grid)

5. Application fields




Other application fields:
- Industry:
  > iron ore, metals, methanol, agriculture (n.s.)

6. Comments / Remarks
   - The strategy focuses on prioritising support for fossil-free hydrogen only, rather than banning blue or grey hydrogen. Regulations and support programs are designed to primarily support investments in fossil-free hydrogen.

**TÜRKIYE (TUR)**

Türkiye Hidrojen Teknolojileri Stratejisi Ve Yol Haritası

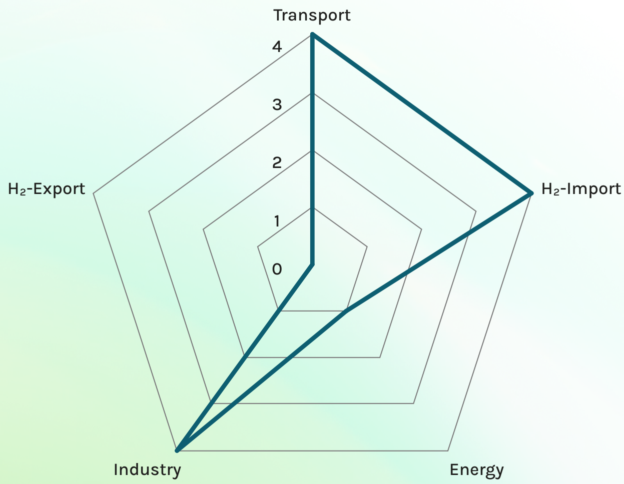
1. General information
   - Strategy and Roadmap
   - Publisher: Ministry of Energy and Natural Resources – Türkiye
   - Published: 2023
   - Time horizons: 2030, 2035, 2040, 2053

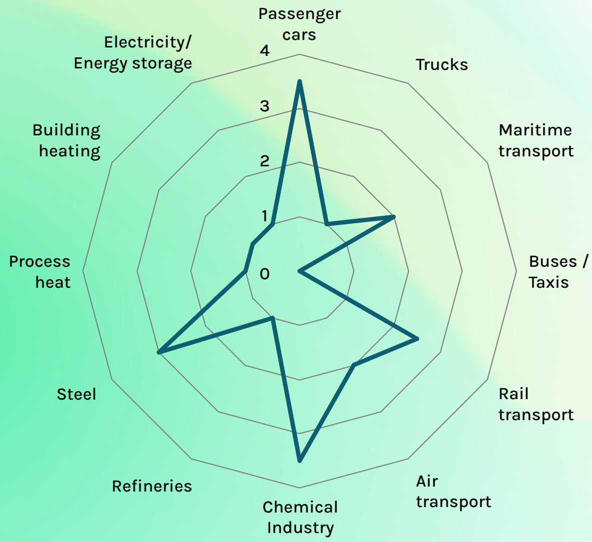
2. Targets
   - Electrolysis capacity: 2 GW by 2030, 5 GW by 2035, 70 GW by 2053
   - Climate neutrality by 2053
   - Target price: 2.40 USD/kg by 2035, 1.20 USD/kg by 2053

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✗
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Hydrogen production based on fossil fuels without CCUS e.g. with lignite coal
   - Hydrogen production based on fossil fuels with CCUS during a transitional period
   - Use of electrolysis based on renewable electricity
   - Use of electrolysis based on nuclear energy
   - Hydrogen production based on biomass
   - Hydrogen production based on pyrolysis
   - Hydrogen production based on fermentation (in bioreactors)

5. Application fields




Other application fields:
- Transport:
  > sodium borohydride for unmanned vehicles, batteries, maritime and road transport, military use, space transport (n.s.), forklifts (n.s.), methanol & ammonia (s.t.–l.t.)
- Industry:
  > fertilisers/ammonia (s.t.–m.t.), cement (s.t.–m.t.), glass & ceramics (s.t.–m.t.), desulphurisation (n.s.), hydrogen peroxide & hydrogen chloride (s.t.–l.t.)

