The House of Hydrogen

A Holistic Approach to Developing a European Hydrogen Market

A SIX White Paper

Foreword

Hydrogen markets are emerging as a critical component of the global energy transition, driven by the need to decarbonize industries, reduce greenhouse gas emissions, and achieve climate goals. Green hydrogen, produced from renewable energy sources, offers a versatile and sustainable alternative to fossil fuels. Its applications span across various sectors, including transportation, power generation, industrial processes, and heating, making it a key player in the future energy landscape.

The development of hydrogen markets involves the production, storage, transportation, and consumption of hydrogen, along with the establishment of regulatory frameworks. As hydrogen production scales up and demand increases, efficient and transparent markets will be essential for balancing supply and demand, ensuring price discovery, and enabling the flow of capital into hydrogen projects.

SIX Swiss Exchange partnered with the University of St. Gallen to examine the current state of the hydrogen market, with a particular focus on Europe. This study highlights the challenges and uncertainties along the hydrogen value chain. Students from the University of St. Gallen have proposed practical tools and strategies to influence the future development of the global hydrogen market. We hope you find this paper both insightful and enjoyable to read.

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Executive Summary

This paper aims to characterize hydrogen as an energy carrier and to present strategies to foster a livelier European hydrogen market. After introducing the topic, the current state of hydrogen markets is examined, followed by a development outlook in Europe. Afterwards, European hydrogen regulations are explored and compared to China's regulations, which are a driving force for their hydrogen advancements. Then, development strategies for a livelier European hydrogen market are introduced.

While mainly produced through carbon-emitting techniques, hydrogen can be produced sustainably and carbon-free. Therefore, it is often seen as a cornerstone of a green energy future. Hydrogen is used in many industrial applications, such as for the chemicals industry or for fertilizer, but it can also be used to produce carbon-free steel or for transportation. In many of these applications it represents the only viable replacement for the current carbon-intensive alternatives. As of now, all parts of the hydrogen value chain represent significant cost drivers, especially storage and transportation. For hydrogen to be a viable competitor in industrial applications, its price must decrease.

As its crucial role in the future of the energy landscape is undeniable, many governments are pushing for hydrogen adoption. This includes governments in Europe, where numerous investments have been made in this space. Despite a surge in announced projects and investments, Europe currently lags behind leading players such as China in developing a mature hydrogen market. A significant difference lies in their approaches: Europe prioritizes green hydrogen production to address climate concerns, while China emphasizes scaling hydrogen output regardless of carbon intensity. This strategic divergence underscores Europe's challenge in balancing sustainability with the competitive pressures of the global hydrogen economy.

To develop a mature hydrogen landscape, Europe must confront its hydrogen market risks and early-stage challenges. Investors remain cautious, partly due to uncertainties around infrastructure development, regulatory consistency, and return on investment. Addressing these perceived risks requires a holistic and integrated strategy – the "House of Hydrogen." The "House of Hydrogen" is a framework developed by Students of the University of St. Gallen that offers five interconnected approaches to reduce investment risk and drive market growth. The "House of Hydrogen" consists of a "HY Catalyst" program designed to accelerate innovation by supporting new developments; initialising the trading of bonds focused on green hydrogen infrastructure development; cross-commodity hedging to stabilize hydrogen prices for producers and consumers; a "Financing Platform" that connects project developers and investors; and lastly, a data hub to help increase market transparency and build actionable insights.

Together, these proposals address key barriers in Europe's hydrogen ecosystem by creating a foundation of trust, financial stability, and operational transparency. Startups supported by the "HY Catalyst" can leverage the financing platform to secure funding, de-risk projects with bonds and hedging, and refine strategies using insights from the Data Hub. This interconnected system not only alleviates perceived risks but also builds momentum for market expansion and adoption.

By integrating these elements, the "House of Hydrogen" aligns economic opportunity with environmental sustainability, ensuring Europe's hydrogen ambitions are both scalable and achievable. These solutions provide a pathway to bridge the investment gap, whilst enabling Europe to compete with global leaders like China, and contribute to achieving long-term clean energy goals while offering significant opportunities for financial infrastructure providers.

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List of Abbreviations

Bn	Billion
°C	Celsius
CCS	Carbon capture and storage
CO_2	Carbon dioxide
e.g.	exempli gratia (eng. for example)
ESG	Environmental, Social and Governance
ETF	Exchange Traded Fund
EU	European Union
HY	Hydrogen
i.e.	id est (eng. that is)
IT	Information Technology
Kg	Kilogram
kWh	Kilowatt hours
LNG	Liquefied natural gas
n.d.	no date
SMR	Steam methane reforming
TWh	Terawatt hour
TWSC	Thermochemical water splitting cycles
U.S.	United States
WEF	World Economic Forum

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1 Introduction

Hydrogen shows significant potential in areas where other renewable energy sources fail to present viable alternatives. For example, hydrogen can help decarbonize carbon-intensive sectors such as heavy industry (chemical, refineries, steel), transportation (shipping, heavy-duty vehicles),energy storage *(WEF, 2023).* Therefore, green hydrogen is regarded as "an important part of the puzzle for a functioning clean energy ecosystem in Europe," Dan Jørgensen, European Commissioner for Housing and Energy *(Virone et al., 2024).* This sentiment is mirrored by global efforts to scale up hydrogen production and usage, illustrated by governmental initiatives with ambitious growth targets. **With $1 trillion worth of global investment needed by 2030 to meet targets set by key players such as the EU with its net zero goals or China's ambitious growth targets discussed in Chapter 3 – but only $570 Bn in direct investments announced – there remains a significant $430 Bn funding gap** *(Hydrogen Council & McKinsey & Company, 2023, p.12).* This highlights the need for a more dynamic hydrogen financing market. Financial infrastructure providers are pivotal to the European energy transformation. Given the substantial investments required, these providers will play an integral role in shaping the market's trajectory.

Worldwide initiatives in hydrogen are heating up, leading to 1,418 hydrogen projects being announced by the end of 2023, of which 540 were in Europe. This, along with the opening statement, shows Europe's commitment to hydrogen as part of its energy future. While more funding is necessary, Europe ranks first in hydrogen investing, with the most significant share coming from the EU and national governments. While Europe is determined to lead into 2030 and beyond, currently, the leader of announced hydrogen investment is China *(Hydrogen Council & McKinsey & Company, 2023, p.5; Hydrogen Europe, 2024, p.6–7).*

This paper presents an introductory view of hydrogen as a clean energy source and strategies to develop European hydrogen markets. Specifically, the status quo of hydrogen, its future in Europe, and the European regulatory landscape will be characterized in a global context. Further, concrete proposals to support European hydrogen investments are discussed.

The lack of funding, despite significant public, private, and governmental interest in green hydrogen, comes down to uncertainty, risk, and a lack of trust in the hydrogen market. The drivers of uncertainty and risk will be explored in Chapter 2, where an overview of the hydrogen value chain is presented, covering production, transportation, storage, use cases, and demand drivers. Then, the cost structure is examined, followed by an analysis of project maturity and an outlook for hydrogen.

In Chapter 3, the role of regulations in the hydrogen market is explored, first focusing on European regulations, then on Chinese regulations, and finally comparing the two.

Chapter 4 discusses a proposal developed by the authors to kickstart European hydrogen investments. A "HY Catalyst" program, cross-commodity hedging, hydrogen infrastructure bonds, a financing platform, and a data hub are presented as ways to increase trust and investments. These approaches are organized within the "House of Hydrogen," a holistic approach to develop the European hydrogen market.

The tools and strategies in the "House of Hydrogen" are not only practical suggestions but also illustrate how financial infrastructure providers can influence the hydrogen market's development. By bridging the funding gap and mitigating market risks, these stakeholders can help build a robust, prosperous, and sustainable European hydrogen ecosystem.

2 Characterising the Hydrogen Landscape

To allow for a substantiated understanding of how a European hydrogen market can be developed, it is important to initially grasp all aspects of the hydrogen value chain. To this end, production, storage, distribution and the demand, as well as applications of hydrogen, are analyzed in this chapter. Then the cost of hydrogen is broken down along the value chain from the viewpoint of an end user. Following that, the maturity of hydrogen infrastructure is assessed. Lastly, we give an outlook on the development of hydrogen as an energy source.

