



LIETUVOS RESPUBLIKOS ENERGETIKOS MINISTERIJA

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Adresatams pagal sąrašą

2020-

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**SUSITIKIMO DĖL VANDENILIO TECHNOLOGIJŲ PLĖTROS GALIMYBIŲ
ATMINTINĖ IR PASIŪLYMAS DĖL TOLIMESNIŲ VEIKSMŲ**

Dėkojame Jums už dalyvavimą š. m. rugsėjo 18 d. Lietuvos Respublikos energetikos ministerijos organizuotoje diskusijoje vandenilio technologijų vystymo potencialo Lietuvoje tema ir siunčiame Jums šio susitikimo atmintinę (toliau — atmintinė).

Atsižvelgiant į atmintinėje išdėstytą informaciją ir tai, kad susitikimo metu dėl laiko stokos nebuvo detaliai aptartas tolimesnio bendradarbiavimo formatas, kviečiame Energetikos ministerijai iki **2020 m. spalio 12 d.** teikti siūlymus el. paštu zilvinas.danys@enmin.lt dėl naujo nacionalinio vandenilio technologijų vystymo potencialo skatinimo formato steigimo ar esamų bendradarbiavimo formatų išplėtimo ir pritaikymo reguliarioms diskusijoms ir bendroms veikloms Lietuvoje šioje srityje koordinuoti.

2020 m. spalio 26 dieną bus organizuojama papildoma diskusija gautiems siūlymams aptarti. Apie Jūsų įmonės ar institucijos deleguoto atstovo dalyvavimą maloniai prašome pranešti el. paštu ieva.visockiene@enmin.lt.

PRIDEDAMA:

1. Diskusijos vandenilio technologijų vystymo potencialo Lietuvoje tema atmintinė, 3 lapai.
2. ES šalių narių pasiskirstymo prioretizuojant vandenilio plėtrą lentelė, 1 lapas.
3. „Švaraus vandenilio Europai“ Europinės partnerystės pasiūlymas, 73 lapai.

Viceministrė

Lina Sabaitienė

Lietuvos Respublikos energetikos ministerijos
2020 m. d. rašto Nr.
gavėjų sąrašas

1. „Achema“ AB,
2. „Amber Grid“ AB,
3. „EPSO-G“ UAB,
4. „Ignitis grupė“, AB,
5. „Klaipėdos nafta“ AB,
6. „Litgrid“ AB,
7. „ORLEN Lietuva“ AB,
8. „SG dujos“ AB,
9. Lietuvos energetikos agentūra,
10. Lietuvos energetikos institutas,
11. Lietuvos keleivių vežimo asociacija,
12. Lietuvos nacionalinės vežėjų automobiliais asociacijos „LINAVA“
13. Lietuvos pramonininkų konfederacija,
14. Lietuvos Respublikos aplinkos ministerija,
15. Lietuvos Respublikos ekonomikos ir inovacijų ministerija,
16. Lietuvos Respublikos susisiekimo ministerija,
17. Lietuvos SGD klasteris,
18. Valstybinė energetikos reguliavimo taryba,
19. Vandenilio Energetikos Asociacija.

Draft proposal for a

European Partnership under Horizon Europe

Clean Hydrogen for Europe

Version 15 June 2020

Summary

Europe's ambitions will require clean hydrogen at scale. Without it, the EU will miss its climate, environmental and energy objectives as well as the opportunity to create a strong, European, competitive industry. Clean Hydrogen for Europe aims to accelerate development and deployment of European clean hydrogen technologies, enabling them to contribute to a sustainable, decarbonised and fully integrated energy system.

About this draft

In autumn 2019 the Commission services asked potential partners to further elaborate proposals for the candidate European Partnerships identified during the strategic planning of Horizon Europe. These proposals have been developed by potential partners based on common guidance and template, taking into account the initial concepts developed by the Commission and feedback received from Member States during early consultation¹. The Commission Services have guided revisions during drafting to facilitate alignment with the overall EU political ambition and compliance with the criteria for Partnerships.

This document is a stable draft of the partnership proposal, released for the purpose of ensuring transparency of information on the current status of preparation (including on the process for developing the Strategic Research and Innovation Agenda). As such, it aims to contribute to further collaboration, synergies and alignment between partnership candidates, as well as more broadly with related R&I stakeholders in the EU, and beyond where relevant.

This informal document does not reflect the final views of the Commission, nor pre-empt the formal decision-making (comitology or legislative procedure) on the establishment of European Partnerships.

In the next steps of preparations, the Commission Services will further assess these proposals against the selection criteria for European Partnerships. The final decision on launching a Partnership will depend on progress in their preparation (incl. compliance with selection criteria) and the formal decisions on European Partnerships (linked with the adoption of Strategic Plan, work programmes, and legislative procedures, depending on the form). Key precondition is the existence of an agreed Strategic Research and Innovation Agenda / Roadmap. The launch of a Partnership is also conditional to partners signing up to final, commonly agreed objectives and committing the resources and investments needed from their side to achieve them.

The remaining issues will be addressed in the context of the development of the Strategic Research and Innovation Agendas/ Roadmaps, and as part of the overall policy (notably in the respective legal frameworks). In particular, it is important that all Partnerships further develop their framework of objectives. All Partnerships need to have a well-developed logical framework with concrete objectives and targets and with a set of Key Performance Indicators to monitor achievement of objectives and the resources that are invested.

Aspects related to implementation, programme design, monitoring and evaluation system will be streamlined and harmonised at a later stage across initiatives to ensure compliance with the implementation criteria, comparability across initiatives and to simplify the overall landscape.

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The Strategic Research and Innovation Agenda will be made available publicly at the following links: www.hydrogeneurope.eu and <https://www.cleanhydrogenforeurope.eu/>

¹ https://www.era-learn.eu/documents/final_report_ms_partnerships.pdf

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1 Context, objectives, expected impacts

1.1 Context and problem definition

Europe's transition to a decarbonized energy system is underway. All Member States of the EU have signed and ratified the Conference of the Parties (COP21) Paris agreement to keep global warming “well below 2 degrees Celsius above preindustrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.” This transition will radically transform how the EU generates, distributes, stores, and consumes energies. It will require virtually carbon-free power generation, increased energy efficiency, and the deep decarbonization of transport, buildings, and industry.

The pressure to deliver results in our common efforts to decarbonise our societies without causing disruptive economic damage has never been greater. This challenge is recognised at the highest political levels. A European “Green Deal” is necessary to show that Europe is committed to achieve ambitious climate and environmental goals without sacrificing the prosperity of its citizens.

President Ursula von der Leyen has expressed a wish for the European Commission to pursue CO₂ emission reduction ambitions which go beyond the current targets of 40% reduction by 2030. Furthermore, the political goals of the new Commission include the desire to help decarbonise energy-intensive industries². Frans Timmermans, Executive Vice President of the European Commission, rightly pointed out in his nomination statement that “*hydrogen could be a huge opportunity for our economy*”³.

1.1.1 Why Europe Needs Hydrogen

Europe is undergoing the early stages of an enormous energy transition in order to decarbonise all aspects of our daily lives in a short time. This shift is underpinned by three main elements: energy efficiency, increased use of renewable sources to provide a clean grid, and a switch to other energy carriers. The overarching mission to enable this shift is clear: towards a zero-emission, carbon-neutral Europe.

**The energy transition in the EU will require hydrogen at large scale.
Without it, the EU would miss its decarbonisation objectives.**

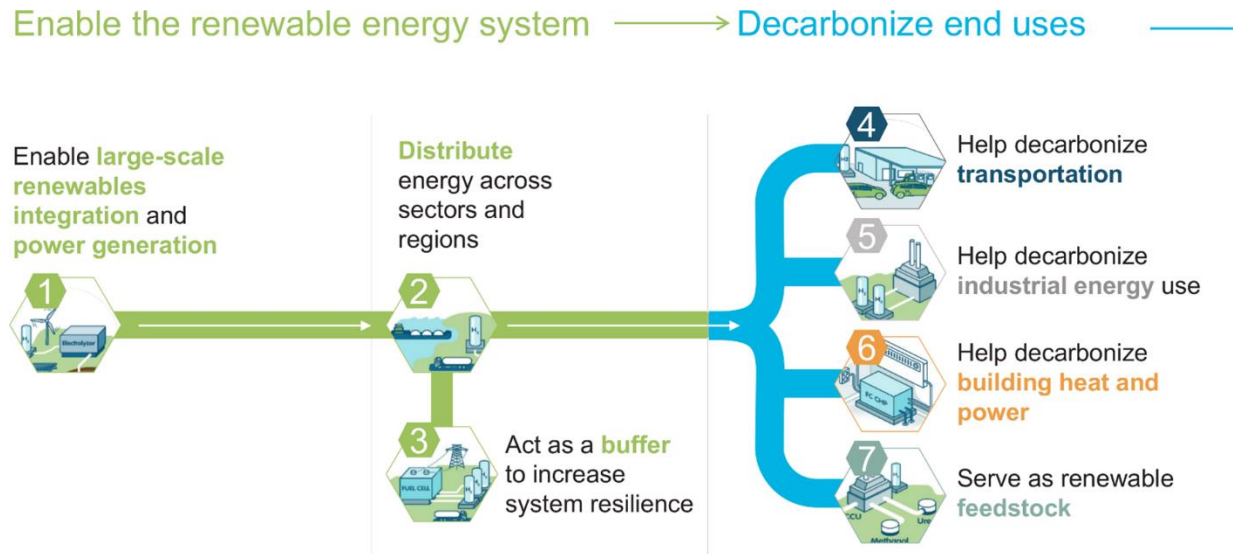
Alongside electricity, hydrogen will become the main energy vector that enables a zero-emission Europe. The overarching reason for this is straightforward: in an energy system dominated by the use of renewable power from wind and solar, using these clean electrons to power whole sectors of the economy poses insurmountable challenges if not complemented by hydrogen. Hydrogen will play a necessary role in integrating large amounts of renewable power in the transport and heating and cooling sectors, which are today hard to decarbonise. As shown in the figure below, hydrogen can:

- serve as a very relevant energy vector, linking renewable energy sources with a number of final uses
- have a zero (or very low) carbon footprint, when produced from electrolysis or natural gas with carbon capture and/or utilisation (CCS/CCU)
- be transported over long distances, allowing distribution of energy between countries
- store energy for long periods of time, serving as a needed system buffer and providing resilience, e.g. in underground storage
- decarbonize a wide range of final uses, providing clean power and/or heat to transport and stationary applications

² Political Guidelines for The Next European Commission 2019-2024, https://ec.europa.eu/commission/sites/beta-political/files/political-guidelines-next-commission_en.pdf

³ Frans Timmermans, Executive Vice President of the European Commission, 8th October 2019, <https://www.europarl.europa.eu/resources/library/media/20191009RES63850/20191009RES63850.pdf>

Figure 1: The need for Hydrogen for deep decarbonisation of Europe's economy



Source: Hydrogen Council

Hydrogen is not simply a potential contributor to solving the challenges posed by the energy system transition, offering a future solution with a number of advantages, particularly when used in fuel cells. **Hydrogen is a solution without which Europe cannot achieve its 2050 goals on GHG emissions reduction.**⁴

Hydrogen is the best (or only) choice for at-scale decarbonisation of selected segments in transport, industry, and buildings. Specifically:

- The decarbonisation of the gas grid that connects Europe's industry and delivers more than 40% of heating in EU households and 15% of EU power generation requires hydrogen.
- In transport, hydrogen is the most promising decarbonisation option for aviation, ships, trains, trucks, buses, large cars, and commercial vehicles, where the lower energy density (hence lower range), weight, high initial costs, and slow recharging performance of batteries are major disadvantages.
- Industry can use hydrogen to produce high-grade heat, it can use it directly as a chemical feedstock (for example, in steelmaking, substituting coal-based blast furnaces; ammonia production; hydrotreating in refineries in chemical processes and others) or use it as synthetic methane in order to decrease hard to abate CO₂ processes (e.g. in the production of cement)

Figure 2, below, shows the challenge of limiting climate change below 2 degrees in Europe. The gap between the reductions achieved in the reference technology scenario (RTS) and what is required under the 2-degree scenario (2DS) cannot be filled without hydrogen technologies.

⁴ This does not mean that other technology solutions cannot/should not contribute to these decarbonisation goals. Rather, hydrogen can help solve inherent deficiencies that pose constraints to such solutions becoming enough on their own to achieve these objectives.

Figure 2: Contribution of hydrogen to achieve the 2-degree scenario agreed in Paris

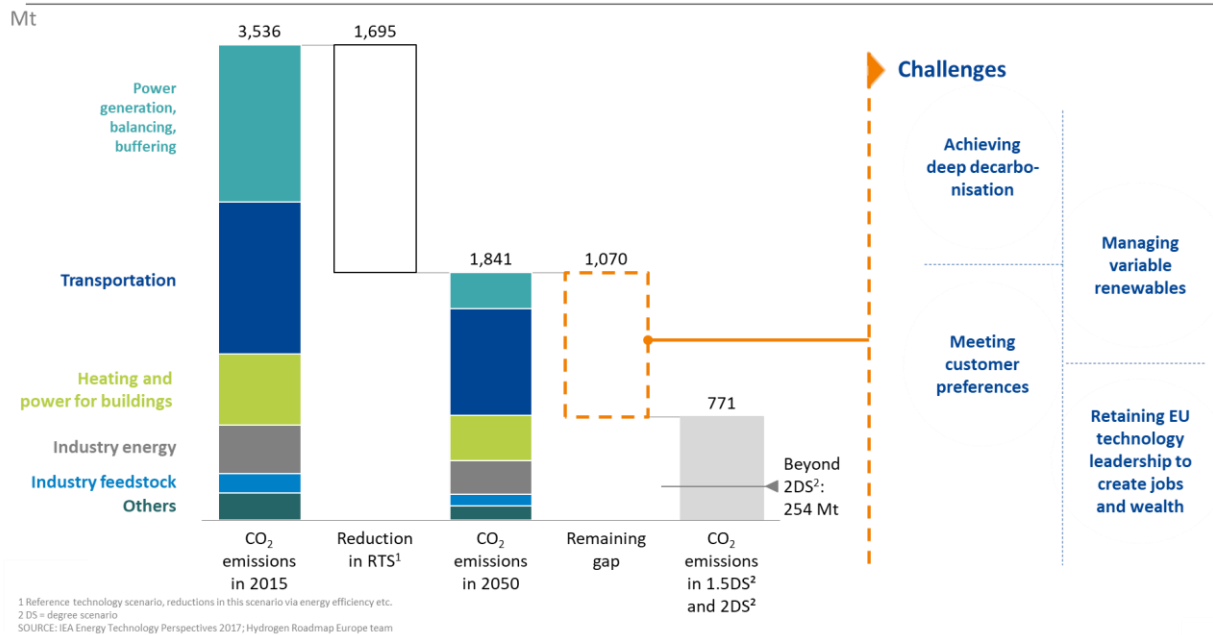
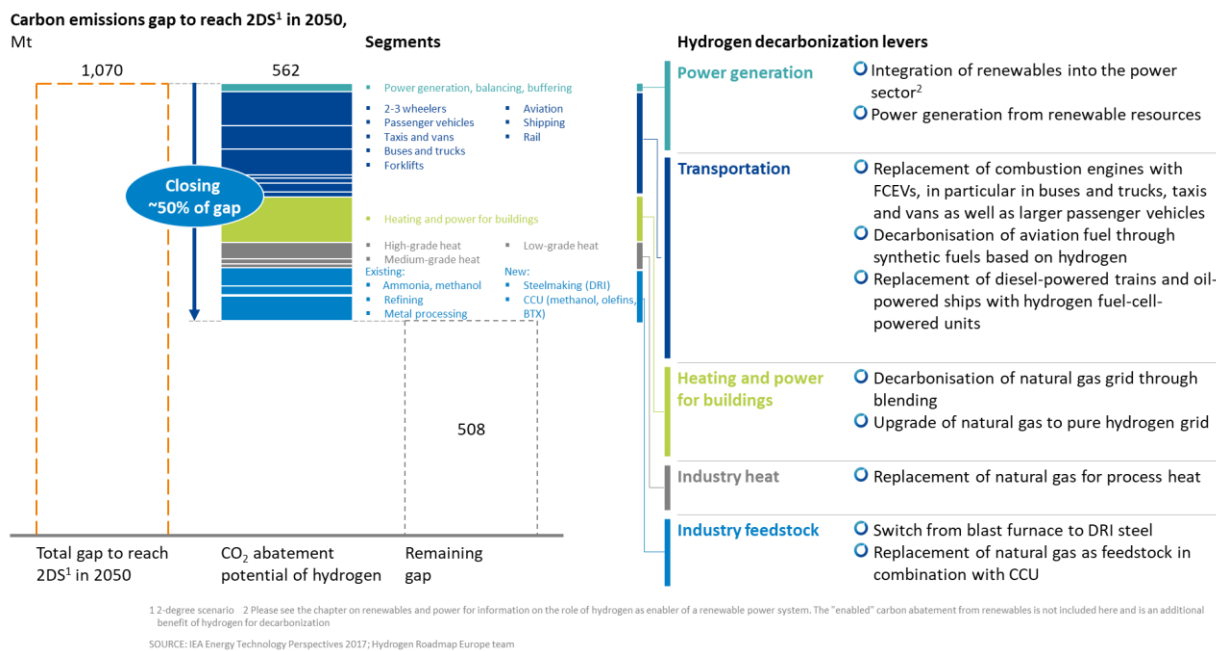


Figure 3, further break downs the CO₂ reduction potential of each sector implementing hydrogen technologies, depicting the importance of deployment of hydrogen across all sectors.

Figure 3: Contribution of hydrogen technologies in CO₂ reduction within across the various sectors.



1.1.1.1 Renewable integration and decarbonisation of electricity

The decarbonisation of the electric grid does not in itself require hydrogen since it is in itself an energy vector, rather than a supply of primary energy. However, the ability to absorb large quantities of renewable power and to store energy for long periods of time remains crucial. Today, a reserve capacity of ca. 15% exists as a means to store energy. As the percentage of RES penetration increases, so does the need for long-term storage, since this clean electricity may not be needed when it is being produced and would otherwise be curtailed. To give a sense of the problem, in Germany and Lithuania alone in 2017, ~7,800 GWh of renewable electricity was lost, as it could not be consumed or stored. This energy, if used in FCEVs, would have powered over 1 million vehicles for an entire year.

The use of hydrogen as a means to store renewable electricity coming from RES is not only the best solution to the issue of long-term storage, but furthermore the way to enable the decarbonisation of

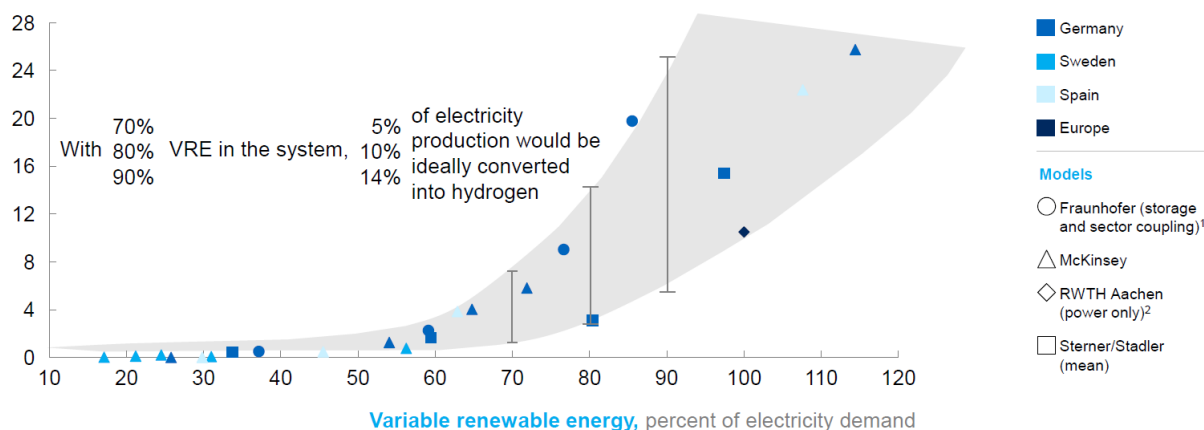
transport and heat: it enables the transfer of clean energy from the point of production to its final use. This is how energy and transport are linked in a zero-emission world.