## URUGUAY (URY)

Green Hydrogen Roadmap in Uruguay

### 1. General information

- Roadmap
- Publisher: Ministry of Industry, Energy and Mining – Uruguay
- Published: 2022
- Time horizons: 2022–2024, 2025–2029, 2030–2040

### 2. Targets

- Electrolysis capacity: 100–300 MW by 2025, 1–2 GW by 2030, 10 GW by 2040
- Climate neutrality by 2050
- Target price (production cost): 1.50–2.40 USD/kg by 2025, 1.20–1.90 USD/kg by 2030, 1.10–1.70 USD/kg by 2040, 1.00–1.40 USD/kg by 2050
- Dedicated production volume: 1 Mt by 2040
- Dedicated vehicle volume: 6500 in 2030, 17 500 in 2040 (heavy duty vehicles)

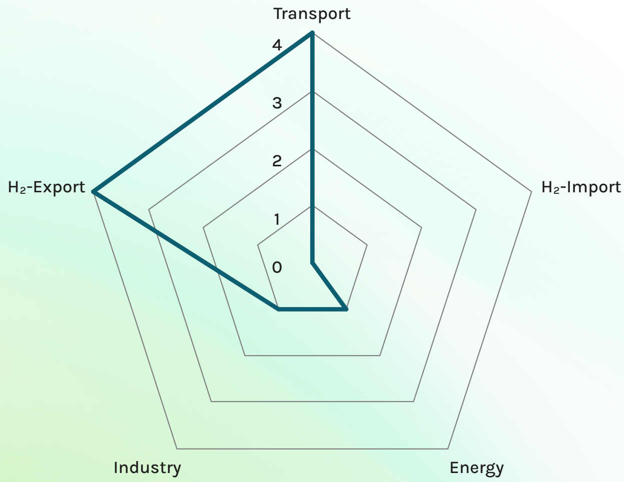
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

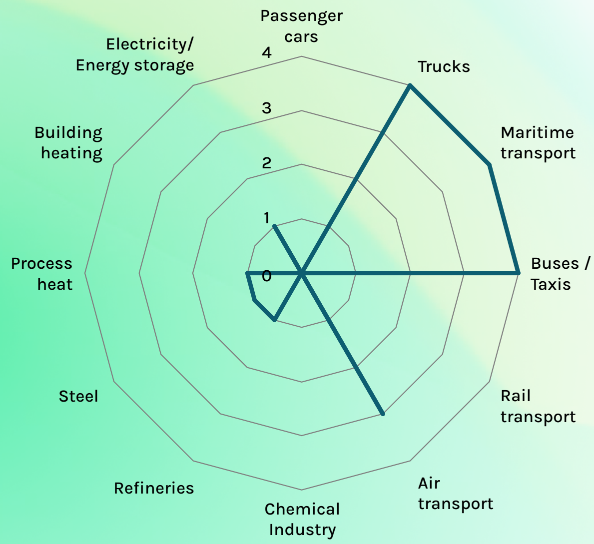
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Use of electrolysis based on renewable electricity

### 5. Application fields




Other application fields:

- Transport:
  - > synthetic fuels (e-methanol, e-jet-fuel) (s.t.), agricultural vehicles (s.t.)
- Industry:
  - > fertilisers (m.t.)

## UNITED STATES OF AMERICA (USA)

U.S. National Clean Hydrogen Strategy and Roadmap

### 1. General information

- Strategy and Roadmap
- Publisher: U.S. Department of Energy
- Published: 06/2023
- Time horizons: 2030, 2040, 2050

### 2. Targets

- Electrolysis capacity: 3 GW by 2030
- Climate neutrality by 2050
- Target price: 2 USD/kg from electrolysis by 2026, 1 USD/kg within a decade
- Dedicated production volumes: 10 Mt/a by 2030, 20 Mt/a by 2040, 50 Mt/a by 2050

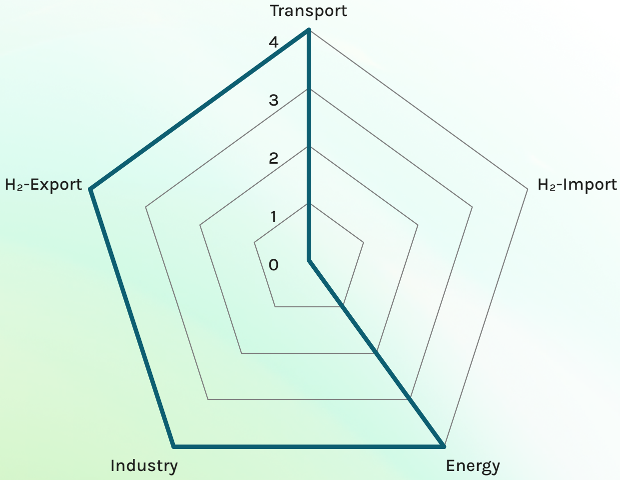
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