2.1 Hydrogen Definition and Production Methods

Making up around 75% of the universal mass, hydrogen is the most common element in the universe. Its abundance comes down to its simplicity, consisting of one proton and one electron in its most common isotopic state, it was the first element that formed according to the Big Bang Theory alongside helium *(Méndez Delgado, 2023).* At standard temperature it is a colourless and odourless gas and commonly reacts with oxygen to form water. When hydrogen is mixed with oxygen gas and combusts, it results in an exothermic reaction, during which energy in the form of heat and light is released. One kilogram of hydrogen is equivalent to roughly 33kWh of usable energy – around three times more than gasolines 11.76 kWh per kilogram *(U.S. Department of Energy, n.d.-a).*

According to the fundamental principle of the conservation of energy – energy cannot be created or destroyed – for hydrogen to be that energy dense must also mean its production is energy intensive. Whether hydrogen is considered energy friendly therefore depends on the type of energy used to produce it. As shown in **figure 1**, hydrogen can be divided into different categories based on how it is produced *(Schranz, n.d.).*

While there is a plethora of hydrogen production methods, five are explained in further detail. These are coal gasification, as it is a readily utilized example of brown hydrogen production; steam-methane reforming (SMR), as it is currently the most common production method; electrolysis, as it is the most popular production method of green hydrogen and methane pyrolysis and thermochemical water splitting cycles (TWSC), as they showcase promising future production methods.

2.1.1 Coal Gasification

Coal Gasification is a process whereby a coal-based feedstock is converted into hydrogen by heating it in the presence of steam and oxygen. The complex chemical reactions involve varying different pressure and temperature within the gasification system. The gasifier produces a so-called "synthesis gas", which is made of hydrogen and other components, such as physical particulates, carbon oxide and carbon dioxide. Further, methane and water are part of the synthesis gas. This gas is then filtered to remove physical particles and then the hydrogen is separated out. Other byproducts are used for fuels and chemicals *(Stiegel & Ramezan, 2005, p.176).*

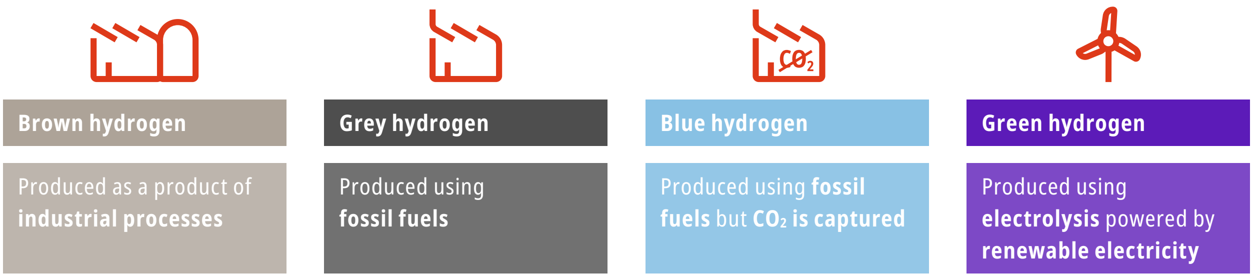

Figure 1: Different production methods of hydrogen (own illustration based on Schranz, n.d.)

When Coal Gasification is classified as **brown hydrogen,** it is a process carried out on its own, but complimentary to an existing industrial process. For example, coal is burned to generate electricity and coal gasification can be used to transform what would otherwise be waste into hydrogen. Since this provides considerable synergies, Coal Gasification can meaningfully compete with SMR, which is introduced in the next subchapter *(Stiegel & Ramezan, 2005, p.173).*

When Coal Gasification is carried out by itself for the sake of producing just hydrogen, it is considered grey hydrogen just as **Steam Methane Reforming (SMR)** is.

2.1.2 Steam Methane Reforming

SMR is a thermochemical, endothermic, i.e. energy absorbing, process. Natural gas serves as the starting point and hot steam at a temperature between 700–1,000 °C reacts with methane under pressure using a catalyst and oxygen, producing carbon monoxide and hydrogen *(U.S. Department of Energy, n.d.-a).*

It is one of the few technologies currently viable to produce hydrogen on an industrial scale *(Discover The Greentech, 2023).* With an efficiency rate of 65% to 75% it is currently also the most efficient way to produce hydrogen. While most plants use natural gas, other sources like methanol, fuel oil and diesel are also possible. Around three quarters of the current annual output of hydrogen are produced using natural gas.

One disadvantage of the method is its production of CO_2, with 10 tons of CO_2 output per ton of hydrogen produced. If not stored in carbon-capture-storage (CCS) facilities or utilized in any other way, the process is considered harmful to the climate as the CO_2 escapes unhindered into the atmosphere. Therefore, hydrogen produced from SMR is considered **grey hydrogen.**

2.1.3 Electrolysis

This method uses an electrolyser which uses electricity to split water into hydrogen and oxygen. The technology is particularly promising as it produces **green hydrogen** due to its carbon-free and environmentally friendly nature when using renewable electricity. The technology can be used in both small and industrial environments to produce large quantities of hydrogen *(TÜV Nord, n.d.).*

Currently, the technology is not competitive with conventional processes such as SMR, and production costs still need to be significantly reduced *(U.S. Department of Energy, n.d.-d)*. There are various electrolysis processes in use. Three common processes are alkaline electrolysis, polymer electrolyte membrane electrolysis and solid oxide electrolysers *(U.S. Department of Energy, n.d.-b; TÜV Nord, n.d.).* Each of these processes offers its own unique advantages and disadvantages, and researchers are still improving each method.

Alkaline electrolysis offers several advantages. It is known for its high efficiency, which makes it economically viable for large-scale industrial production. The process is also characterized by the longevity of the production plant. The electrolysers used are well suited for industrial applications due to their low cost and viability for economies of scale *(Stargate Hydrogen, 2023).*

Polymer electrolyte membrane electrolysis uses a solid polymer electrolyte as a membrane and can be used relatively flexibly and is insensitive to partial load peaks. It is therefore particularly suitable for the production from volatile renewable energy, such as wind energy. Additionally, it is characterized by high efficiency, with a degree of efficiency between 60% to 70%. However, the need for rare precious metals such as iridium results in high material costs. Still, the technology shows potential for further development *(Weik, 2024).*

Solid oxide electrolysers operate at ten times the temperature that polymer electrolyte membrane electrolysers do, presenting a significant heating challenge. However, it can use waste heat from, for example, nuclear energy to function, and shows significant potential for symbiosis with other technologies *(U.S. Department of Energy, n.d.-b).*

2.1.4 Methane Pyrolysis

Also known as “methane cracking”, this method also uses natural gas, i.e. methane as its starting product. With the addition of energy, natural gas is broken down at high temperatures into hydrogen and solid carbon *(Ineratec, n.d.).* While promising, no large-scale industrial application has yet been achieved yet. Currently, only test plants are in operation, and it will be several years before there is implementation on a larger industrial scale *(Wernicke, 2021).* The process is considered environmentally friendly and needs lower amounts of energy compared to other methods.

As no CO_2 is produced – only solid carbon – the carbon by-product can be utilized much more easily, for example, in industry, agriculture or as a building material. Since all the produced carbon is captured as a solid by-product, it is considered a **blue hydrogen** source. Methane pyrolysis only requires around a fifth of the energy that electrolysis would use. Therefore, overall efficiency is significantly higher *(SFC Energy, n.d.).*

2.1.5 Thermochemical Water Splitting Cycles

Using Thermochemical Water Splitting Cycle (TWSC), water is split into hydrogen and oxygen in several loops at high temperatures. The energy required for this is provided, for example, by means of concentrated solar energy, waste heat or nuclear energy *(U.S. Department of Energy, n.d.-c).*

The process promises very low to no CO_2 emissions and originated in the mid-1960s. However, there are still numerous hurdles to overcome and industrial application is not yet possible. Nonetheless, the process has enormous potential in the long term, as it enables the production of hydrogen in large quantities. Further, no catalyst is required, and expensive or rare elements are not needed. The use of waste heat allows for decentralized hydrogen production. Since TWSC ideally produces no carbon emissions, it can be considered a source of **green hydrogen** *(Torre, 2022).*

While hydrogen is often considered a clean energy source, the currently most popular production method of SMR produces large amounts of CO_2. For hydrogen to be truly clean, there needs to be a shift towards green hydrogen production methods which use electrolysis and sustainable electricity from – for example – wind or solar. As this remains costly today, the financial sustainability of hydrogen as a clean energy source remains questionable.

2.2 Storage of Hydrogen

Hydrogen storage systems can be divided into two categories: physical- and material-based storage. Different vessel types can be selected based on the application field with a compromise between technical performance and cost *(Rivard et al., 2019).*

In the more popular physical based storage, hydrogen is altered in its physical state, namely increasing the pressure or by decreasing the temperature. When increasing the pressure, hydrogen is stored as a compressed gas in high pressure vessels. When decreasing the temperature below its evaporation temperature, it is stored as a liquid. Combinations of both physical based storage methods can be used.