Figure 4: The need for Hydrogen generation to ensure system efficiency

In simulations of the power system, the optimal deployment of sector coupling grows steadily until roughly 60% of variable renewable sources and then accelerates rapidly



Hydrogen demand, percent of electricity production

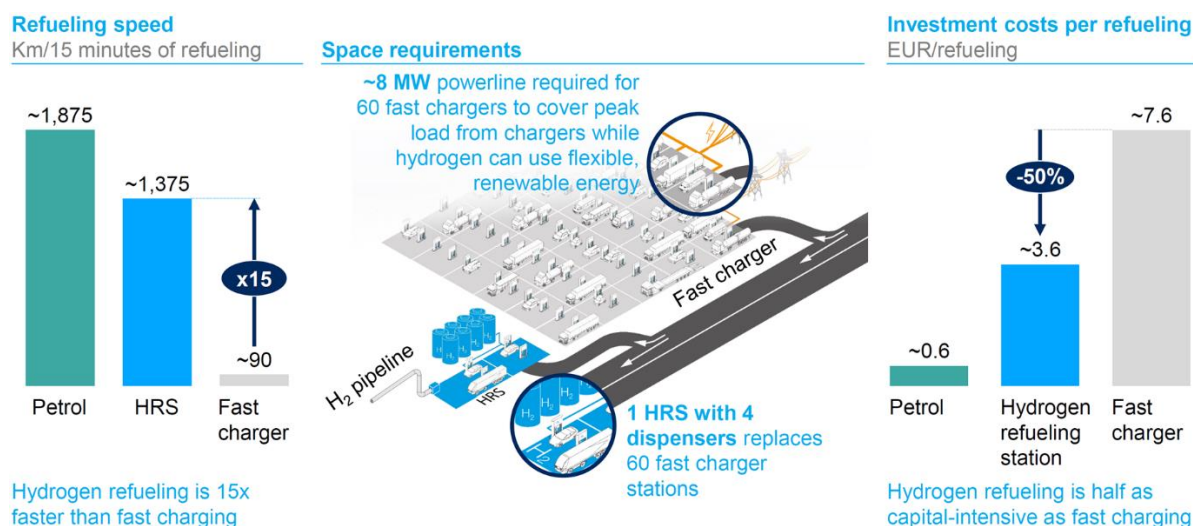


Source: Hydrogen Roadmap Europe

1.1.1.2 Zero Emission Transport

Decarbonising transport requires a huge conversion to electromobility, where hydrogen fuel cells and batteries co-exist as the major complementary contributors. While many studies focus exclusively on the use of batteries, their limitations must be recognised, especially when considering their ability to power heavy-duty vehicles such as buses, coaches and trucks. For road vehicles, range, recharging time and infrastructure needs (in terms of space and demands on the power grids) represent major impediments for large scale introduction of BEVs. By way of illustration, imagine a highway service station where each customer takes 30' to go through any one dispenser.

Figure 5: Scale challenges faced by BEV as opposed to FCEVs

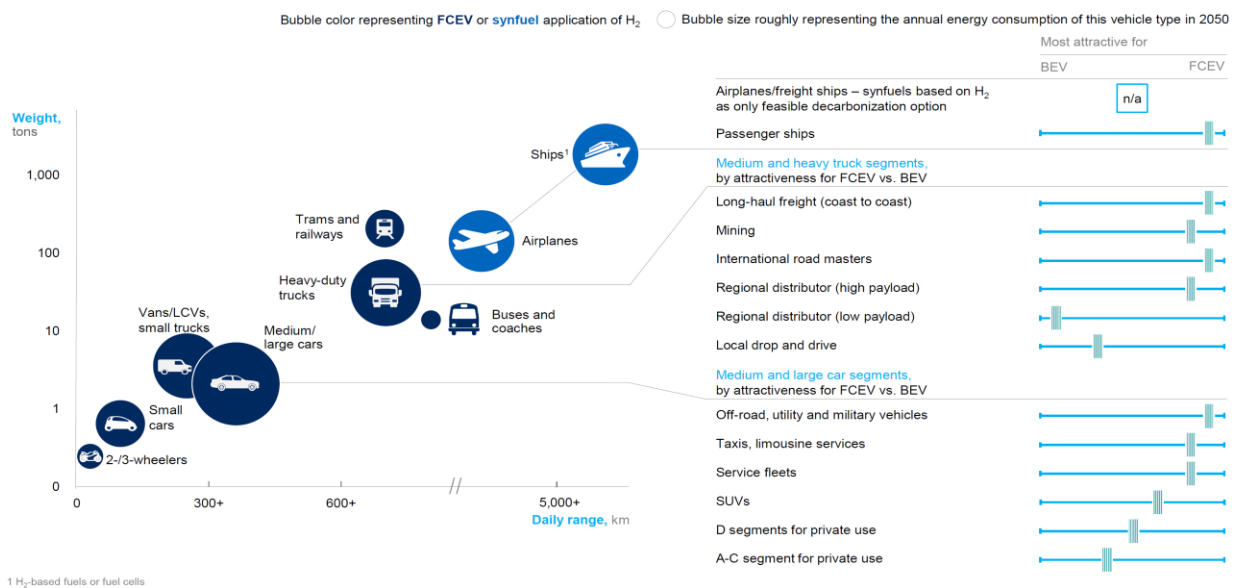


Source: Hydrogen Roadmap Europe

Besides the lack of customer convenience, there is the question of the requirements on an electrical installation based on how many dispensers the operator would need and how much space they would take. For long-distance travel it would clearly pose major issues intrinsic to the technology (e.g. imagine the situation on peak days during summer holidays). Therefore, it is clear that **hydrogen must complement batteries** as the fuels of choice in zero emission electromobility. Due to the intrinsic

technology constraints, the heavier the vehicles are, the longer they need to travel, and the quicker they need to refuel, the better the case for hydrogen vehicles. This argument also can be transposed to other modes of transport (maritime, rail and aviation).

Figure 6: Appropriateness of Hydrogen in various mobility applications

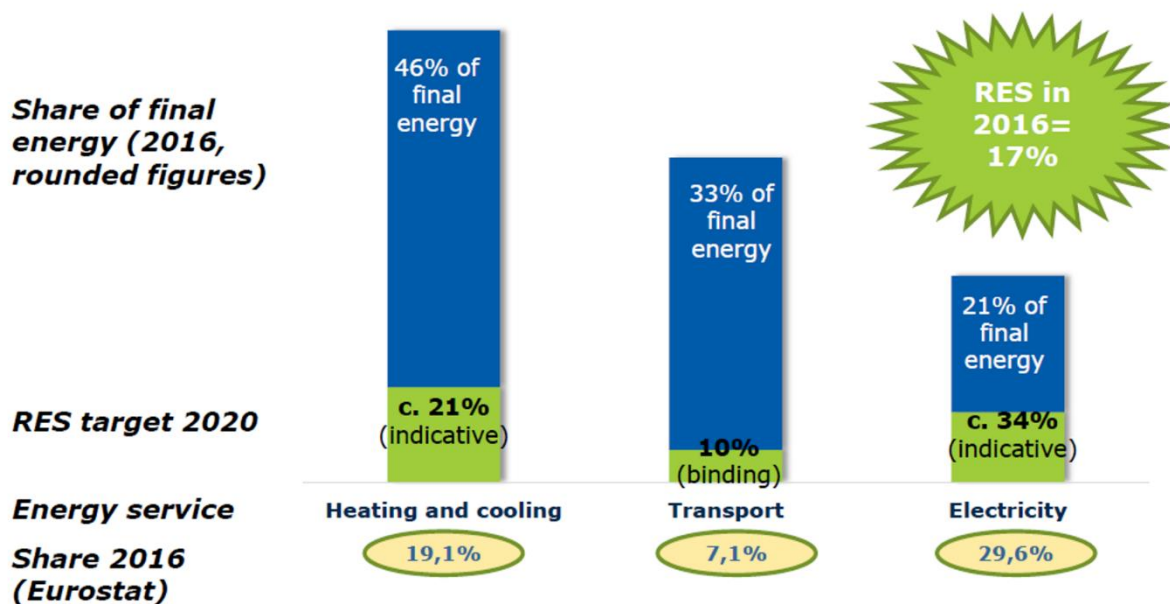


Source: Hydrogen Roadmap Europe

1.1.1.3 Decarbonisation of Heating

The decarbonisation of heat also follows a similar logic. Unless a massive undertaking sweeps through Europe in the next 20-30 years to convert all buildings (residential, commercial, industrial) to become essentially passive, the primary energy source to provide space heating requirements must be zero emission and carbon-neutral. In addition, since process heat also accounts for a substantial share of the final energy use (46% in 2016), it must be decarbonized as well.

Figure 7: Renewable shares in Europe



Source: European Commission, Stakeholder Platform Plenary, Brussels, 25th of march 2019

The progressive use of hydrogen as a carbon-free substitute for natural gas is the most promising solution (alongside electrification and the use of biogas). Like natural gas, it can be easily transported everywhere and provides alternative means of seasonal storage. The technical feasibility is proven (there are existing

H₂ pipelines in Europe even today). In parallel, progressive injection of hydrogen into the existing natural gas grid is also possible, although legal limits vary from country to country up to 20%. Importantly, hydrogen produced from renewable sources provide a realistic vector for increasing the share of renewable content within heating and cooling. Indeed, 13 Member States⁵ have already foreseen within their draft national energy and climate plans the injection of hydrogen into their gas grids.

1.1.1.4 Decarbonising Industry through the use of H₂ as feedstock

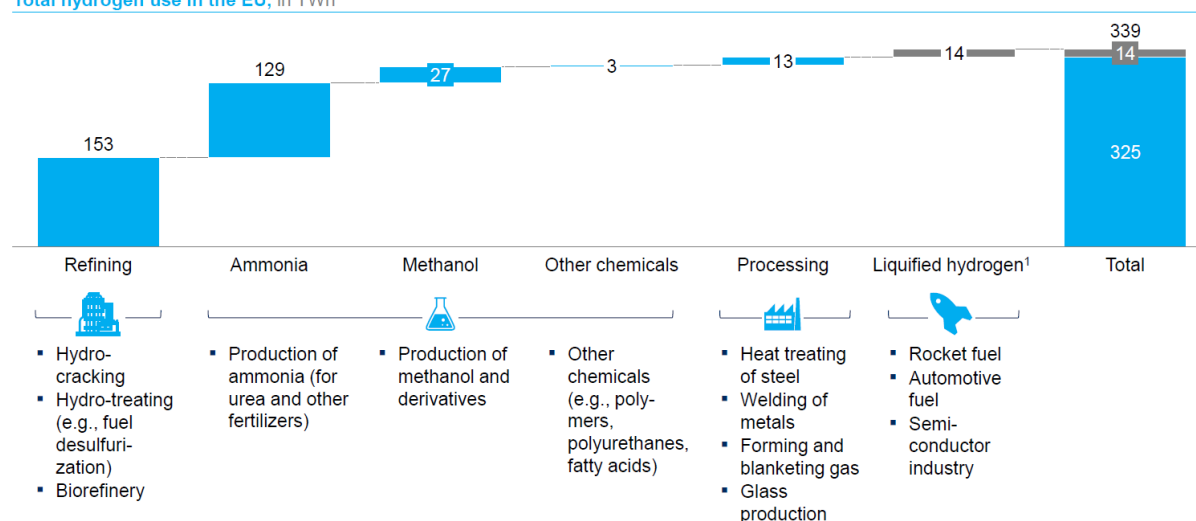
Most of the 70 million tonnes of hydrogen produced globally today is for industrial uses and thus transition to clean hydrogen will have a huge impact on the CO₂ footprint of industry.

One of the most promising applications for clean hydrogen is through its use as feedstock. For example, hydrogen can directly replace coal in the manufacturing process for **steel** through DRI (direct-reduced iron). In this way, its environmental impact is maximised, by substituting a fossil fuel such as coal for a clean one such as hydrogen, in an industry that is known as a large contributor to GHG emissions (it accounts for about a quarter of all industry emissions).

Currently, the main use of hydrogen is in the chemicals industry, mostly in refineries and for the production of ammonia and methanol (see Figure 8). The primary method of production is through the reformation of natural gas. Because of the increasing pressure on these industries to lower their CO₂ emissions, they are considering the potential decarbonisation of the hydrogen feedstock. In this regard, the use of green hydrogen produced from renewable energy sources and low carbon hydrogen hold an enormous potential, all the more so if we consider the increasing demand for these chemical products worldwide over the next few decades.

Figure 8: Total hydrogen use in the EU

Total hydrogen use in the EU, in TWh



Source: Hydrogen Roadmap Europe

In addition to steel, refining, ammonia production, other hard to abate industries can also benefit from the use of clean hydrogen. For example, in the production of cement carbon capture and utilisation can make use of clean hydrogen to produce synthetic methane.

1.1.1.5 Air quality

According to the EEA, large percentages of the EU urban population are exposed to high levels of pollutant concentrations⁶. As a result, every year about 600,000 EU citizens die prematurely due to air quality issues. At worldwide level, it amounts to 6.5 million deaths a year, with 36% of deaths due to lung cancer and 34% by “ACV” (accident cardio vasculaire) linked to air pollution.

⁵ AT, BE, CZ, EL, FR, DE, IE, IT, NL, PT, RO, ES, UK

⁶ <https://www.eea.europa.eu/publications/air-quality-in-europe-2019>

Figure 9: Percentage of the urban population in the EU-28 exposed to air pollutant concentrations

Pollutant	EU reference value (*)	Urban population exposure (%)	WHO AQG (*)	Exposure estimate (%)
PM ₁₀	Day (50)	13-19	Year (20)	42-52
PM _{2.5}	Year (25)	6-8	Year (10)	74-81
O ₃	8-hour (120)	12-29	8-hour (100)	95-98
NO ₂	Year (40)	7-8	Year (40)	7-8
BaP	Year (1)	17-20	Year (0.12) RL	83-90
SO ₂	Day (125)	< 1	Day (20)	21-31

Key	< 5 %	5-50 %	50-75 %	> 75 %
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Notes: The reference concentrations include EU limit or target values, WHO AQGs and an estimated reference level (RL).
For some pollutants, EU legislation allows a limited number of exceedances. This aspect is considered in the compilation of exposure in relation to EU air quality limit and target values.
The comparison is made for the most stringent EU limit value set for the protection of human health. For PM₁₀, the most stringent limit value is for the 24-hour mean concentration, and for NO₂ it is the annual mean limit value.
The estimated exposure range refers to the maximum and minimum values observed in a recent 3-year period (2015-2017) and includes variations attributable to meteorology (as dispersion and atmospheric conditions differ from year to year) and to the number of available data series (monitoring stations and/or selected cities) that will influence the total number of the monitored population. The estimate for 2017 is presented in the main text of this report.
As WHO has not set AQGs for BaP, the RL in the table was estimated, assuming WHO unit risk for lung cancer for polycyclic aromatic hydrocarbon mixtures and an acceptable risk of additional lifetime cancer risk of approximately 1 in 100 000.
(*) In µg/m³, except BaP, which is in ng/m³.

Source: EEA, 2019a.

These significant impacts are spurring a call to action in major European cities. Initiatives to curb the use of fossil fuels, for instance by cutting the access of diesel and gasoline-powered vehicles to city centres, and the announcements issued recently by cities and even national governments regarding bans of sales of vehicles with combustion engines, all give an indication of the size of the problem and the need to find workable solutions as soon as possible. **Being zero emission, hydrogen technologies in all applications are one of these solutions.**

1.1.1.6 Job Creation and Economic Growth

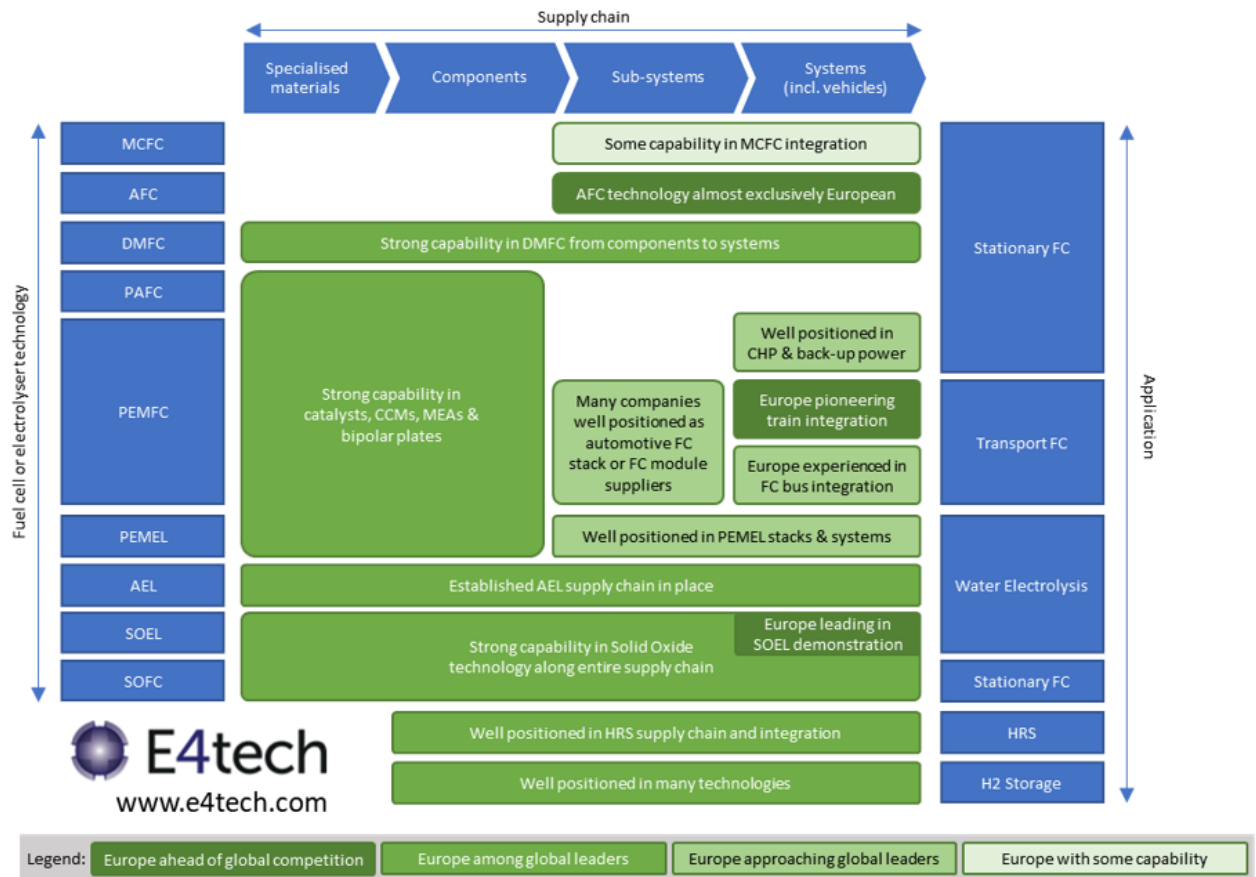
European industry has made great strides and is poised to take the next step and achieve significant levels of commercialisation. This will enable significant economic growth to take place primarily within Europe, keeping high value-added jobs, and creating a supply chain of EU companies around a new suite of products based on hydrogen and fuel cell technologies.