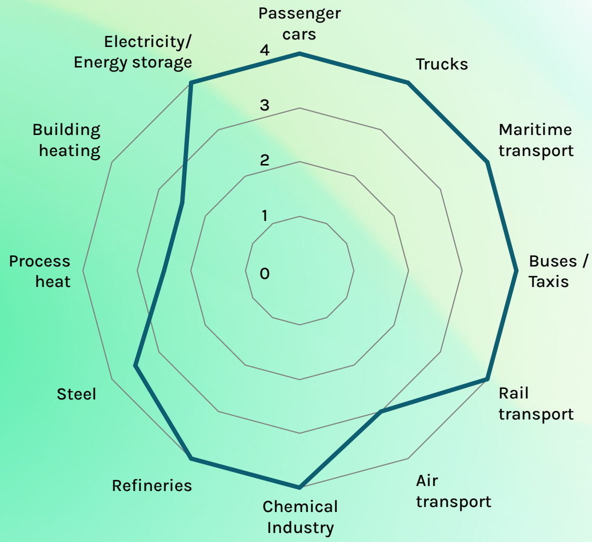
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✓
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✓

### 4. Hydrogen production

- Hydrogen production based on fossil fuels with CCUS
- Hydrogen production based on fossil fuels without CCUS
- Use of electrolysis based on renewable electricity
- Use of electrolysis based on nuclear energy
- Hydrogen production based on biomass
- Hydrogen production based on residual raw materials
- Hydrogen production based on thermochemical, biological and photoelectrochemical processes

### 5. Application fields




Other application fields:

- Transport
  - > miscellaneous: forklifts, off-road vehicles, off-road equipment (mining, construction, agriculture) (n.s.)
- Industry:
  - > liquid fuels, ammonia, methanol, biofuels from biomass (m.t.-l.t.), cement (n.s.), food (n.s.)

### 6. Comments / Remarks

- Please also refer to documentation on the Hydrogen Energy Earthshots Initiative

## CALIFORNIA (US-CAL)

The California Fuel Cell Revolution

### 1. General information

- Roadmap
- Publisher: California Fuel Cell Partnership
- Published: 07/2018
- Time horizons: 2018, 2030

### 2. Targets

- FCEVs: 1 000 000 (2030)
- $H_2$ filling stations: 200 (2025), 1000 (2030)

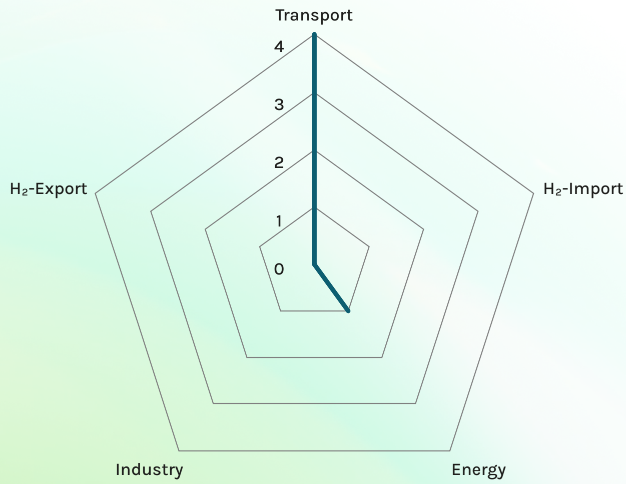
### 3. Strategic approach (✓ = addressed; ✗ = not addressed)

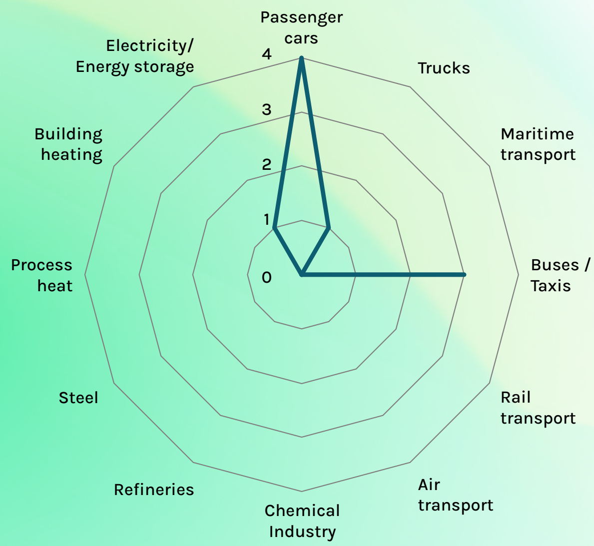
- Establishing the $H_2$ economy ✓
- New jobs/training of specialised staff ✗
- Subsidies/government support ✓
- International cooperation ✓
- Reduction of $H_2$ costs ✓
- Carbon pricing ✗
- Infrastructure development ✓
- Regulatory framework/certifications ✓
- R&D ✗

### 4. Hydrogen production

- Use of electrolysis based on renewable electricity

### 5. Application fields




### 6. Comments / Remarks

- This non-governmental roadmap focuses on fuel cell applications, primarily in transport but also in the energy system. Therefore, no other hydrogen applications are considered in this roadmap.