In the case of material-based storage, additional materials as "carriers" are applied. They can bond with hydrogen atoms, either physically or chemically, and thus enhance storage density as well as safety, compared with those of physical based storage systems *(U.S. Department of Energy, n.d.-d).* Currently, most material-based storage technologies are still in the laboratory or demonstration phases.

Beyond man-made storage solutions, natural formations can also be used for hydrogen storage *(Doe & Smith, 2022).* Underground hydrogen storage in salt caverns, depleted gas reservoirs or aquifers are showing promise for different storage needs. For example, salt caverns are the best candidates for storing pure hydrogen due to their tight deposits, favourable mechanical properties, chemical resistance, and viscoelastic evaporitic rocks, which provide excellent sealing. However, unlike aquifers, salt caverns are small in volume and scarcely distributed.

2.3 Distribution of Hydrogen

The transportation of hydrogen is similar to that of natural gas, it can be transported through pipelines, by trucks and rail or via shipping lanes in liquid or gaseous form *(entsog et al., 2021).*

Pipeline infrastructure requires high upfront investment but becomes economically efficient when transporting large quantities, making it ideal for supplying hydrogen to large industrial users. Additionally, existing infrastructure built for natural gas can be retrofitted or used concurrently for hydrogen *(entsog et al., 2021, p. 3–10).*

Land transportation, other than pipelines, is mostly carried out by trucks, trailers or rail and is done either in gaseous form or as a liquid in the above-mentioned storage states *(entsog et al. 2021, p. 8).*

Shipping is the third viable method for transporting hydrogen, particularly for intercontinental deliveries. On ships, hydrogen can be transported as a gas or liquid or in a compound form, for example, as a liquid in organic hydrogen carriers or as ammonia (*entsog et al., 2021, p.8).*

2.4 Demand for Hydrogen

Over the coming decades, demand for blue and green hydrogen will grow substantially, while demand for grey hydrogen will decline. Even in the most pessimistic growth scenario, demand for green hydrogen in 2050 will be larger than grey hydrogen at its peak. More optimistic scenarios – including continuing current growth momentum or net zero requirements – promise demand much larger than that.

Currently, the annual global demand of green hydrogen is approximately 2,997 TWh. **By 2050, this demand is projected to range from 4,163 TWh in the most pessimistic scenario to 19,481 TWh in the most optimistic scenario** *(Gulli et al., 2024).* These prognoses are supported by other growth projections, for example, by the Paul Scherrer Institute, which anticipates demand to be between 3,696 TWh and 20,446 TWh. The demand for green hydrogen is expected to reach between 73% to 100% of demand by 2050 *(Gulli et al., 2024).*

Predicted demand growth will occur in phases, shaped by sectoral variations in infrastructure readiness and regulatory frameworks *(Ulreich & International Chamber of Shipping, 2024).* By 2040, hydrogen demand is projected to double, driven mainly by the industrial sector where it serves as a baseload energy source *(Ulreich & International Chamber of Shipping, 2024, p.4).* **By 2050, hydrogen is predicted to account for 4% to 11% of global energy supply, equating to 2,997 TWh to 19,980 TWh annually** *(Ulreich & International Chamber of Shipping, 2024, p.6).*

Northwest Europe is a critical region for hydrogen demand, driven by its industrial base and infrastructure. Key drivers are the chemical industry, particularly in Germany and the Benelux region, which account for 7.3% of global chemical turnover and drive material-use hydrogen demand. Steel and cement production are also significant demand sources. Ports in the Netherlands and Belgium are crucial logistics hubs for Europe, handling crude oil, coal, and Liquefied Natural Gas (LNG), which positions the region as a potential hydrogen hub. The current hydrogen consumption in Northwest Europe is 95 TWh, predominantly consisting of grey hydrogen. By 2050, under a scenario focused on industrial applications, hydrogen consumption is projected to increase to 214 TWh. This scenario anticipates primary use in industrial sectors, with limited adoption in transportation and heating. This growth emphazises the region's critical role in meeting future hydrogen demand and achieving net zero goals *(Ulreich & International Chamber of Shipping, 2024, p.26–27).*

2.5 Application of Hydrogen in Different Areas

Hydrogen is increasingly recognized as a pivotal component of the global energy transition, driven by ambitious climate neutrality strategies and technological advancements. This subchapter explores hydrogen applications across key sectors, focusing on its potential to decarbonize industries, transportation, and energy systems. While often considered as an instrument to revolutionize and decarbonize the mobility industry, currently almost half of use cases for hydrogen are in heavy industries like the production of ammonia or methanol. The other half is applied within refining processes *(Ulreich & International Chamber of Shipping, 2024, p.11).*

Hydrogen has immense potential to decarbonize industries, but its widespread adoption depends on overcoming production costs, storage challenges, and infrastructure limitations.

Industrial demand is projected to remain the primary driver of hydrogen consumption through 2050. Our analysis is built on research from *Ulreich & International Chamber of Shipping (2024)*. Today, approximately three-quarters of global hydrogen demand comes from refining operations and chemical processes. By 2050, hydrogen is expected to serve as the main energy source in industries such as refining and chemicals, steel and cement production, where it replaces fossil fuels in high-grade heat applications. In refining and chemicals, hydrogen is extensively used to desulfurize fuels and in chemical production for ammonia and methanol. The transition from grey to green hydrogen in these processes is critical for achieving sustainability goals. For steel production, hydrogen presents a transformative opportunity to decarbonize steelmaking. By replacing coal as a reducing agent when removing oxygen from iron ore, hydrogen can significantly reduce CO_2 emissions. However, the implementation of hydrogen-based technologies in steel production needs substantial infrastructure changes and will take a long time to implementation. Cement production is another energy-intensive process where hydrogen can replace conventional fuels, thereby contributing to lower emissions in this sector.

While transportation currently represents a smaller portion of hydrogen demand, it is anticipated to grow up to a 17% by 2050 *(Ulreich & International Chamber of Shipping, 2024, p.4)*. It is essential in its application particularly in segments where electrification is less feasible. Hydrogen-powered fuel cell vehicles offer a viable alternative for long-haul trucks, buses, and other heavy-duty vehicles or ships, benefiting from hydrogen's high energy density and quick refuelling times. The aviation sector, however, faces challenges in adopting hydrogen due to the weight and complexity of storage systems. Similarly, hydrogen adoption in shipping competes with LNG and other low-emission fuels, although ammonia derived from hydrogen is emerging as a promising maritime fuel *(Liebreich Associates, 2024).* Hydrogen trains have been successfully piloted in regions where electrification is costly or impractical, offering a cleaner alternative to diesel-powered locomotives.

In the future, Hydrogen could have an important role in energy storage and grid stabilization, which is supporting the integration of renewable energy sources. Hydrogen can store surplus electricity from wind and solar power, balancing supply and demand in energy systems. This application is particularly relevant in regions with high renewable energy penetration. Hydrogen is a flexible energy carrier and can be produced and converted into electricity on demand, which enables its use in grid stabilization, addressing intermittency issues associated with renewable energy.

Current drivers of hydrogen demand can be seen in **figure 2**. As described above, **the main consumers of hydrogen are of an industrial nature, with refining and ammonia production leading the demand statistics.**