This ecosystem is best showcased by a company called “H2 Logic”, set up in 2003. This Danish SME anticipated the need for low-cost, reliable and user-friendly hydrogen refuelling stations (HRS). Having field tested its products with the help of JU funding, it went on to participate successfully in several FCH JU-funded projects and grew from its initial three co-founders to a team of 77 people. In 2015 H2 Logic was sold on and became NEL Hydrogen, a new company currently employing 200 people and with a presence in both Europe and the US. It recently invested € 9 million in a manufacturing plant in Denmark with the capacity to build around 300 HRSs a year, enough to fuel 200,000 hydrogen vehicles.

This situation may be put in contrast to past and present experiences in other innovative technologies. For example, it is widely acknowledged that Asian manufacturers have won the race on PV panels and now have an overwhelming share of the market. Similarly, the batteries being used in BEVs are largely made in Asia. European OEMs in these market segments are not able to compete, due to steps taken at policy and investment levels in previous years that have led to the current situation

The FCH sector contains many large and small players globally and many applications are on the verge of economic competitiveness after years of investment and development. European companies have become increasingly established as leaders in their respective fields. This is illustrated in the charts below showing the relative position of EU actors in the supply chain with respect to competitors outside Europe

Figure 10: European global leadership in various hydrogen technologies



Source: E4Tech analysis based on Study on Supply Chain for Hydrogen and Fuel Cells Technologies, internal study commissioned by the FCH 2 JU, February 2017

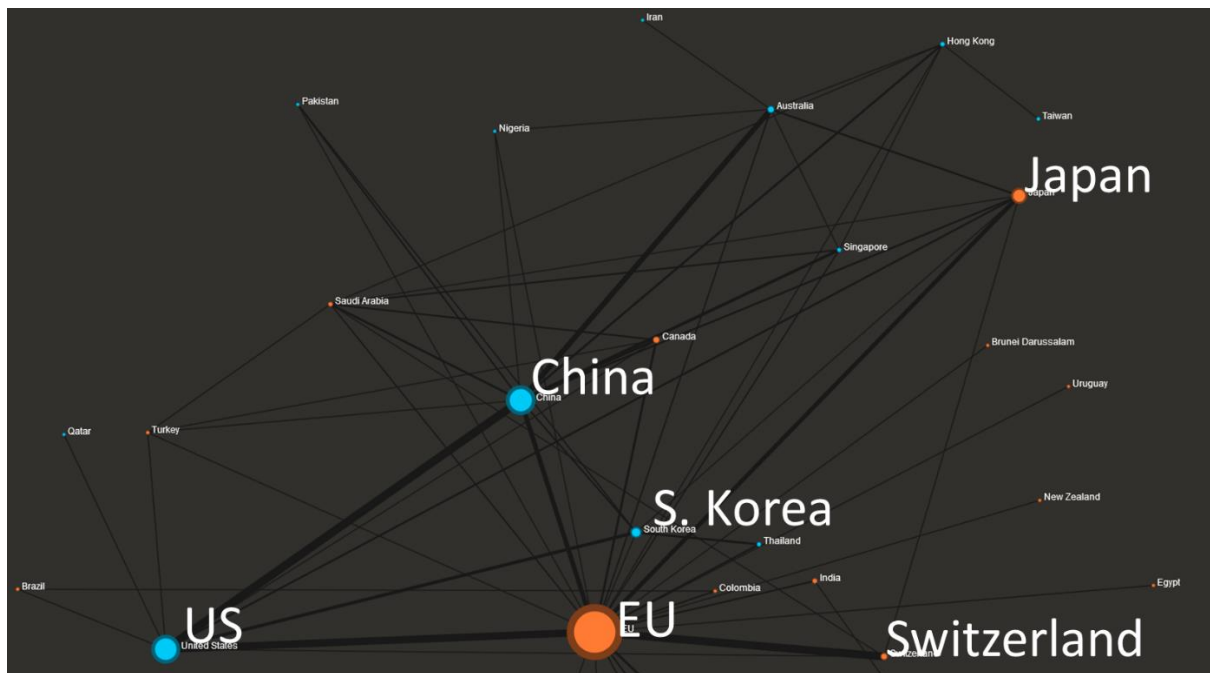
Figure 11: PEM electrolysis: Number of publications, patents, etc. 2004 - 2017⁷



Source: EU, Joint Research Centre, Tools for Innovation monitoring (TIM) Analytics

⁷ EU 823, US 430, China 270, JPN 193, S. Korea 143

Figure 12: SOE electrolysis: Number of publications, patents, etc. 2004 - 2017⁸



Source: EU, Joint Research Centre, Tools for Innovation monitoring (TIM) Analytics

Indeed, similar initiatives as the FCH JU have been put in place worldwide, such as the ones already initiated in Asia (Japan, Korea) and in the USA (New Clean Energy Manufacturing Initiative). Based on these and other experiences around the globe, it is reasonable to believe that the deployment of the European industrial offer should start focusing on key enabling components or sub-systems with associated pilot lines in order to be able to maintain global leadership and continue to compete in this critical emerging market.

Data obtained by the Hydrogen Council⁹ indicate that realising the vision laid out in this document would contribute over 850,000 jobs in Europe by 2030. The Hydrogen Roadmap Europe analysis shows that the potential for hydrogen in Europe is even higher in 2050, with 5.4 million direct jobs being created by an industry which generating more than €800 billion annually.

1.1.1.7 Security of Energy Supply

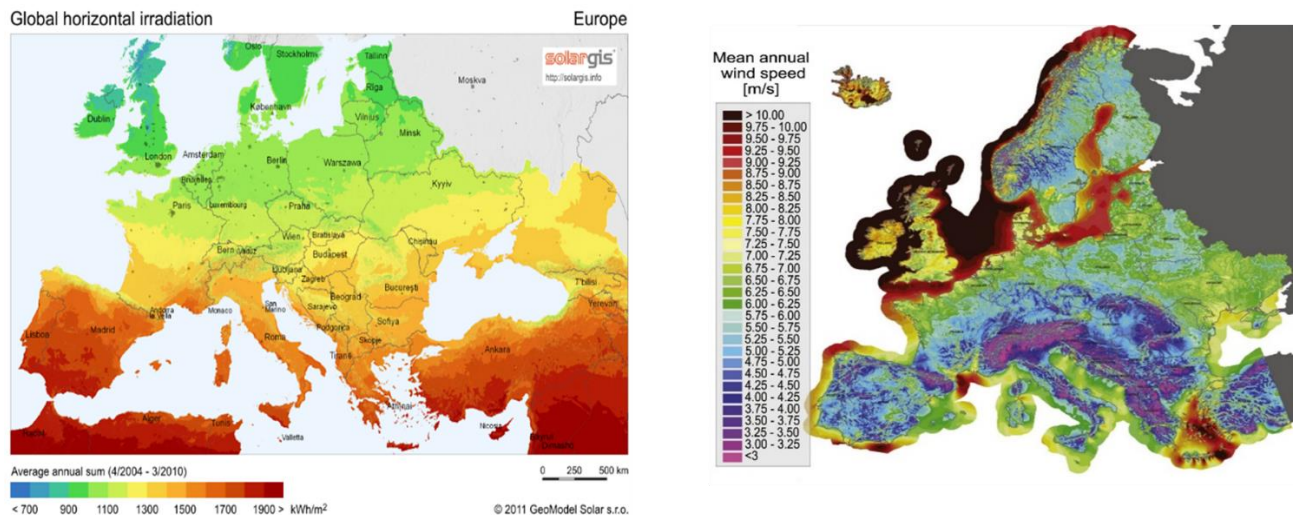
In line with European policy, hydrogen will contribute to secure a supply of energy in the EU in the future. This is a key aspect, as today Europe imports a large share of its primary energy needs (mostly natural gas and oil - Europe imports over €1 billion worth per day), and to a large degree from geographic areas that do not exhibit the desired level of stability. This is why locally produced hydrogen from renewable energy sources or non-renewable low carbon electricity available in Europe provides an excellent complement to these sources, as it displaces these fossil fuels coming from beyond our borders. Achieving high levels of this displacement can have additional indirect benefits (e.g. improved health of citizens, regional stability, additional business opportunities for exporting of technology and hydrogen fuel to other areas of the world, etc.).

Clean hydrogen can be produced anywhere in the world where renewable potential exists. Even if the EU continues to be a net importer of energy, the choice as to where this energy will be imported from would significantly increase in a world where clean hydrogen is traded as a commodity. This will have significant positive geo-political implications and create additional leverage for external trade and neighbourhood policy.

⁸ EU 508, China 255, US 246, JPN 121, S. Korea 74.

⁹ “Hydrogen: Scaling Up”, November 2017. Available at: hydrogencouncil.com. Calculated using McKinsey Input-Output Model (Germany; base data: Destatis); TAB (2012).

Figure 13: Renewables in Europe¹⁰



Source: Solargrids, Ad v. Wijk (TU DELFT)

1.1.2 Why hydrogen needs Europe: Market failure prevents large scale deployment

Europe is currently in an excellent position to achieve a significant level of penetration of hydrogen and fuel cell technologies over the next decade, at a level that can: (a) prove that hydrogen can fulfil a key role towards fighting climate change and improving public health; (b) act as a central pillar in the decarbonisation and elimination of other harmful emissions of everyday activities; and (c) positively impact the economy thanks to a broad and competitive supply chain that keeps Europe in a leading position and creates a new wave of high skill jobs.

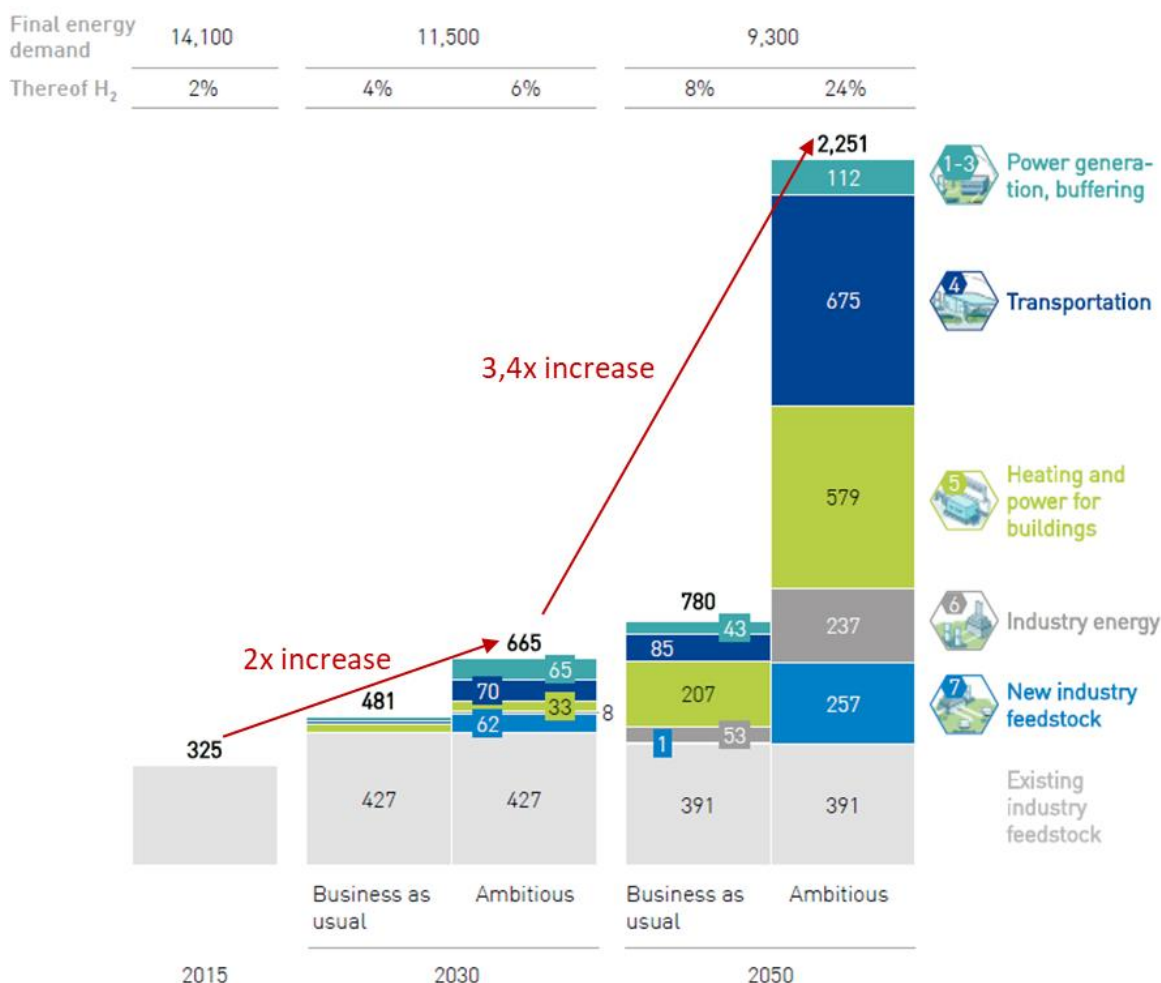
In order for the EU to achieve the 2-degree target, an ambitious scenario for hydrogen deployment needs to unfold. Unfortunately, **despite significant progress** achieved by research and industry with the support of the EU Commission, through the FCH JU, **work remains to be done** before hydrogen can live up to the immense potential for revolutionising our fossil fuel-based economies.

If the right measures are taken now at EU, national and local level, hydrogen could provide up to 24% of total energy demand, or up to ~2,250 TWh of energy in the EU by 2050.

Realizing this ambition will require a significant step up of activities along the whole value chain. The ramp-up should start now as hydrogen and fuel cell technologies are technically ready for most segments and the **EU industry must scale up** to reduce costs and gain a leading position in the global energy transition economy. Towards 2030, research and deployment should focus on priority segments such as: (1) large-scale low-carbon hydrogen production, (2) cost-efficient hydrogen storage, distribution and storage and (3) key end-uses such as industrial use, commercial transportation fleets, larger passenger vehicles, heavy transport (trucks, trains, ships), aviation as well as hydrogen introduction into the natural gas grid.

¹⁰ Solar irradiation (left) and wind speed at 80 m height (right) in Europe.

Figure 14: Hydrogen demand in 2050 in Europe, under various scenarios



Source: Hydrogen Roadmap Europe

Achievement of this positive vision of the future will require a coordinated approach by policymakers, industry, and investors. If this level of cooperation does not emerge and current policies remain in place, hydrogen will see much lower deployment levels and decarbonization targets will remain unmet. Figure 14 describes such a development, the business-as-usual (BAU) scenario. In this scenario, hydrogen demand would amount to only about 780 TWh in 2050 (compared with 2,250 TWh in the ambitious scenario). The use of hydrogen would abate about 100 Mt of CO₂ by 2050, leaving a gap of approximately 960 Mt to the 2-degree scenario.

1.1.2.1 Significant progress achieved...

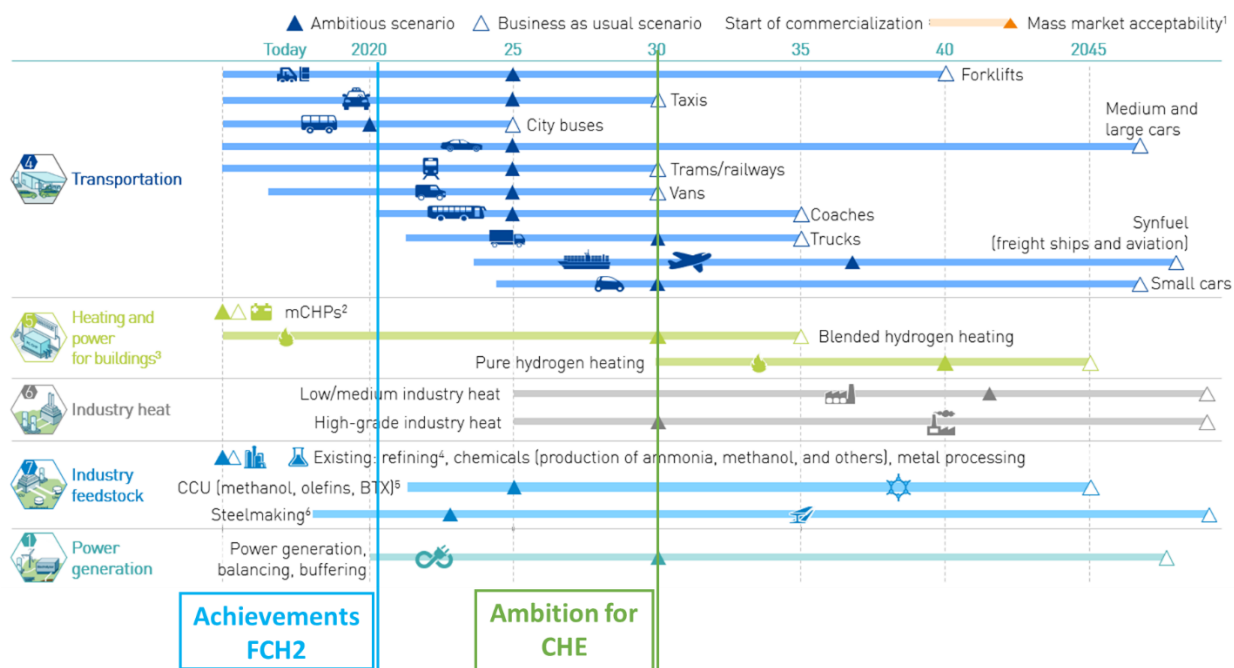
The evaluations of the FCH 2 JU have shown that the impact of the activities undertaken by the partnership have been significant and far reaching. Moreover, these evaluations pointed out that “the choice of a Joint Undertaking as instrument continues to ensure good alignment with both policy and industrial objectives. [...] Europe's competitive position would be less favourable without the activities of the FCH 2 JU”. This chapter recounts the areas in which the FCH JU has been found to have been effective (in order to learn from the positives) while the subsequent section highlights the challenges that remain and the areas which require increased effort. When going deeper into the planned implementation, (Chapter 2) the lessons learned from previous evaluations (and not only), are given practical form, as they inform the proposed changes in the inner working, governance and coordination of the proposed partnership.

Hydrogen applications climbing the TRL ladder

As depicted in Figure 15, a series of technology/applications have been brought to maturity with the support of the FCH JU. For example, passenger cars, vans, material handling and domestic and

commercial hydrogen burners are now ready (or expected to be ready soon) for mass commercialisation. While technological building blocks should still be subject to improvement, **no additional support for demonstration activities is required for these applications in the next financial period.** For these applications, it is time that the market, industrial players and other policy instruments to take over and continue (mass) deployment. **This success could not have occurred without the FCH JU**, which is demonstrating thousands of light duty vehicles and which has kick started the deployment of the much-needed hydrogen refuelling requirements for further European uptake.¹¹

Figure 15: Status of maturity of various hydrogen applications



The progress achieved in cars and buses¹² should now be replicated in other transport applications such as coaches¹³, trucks, ships and aviation. These applications will require, in the next financial period, support from a future partnership, Clean Hydrogen for Europe, in order to follow the same success curve as the applications which reached maturity during the FCH 2 JU.

As regards fuel cells (FC) for power production several technology leaders in this sector (most of them EU heating companies) are approaching commercialisation. As regards the larger (industrial size) maturity is not far off.

The success registered so far by the FCH 2 JU does not eliminate the need to continue the development of hydrogen infrastructure and improvement of core technological building blocks in all the applications presented above. It also does not eliminate the need to invest in research, development and demonstration (including at scale) of applications which have not yet reached maturity, but it does show that public investments pays off in the long term and should be replicated, at scale, using those applications which are now lagging behind and will require prioritisation in the next financial period (see Chapter 2).