**SOUTH AFRICA (ZAF)**

Hydrogen Society Roadmap for South Africa

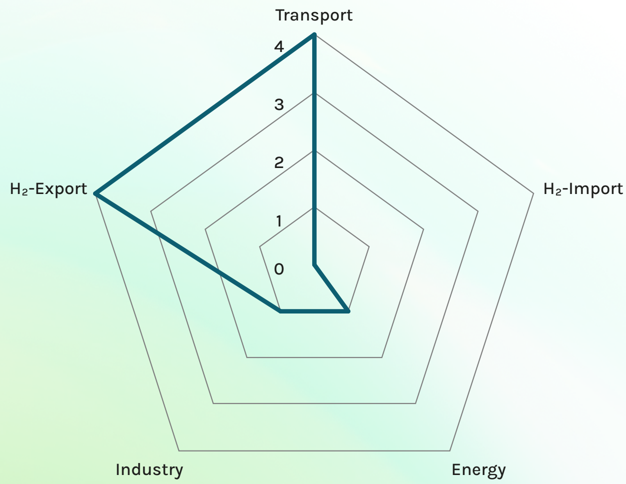
1. General information
   - Roadmap
   - Publisher: Department of Science and Innovation – South Africa
   - Published: 2021
   - Time horizons: 2024, 2030, 2050

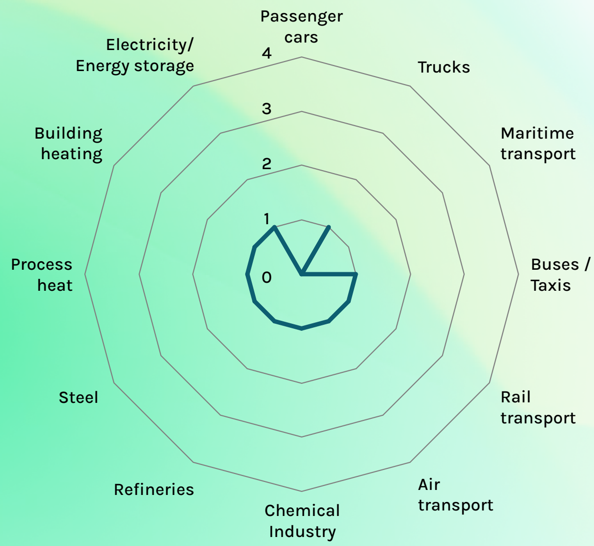
2. Targets
   - Electrolysis capacity: 1 MW in 2020s, 1.7 GW by 2030, 15 GW by 2040
   - Climate neutrality by 2050
   - Target price: 1.60 USD/kg by 2030
   - Dedicated production volume: 2 Mt in 2020s of grey $H_2$, 500 kt/a as of 2030
   - Dedicated vehicle volume: 100 buses and heavy duty vehicles by 2025,
   - 500 buses and heavy duty vehicles by 2030
   - Dedicated filling stations: 5 by 2025

3. Strategic approach (✓ = addressed; ✗ = not addressed)
   - Establishing the $H_2$ economy ✓
   - New jobs/training of specialised staff ✓
   - Subsidies/government support ✓
   - International cooperation ✓
   - Reduction of $H_2$ costs ✓
   - Carbon pricing ✓
   - Infrastructure development ✓
   - Regulatory framework/certifications ✓
   - R&D ✓

4. Hydrogen production
   - Replacing of hydrogen based on fossil fuels without CCUS
   - Use of electrolysis based on renewable electricity

5. Application fields




Other application fields:
- Industry:
  > cement, mining, metals (n.s.)

# Contact

**CONTACT**
Jens Artz
jens.artz@dechema.de

**AUTHORS**
Jens Artz, Marie Biegel, Dominik Blaumeiser, Michaela Löffler, Andrea Lübcke, Anna Runkel and Emre Yildirim

**PUBLISHER**

DECHEMA
Gesellschaft für Chemische Technik und Biotechnologie e.V.

Theodor-Heuss-Allee 25
60486 Frankfurt am Main

info@dechema.de
www.dechema.de

acatech
NATIONAL ACADEMY OF SCIENCE AND ENGINEERING

Karolinenplatz 4
80333 Munich

info@acatech.de
www.dechema.de

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