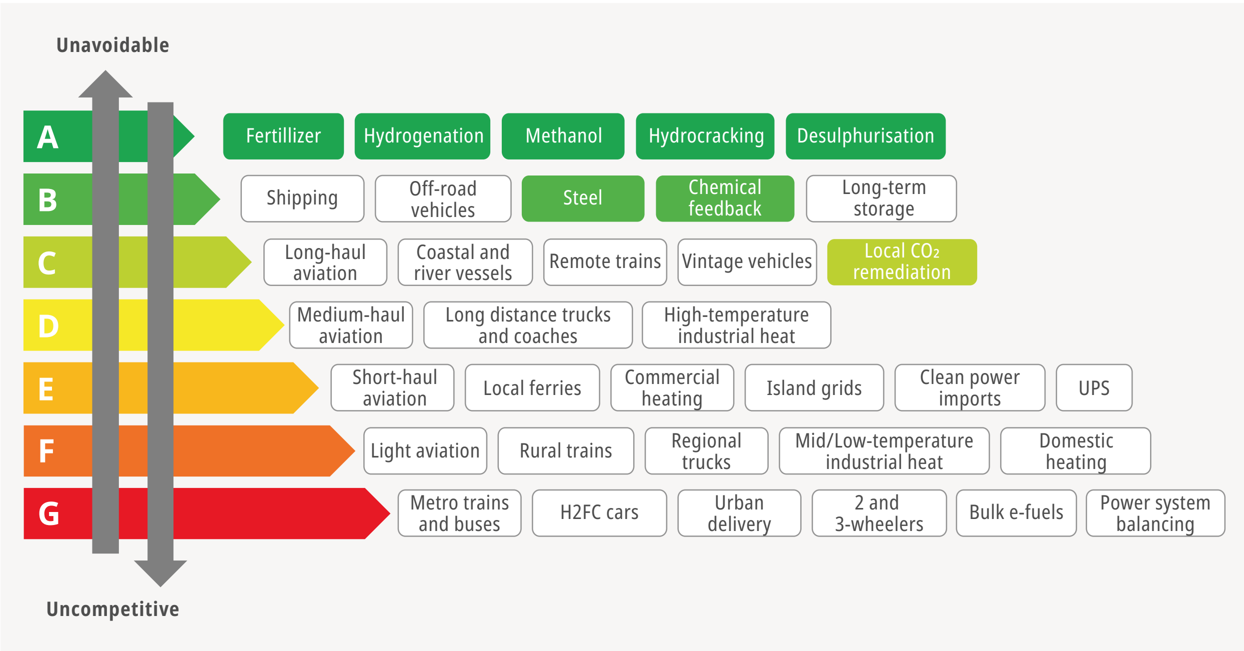

Figure 2: Clean Hydrogen Ladder: Chemicals & processes (own illustration based on Liebreich Associates, 2021)

To better understand the applications of hydrogen and predict future areas of demand, *Liebreich* Associates developed the *Clean Hydrogen Ladder (2021) depicted in figure 3.* While many applications of hydrogen are possible, it is necessary to look at what makes economic sense. The Clean Hydrogen Ladder gives an insight into how much sense it makes for an industry to adopt hydrogen. As seen in **figure 3**, while the adoption of hydrogen is unavoidable for industries such as fertilizers or steel, a hydrogen solution would be uncompetitive for urban delivery.

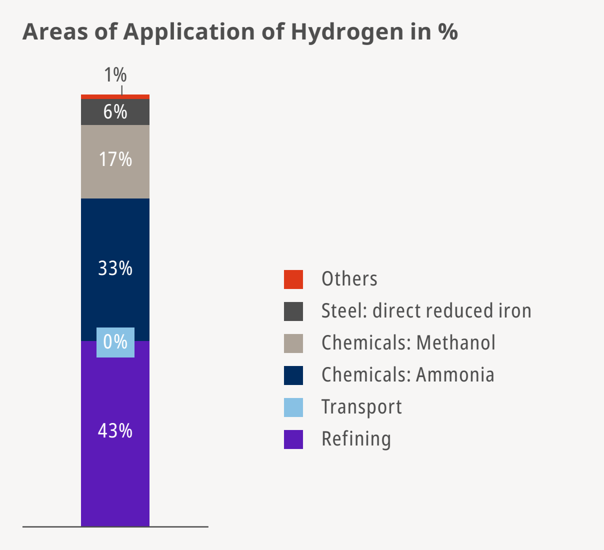

Figure 3: Areas of Application in 2022 (Ulreich & International Chamber of Shipping, 2024, p.11).

2.6 Costs of Hydrogen Along the Value Chain

Now that each part of the hydrogen value chain has been analyzed – production, transportation, storage and end usage – we can look at the price effect that each element has on the end usage cost on hydrogen. As mentioned above, a critical condition for hydrogen markets to develop in a sustainable manner is that costs need to be reduced significantly. The costs differ depending throughout the value chain. **Station or storage effects account for 50% of the end price of hydrogen, while delivery makes up 35% and production takes the remaining 15%.** *(WEF, 2024)*

To gain a better understanding of the cost structure of the hydrogen value chain, the cost of production and cost of storage are examined.

2.6.1 Cost of Production

A study by Pal et al. from 2023 evaluated different hydrogen production processes and its costs. It gives a first impression about expected costs for different production methods.

They found that production of SMR is quite cost-efficient, while green hydrogen production exhibits the highest production costs at $4/kg as compared to SMR's $1.28/kg. A consensus view has developed that expects the costs of green hydrogen to drop to below 3€/kg. However, changing economic conditions in central Europe now leads to an adapted assumption of production prices between 5 and 8 €/kg by 2030 according to BCG (*Burchardt et al., 2023*).

2.6.2 Cost of Storage

If we break down the storage costs, we see that 65% of the delivery costs are based on two factors: the compression and liquefaction of hydrogen and the actual storage. Other factors include refrigeration and the dispense of stored hydrogen *(WEF, 2024).*

2.7 Maturity of Hydrogen Infrastructure

In this subchapter, we assess the maturity of hydrogen infrastructure and identify associated challenges. In a study conducted by the Hydrogen Council in collaboration with McKinsey in 2023, the current state of the global hydrogen economy was analyzed.

By the end of 2023, 1,418 projects to produce clean hydrogen had been announced worldwide as can be seen in **figure 4**. Of these, over 1,000 are expected to be partially or fully completed by 2030, representing an investment of around $570 Bn. Around $300 Bn of this will be spent on large scale, so-called giga-scale projects. With around 540 projects, Europe leads in this area, followed by North America's 248. With around $193 Bn in announced investments, Europe also leads in terms of investments *(Hydrogen Council & McKinsey & Company, 2023, p.6)*. By 2023, an increase of 1,499 TWh of hydrogen was announced by 2030 by different market participants. Most of the announced projects are in Europe with 470 TWh of added hydrogen production, followed by North America with 336 TWh. Besides Europe and North America, China can be observed as a significant cluster of hydrogen development. This will be further discussed in chapter three from a regulatory viewpoint.

By 2050, key enablers like physical infrastructure will be essential, with over 163,000 hydrogen refuelling stations for trucks needed globally and over 40,000 kilometres of hydrogen pipelines required in Europe.

As can be seen in **figure 5**, there is a significant investment gap of $430 Bn by 2030 for hydrogen projects, the majority of which is a deficit of investments in hydrogen enabling infrastructure (for transportation and storage of hydrogen). **One of the main reasons for the reluctance to invest is the uncertainty about the future and role of hydrogen** (*Hydrogen Council & McKinsey & Company, 2023, p.12)*. With the European Hydrogen Backbone initiative, a group of 33 energy infrastructure providers want to counteract this and build a competitive infrastructure throughout Europe to further support the expansion of hydrogen usage *(European Hydrogen Backbone, n.d.)*. Beyond financial challenges, storage challenges remain, as high-density hydrogen storage is still an unsolved issue.

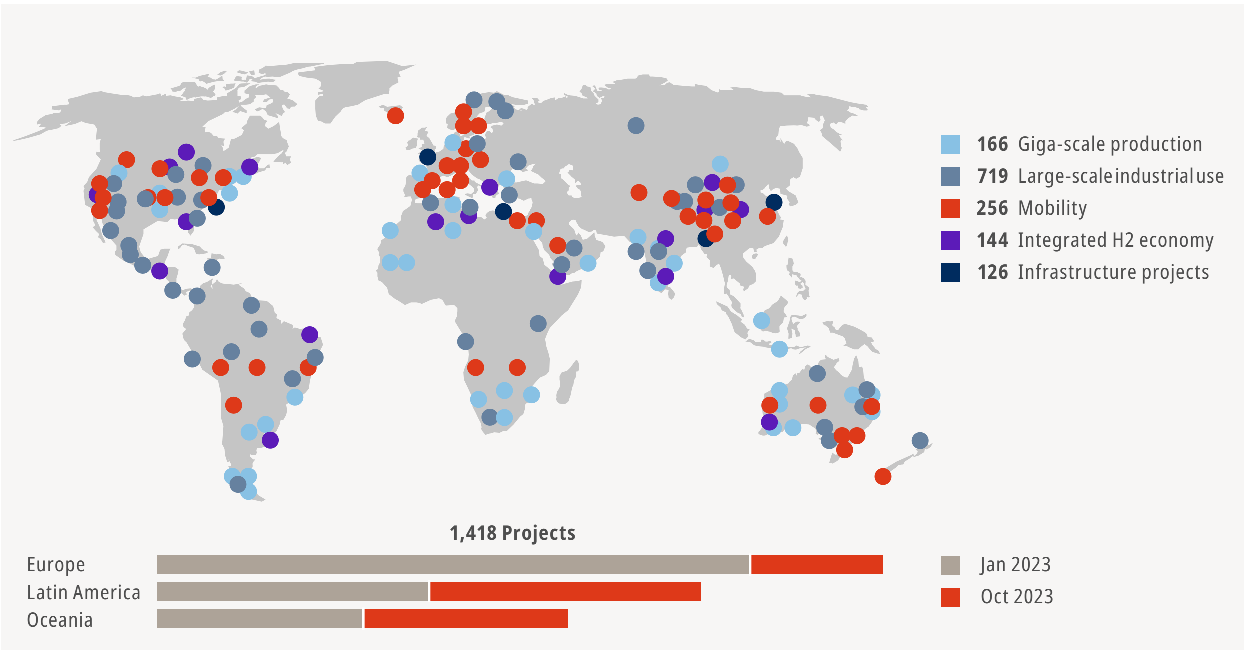

Figure 4: Overview of hydrogen projects worldwide (own illustration based on Hydrogen Council & McKinsey & Company, 2023, p.6)

Overall, we see a market that is underfinanced and lacking critical infrastructure. For hydrogen to develop in accordance with its projected demand and reach maturity, higher financial commitment to realize announced projects is required.