A densely structured European hydrogen ecosystem

One of the main achievements of the FCH JU is that it contributed¹⁴ to structure and mobilise an otherwise fragmented landscape of different sectors and industries and to convince competing or different, unrelated

¹¹ The total number of HRS to be supported by FCH 2 JU will reach 99, of which 48 were deployed in 2018

¹² Fuel efficiency has increased three-fold in 15 years and refueling time has more than halved. In this period, the costs of fuel cell buses have decreased by almost 400% as a result of the efforts of the FCH JU, as demonstrated by the Interim Evaluation of the Fuel Cells and Hydrogen 2 Joint Undertaking (2014-2016) operating under Horizon 2020 - Experts Group Report

¹³ While some work still remains for hydrogen fuel cell buses and coaches to be fully competitive against diesel incumbents, it is not far off.

¹⁴ Commission Staff Working Document - Interim Evaluation of the Joint Undertakings operating under Horizon 2020, {SWD (2017) 339 final}

stakeholders to work together towards clear objectives¹⁵. **The impact of this achievement cannot be understated.** Before the existence of the FCH JU, one could not speak about a “hydrogen sector” at all, let alone a common strategy, vision and action plan. Whatever activities existed, they took place in isolation, disconnected from each other, most were focused on low TRL research or took place without large-scale roll-out in mind. This situation has changed fundamentally but the **progress achieved is fragile. A strengthened institutional European Partnership is essential** to maintain stakeholders on track and committed towards the realisation of a common agenda.

Strengthening regional and international ties

In 2017, the FCH 2 JU launched an initiative to help European regions and cities harness hydrogen and fuel cells to realise their energy transitions. It entered into Memoranda of Understanding with over **90 regional and municipal public authorities**¹⁶, with the objective to advance the commercialisation of these technologies, as they are increasingly driven by public authorities¹⁷.

Due to the cooperation between the JU’s and the Commission’s activities, hydrogen is now a part of the Mission Innovation¹⁸ challenge announced at COP 21 as world leaders came together in Paris to commit to ambitious efforts to combat climate change.¹⁹ In addition, the FCH JU has supported the European Commission in international activities with International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE 19 countries plus the European Commission) within the International Energy Agency (IEA) Hydrogen Implementing Agreement and the IEA Advanced Fuel Cell Implementing Agreement.

The topic of international cooperation through hydrogen has been mentioned by the new Commission. As explicitly stated by Vice-President Timmermans: cooperation in the South of the Mediterranean Sea will become even more important in the next period, given the region’s immense potential to produce and export renewable hydrogen, as such more alignment and coordination across the different EC services, European private partners and other relevant stakeholders will be required in the future. A future partnership should support the Commission to strengthen regional and international collaboration on hydrogen.

A much better leverage effect as compared to other densely structured hydrogen ecosystem

Under Horizon 2020 rules, the FCH 2 JU was required to demonstrate a leverage effect of 0.57.²⁰ This requirement was significantly over-achieved. By the end of 2018, the leverage effect from members alone had reached €1.36.²¹

Furthermore, as seen in the table below, certified, reported and planned additional activities²² over 2014 – 2020 total an amount of €1.218 billion. This means that, taking into account in-kind contributions of private partners, the total leverage effect (in projects and in additional activities) is 2.67. In other words, for every euro of EU contribution for all signed H2020 FCH 2 JU grant agreements, private partners (members of Hydrogen Europe and Hydrogen Europe Research) will have committed to spend €2.67 either on FCH 2 JU projects or on additional activities

This demonstrates the positive impact that a public-private partnership can have on incentivizing private funding around the achievement of EU policy objectives.

¹⁵ The objectives of the FCH JU, as laid down in its founding regulation.

¹⁶ Over 90 regional and municipal public authorities from 22 countries representing about 25% of Europe’s population, surface area and GDP

¹⁷ The surveys undertaken by the FCH JU with regions assessed project implementation intentions in excess of €1.8 billion over the next 5 years

¹⁸ <http://mission-innovation.net/our-work/innovation-challenges/renewable-and-clean-hydrogen/>

¹⁹ Mission Innovation is a global initiative of 24 countries and the European Commission. Clean and Renewable Hydrogen represents Innovation Challenge 8, and has as objective to accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale

²⁰ Article 4, Council Regulation 559/2014 establishing the Fuel Cells and Hydrogen 2 Joint Undertaking

²¹ FCH 2 JU Annual Activity report 2018, available at: <https://www.fch.europa.eu/sites/default/files/FCH%202020JU%20Annual%20Activity%20Report%202018%20-%2028ID%206079970%29.pdf.pdf>

²² Costs incurred in implementing additional activities outside the work plan of the FCH 2 Joint Undertaking contributing to the objectives of the FCH JU (Art 4.2 b, Regulation 559/2014.

Table 1: Cumulative certified, reported and planned private Additional Activities and contribution in projects for 2014 – 2020 compared to EU contribution to the FCH 2 JU– snapshot of 12 November 2019

in € million	Certified 2014-2018	Preliminary report 2019	Planned 2020	TOTAL 2014 - 2020
Private additional activities (IKAA)	667	238	313	1.218
in € million	Committed 2014-2018	Estimated 2019	Estimated 2020	TOTAL 2014 - 2020
Private contribution in projects (IKOP)	391	170		561
EU Contribution				665

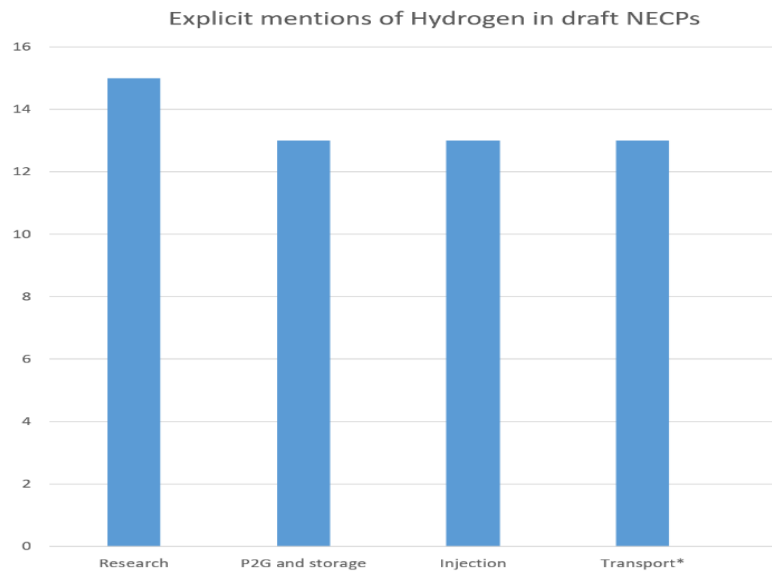
Communication and dissemination got the message across

There has been a much broader acknowledgement that Europe needs to strive for deep decarbonisation and that hydrogen technologies are a necessary component of this deep decarbonisation.

Over the past few years, policy makers across Europe have significantly increased their awareness, knowledge and recognition of hydrogen technologies:

- All EU Energy Ministers signed, in September 2018, the Hydrogen Declaration, committing themselves “to maximise the great potentials of sustainable hydrogen technology for the decarbonisation of multiple sectors, the energy system and for the long-term energy security of the EU”.
- Member States rely on hydrogen technologies to achieve energy and climate plans (NECPs). In the draft NECPs submitted at the end of 2018, 13 Member States explicitly mentioned the use of power-to-gas, storage and injection of hydrogen into their gas grids as a means to achieve their targets in heating and cooling. The same number of countries explicitly mentioned the use of hydrogen in transport while 15 Member States explicitly mentioned the importance to continue **and step-up** research and innovation in hydrogen technologies.
- At EU level, the EU Council called on the European Commission to “undertake and analysis of sector coupling and sector integration technologies including the production of hydrogen and explore initiatives for efficient integration and deployment of such technologies and energy carriers”.

Figure 16: Number of Member States explicitly mentioning hydrogen technologies in draft national energy and climate plans



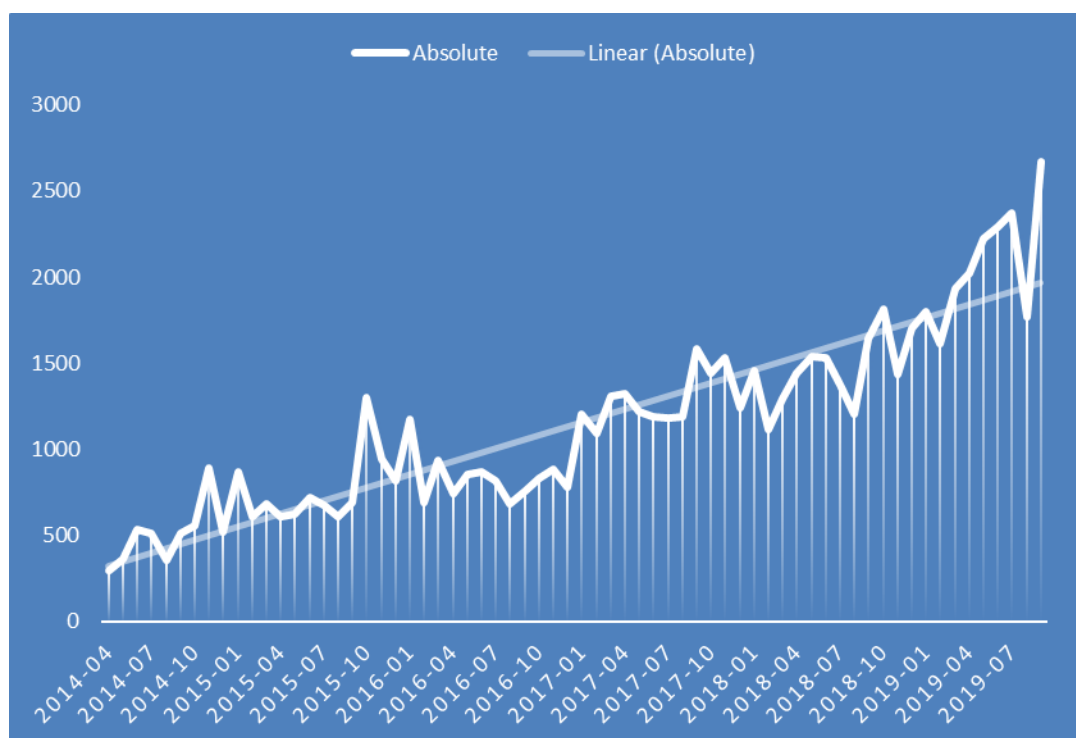
More interest in hydrogen technologies by the media and the general public

It should come to no surprise that, due to its immense potential to transform our energy system, hydrogen is becoming, more and more, a topic of discussion among policy makers, industry and research. What is more striking, perhaps, is the interest shown by mainstream media (as a proxy for the general public) in the past few years. Figure 17, below, depicts this trend from 2014 to 2019. The European Media Monitor²³ has analysed close to 500 million articles in European media and has found that more than 75 000 covered hydrogen and/or different parts of the FCH value chain. The coverage of the FCH sector in European media between 2014 and 2019 has increased, on average by 55% each year.

This growing attention by European media is striking and it shows that FCH technologies are becoming, more and more, prominent in the minds of the general public.

²³ <https://emm.newsbrief.eu/NewsBrief/clusteredition/en/latest.html>

Figure 17: Media coverage of fuel cells and Hydrogen in European press



Source: European Media Monitor

In terms of the content being discussed within media articles, most articles covered: fuel cells (49%), FCH cars (41%); energy storage (32%) and, more broadly, the introduction of hydrogen in transport (23.5%). The connection of hydrogen and the renewable sector (8%), as well as the introduction of hydrogen in industry (7.7%) and within the gas grid (6.5%) were also topics which benefited from considerable media coverage within this period. Almost 2% of all articles between 2014 and 2019 which discussed hydrogen also explicitly mentioned the role of the FCH JU within the sector.

Figure 18: Categories most covered by European media (2014-2019)

Categories used	#articles triggered	% for this category
Hydrogen-FuelCell	36951	48,90%
Hydrogen-Cars	30954	41,00%
Hydrogen-EnergyStorage	24328	32,20%
Hydrogen-FuelCells-Transport	17676	23,40%
Hydrogen-Renewables	5881	7,80%
Hydrogen-Industry	5830	7,70%
Hydrogen-Bus	5323	7,10%
Hydrogen-Gasgrid	4928	6,5%
Hydrogen-Boats	3785	5%
Hydrogen-Trucks	3071	4,10%
Hydrogen-Trains	2308	3,10%
FCH JU Projects	1959	2,6%
HydrogenEurope	1851	2,5%
FuelCell-Hydrogen_JointUndertaking	1218	1,6%
Hydrogen-Planes	1161	1,5%

Hydrogen-MHVs			539	0,7%
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Source: European Media Monitor, November 2019

Safety, regulations, codes, standards

As a consequence of its central role in overseeing the implementation of projects, the FCH 2 JU has centralised a vast amount of knowledge in terms of legal and administrative barriers, applicable regulations, standards and codes as well as experience in managing safety.

Safety, in particular, is essential in the advancement of hydrogen fuel cell technology. The FCH 2 JU ensured that education and communication around the technology are also given prominence. To this end, the European Hydrogen Safety Panel (EHSP) was established. The EHSP is a multidisciplinary pool of experts, the mission of which is to assist the Programme Office in assuring that hydrogen safety is adequately managed, and to promote and disseminate hydrogen safety culture within and outside of the FCH 2 JU programme.

Also, the JU set up the Regulations, Codes and Standards Strategy Coordination (RCS SC) Group whose main tasks are to identify and prioritize RCS needs of strategic importance for the EU, as well as identifying Pre-Normative Research (PNR) activities to support the RCS priorities, tailor PNR and other RCS-related activities in the FCH 2 JU programme.

This knowledge has (i) helped identify priorities for further research (especially in the PNR area); (ii) has helped projects overcome barriers by sharing best practices and solutions; (iii) has contributed to building a knowledge base for the safe deployment of hydrogen technologies and, finally, (iv) has helped to inform the agenda of other organisations such as standardisation bodies (CEN-CENELEC, ISO, IEC, etc.) and the European Commission by highlighting barriers and associated drivers. This complements the core functions of the PO by incorporating the practical experience built-up

Developing European Start-ups and SMEs

Another example of the JU's added value in addressing critical issues that respond to major socio-economic challenges is its relationship with start-ups and SMEs, this success is exemplified by Italian microgrids and energy storage company Electro Power Systems (EPS)²⁴ ; Elcogen²⁵; H2 Logic²⁶ and many others.

1.1.2.2 ... but work still remains to be done

As shown in Figure 15, while work still remains in some areas, a number of technology/applications are technologically mature and ready for mass commercialisation. The work of the FCH JU over the past decade has brought hydrogen to the brink of widespread deployment, but **market failure and fragmentation prevent clean hydrogen from reaching their full potential as the missing link in an integrated, sustainable and clean energy system.**

The underlying **core challenges**, which cause bottlenecks and market failures, preventing hydrogen technologies to reach mass market status, are diverse in nature and **differ depending on the application and the technology they concern.** These challenges can be summarised as followed:

²⁴ EPS's innovative power-to-power technology energy storage solution in off-grid and isolated microgrid applications has attracted the interest of major EU and global utilities. Today, thanks to the backing of the FCH JU funding since 2009 and other EU financing facilities like the EFSI (managed by the EIB) for the development and demonstration of products, EPS attracted the global energy actor ENGIE into its investors structure

²⁵ Once a small start-up, this Estonian enterprise is now the manufacturer of the world's most efficient solid oxide fuel cell (SOFC) technology and has more than 60 customers globally. The FCH JU enabled Elcogen to finance R&D work with leading European institutes

²⁶ Set up in 2003, this Danish SME anticipated the need for low-cost, reliable and user-friendly hydrogen refuelling stations (HRS). Having field tested its products with the help of JU funding, it went on to participate successfully in several FCH JU-funded projects and grew from its initial three co-founders to a team of 77 people. In 2015, H2 Logic was sold on and became NEL Hydrogen, a new company currently employing 200 people and with a presence in both Europe and the US. It recently invested € 9 million in a manufacturing plant in Denmark with the capacity to build around 300 HRS a year, enough to fuel 200,000 hydrogen vehicles

1. A number of technologies/applications do not exist yet or **are not mature enough**. For these applications, further Research & Innovation (R&I) is necessary to progress in Technology Readiness Levels (TRL).
 - Where R&I does take place (outside of the context of the current FCH JU) it is fragmented between various Member States and isolated companies.
2. For technologies/applications **that are, technologically, ready for deployment**, they face different challenges:
 - Hydrogen solutions remain more expensive for a good part due to **the absence of volume** (need for improved Industrialisation and Manufacturing Readiness Levels);
 - Unlike other technologies there is **no first mover advantage**: the first mover is not able to get such a market advantage where future profits can compensate for early losses;
 - The deployment of hydrogen applications is **usually part of a broader systems** involving other hydrogen applications and/or other sectors therefore **requiring a large coordination effort**;

For these applications, the main challenge is to get policies that will push their introduction into the market, generate volume and decrease costs. However, beyond policies (which are out of scope of the objectives of the R&I partnership), there is still a need for: (i) **substantial R&I effort** even for those technologies/application that are mature enough to enter the market **to improve efficiency, cost, durability and manufacturability** and (ii) **coordinated roll-out** and deployment of comprehensive systems, covering clean hydrogen production, transport and distribution and finally, end-use applications.

3. As it is very rapidly becoming necessary (and possible) to produce and use large quantities of clean hydrogen, **transport, storage and distribution is at risk of becoming a bottleneck for the accelerated rollout of hydrogen technologies** at scale. This central pillar between production and consumption requires new (pipelines, refuelling stations) and old (existing gas infrastructure, salt caverns) solutions to work together in a decarbonised energy system.

All applications, irrespective of TRL, manufacturing readiness level (MRL) and scale suffer from the same horizontal problem: low carbon and renewable hydrogen is **not available cheaply and at scale in all regions** where it is destined to be consumed. This is directly linked to, *among other factors*, the cost of (i) renewable energy, (out of scope of the R&I partnership) (ii) electrolyzers and (iii) of other low-carbon hydrogen production technologies (e.g. CCS technologies).

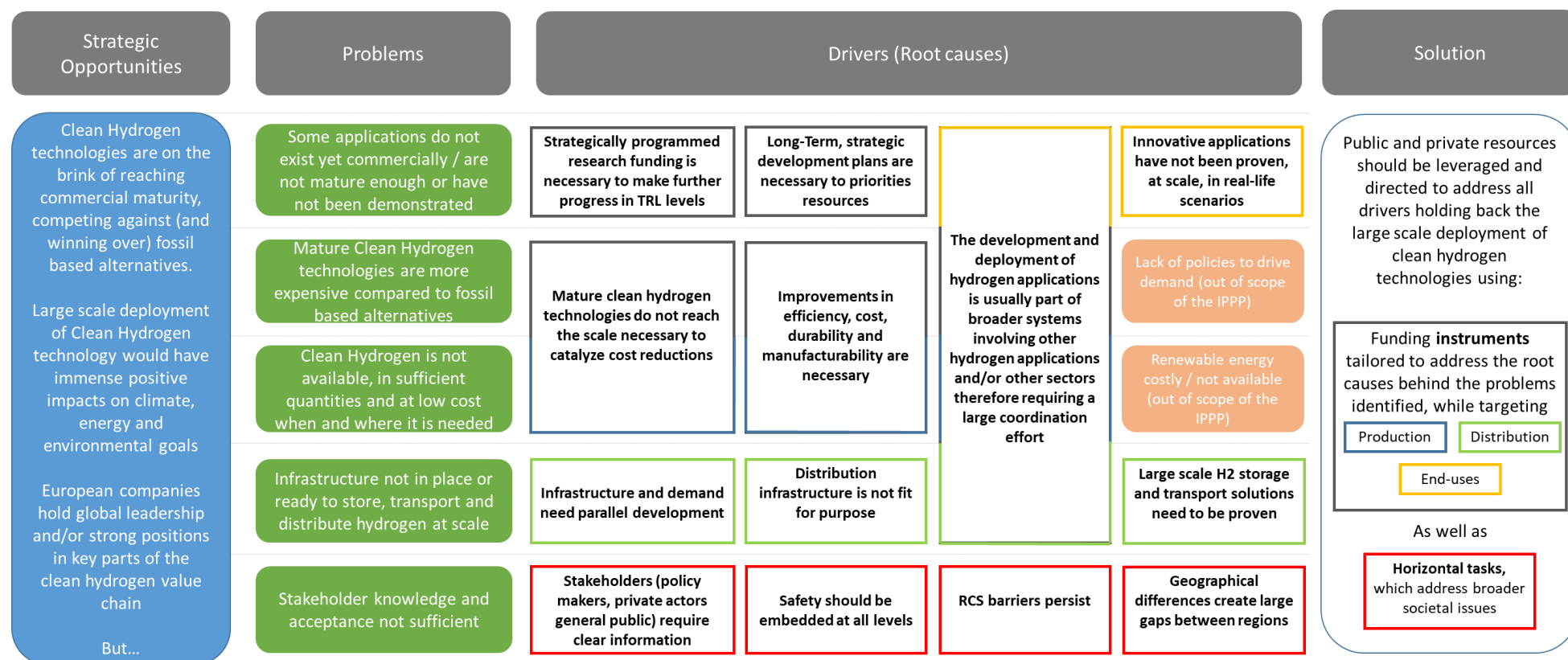
In addition to these core challenges, a number of systemic (or horizontal) challenges further exacerbate the difficulties presented above and/or risk to derail the progress already achieved. These peripheral challenges, which negatively impact overall stakeholder awareness and acceptance of the technologies include:

- (i) **RCS barriers**, most notably the lack of technical regulations and/or accepted standards, which prevent large scale, international deployment of standardised products. In many instances, the lack of clear rules, regulations and standards is a core reason why “projects” do not evolve into mass market “products”. Codes, regulations, and standards for hydrogen technology, for example regarding hydrogen refuelling infrastructure and hydrogen admixture in natural gas networks, will need to be developed at EU level to ensure hydrogen applications are not restricted in their roll-out. The lack of a common definition of clean hydrogen and a common methodology to calculate the CO₂ footprint hinders the trade of hydrogen as a commodity.
- (ii) **Safety of FCH technology** is essential to building the confidence needed for widespread take-up. The hydrogen industry has immense experience, build up in an industrial setting, in handling large amounts of hydrogen safely. However, the relative lack of general experience with introducing hydrogen in settings where it was not traditionally located (in people’s cars, buses, homes, fuelling ships or in refuelling stations alongside conventional fuels) increases the time necessary for products to be rolled-out commercially. A culture of safety (including effective yet sensible rules and regulations) needs to be built up alongside the technology itself. The mass scale introduction of hydrogen technologies beyond their traditional industrial setting should be built on a strong foundation of safety. Recent safety related events have shown that more efforts are required to embed such a culture within this fast-growing sector.

- (iii) **Knowledge management** and knowledge transfer, human resource developments and trainings are all necessary components to ensure that deployment takes place simultaneously in different sectors of the economy at various levels (from technicians to CEOs), in public and private entities. Mass deployment requires strong knowledge management and effective dissemination of this knowledge. Training programmes will need to be designed and capacity building planned so that markets are prepared for the introduction of hydrogen technologies. Developing the necessary talent to support a growing hydrogen industry will require time for preparation and time for implementation. Training programmes should be instituted sooner rather than later, so that support capacity can be scaled up in conjunction with technological capacity across sectors.
- (iv) **Geographical differences.** The differences between advanced countries and those which lag behind risks creating unsurmountable gaps in technological deployments, regulatory frameworks, level of knowledge and public acceptance. This risks further exacerbating the funding gap in such countries and endangers the roll-out of the technologies at a European scale. Widespread application of the technology could be hindered by regulatory differences for safety or standards between countries, regions and/or localities. Such differences must be minimised through transnational and regional cooperation. Facilitating hydrogen's integration into EU-wide markets will require close collaboration between member states and EU-level political conversations and decisions. In order for hydrogen technologies to succeed in Europe, the entire EU should be able to experience the benefits, economic and environmental that such technologies can bring.
- (v) **Skilled educated manpower.** The training of educated manpower is crucial to succeed in the needed scaling-up of this emerging new European industry. It consists either to attract and educate young operators, technicians and engineers or to readapt existing workforces in declining and carbon impacting industries.

The problems presented above are depicted in Figure 19, which aims to not only shed light on the issues which prevent clean hydrogen technologies from reaching commercial maturity and out-competing fossil based alternatives, but also to reflect on the possible solutions which can be employed to overcome each of the root causes.

Figure 19: Problem tree behind the proposed institutional public private partnership



The problems presented above require coordinated action. While technological problems should be tackled directly through deployment of the Strategic Innovation and Research Agenda (SIRA) and implemented through annual programmes composed of different types of instruments (see 1.2.2.1). The proposed partnership should take a strong role in tackling horizontal challenges if the problems are to be addressed.

1.2 Common vision, objectives and expected impacts

1.2.1 Common vision of the Clean Hydrogen for Europe Institutionalised European Partnership

A **European Partnership on Clean Hydrogen** is one of the R&I interventions proposed in the Climate, Energy and Mobility Cluster that aims to develop cross-sectoral solutions for decarbonisation²⁷.

As a key technology for the low-carbon transition, hydrogen and the Clean Hydrogen for Europe partnership are key pillars to deliver on the EU's strategic priorities and contribute to the realisation of EU objectives and policies as well strengthen the European Research Area. Clean hydrogen and associated technologies such as fuel cells are important decarbonisation solutions that can be applied in a wide range of end-use sectors. Bringing clean hydrogen applications to large-scale deployment levels would generate high environmental impacts in areas where alternatives for decarbonisation are scarce - such as industry (steel, chemical, petrochemical etc.), heavy duty transport (incl. shipping, maritime, and rail) and heating and cooling²⁸. It would also serve to generate economic benefits in Europe, increase energy security and diversify energy supply.

Given these potential impacts, Clean Hydrogen for Europe's main goal is to **enable European hydrogen technologies (mature and developing) to live up to their potential as the missing link in achieving a sustainable and decarbonised energy system, fully integrated with consuming sectors**, in particular those which are hard to electrify. Our common vision for the partnership is that it would **accelerate the development of clean hydrogen technologies** to the point **where market and policy mechanisms can take over** and continue deployment in a way that allows them to have a significant contribution to European climate, environmental and economic objectives. The partnership would achieve this goal by leveraging technical and financial resources²⁹ from both private and public sources in pursuit of clearly defined objectives fully in line with the policies of the EU.

Figure 20: Overall ambition and policy impacts pursued by Clean Hydrogen for Europe



Our vision for the partnership is that it will produce noticeable, quantifiable contributions towards the achievement of (even more ambitious) climate targets in 2030 and pave the way for carbon neutrality

²⁷ European Commission (2019), Orientations towards the first Strategic Plan implementing the research and innovation framework programme Horizon Europe. Co-Design via web open consultation.

²⁸ European Commission (2019) European Partnership Clean Hydrogen. Inception Impact Assessment

²⁹ A leverage effect which should go well beyond the leverage factor of similar programmes

in 2050. Our vision is highly developed, broken down in detailed technological roadmaps covering all applications under the scope of the partnership, with clear targets, milestones and indicators.

These roadmaps, which collectively make up our Strategic Research and Innovation Agenda (SRIA) are explained in a separate document. This vision is shared by more than 173 industry companies representing the entire hydrogen value chain, including OEMs, energy companies, as well as current and future end-users of hydrogen. Alongside industry, 78 research organisations are committed to realising this vision and are ready to contribute. In addition to this clear commitment by the members of Hydrogen Europe and Hydrogen Europe Research, organisations representing sectors relevant to the energy transition are also included in a broad coordination effort to maximise the outreach of the work of the partnership and further increase the achievement of clear, visible impacts for the EU and its citizens by 2030. This wide and diverse commitment allows the implementation of **a holistic vision for the introduction of clean hydrogen across various segments of the economy in a coordinated manner.**

The EU's decision to support the fuel cells and hydrogen (FCH) sector through an R&I Partnership in the past has had an immensely positive effect already and will have long lasting impacts. In the absence of the Fuel Cells and Hydrogen JU, the technological maturity of European FCH technologies would have been far below the level seen today. The sector stands at the brink of mass market commercialisation today through the combined efforts of research, industry and the public sector who have pulled together technical resources, know-how and funds in the service of the common objectives pursued by the FCH JU.

The success of the FCH JU to spur innovation and bring numerous FCH applications close to mass market commercialisation should be replicated in new, high impact, sectors such as heavy-duty transport, maritime, aviation, heating and industry. Horizontal research to improve the underlying capabilities of technological building blocks will continue to reinforce Europe's leadership position in this field and accelerate mass market adoption. Coordinated roll-out of technologies across the entire energy system will overcome the risks associated with fragmentation and co-dependency and will enable hydrogen to live-up to its potential of the missing link in the energy transition. Cross-cutting efforts will pave the way for safe and frictionless roll-out of the technologies at scale.

It is our view that reinforced and more strategic support for hydrogen-based technologies in the framework of an Institutionalised European Partnership (IEP) will bring tremendous benefits for Europe in terms of climate as well as economic objectives. The seeds planted in the next decade could ensure that, by 2050, 560 million tonnes of CO₂ could be abated annually by hydrogen technologies in an industry that creates more than 5.4 million direct jobs and generates more than €800 billion annually.

Figure 21: Contribution of Hydrogen technologies in Europe in 2050

BESIDES CO₂ ABATEMENT, DEPLOYMENT OF THE HYDROGEN ROADMAP ALSO CUTS LOCAL EMISSIONS, CREATES NEW MARKETS AND SECURES SUSTAINABLE EMPLOYMENT IN EUROPE

2050 hydrogen vision



Source: Hydrogen Roadmap Europe

This vision cannot be achieved in the absence of strong commitment from industry, research and the public sector in Europe. And while the FCH JU has had many achievements (see section 1.1.2.1), much more remains to be done.

First, Clean Hydrogen for Europe should build on the valuable capacities of the FCH 2 JU in **programme design and implementation** and continue to deliver **high quality research and innovation projects**, directed towards **new applications, strengthening the capabilities of core technology building blocks and complete hydrogen energy systems**. It should build on its capacity to foster cooperation with Member States, regions and cities in order to ensure coordinated and geographically balanced deployment.

Second, it should step-up efforts to coordinate with other EU programmes to ensure that research and innovation works coherently with market deployment mechanisms such as CEF, the ETS Innovation Fund, regional and development funds etc. It should strengthen its work on horizontal issues such as regulations, codes and standards and on knowledge management and dissemination. Building on the good work already done, it should take an even stronger role in reinforcing a culture of safety among the stakeholder community.

Finally, the new partnership should strengthen and deepen its cooperation with other sectors. As explained above, hydrogen is key for the integration of renewables in all parts of our energy systems and to decarbonise all major final uses, such as transport, heat and power for buildings, and industry as a source of heat and as feedstock. First, this requires a structured cooperation with the renewable sector (wind and solar) which can increase their penetration thanks to hydrogen. Indeed, in a number of European Regions renewables are reaching their limits, can no longer be absorbed by the grid and end up being curtailed³⁰. Second, it requires intense cooperation with the industries that can be decarbonised through hydrogen: iron and steel, chemicals, refineries and fertilisers and all industries that require large quantities of high-grade heat that are hard to electrify. As an illustration, it is possible to decarbonise the steel production by replacing coke by hydrogen both as a heat source and a reducing agent. This requires major innovation and investment from both the hydrogen and the steel industry. This cannot be done without intense coordination. Thirdly, a similar intense cooperation is also necessary with the heat and gas industries. Through power-to-gas, hydrogen links the electricity and the gas grids and contributes to the integration of renewables and to the decarbonisation of the gas grid and therefore also the heat sector. On transport, the coordination is already well established. Many industrial actors are members of Hydrogen Europe, the FCH 2 JU has created a coalition of users (cities, regions, bus operators, ports, airports. Similar links with the logistic (trucks), rail, maritime and aeronautic sectors will be necessary as hydrogen enters these fields.

1.2.2 General and specific objectives of Clean Hydrogen for Europe

The general policy objectives and expected impacts of the proposed Institutionalised European Partnership on Clean Hydrogen for Europe have been designed to be fully in line with the objectives laid out by the Commission. In particular, they serve to directly support 4 key dimensions (and have an indirect impact on one other) of the European Green Deal proposed by President Ursula von der Leyen and implemented by Commissioner Frans Timmermans. In particular, as explained in section 1.1.1, the mass introduction of clean, low-carbon, hydrogen:

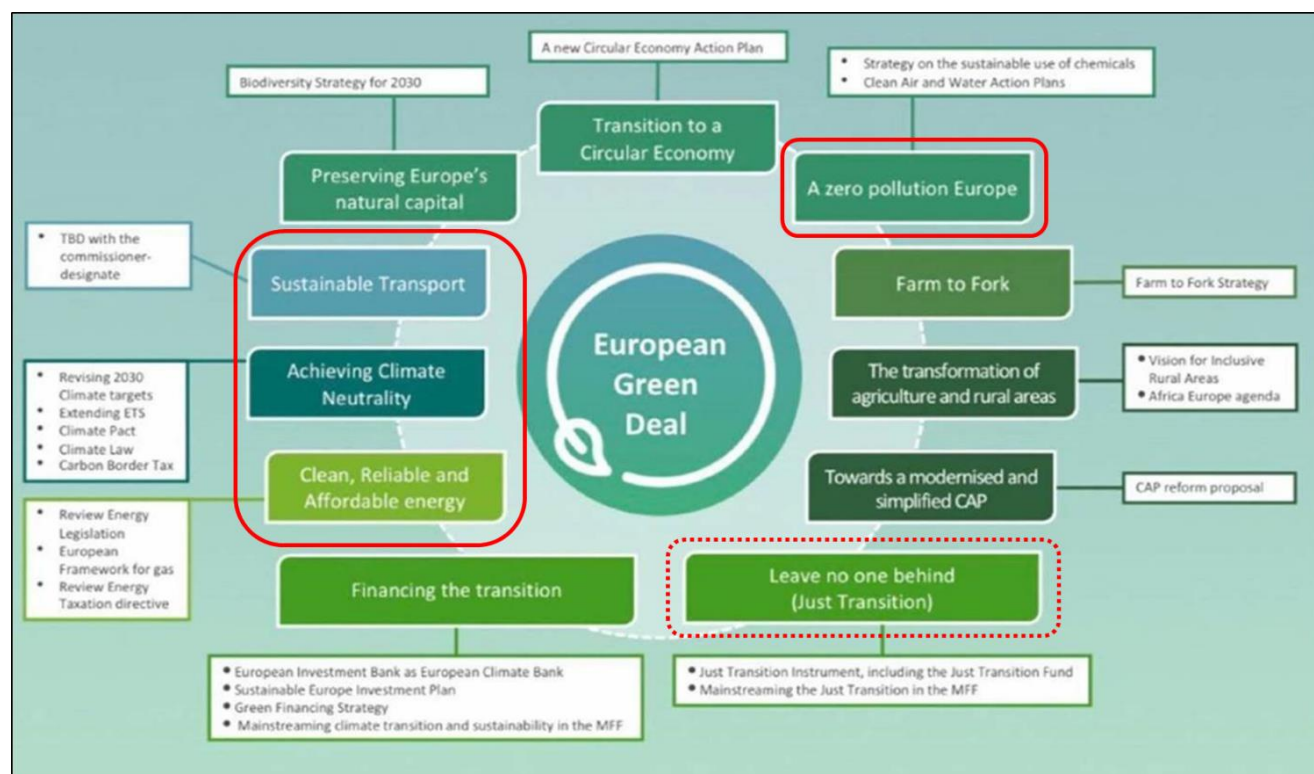
- (i) will serve as a key element to ensure the decarbonisation (in a sustainable and achievable manner) of **transport** (in particular commercial fleets, buses, heavy duty transport, shipping, aviation, etc.), as well as other sectors of the economy such as **heating and industry**;
- (ii) enables Europe to set **more ambitious**, yet achievable, **climate targets** (emission reduction and renewable integration) in 2030 and provides the **only realistic scenario** in which Europe can achieve **climate neutrality** within a reasonable timeframe (e.g. 2050);
- (iii) enables the **integration of all energy sectors** (producing, storing, transporting and consuming sectors), thereby ensuring system efficiency and higher renewable energy penetration. Only by integrating all sectors, via hydrogen, within an efficient system can **clean energy** be provided to all consuming sectors **in a reliable and affordable manner**;

³⁰ As the share of variable RES in a system grows, so does the frequency and severity of potential overgeneration of renewable energy which results in generation curtailment. In 2018 in Germany alone the TSO was forced to curtail 5,436 GWh of renewable electricity.

- (iv) contributes to **reducing air pollution** in Europe: in cities, in ports, on motorways in industrial zones, etc.

In addition to the above, the objectives of the partnership will also support (albeit indirectly) a **just transition** (as explained in section 1.1.1.6), as it will ensure that key supply chains, jobs and value creation remains in Europe as well as the **transition to a circular economy**.

Figure 22: The objectives of the Clean Hydrogen for Europe are fully aligned with the goals of the European Green Deal



The hydrogen sector, coordinated by Hydrogen Europe, Hydrogen Europe Research and the FCH 2 JU has carefully analysed the research and development needs of the sector and drafted a number of technology roadmaps, detailing the pathway towards mass market commercialisation of hydrogen-based technologies (including targets, indicators and milestone) up to 2030 and beyond.

Considering the pathway envisioned for each application in our technology roadmaps (See SRIA, in a separate document), we propose to organise the future European Partnership around three equally important pillars, gathering the most important roadmaps into a coherent programme based on **3 convictions**³¹:

- (i) It is absolutely necessary to be able to produce massive amounts of clean hydrogen at affordable costs;³²
- (ii) We need to be able to transport, store and distribute massive quantities of hydrogen at low costs³³
- (iii) We need to develop additional large end uses applications:
 - In transport, in particular, heavy duty, maritime and aviation
 - In buildings, for providing clean heating and power
 - In industry, in particular steel, refineries and the chemical sector.