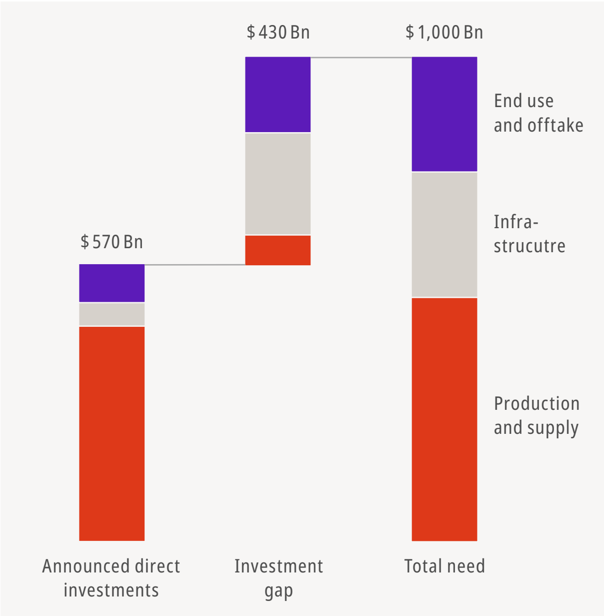

Figure 5: Investment overview hydrogen until 2023 (Hydrogen Council & McKinsey & Company, 2023, p.12)

2.8 Outlook of Hydrogen Production & Demand

Demand for hydrogen will increase in the years up to 2050. This is primarily due to the efforts of the global community to reduce CO_2 emissions in which hydrogen can play an important role. However, grey hydrogen still accounts for a large proportion of the volume produced today. Nonetheless, most plants commissioned from 2025 onwards will produce green hydrogen. With that, green hydrogen will become increasingly competitive, while demand for grey hydrogen will decline. Demand for green hydrogen is also expected to grow, with increasing applications in transport, mobility and industry, while further efficiency gains in production will make hydrogen an increasingly attractive alternative energy resource.

To meet the growing demand for clean hydrogen, timely deployment of infrastructure across the value chain is crucial. By 2050, key enablers like physical infrastructure, e.g. pipelines and refuelling stations for trucks, will be essential. Technological advancements, particularly in fuel cells for heavy-duty vehicles and marine vessels, are necessary for sectors where hydrogen technology is still developing. Coordination between governments and the private sector will be vital to ensuring infrastructure is established at the pace required for decarbonization goals. The rapid adoption of natural gas in the EU in the 1960s and 70s demonstrates that significant shifts in energy systems are achievable with sufficient competitiveness and support *(Gulli et al., 2024).*

Naturally, forecasts are subject to great uncertainty. A positive development to promote a renewable hydrogen economy has additional requirements, these include: the associated infrastructure must be expanded; the corresponding demand must be available; and the energy source must be economically competitive. According to a McKinsey report, the upscaling of the corresponding infrastructure and the further development of existing technologies are seen as key to success *(Gulli et al., 2024).* To this end, governments must also define the regulatory framework conditions and promote such expansion in cooperation with companies *(Gulli et al., 2024).*

Growing demand for clean hydrogen would require timely deployment of infrastructure across the value chain.

3 Hydrogen from a Regulatory Perspective

In a study by Wasserstoff-Kompass that lists a total of 43 nations that have presented specific national hydrogen strategies, China, the European Union and several European nations are among them *(DECHEMA & acatech, 2024).*

Before diving into a comparison between the regulatory side of European and Chinese hydrogen strategies, both regulatory environments are discussed in detail.

3.1 Regulatory Landscape in Europe

Switzerland is actively developing its hydrogen strategy to align with the EU to integrate into the broader European hydrogen market *(Itaizul, 2024).* To understand the overarching European hydrogen market, one must understand the underlying political intentions and strategy. The EU hydrogen strategy can be subdivided into the following three phases:

- **Phase 1 (Until 2024):** Focuses on decarbonising existing hydrogen production and promoting the installation of at least 53 TWh of renewable hydrogen electrolysers.
- **Phase 2 (Until 2030):** Aims to make hydrogen an intrinsic part of the EU's integrated energy system, with at least 350 TWh of renewable hydrogen electrolysers i.e. green hydrogen.
- **Phase 3 (Until 2050):** Envisions the large-scale deployment of hydrogen technologies across all hard-to-decarbonize sectors.

The strategy includes ambitious production targets, but also aims to import additional 333 TWh of hydrogen by 2030, as outlined in the REPowerEU Plan. The Renewable Energy Directive (RED III) is the EU's updated framework to promote renewable energy production. It aims for a renewable energy target in the energy mix of at least 42.5% by 2030 but also has sector-specific targets, streamlines the permission process, and encourages the use of green hydrogen and sustainable biomass. This energy mix incorporates wind, solar, hydro, geothermal, and sustainable biomass *(European Commission, 2024).*

Recently, a legislative package comprising directive (EU) 2024/1788 and regulation (EU) 2024/1789 were introduced in May 2024. This package updated the rules for the EU natural gas market to facilitate the uptake of renewable and low-carbon gases, including green hydrogen, ensures security of supply and affordability of energy for EU citizens, and creates a level playing field for hydrogen market development and infrastructure *(European Commission, 2020).*

Among many others, *The Kopernikus-Projekt Ariadne Potsdam-Institut für Klimafolgenforschung* reviewed the EU's regulatory strategy and identified critical gaps and challenges. One key issue is the missing clear long-term strategy that defines the role of low-carbon hydrogen. This creates uncertainty and risks regarding the EU's climate mitigation efforts. Further, existing legislation contains regulatory gaps and inconsistencies, particularly regarding emissions in the production lifecycle (e.g. non-permanent storage of captured fossil carbon) *(Bruch & Knodt, 2024).* Others recommend significant changes in the EU's regulatory strategy. *Hydrogen Europe (2022)* suggests that market principles, such as clear definitions and greenhouse gas thresholds for all hydrogen categories are necessary. Furthermore, tariff discounts should be introduced to support the rollout of renewable and low-carbon hydrogen across all levels of infrastructure, while a more supportive investment framework is needed to accelerate the development of hydrogen. Additionally, to efficiently coordinate grid planning and integration efforts, grid governance should prioritize the creation of dedicated hydrogen grids, the reuse of existing gas infrastructure where practical, and the creation of the European Network of Network Operators for Hydrogen *(ENNOH) (Hydrogen Europe, 2022).*

3.2 Regulatory Landscape in China

Since China is the world's leading hydrogen producer with its excellent hydrogen fuel-cell stack technology and the notable cost advantages, it is crucial to analyse their strategy to learn from them and compare their long-term strategies with the European ones. Additionally, China is positioned as the leading producer of hydrogen with 1,099 TWh produced annually, 99% of which is produced using grey and brown production methods. The largest share of its hydrogen is produced using coal gasification contributing to 60% of production, while hydrogen from gas accounts for 25% and production from other and industrial sources represents 14%. Only 1% of hydrogen in China is produced through electrolysers *(Stephan, 2022).*

In October 2023, China released its first national-level guidelines to establish standards in the hydrogen energy industry. These guidelines were issued by the Standardization Administration of China, together with the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Ecology and Environment, the Ministry of Emergency Management, and the National Energy Administration with the aim of standardizing and promoting the sector's development *(Standardization Administration of the P.R.C., 2023).*

With China racing towards its carbon peaking and net zero goals, the Chinese authorities unveiled a plan to develop hydrogen energy. This plan outlines a phased approach *(The State Council, 2022):*

- **By 2025:** Establish a relatively complete hydrogen energy industry development system. The innovation capability will be significantly improved, and the core technologies and manufacturing processes will be mastered. The annual hydrogen production from renewable energy is expected to reach 3.33 TWh to 6.66 TWh which will become an important part of new hydrogen energy consumption and reduce carbon dioxide emissions of 1–2 million metric tons per year. This modest target will represent only 0.3% to 0.6% of the 1,099 TWh of fossil-fuel based hydrogen consumed in 2020 *(Lou & Corbeau, 2023).*
- **By 2030:** Achieve a reasonable and orderly industrial layout and wide use of hydrogen production from renewable energy, which will be supporting the carbon peaking goals.
- **By 2035:** Significant increase of the proportion of hydrogen produced from renewable energy in terminal energy consumption. This will play a crucial role in China's green energy transformation.