³¹ These convictions reflect analytical results conducted internally, (e.g. the Hydrogen Roadmap Europe, available at: <https://www.fch.europa.eu/publications/hydrogen-roadmap-europe-sustainable-pathway-european-energy-transition>) as well as externally, by organizations such as the IEA (e.g. <https://www.iea.org/hydrogen2019/>)

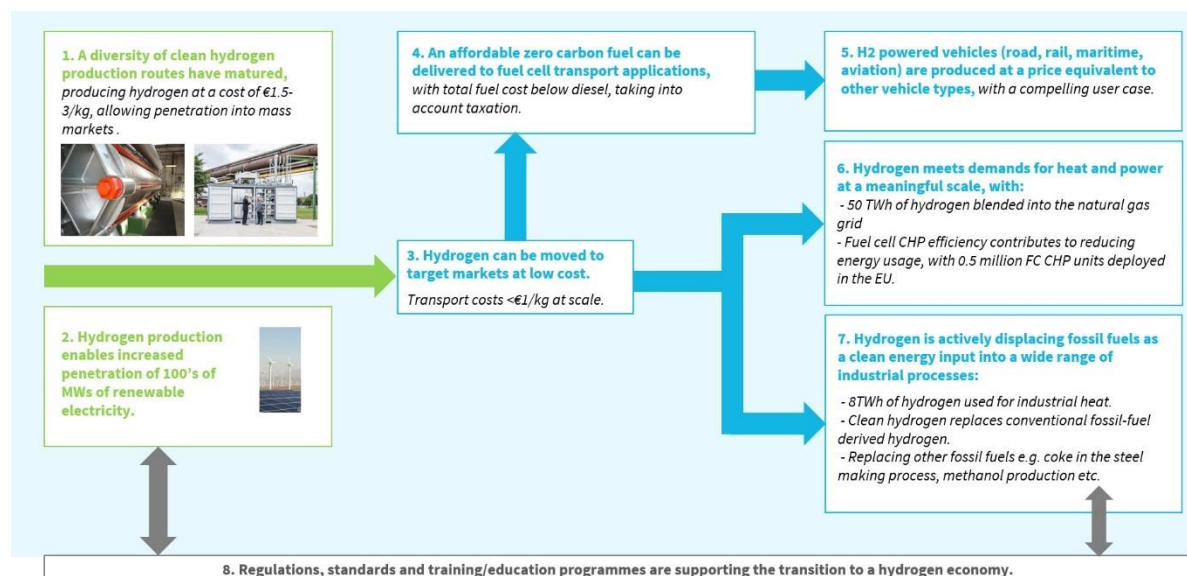
³² Producing hydrogen at a cost of €1.5-3/kg, allowing penetration into mass markets, as shown in Figure 23

³³ Hydrogen transport costs <€1/kg at scale, as shown in Figure 23

These convictions provide a clear framework for the definition and organisation of the Institutionalised European Partnership.

Clear 2030 targets associated with each specific objective of our proposed intervention logic are presented in sections below. Beyond these, even more detailed targets and KPI's are proposed for each technology roadmap that comprise our proposed SRIA.

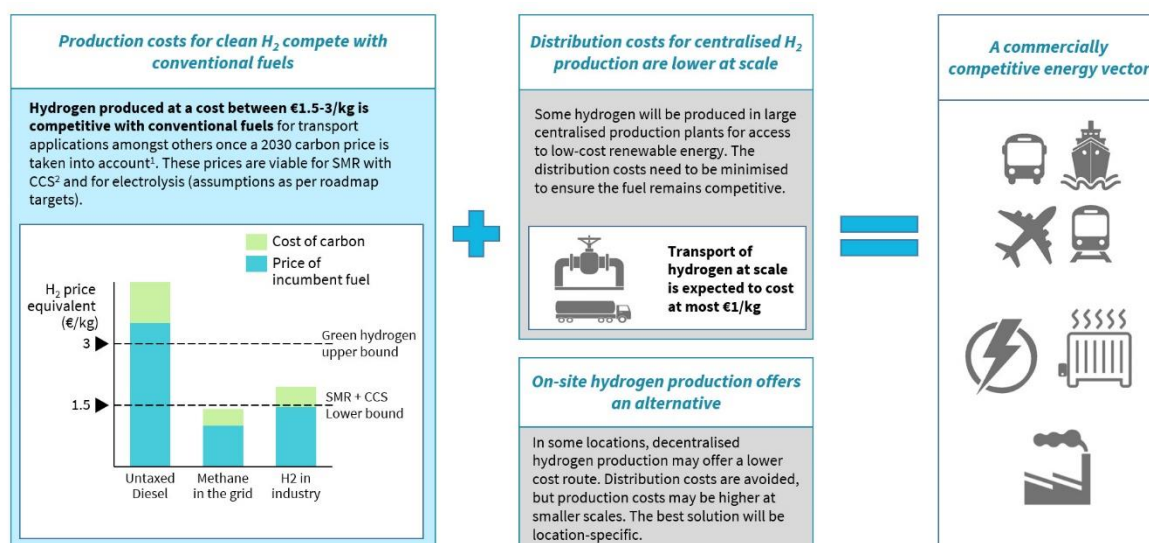
Figure 23. Main targets of the SRIA of Clean Hydrogen for Europe



Source: Hydrogen Europe.

By achieving these targets, **clean hydrogen can be produced and distributed to markets at competitive prices**, at which point, **market and policy mechanisms can take over** deployment of the technology, a point which will mark the successful achievement of the objectives of the partnership.

Figure 24: Clean hydrogen technologies live up to their potential and become competitive against fossil-fuel based competitors



Source: Hydrogen Europe

In order to realise the vision above, the following **general objectives** of the European Partnership on Clean Hydrogen for Europe are proposed:

1. GO1: Accelerate the commercial readiness of nearly zero GHG emission (clean) hydrogen-based technologies across energy, transport, building and industrial end-uses.
2. GO2: Enable at scale deployment capacity for key parts of the clean hydrogen value chain.
3. GO3: Ensure a safe and frictionless deployment of clean hydrogen technologies.

All activities of the partnership should aim to maximise the leverage effect of the programme by ensuring that technical and financial resources from both the private sector are directed towards the policy objective pursued by the programme. This entails incentivising (even) more private R&D investment as well the capitalisation of expertise held by private actors to fulfil tasks within the remit of the Institutionalised European Partnership (e.g. on annual programme implementation and development, RCS, Safety, etc.).

The proposed Institutionalised European Partnership builds on the achievements of the FCH JU but exhibits a much higher level of ambition, both in terms of the technologies covered by the SRIA, as well as the implementation of horizontal tasks. The increased level of ambition is exemplified by:

- Acting in a coordinated way alongside all parts of the value chain: (i) production, (ii) distribution and (iii) end-use
- Targeting over 20 different technological roadmaps within 10 specific objectives, each of them with detailed KPI's specific success criteria.
- Implementing a well-defined and detailed strategic research and innovation agenda, which appropriately balances large scale, high TRL, activities without neglecting the investment necessary for promising, yet longer term, low TRL research activities.
- Strengthening the role of horizontal tasks based on the lessons learned in the previous financial period, intensifying the role of those activities which have proven to be effective.
- Adding a specific role for the partnership in harbouring a culture of safety at all levels of deployment of the technology

Figure 25 provides an overview of intervention logic behind Clean Hydrogen for Europe while subsequent sections provide more details about each objective and task. The Strategic Research and Innovation Agenda (SRIA) contains more in-depth KPI's for each specific objective, ensuring that they are all expressed in SMART framework. Monitoring the achievement of impacts should be a key part of the implementation of the partnership, with annual reporting and periodic evaluations assessing regularly the degree with which the intervention is achieving its targets.

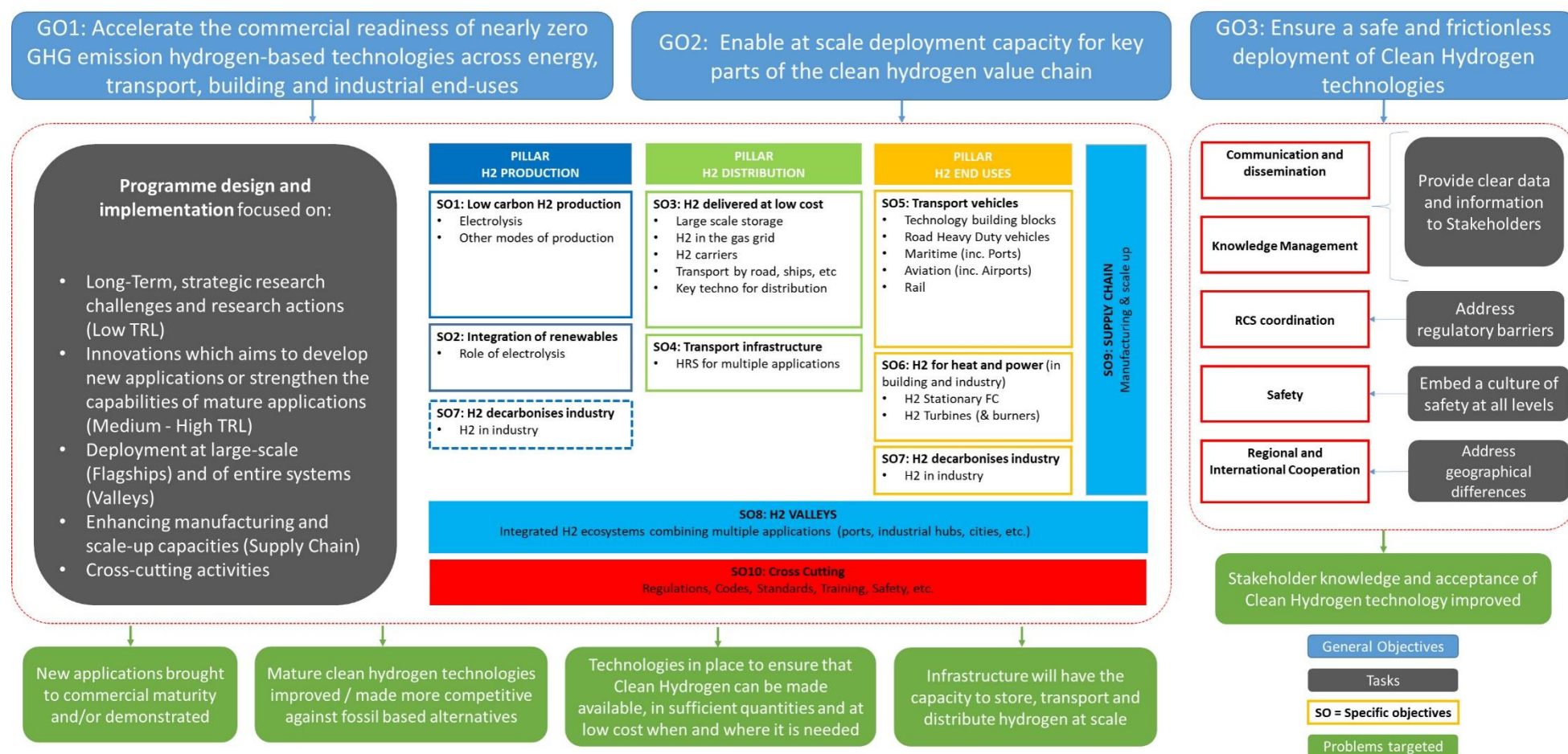
Importantly, this intervention logic has been constructed with special attention given to the need to ensure synergies and avoid any duplication of efforts with potential partnerships in sectors where hydrogen can also play a role. These include: the waterborne, rail, clean aviation, clean steel, clean and circular industry sectors. The synergies of scope and areas of common competence are discussed in detail in Annex I while Section 1.2.3 further discusses the mechanisms employed to ensure continuous coordination with throughout the implementation of the partnerships.

Overall, €52 billion of investment will be needed to realize this vision in the decade 2020-2030. While the bulk of this investment will come from private investors and must be triggered by proper regulation and member states support, we estimate that 8.7 billion investment can be triggered by EU funding and financing action, with roughly 1/3 third coming from EU public contribution and 2/3 from private investment. 70 % of the €8.7 billion programme would be provided through existing or planned EU support funds like CEF Transport and Energy or the ETS Innovation Fund (mostly market deployment actions). The remaining 30%, i.e. €2.6 BN would be financed through the European Partnership on hydrogen (**Clean Hydrogen for Europe**). As is expected in case of a public-private partnership **the contribution will be shared equally by the private partner (industry and research) and the public partner** (the European Commission). Financial resource aspects are explained in more detail in section 0.

From a technology perspective, the successful implementation of the partnership will mean that, in 2030, most applications³⁴ within the scope of the programme will have reached commercial maturity and will no longer require support from a partnership instrument for further development. At that stage, for those applications, it will be up to market and other policy mechanisms to take over and ensure mass deployment. This evolution has already been witnessed for a number of applications supported by the FCH 2 JU (e.g. cars and forklifts). While technological research and development will always remain a moving target, as improvements can always be sought, the need for a continued partnership past 2030 can only be assessed in the context of the policy ambitions and long-term goals that will dominate the debate in 2030 similar to how the current partnership request has been constructed in the context of the policy goal of carbon neutrality in Europe by 2050, which had not been assumed at the time of establishment of the FCH 2 JU.

³⁴ See detailed technology roadmaps for more details. Aviation technologies, and to a certain extent, maritime applications are not expected to reach full commercial maturity by 2030.

Figure 25: Intervention logic of the Institutionalised European Partnership on Clean Hydrogen for Europe



1.2.2.1 GO1: Accelerate commercial readiness

The central objectives of the partnership, GO1 and GO2 are to be implemented through the partnership's core task of **designing and implementing** annual and multi-annual programmes, which operationalise our strategic innovation and research agenda. It is particularly in this area where the FCH 2 JU has demonstrated its highest capacity to deliver meaningful, positive results in the past financial period and we have the confidence that the new partnership structure will build on this capacity and deliver even higher quality innovation projects.

The core of the innovation programme should be structured along **three, equally important, pillars**: (i) hydrogen production, (ii) distributions and (iii) use. Within these pillars, seven specific objectives are to be pursued, as shown in the figure above.

The **specific objectives** within each of these pillars are, in turn, broken down in clearly defined, concrete, operational roadmaps. Each of these roadmaps are explained below and elaborated in greater detail (with more specific targets, indicators, measures, etc.) in our Strategic Research and Innovation Agenda.

Figure 26: Targets and KPIs associated with Pillar (i) Hydrogen Production

PILLAR H2 PRODUCTION	- Up to 40 GW of electrolysis is installed in Europe. - Commercially available electrolysis is capable of producing sustainable zero emission hydrogen at a cost of < €3/kg. - European players are global leaders in electrolyser sales, with the supply of 80 GW (including 40 GW exported outside of EU). - A range of technologies other than electrolysis can produce net-zero carbon, low cost (€3/kg) hydrogen at scale, are operating either at industrial scales or close to industrial scales. - Fossil based routes including CCS achieve cost below €2/kg. (CHE funding scope limited to low TRL activities)
SO2: Integration of renewables • Role of electrolysis	- More than 40 GW of renewable generation accommodated as a result of hydrogen production by electrolysis, resulting in the transfer of 70-140 TWh of Europe's renewable electricity to other sectors (transport, industry, gas) - Avoidance of at least 16M tons of CO2 per annum to the atmosphere.
SO7: H2 decarbonises industry • H2 in industry	- Green hydrogen introduced in industrial processes (steel, petrochemical, ammonia production) and in industrial heat and power generation replaces fossil-fuel derived hydrogen and fossil fuels in industrial uses, saving 60 MtCO2/year.

Figure 27: Targets and KPIs associated with Pillar (ii) Hydrogen Distribution

PILLAR H2 DISTRIBUTION	
SO3: H2 delivered at low cost • Large scale storage • H2 in the gas grid • Transport and storage in liquid carriers • Transport by road, ships, etc • Key techno for distribution	- Hydrogen storage is established and incentivised in European and Member State energy policy. - Large-scale underground storage demonstrated at <€30/kg of hydrogen storage capacity. - Distributed above ground stores for <€300/kg. - 50 TWh per annum H2 is blended into the natural gas grid. - >10 EU regions implementing 100% H2 industrial and mobility sectors, with some residential use appearing. - Clean H2 use for heat saves 7 MtCO₂/pa. - A range of hydrogen carriers are being used commercially to transport and store hydrogen at low cost and optimised roundtrip efficiency. - H2 transport costs < €1/kg across all transportation methods. Road transport networks offer efficient solutions to deliver hydrogen across Europe. - New large H2 pipeline networks are serving hydrogen energy users with low carbon hydrogen. - Range of compression and purification techniques develop and compete. - European companies supply world leading components which remove the existing technical barriers to the hydrogen distribution.
SO4: Refueling infrastructure • HRS for multiple applications	- 3,700+ HRS installed across Europe, achieving continent wide coverage and enabling sales to private car customers. - HRS cost decreased by >50% compared to today - >99% reliability.

Figure 28: Targets and KPIs associated with Pillar (iii) Hydrogen End-use

PILLAR H2 END USES	
SO5: Transport vehicles <u>Priorities</u> • Technology building blocks • Road Heavy Duty vehicles • Maritime (inc. Ports) • Aviation (inc. Airports) • Rail	- Next generation hydrogen power and energy systems optimised to allow FCEV vehicles to be offered on a cost competitive basis from light to heavy duty markets. - 2030 European fleet of FC HDV > 50,000. After 2030 sales will ramp up, due to new CO₂ regulations and FC HDV TCO competitiveness. - By 2050 FC HDV will be worthy of up to 40 % of annual sales. - FC passenger ships reach mass market acceptance for in-land and coastal vessels, using hydrogen as a preferred fuel. - Larger vessels select FCs as a preferred zero emission propulsion solution, using a range of fuel types. - Aviation: MW-range FC developed for small/medium range aircrafts (either propulsive or APU) and LH₂ storage and distribution systems developed. - 1 in 5 trains sold for non-electrified railways are powered by H₂
SO6: H2 for heat and power (in building and industry) • H2 Stationary FC • H2 Turbines (& burners)	- Widespread CHP uptake for domestic and commercial buildings and EU supply chain developed. - 100% hydrogen ready Gas Turbines for sustainable dispatchable power and heat.
SO7: H2 decarbonises industry • H2 in industry	- Green hydrogen introduced in industrial processes (steel, petrochemical, ammonia production) and in industrial heat and power generation replaces fossil-fuel derived hydrogen and fossil fuels in industrial uses, saving 60 MtCO₂/year.

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In addition to working within each of these pillars, as explained in the problem definition, mass deployment requires coordination action to be taken at system level. As a result of this, an additional horizontal objective (SO8: H2 Valleys) will aim to lay the groundwork for integrated hydrogen ecosystems combining multiple applications across the different pillars. The target of this specific objective will be to ensure the existence of several integrated ecosystems combining multiple applications, in ports, airports, industrial hubs, cities, etc. across the EU.

Delivering results on each of these objectives will need tailored interventions in the form of specially designed funding **instruments**, which address the core drivers preventing clean hydrogen technologies

from reaching their potential as key enablers of the decarbonized, sustainable energy system. These instruments are fully in line with the funding instruments foreseen by Horizon Europe, but adapted to maximise the effectiveness of the partnership. They are described in detail in section 2.1.

1.2.2.2 GO2: Enable at scale deployment capacity

Beyond the key environmental impacts resulting from development of clean hydrogen applications (GO1), the new partnership should deliver benefits for Europe in terms of industrial policy, supply chain development, jobs and value creation. This general objective is mainly operationalised by SO9: Supply chain support and by industrialisation actions (see below). In reality, this objective will be indirectly achieved by the implementation of all other specific objectives, as European capacities are an underlying element behind all activities envisioned by the partnership.

The starting point is that Europe enjoys leadership or strong position in key areas of the value chain, but that this leadership position is threatened by massive investments being made in other regions of the world (Japan, Korea and China). The new partnership should act to strengthen European value chains by ensuring the technological leadership of the building blocks of the hydrogen value chain. This can be done, for example, by supporting the incremental and breakthrough improvements of the performance (durability, efficiency, resilience, lifetime) of key building blocks along the value chain, as well as supporting cost reduction through research into, for example, the replacement or reduction of the need for expensive and critical raw materials such as platinum or iridium. By reducing these CRMs, it will by the way also significantly contribute to reduce the European dependency on energy supply.