There are two main targets laid down in the plan: green hydrogen as production and hydrogen fuel cell vehicles in 2025. The two targets are arguably conservative compared to the goals set in the two years before. There seems to be a slight shift from the former infrastructure-focused approach to the mobility market *(Yuki, 2022).*

In contrast to the national plan, there are various provinces and municipalities that have set more ambitious goals for 2025.

Collectively, these regional targets aim for over 36.63 TWh to 40 TWh of renewable hydrogen production by 2025, exceeding the national target by more than 10 times. Inner Mongolia leads these efforts with a goal of 16 TWh per year by 2025. This province is leveraging its abundant renewable energy resources to promote renewable hydrogen, particularly to replace grey hydrogen in coal-chemical industries *(Lou & Corbeau, 2023).*

While climate mitigation is a significant driver of China's hydrogen strategy, industrial and economical motivations appear more prominent in the short term. Notably, China has not formally defined "renewable hydrogen", indicating a lesser emphasis on carbon intensity compared to the EU and the US. Both central and local governments in China refer to "hydrogen" and "green hydrogen" without providing explicit definitions. This ambiguity is reflected in the lack of mechanisms to regulate the sources or carbon intensity of hydrogen in China's current policy framework *(Lou & Corbeau, 2023).*

China has abundant sources of renewable energy, and they are well placed to power the development of green hydrogen, but no clear pathway has been established for the development of green hydrogen. The main constraints for expanding green hydrogen in China are high costs, market demand, insufficient infrastructure and the absence of industry standards and certifications. The white paper from *WEF et al. (2023)* proposes six development goals accompanied by key objectives for each goal and 35 enabling measures and recommendations. They draw on the green hydrogen roadmaps for the EU and Japan, and centre on building a new energy system and a full supply chain of hydrogen though industrial, regional and global collaborations *(WEF et al., 2023).*

3.3 Comparative Analysis: European Union & Switzerland vs. China

Unlike the EU and the US, China has placed less emphasis on carbon intensity, as evidenced by the earlier mentioned absence of a formal definition of "renewable hydrogen" by the Chinese government. An overview of the key differences between European and Chinese hydrogen strategies is seen in **figure 6**. In addition, the draft of the Energy Law of the People's Republic of China does not differentiate between various hydrogen production approaches. This contrasts with legislation in the EU and the US, which tends to specifically regulate and promote renewable hydrogen produced from renewable energy sources. These factors demonstrate that China has a less defined and regulated approach to renewable hydrogen compared to the EU and the US, reflecting significant differences in priorities and regulatory approaches in hydrogen development *(Lou & Corbeau, 2023)*. The focus of China's research is specifically hydrogen energy, a carbon-free secondary energy source where the biggest challenge are the costs, because "the production of green hydrogen without carbon emissions cannot be conducted on a large scale owing to its high costs" *(Hui et al., 2024, p. 26)* whereas the EU focuses on optimizing electrolyser capacity and production mass *(Hui et al., 2024, p. 26; DECHEMA & acatech, 2024).*

Regulatory frameworks play a crucial role in shaping the hydrogen economy, with Europe's sustainability driven policies contrasting with China's scale-focused approach, each presenting unique challenges and opportunities.

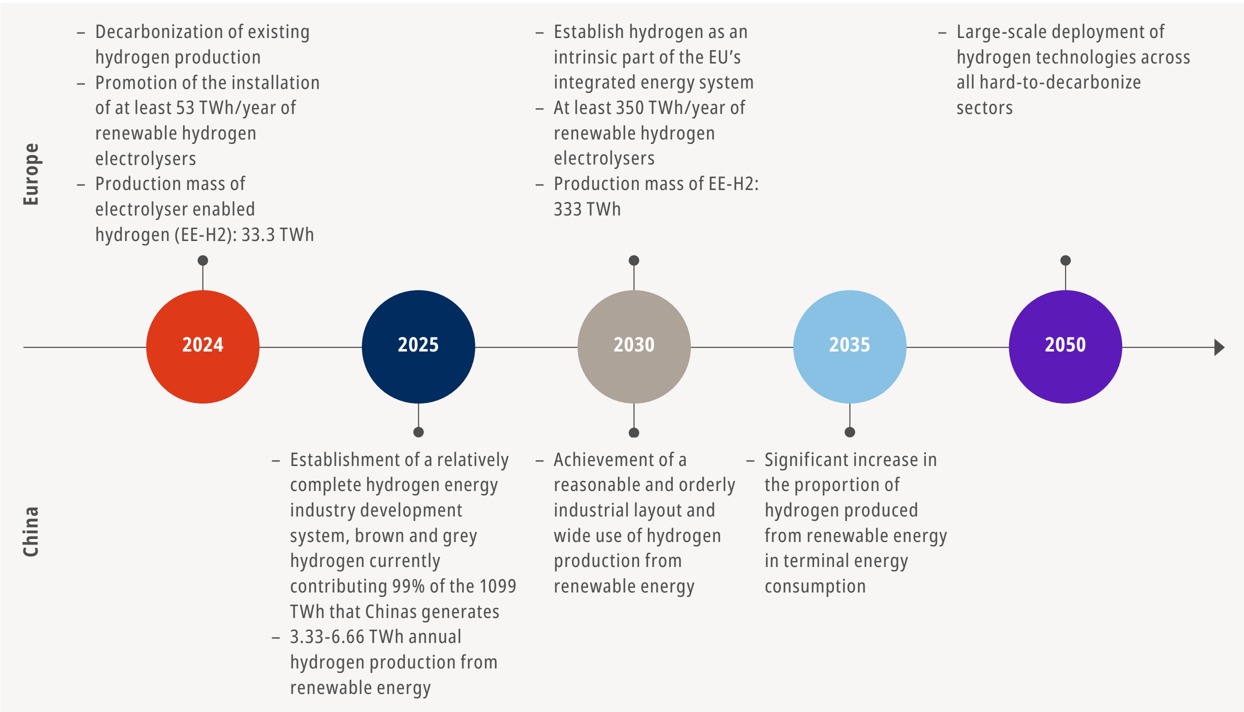

Figure 6: Timeline for hydrogen initiatives in Europe and China until 2050 (own illustration, adapted from Hui et al, 2024; DECHEMA & acatech, 2024)

4 The House of Hydrogen

In this section, a proposal developed by the university students to kickstart European hydrogen investments are discussed to accelerate development of the hydrogen market. The "House of Hydrogen" model, as seen in **figure 7**, is a multi-faceted framework designed to position financial infrastructure providers as a driving force for the development of the European hydrogen market. By integrating a comprehensive approach that bridges trading, investment security and credibility, this model goes beyond traditional financial products. Recognising that the hydrogen industry is still in its infancy, the "House of Hydrogen" addresses its early stage needs by supporting its foundational development and fostering growth through targeted initiatives.

Its foundation is the credibility of products and market players, the cornerstone of the hydrogen industry. Ensuring market confidence requires maturity through research, regulatory certainty and a strong, collaborative community that facilitates knowledge sharing. These elements provide a solid foundation for reliable and scalable market operations.

The HY Catalyst, an accelerator programme designed to nurture start-ups and drive innovation, plays a key role in this foundational layer by equipping new entrants with the tools and connections they need to thrive.

The middle layer, "Investment Security", prioritizes the creation of a secure and supportive environment for stakeholders and companies. Using robust financial instruments such as cross-commodity hedging and infrastructure bonds, the model mitigates risk and enables long-term investment in hydrogen infrastructure and innovation, ensuring stability for all market participants.

At the top of the house is "Trading and Investments", which focuses on practical solutions to improve market functioning. Key initiatives such as a financing platform provide streamlined access to capital, promote transparency and foster collaboration between stakeholders, enabling the hydrogen market to evolve towards a fully functioning trading ecosystem.