The targets for this specific objective include:

- Ensuring that EU manufacturers are global leaders
- At least 2 European suppliers exist for the most critical components
- Ensuring that Non-FCH mature supply chain has adapted.
- Enlarging supplier capacity, thereby reduction cost

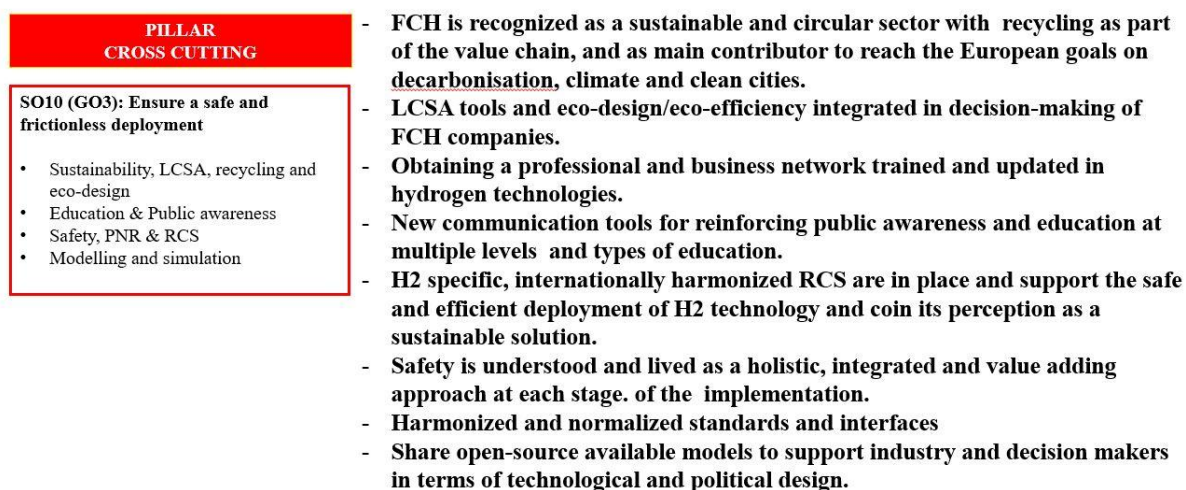
1.2.2.3 GO3: Ensure a safe and frictionless deployment of hydrogen technologies

As explained in section 1.1.2.2, in addition to the core challenges tackled through the achievement of GO1 and GO2, a number of systemic challenges further exacerbate the difficulties associated with mass market commercialisation of hydrogen based technologies and/or risk to derail the progress already achieved. GO 3 aims to tackle these challenges by enabling the partnership to pursue specific objectives aimed at:

- (i) Proactive communication on the importance of clean hydrogen technologies and dissemination of the results of the programme, ensuring that breakthroughs are immediately taken up by the wider market.
- (ii) Knowledge management which *inter alia* will ensure that annual programmes reflect the realities observed on the market and adapt to growing needs and changing circumstances.
- (iii) RCS coordination ensuring a safe and frictionless deployment of the technologies ready for commercialisation.
- (iv) Embedding a safety culture into all activities performed, ensuring that project implementation and subsequent deployment is done safely and without incidents which may delay or derail roll-out.
- (v) Regional and international cooperation which addresses geographical differences, enabling (i) penetration of clean hydrogen technologies across the territory of the EU, in a way that makes best use of capacities and resources of each region and (ii) the propagation of knowledge internationally.

The targets associated with this objective are outlined in the figure below.

Figure 29: Targets associated with General Objective 3

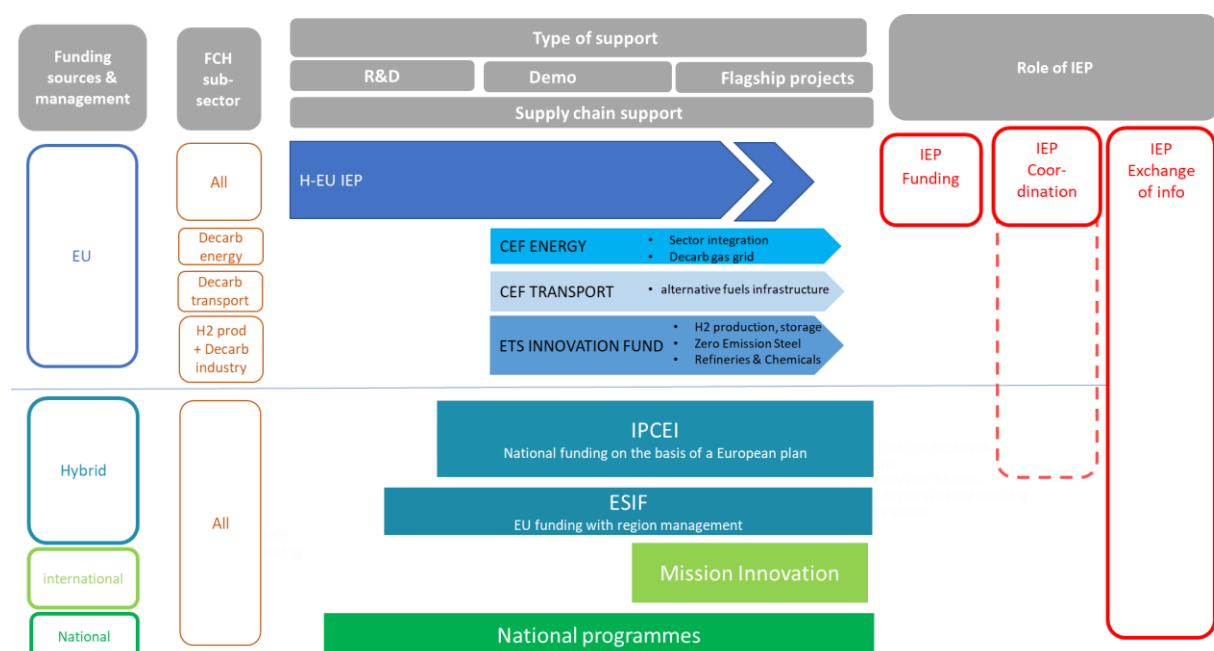


1.2.3 Synergies with other EU, national, regional and international funding programmes

The FCH 2 JU has an excellent track record in cooperating with other EU funding programmes (in particular CEF and ESIF as well as other instruments managed by the EIB) and national programmes. Projects benefited from blending of financing instruments, which, in other cases, the different instruments have funded complementary projects in a coordinated manner.

As shown in the figure below, the Horizon Europe funds dedicated to the partnership can cover low TRL R&D projects as well as medium TRL demonstrations and flagship projects at scale. As such, it may benefit from synergies with other financial programmes which are mostly focused on deployment activities. As an example, projects under SO3 (“H2 delivered at low cost”) and SO4 (“Refuelling infrastructure”) have a strong connection with CEF Energy and Transport respectively while SO7 (“H2 decarbonises industry”) can be linked to the ETS innovation fund.

Figure 30: Clean Hydrogen for Europe can contribute to coordination of programmes funding hydrogen technologies.



Programming the dedicated funds. The Institutionalised European Partnership will programme and implement the dedicated funds from Horizon Europe.

The initiative will also support the Commission in the coordination of relevant international cooperation efforts on the hydrogen economy, by involving non-EU market players with their own strengths that can complement EU company operations and well-established partnerships with international actors e.g., the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE); Mission Innovation – Renewable and Clean Hydrogen Challenge, Clean Energy Ministerial (CEM) Hydrogen Initiative, Hydrogen Energy Ministerial (HEM), etc...

Exchange of information: the connection that the Institutionalised European Partnership has with member states, regions, Mission Innovation enable it to support the Commission in coordination with their programmes through regular exchanges of information

1.2.4 Synergies with Member states policies and actions

The proposed partnership has aligned its strategic and innovation agenda with national Member States policies and actions. This has been done through a careful analysis of the draft National Energy and Climate plans (NECPs) published by all Member States in 2019 and revised in 2020. The ambitions of Member States and the role that they foresee for Clean Hydrogen technologies for achieving their climate targets were taken into account when prioritising research activities within the next financial period.

During implementation, the proposed Institutionalised European Partnership will step-up its efforts to coordinate its activities with the objectives and goals pursued by Member States. It will do so by constantly monitoring national policies through a fuel cells and hydrogen observatory. This activity, kick-started by the FCH 2 JU, mobilises a network of national associations and correspondents covering the entire EU and other key hydrogen jurisdiction, reaching approximately 35 countries globally.

Exit strategy

The Partnership should pave the way for the implementation of clean hydrogen technologies and solutions from 2030 onwards. The achievement of this goal would imply that there is no need to extend the duration of the Partnership after the lifetime of Horizon Europe. The RD&I activities related to clean hydrogen are of key interest for Hydrogen Europe and its members. It will monitor the projects co-financed by Horizon Europe until the end of their lifetime and will form the key platform for exchanges of information regarding RD&I activities related to the Partnership, their implementation and possible barriers to implementation

1.3 Necessity for a European Partnership

The challenges, vision, goals and objectives presented above are best achieved through an Institutionalised European Partnership. Any other instrument will not be as effective in taking on the challenges faced by clean hydrogen in the energy transition.

In the absence of a strong coordinating force hydrogen technologies risk developing in many, different, and often contradictory, directions.

Firstly, and perhaps most importantly, due to the complexity of the problem definition and the versatility of clean hydrogen technologies, an **institutional partnership is the only instrument that displays the necessary level of directionality** and ensures that the efforts of partners and the union go into the direction of the agreed objectives. Without strong directionality, it risks developing in many, different, and possibly contradictory directions. This statement is particularly true at this stage of development of the hydrogen sector, which attracts numerous new players at an ever-growing rate³⁵.

Besides, the SRIA and multi-annual work programmes, a European Partnerships allows to:

- (i) **build trust and buy-in into the long-term strategy:** Hydrogen is a highly versatile element, it can mean different things to different actors, it can be stored, burned or used in a fuel cell. It can be used as hydrogen (gas or liquid), stored at different pressures, turned into other elements

³⁵ Hydrogen Europe has received 20 new applications for membership in the first two months of 2020.

(e.g. P2L, Synthetic methane) or blended with other gases. It can be used in a wide range of applications. It can be renewable, low-carbon, “blue”, “grey”, “black” or even “yellow”. In essence, it means different things to different people. A partnership approach allows building on the potential of hydrogen and on the competences of private actors and directs those towards the long-term strategy and the effective achievement of public policy goals. In the absence of trust and buy-in (built through collaboration within a European Partnership), existing players will pursue their short-term objectives independently, ultimately slowing down overall mass-market adoption.

- (ii) **align the efforts of new-entrants with the long-term strategy:** The growing interest in hydrogen technologies is nothing short of impressive³⁶. This is true for both private and public actors. This represents both an opportunity for the sector to grow and expand, as well as a risk of duplication of efforts and multiplication of solutions. An R&I partnership is able to harness the energy of new-entrants and channel it towards the objectives of the long-term strategy by including them into the decision-making process. Similar to the point above.
- (iii) **channel the know-how of private partners:** partners at all levels (research and industry) have significant knowledge of hydrogen technologies, capacities for further development, innovation and capability to turn research into commercial applications. This knowledge is best harnessed through the inclusive process of annual work programme development implemented through a partnership approach.

In addition, the signatories of this proposal believe that an Institutionalised Partnership is needed in order to:

- (iv) **better incorporate a feedback loop in all decision making:** Building on the results of the programme, on technological progress outside of the partnership as well as evolutions on the market (highlighted by private partners) and changes in policy (reflected by the Commission), the institutional form would allow to better adapt its yearly programmes to reflect up-to-date realities in unison between the private and public partners.
- (v) Ensures **optimal management of a highly complex programme** through the use of a dedicated back-office.

Institutionalised European Partnerships formed under Article 187 require financial and in-kind contributions from private actors. As shown by previous evaluations and most recent data, the FCH 2 JU has been **significantly more successful at leveraging private investment and directing it towards the achievement of EU policy goals**³⁷ than any other form of research and innovation funding. Indeed, as further explained in section 0, in order to align with the new definition of **additionality**, we propose lower funding rates within the Institutional partnership of Clean Hydrogen for Europe than in Horizon Europe. This commitment will further increase the visible impact of each EUR of public money spent within the partnership beyond what is currently achieved.

In addition to the above, an institutionalised partnership, supported by a programme office (PO) allows to ensure a coherent alignment between the objectives and the day-to-day operations of the partnership: it provides support in establishing and managing an appropriate accounting system; manages the calls as provided for in the annual work plan and the administration of the agreements and decisions; provides Members and other bodies of the JU with relevant information and support; acts as the secretariat of the bodies of JU. In addition, the PO also ensures that synergies between different programmes are

³⁶ The Hydrogen ecosystem is limited to the members of Hydrogen Europe (as participation in the FCH 2 JU shows with ~50% of the budget distributed to non-members, despite a growing membership). Nevertheless, the evolution of membership of Hydrogen Europe is a good indication of the growing interest of European stakeholders in hydrogen technologies. The membership of the FCH Industry Grouping (the industry side of Hydrogen Europe) has grown from 65 entities in 2008 to 173 entities, around 40% of which being SMEs, covering 23 countries and the entire hydrogen value chain. The membership of the Research Grouping (the research arm) has grown from 45 members in 2009 to 78 research institutions and universities today (covering 22 countries). This wide and diverse membership allows the implementation of a holistic vision for the introduction of hydrogen across various segments of the economy in a coordinated manner.

³⁷ By the end of 2018, the leverage effect from members alone had reached 1.36, significantly more than the required 0.57. Over 2014 – 2020, the total leverage effect (in projects and in additional activities) is 2.67. See section 1.1.2.1 for detailed data.

created, it manages the global communication on the programme, as well as a number of horizontal actions dedicated to help the sector as follows:

- **Knowledge and innovation management:** The PO ensures that the state of R&I progresses from one project to the next by following project results and including them in the basis for future calls; this leads to the increase of TRL levels, but also ensures that the experience from field-testing returns to the research loop for future developments.
- **Central Hub:** The FCH community is diverse and inclusive: SMEs³⁸ alongside major industry players, universities and research organisations, and many stakeholders on the path to commercialisation, including NGOs, utilities, heating operators, transport operators, energy service companies, energy and mobility associations, municipalities, regional authorities, and Member States. The PO allows to act as a knowledge hub that any stakeholder can contact to receive relevant information.
- **Innovation monitoring:** In order to be at the forefront of innovation and to be able to design the annual programmes in the most efficient way, the PO established several horizontal collaborations, for example, with the JRC in the field on innovation monitoring by using a dedicated customised part of TIM³⁹. The knowledge established in the back office is then provided to all stakeholders, public or private, allowing the sector a view on the state of play.

Beyond these main arguments, the table below shows how each element of our proposal (vision, objectives, goals) is better served by an European Partnership (possibly Institutionalised) rather than any other form of cooperation.

Table 2: A European Partnership is the most effective way to achieve the programmes objectives

Challenges/Vision/Objectives/Goals	Added value of an institutionalized partnership
Ensure Europe's climate neutrality aligned with the EU Commission's Green Deal	Clean Hydrogen for Europe addresses long term challenges and priorities . These challenges are complex, deeply rooted in our fossil-based worlds and extremely difficult to overcome. Only a highly coordinated partnership which brings together industry, research and the public sector in a stable, long-lasting framework can lead to succeed.
Large scale introduction of hydrogen technologies across the entire energy system	In line with the ambitions set out, all partners involved need to make investments at scale, requiring large amounts of resources, commitments and implying high risks. In order for these to take place, legally long-term binding commitments are necessary to guarantee stability and certainty, and increase investor's confidence.
Counteract the fragmentation across Europe	Hydrogen technologies have the potential to be the missing link and the building block for achieving sectoral integration. Counteracting fragmentation is paramount to achieve this goal. Only an European Partnership can effectively achieve this by acting as a knowledge hub and a well-coordinated collaboration platform, in particular for R&I activities . In the absence of one, the broad stakeholder landscape will likely regress to its traditional silos and interest groups that have dominated the landscape so far.
Accelerate the market entry of hydrogen technologies	The ambitious roll-out of hydrogen technologies across multiple sectors requires not only an optimal management of the

³⁸ The total number of participations in FCH 2 JU funded projects is of 894, 26% of which are SME, whose share in terms of budget is 31.5% (much beyond the Horizon 2020 target of 20%).

³⁹ Tools for Innovation Monitoring (TIM) is an analytics tool that supports policy-making in the European Institutions in the field of innovation and technological development. More information is available here: <https://ec.europa.eu/jrc/en/scientific-tool/tools-innovation-monitoring>

across energy, transport, building and industrial end-users	programme through a dedicated back-office, but also a carefully constructed long-term innovation agenda spanning different sectors and applications and implemented against a well-planned, yet flexible, multi-annual-working programme. We believe that only an Institutionalised partnership is equipped to deliver progress in such a wide range of sectors while managing complex co-dependencies.
Ensuring pole-position for Europe to realise the potential of hydrogen technologies at scale	Delivering on this objective requires a deep understanding on the value chains associated with hydrogen technologies and a directionality of investments in the areas with the highest potential to provide economic as well as climate benefits. This ensures also the right development of the associated supply chains to be established for the scale deployments. With the support of the JRC's tool for innovation monitoring (TIM) and other actors, the FCH JU has developed a deep understanding of the areas where Europe still holds a worldwide leadership position and is therefore best place to ensure that the future partnership acts in a manner consistent with a broad innovation, climate and industrial policy agenda.

1.4 Partner composition and target group

As described in section 1.1.2.1, one of the main achievements of the FCH 2 JU is that, while remaining fully open, it solidified and increased an otherwise fragmented stakeholder landscape comprising of policy makers, research, industry (at all levels of the value and supply chain) and end users of clean hydrogen. This unique approach has allowed to develop and deploy technologies in an integrated manner and at a much higher pace than in the absence of such a partnership. Clean Hydrogen for Europe builds on this strength in order to solidify existing cooperative links and expand the stakeholder community, in particular upstream (renewable energy producers) and down-stream (clean hydrogen consuming industries) industries.

1.4.1 Clean Hydrogen for Europe Partners

The requested Institutionalised European Partnership will be represented, on the **private side** by Hydrogen Europe and Hydrogen Europe Research, which currently consists of:

- 173 industry companies from 23 countries representing the entire hydrogen value chain (equipment manufacturers, integrators, car, bus, truck, train, ship, aircraft OEMs, energy companies, utilities, as well as current and future end-users of hydrogen);
- 78 research organisations from 22 countries representing universities and research technology organisations (RTO) covering all the R&I topics from materials to systems and from hydrogen production to consumption;
- 21 national associations bringing together national players.

The associations are constantly growing and will continue to do so in the next financial period. Access is open to all European companies and research organisations who are committed to the development of clean hydrogen technologies and the achievement of the goals of the proposed European Partnership. In particular, additional renewable /clean energy producers and electricity system operators will be invited to join Hydrogen Europe in order to further expand the stakeholder base and enable large-scale deployment in line with EU goals and targets. Furthermore, engagement with central and eastern European countries will continue to be a priority area for the partnership, in order to ensure a wide and balanced geographical coverage.

The membership of Hydrogen Europe and Hydrogen Europe Research is uniquely positioned to address the objectives of the proposed European Partnership, as described in section 1.2.2 and the intervention logic in Figure 25 as it brings together industrial and research players which have the research and deployment capacity and the will to deliver tangible results in the next financial period. The figures below break down the membership of Hydrogen Europe and Hydrogen Europe Research, in line with how each member is expected to contribute to each of the objective of the proposed IEP.