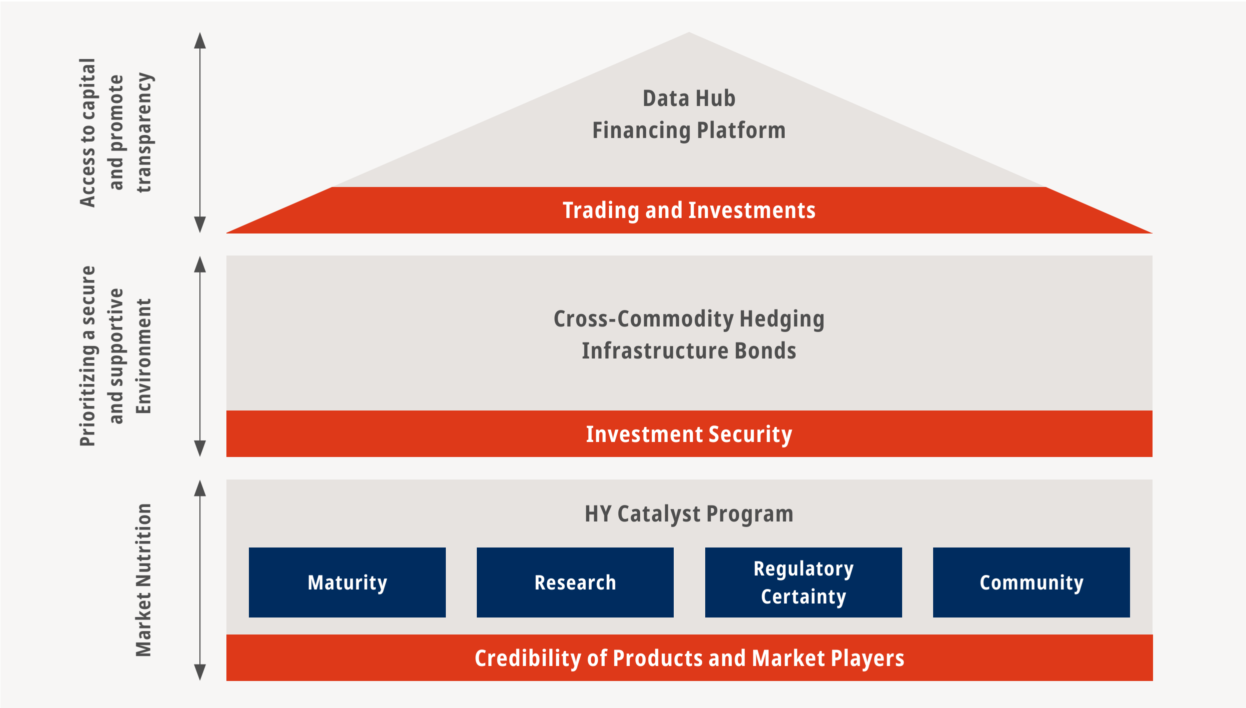

Figure 7: The House of Hydrogen (own illustration)

Altogether, the "House of Hydrogen" integrates key strategies into a coherent framework that drives growth, ensures stability and supports Europe's role as a global leader in the hydrogen economy. This approach underlines the potential to catalyse transformative change in the hydrogen market, paving the way for a sustainable and prosperous energy future.

4.1 HY Catalyst

The "Hydrogen Catalyst" or "HY Calalyst is a one-year program that specifically promotes the long-term development and growth of hydrogen projects. It combines mentorship, industry expertise, funding opportunities, and networking to help start-ups progress in the hydrogen sector. Participants receive mentoring from experienced start-up experts who support them in preparing pitches, setting up their organizations and decision making. A knowledge platform fosters exchanges between start-ups, experts and stakeholders and provides access to leading industry experts to gain insights into market needs, industry-specific trends and technological innovations. This is complemented by contacts to research partners, universities and venture capital firms that can provide financial support.

The programme also offers support and roundtables with commissions, government institutions and companies to foster valuable partnerships. Regulatory and policy advisors help participants navigate the regulatory environment, while a dedicated mergers and acquisitions advisory assists in finding suitable matches with potential buyers and sellers.

The highlight is the Pitch Day, where participants can present their ideas to potential investors, leading to possible funding.

After completion, participants benefit from a post-programme network that promotes a long-term community through informative and informal events.

The "HY Catalyst" offers comprehensive support for innovative ideas in the hydrogen sector and creates the basis for sustainable success.

4.2 Cross Commodity Hedging

The hydrogen market, particularly for green hydrogen, is still in its infancy. Significant challenges such as price volatility, and the lack of a dedicated trading market are an issue. To manage risk, green hydrogen producers should use green energy futures, while consumers should rely on cross-commodity hedging until a robust hydrogen trading market emerges.

For producers of green hydrogen, the cost of renewable electricity is the main driver of green hydrogen prices. These costs can fluctuate due to weather, demand, and grid dynamics. By using green energy futures linked to solar or wind power, producers can stabilize their input costs and offer consistent pricing. For example, locking in electricity prices through futures contracts protects against spot market volatility, ensuring predictable production costs and competitiveness.

Consumers of green hydrogen, such as the industrial and transport sectors, face a different challenge: the lack of hydrogen futures. Cross-commodity hedging offers a solution by using derivatives in correlated markets. For example, natural gas futures can hedge risks for companies switching from natural gas to hydrogen. Similarly, electricity futures can manage the volatility of renewable energy costs, while carbon credit futures can manage costs indirectly by stabilizing carbon compliance costs.

This dual strategy – green energy futures for generators and cross-commodity hedging for consumers – helps to overcome current market constraints. While these methods are interim solutions, they provide essential risk management tools for a growing hydrogen economy and pave the way for future trading instruments and a more stable market.

4.3 Infrastructure Bonds

Infrastructure bonds are financial instruments used to raise capital for large-scale projects such as transport, energy, water, public services, technology, social impact initiatives, disaster recovery infrastructure. Issued by governments, public bodies or private organizations, these bonds provide investors with regular interest payments and a repayment of principal at maturity. In the hydrogen sector, infrastructure bonds provide a critical solution for financing essential projects such as electrolysers, pipelines, storage facilities and refuelling stations, which require significant upfront investment and have long payback periods.

By pooling the resources of investors, infrastructure bonds provide immediate capital for projects while offering a stable, long-term investment opportunity. Often structured as green bonds, they specifically target environmentally sustainable projects and appeal to investors focused on ESG (environmental, social and governance) objectives. These bonds are particularly well-suited to hydrogen infrastructure because of their focus on long-term project lifecycles and their ability to attract both public bodies and institutional investors such as pension funds and insurance companies. An example is the Clean Energy Infrastructure Switzerland (CEIS 3), a collaboration between Swiss Life Asset Managers and UBS Asset Management. It provides institutional investors with access to a diversified portfolio of sustainable energy infrastructure investments in Switzerland. With commitments of CHF 772 million, the initiative plays a key role in financing renewable energy, energy efficiency and critical infrastructure and is aligned with Switzerland's Energy Strategy 2050 *(SwissLife Asset Managers, 2022).*

Infrastructure bonds could play a transformative role in scaling up the hydrogen economy. They address the high upfront costs of infrastructure development, reduce financial risks through government backing, and channel funds directly into building the systems needed to produce, transport and distribute hydrogen. In addition, they can stimulate regional development by creating jobs and attracting further investment. They provide a stable and scalable financing mechanism that is aligned with the long-term goals of the hydrogen sector. By supporting the development of critical infrastructure, they can accelerate hydrogen deployment and contribute to a cleaner, more sustainable energy future.

4.4 Financing Platform

A "Financing Platform" can serve as a critical tool to connect different stakeholders within a given market, enabling streamlined access to capital and promoting transparency in project financing. This concept is particularly relevant in markets undergoing significant change or development, such as renewable energy or technological innovation, where the establishment of robust infrastructure and investment mechanisms is essential.

The primary function of such platforms is to bridge the gap between project developers or start-ups and potential investors, which may include both private individuals and institutional entities. By creating a centralized space for these interactions, the platform increases the

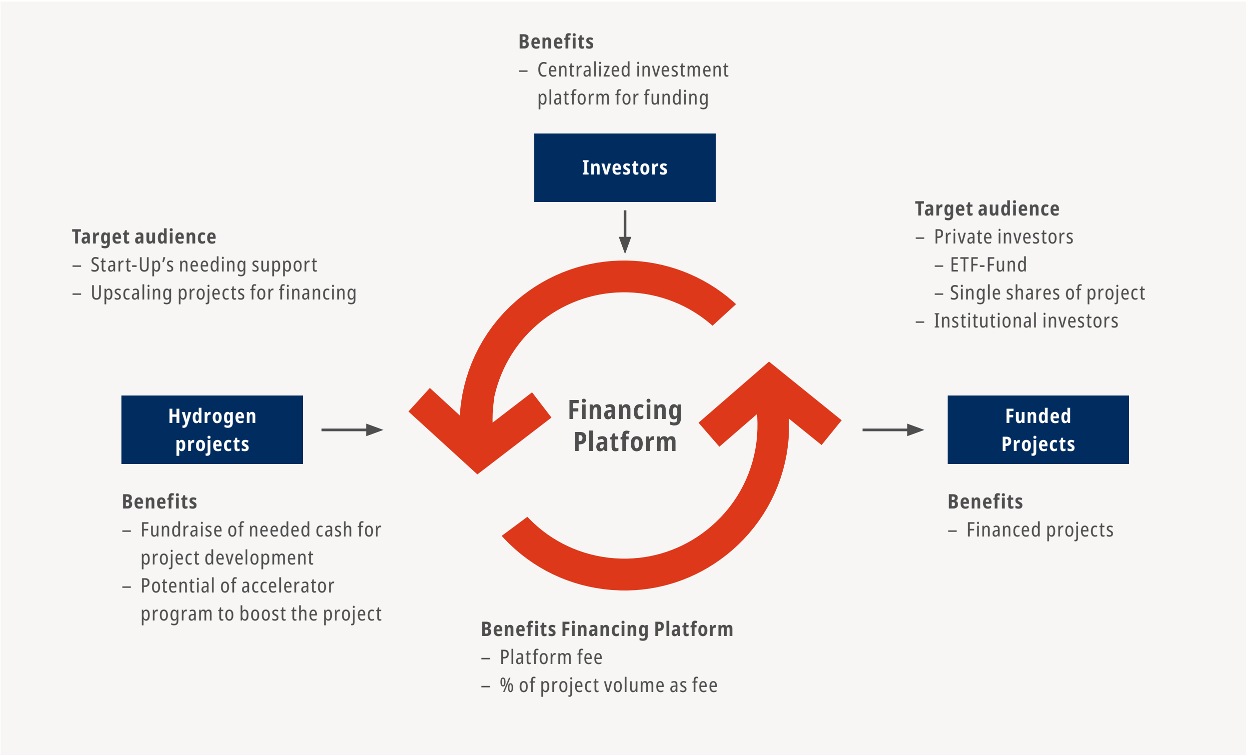

Figure 8: Financing platform prototype

visibility of emerging projects and facilitates partnerships that might otherwise be difficult to establish. These platforms often include features that allow participants to transparently outline their needs and goals, such as specifying their interest in transitioning to more sustainable practices or identifying partners for collaborative initiatives.

An essential component of these platforms is the integration of digital tools, such as auction mechanisms and IT solutions, that enable efficient matching of buyers and sellers or investors and projects. Reverse-Auction-based systems, for example, prioritize cost-effectiveness and direct funding to the most promising initiatives, encouraging healthy competition and innovation in the market. In addition, IT-enabled solutions ensure that stakeholders have access to up-to-date information, can coordinate efforts across borders and maintain transparency in transactions. Figure 8 provides an overview of the above-mentioned aspects of the financing platform and their relations.

The benefits of such platforms extend beyond individual stakeholders, as they contribute to the broader development of the market ecosystem. By aligning interests and facilitating cooperation between different actors, these platforms drive the creation of a comprehensive value chain. They also encourage decarbonization and innovation by providing incentives and reducing investment risks through structured processes. The success of these platforms often depends on strong partnerships with existing institutions or public bodies, using their expertise and networks to enhance credibility and functionality.

4.5 Data Hub

The “Hydrogen Data Hub” addresses a major problem in the hydrogen market: the lack of transparency and availability of data on companies and their performance, especially in Asia. Currently, there is little reliable information available on how Asian hydrogen companies are performing commercially and how they are contributing to the development of the global hydrogen market. This lack of information makes it difficult for investors to make well-informed decisions and identify companies, potential partners or market opportunities.

A Hydrogen Data Hub would therefore be an important tool to fill this gap. It brings together all the important data on hydrogen companies on one platform. In this way, it provides a detailed overview of market trends, company performance and regional developments. This would not only simplify strategic planning and networking in the industry but also improve the efficiency and transparency of the global hydrogen market.

4.6 Impact

The “House of Hydrogen” provides a transformative framework to advance the European hydrogen market, tackling issues such as fragmented infrastructure, regulatory uncertainties, and limited mechanisms. By incorporating credibility, investment security and trading solutions, this model creates a robust foundation for a scalable hydrogen economy, ensuring stability, innovation and growth.

At its core, credibility builds trust through reliable products, transparent operations and cooperation. Regulatory clarity and initiatives such as the “HY Catalyst”, which supports start-ups with mentorship, funding and networks, accelerate innovation and market integration. This foundation fosters a culture of trust and continuous technological advancement. The “Investment Security” layer mitigates financial risks and addresses the industry’s reliance on long-term infrastructure investment. Instruments such as hydrogen infrastructure bonds and cross-commodity hedging can attract ESG-driven investors while stabilizing prices for producers and consumers. These mechanisms reduce risk and increase the attractiveness of the hydrogen sector as an investment opportunity. The apex of the model focuses on trading and investment, enabling scalable market solutions. A “Financing Platform” connects project developers and investors, streamlining financing through digital tools such as auctions and real-time data sharing. Meanwhile, the “Hydrogen Data Hub” increases market transparency, provides actionable insights and fosters global collaboration, especially in underrepresented regions.

Together, these elements create a cohesive system where trust, financial stability and practical tools are mutually symbiotic. For example, start-ups supported by the “HY Catalyst” use funding platforms, de-risk investments through bonds and hedging, and refine strategies using insights from the Data Hub. This cycle fosters market expansion and accelerates adoption. In conclusion, the “House of Hydrogen” brings actionable solutions into a framework that addresses the immediate and long-term needs of the hydrogen market and paves the way for a sustainable and prosperous energy future.

5 Conclusion

While currently not the global leader in hydrogen, Europe's numerous and financially substantial investments are paving the way for a future leadership role. To address one of the paper's aims, hydrogen was introduced as a clean energy carrier, and its role and applications in the future energy landscape were discussed. Despite a surge in announced projects and investments, Europe lags behind leading players such as China in developing a mature hydrogen market. A significant difference lies in their approaches: Europe prioritizes green hydrogen production to address climate concerns, while China emphazises scaling hydrogen output regardless of carbon intensity. This strategic divergence underscores Europe's challenge in balancing sustainability with the competitive pressures of the global hydrogen economy.

The second aim of this paper, characterising strategies for developing the European hydrogen market, is addressed by the "House of Hydrogen." Europe must confront the risks and early-stage challenges of its hydrogen market to close the gap between ambition and reality. Investors remain cautious, partly due to uncertainties around infrastructure development, regulatory consistency, and return on investment. Addressing these risks requires a holistic and integrated strategy. The "House of Hydrogen" provides a framework by offering five interconnected approaches to reduce investment risk and drive market growth.

- **HY Catalyst:** A program designed to accelerate innovation by supporting start-ups with mentorship, funding, and access to networks.
- **Cross-Commodity Hedging:** This mechanism stabilizes hydrogen prices for producers and consumers, reducing volatility and encouraging greater investment confidence in the sector.
- **Infrastructure Bonds:** Long-term financial risks are mitigated through instruments like hydrogen infrastructure bonds, which provide stable financing for large-scale projects while attracting ESG-conscious investors.
- **Financing Platform:** A centralized platform connects project developers and investors, streamlining funding processes through tools such as digital auctions and real-time data sharing, enabling for more efficient capital deployment.
- **Data Hub:** By enhancing market transparency and providing actionable insights, the Hydrogen Data Hub equips stakeholders with the information needed to make informed decisions. The Hydrogen Data Hub promotes global collaboration, especially in underrepresented regions.

Together, these proposals address key barriers in Europe's hydrogen ecosystem by creating a foundation of trust, financial stability, and operational transparency. For example, start-ups supported by HY Catalyst can leverage the Financing Platform to secure funding, de-risk projects with bonds and hedging, and refine strategies using insights from the Data Hub. This interconnected system not only alleviates perceived risks but also builds momentum for market expansion and adoption.

By integrating the elements, the "House of Hydrogen" aligns economic opportunity with environmental sustainability, ensuring Europe's hydrogen ambitions are both scalable and achievable. These solutions provide a pathway to bridge the investment gap, enable Europe to compete with global leaders like China, and contribute to achieving long-term clean energy goals while offering significant opportunities for financial infrastructure providers.

Achieving a competitive hydrogen market requires balancing sustainability goals with economic feasibility, and leveraging structured financial and policy-driven approaches to drive long-term adoption.

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