Figure 31: Stakeholders involved in the achievement of specific objectives 1 and 2 (Low Carbon H2 Production and Integration of renewables)

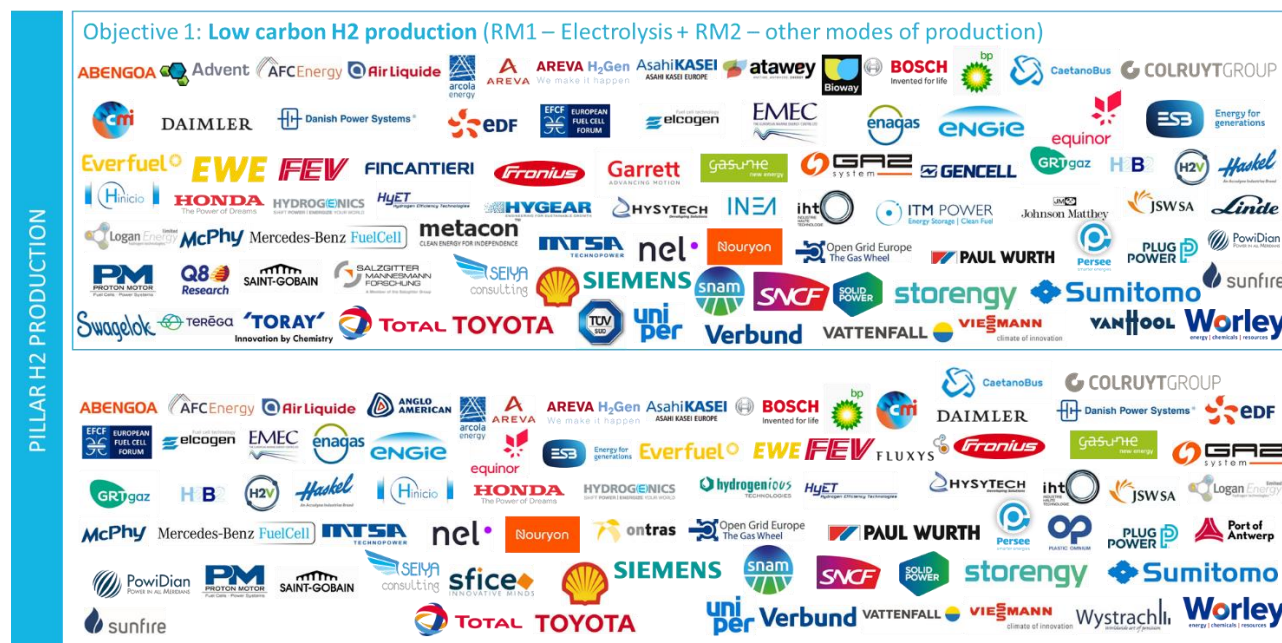


Figure 32: Stakeholders involved in the achievement of specific objective 3 (H2 delivered at low cost)

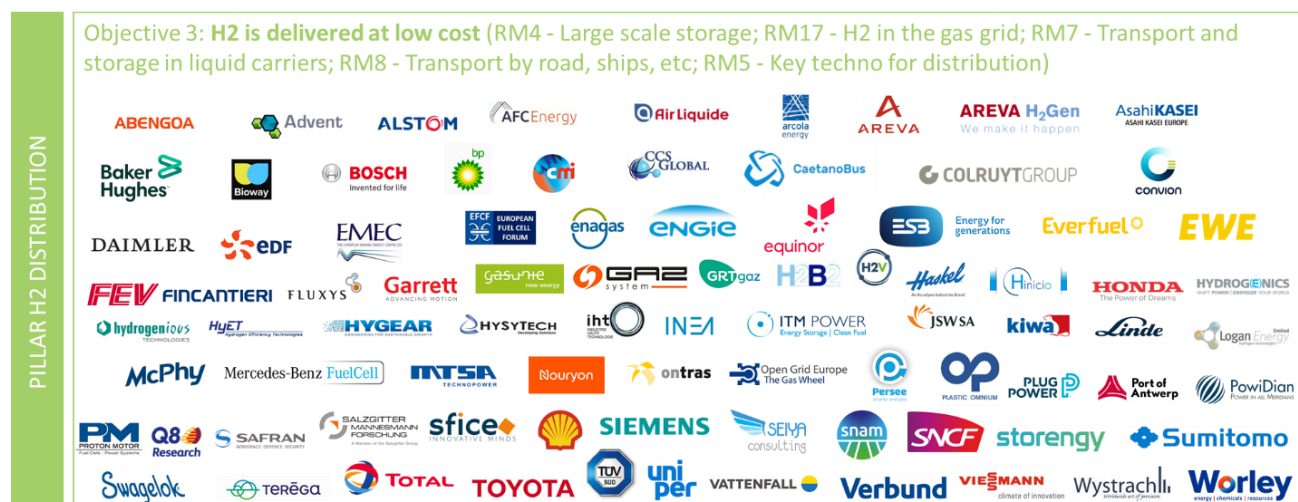


Figure 33: Stakeholders involved in the achievement of specific objective 4 (Hydrogen Refuelling Stations for various applications)



Figure 34: Stakeholders involved in the achievement of specific objective 5 (Transport Vehicles)



Figure 35: Figure 36: Stakeholders involved in the achievement of specific objective 6 and 7 (Heat and Power and Industry)



As can be seen from the above, very strong support exists for the achievement of all specific objectives of the proposed partnership under each of the main 3 pillars (Production, Distribution and End Uses). The other specific objectives (SO8, H2 Valleys, SO9 Supply Chains and SO10 Cross-cutting) are horizontal and will draw on the expertise of all members of the partnership.

Figure 36: Stakeholders involved in the achievement of specific objective 8



On the **public side**, we would appreciate a broad representation of the European Commission services which are relevant to both development as well as deployment of clean hydrogen solutions in order to reflect the growing ambitions of the European Partnership and enable to achievement of objectives across different sectors. This is further elaborated in section 2.3 on Governance.

1.4.2 Engagement with stakeholders not directly covered by the partnerships

Hydrogen Europe and Hydrogen Europe Research have a wide, inclusive, open and growing membership structure. Nevertheless, relevant stakeholders may exist outside the memberships of the two associations. Such stakeholders will be included in the implementation of Clean Hydrogen for Europe in two different ways.

Firstly, (and most importantly) is the interaction of the partnership with “connected sectors” for which clean hydrogen is one of the solutions that can aid them in their decarbonisation efforts. This interaction is explained in detail in section 1.4.3

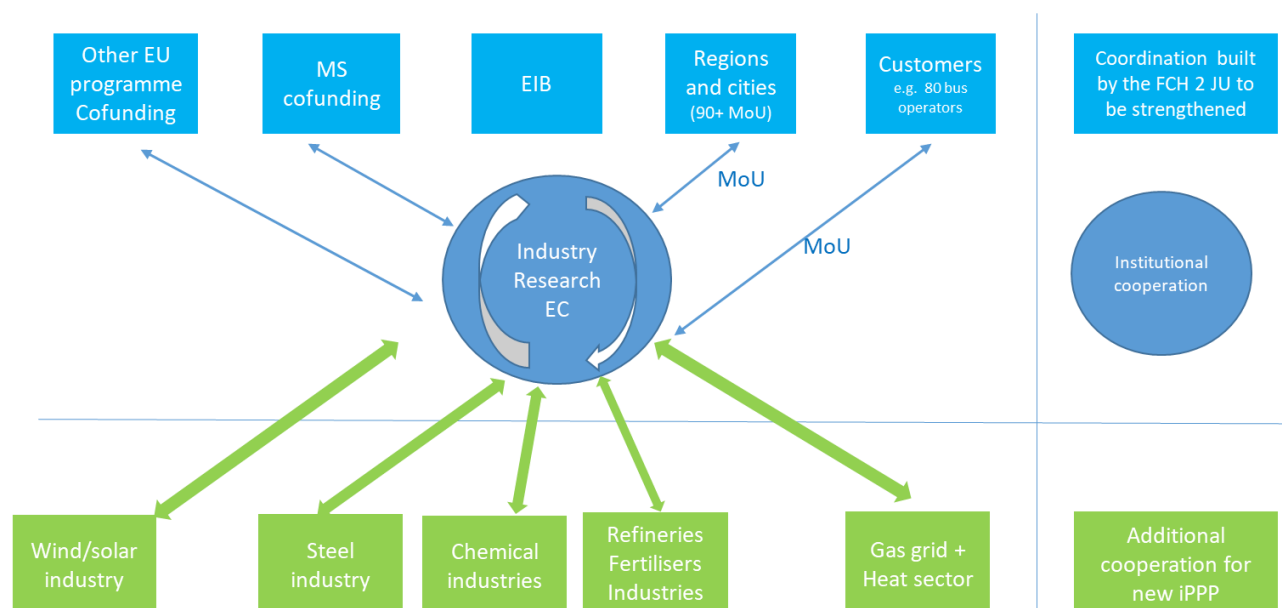
Collaboration with Member States should be achieved through the involvement of a states and regions representatives’ group, as described in section 2.3 on Governance.

Finally, the partnership has, and will continue to, consult stakeholders beyond the groups already covered through open public consultations, such an initial consultation already took place in the context of the preparation of this partnership request and associated SRIA. The results are briefly described in section 1.4.4

1.4.3 Connected sectors and synergies other European Partnerships.

In addition to the partners of Clean Hydrogen for Europe (described in detail in section 1.4), Hydrogen Europe and Hydrogen Europe Research are in constant collaboration with other sectors for which clean hydrogen is one of the solutions that can aid them in their decarbonisation efforts, as shown in the figure below. This collaboration strengthens the outreach of the sector beyond the members of Hydrogen Europe and Hydrogen Europe Research and ensures coordination with related sectors which are either (i) essential for large scale production and distribution of Clean Hydrogen, (ii) can directly benefit from the deployment of Clean Hydrogen technologies or (iii) are key actors supporting the funding and financing of projects while ensuring win-win international collaborations.

Figure 37: Established links between the FCH JU and the wider stakeholder community

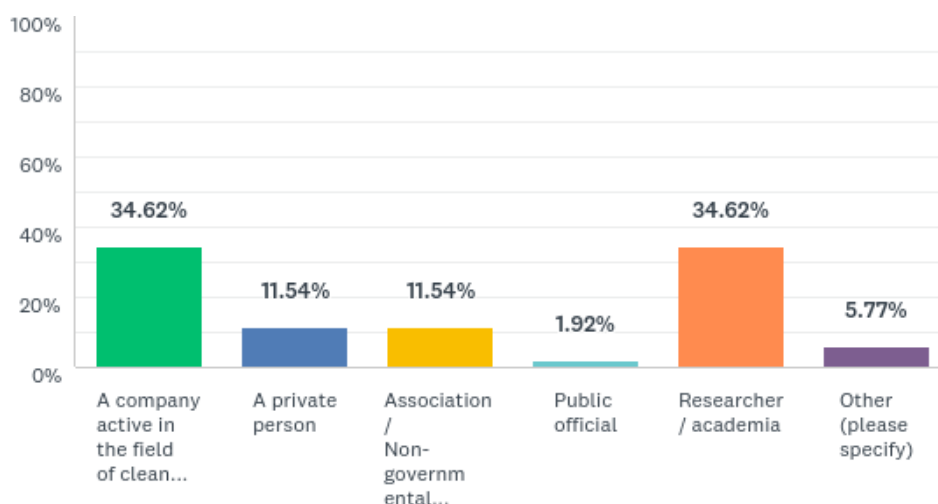


In addition to bilateral cooperation with connected sectors, significant potential for synergies with other European Partnerships in the next financial period has already been identified and reflected in the design of our Intervention logic and SRIA. These are presented in detail in *Annex I – Synergies with other partnerships*.

1.4.4 Public Consultation and Stakeholder engagement beyond partners

In addition to the Public Consultation conducted by the European Commission and the in-depth involvement of partners in the preparation of this candidate partnership, the Strategic Research and Innovation Agenda, problem definition and proposed intervention logic for Clean Hydrogen for Europe have been subject to an open public consultation organised by the private partners. The survey period ran from the 19th of November to the 12th of February (12 weeks). The results (briefly presented below) validate the problem definition and overall proposed approach for addressing the problem drivers, while also providing valuable detailed input which has contributed to further refine the SRIA.

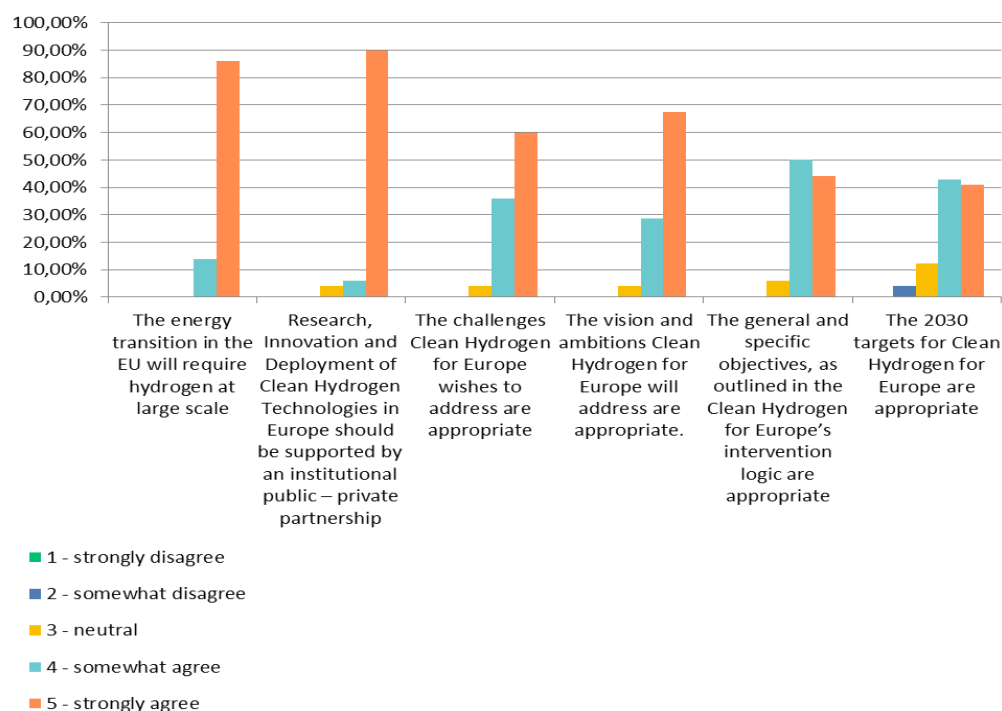
Figure 38: Respondents' profile⁴⁰



⁴⁰ In total 65 responses have been received, mainly from Industry and Academia.

Respondents have shown very strong support for the general agreement on problem definition, vision, objectives, and institutionalised form. The targets for 2030 were generally supported, but more ambition was requested⁴¹

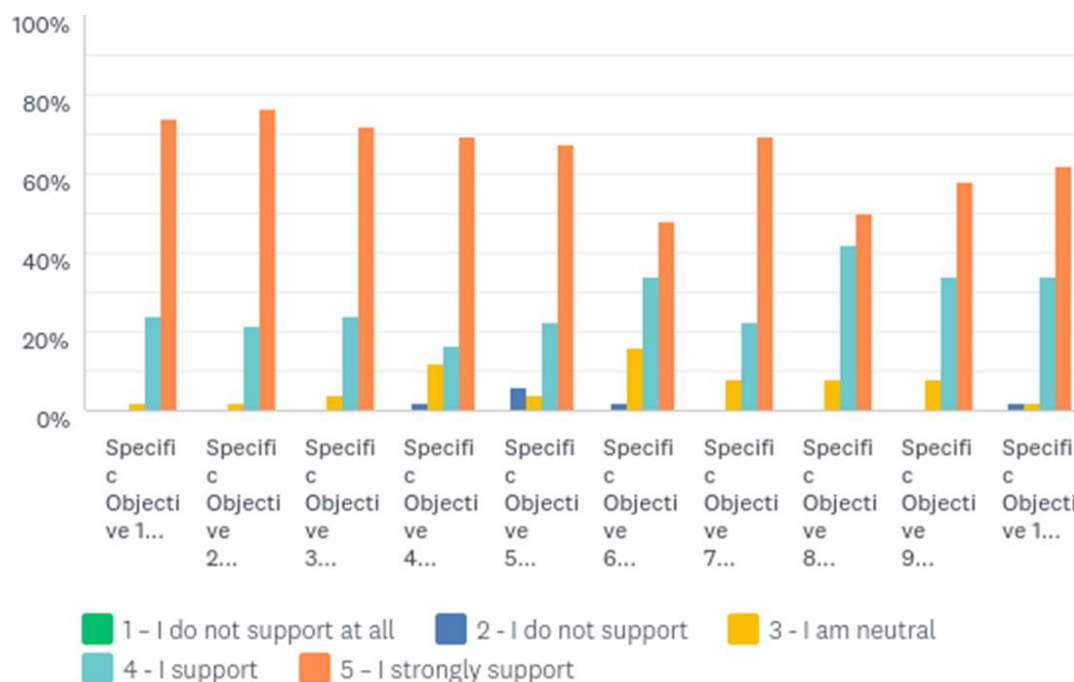
Figure 39: Views on Problem Definition, vision and general objectives



Respondents have shown very strong support for the specific objectives of Clean Hydrogen for Europe in terms of technological development (GO1 and GO2) as well as support for the ancillary tasks ensuring a safe and frictionless deployment (GO3).

⁴¹ More ambition was requested in Production, transport and dispensing infrastructure, hydrogen-ready turbines, Fuel Cell technology, Public Awareness and Training and Education activities

Figure 40: To what extent do you support the 10 specific objectives targeted by the Clean Hydrogen for Europe partnership



Within GO3, respondents have shown particularly high support for the proposed role of the partnership in the area of Safety.

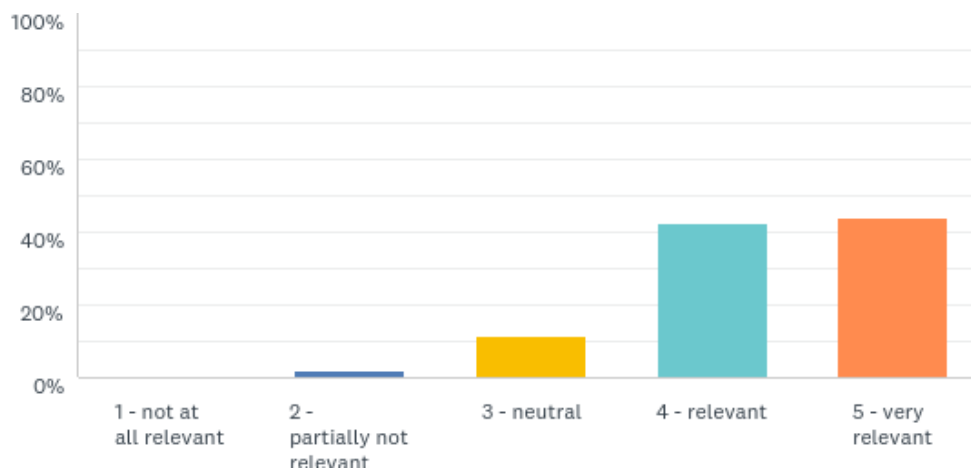
Figure 41: To what extent do you support action to be taken Clean Hydrogen for Europe for ensuring a safe and frictionless deployment of clean hydrogen technologies?



The detailed technological roadmaps presented in the SRIA were considered relevant or very relevant, however, several suggestions for improvement (increased ambition)⁴² were provided by respondents

⁴² The areas suggested by respondents to be given increased attention included: Training and Education, Safety, Hydrogen ready turbines, maritime and aviation (including P2L) and infrastructure and deployment.

Figure 42: To what extent do you believe the 18 technology roadmaps contained in the SRIA are relevant to deliver the impacts aimed by Clean Hydrogen for Europe?



Member States Representatives of the State Representative Group (SRG) of the FCH 2 JU have also been consulted on two occasions with respect to the proposed partnership. Their comments and views have been taken on board in the preparation of this partnership request.

2 Planned Implementation

As described in section 1.2, the proposed European Partnership for Clean Hydrogen pursues three **general objectives**:

1. Accelerate the commercial maturity of clean hydrogen technologies across transport, heating, power production and industry
2. Enable at scale deployment capacity for key parts of the hydrogen value chain
3. Ensure a safe and frictionless deployment of clean hydrogen technologies

While Figure 25, above, presents the intervention logic behind the proposed European Partnership and section 1.2.2 briefly presented the objectives, this section goes into more details regarding portfolio of activities to be undertaken.

2.1 Activities

The activities of the proposed partnership should be structured around the three **general objectives** as presented in the intervention logic (see Figure 25).

Achieving the first two general objectives will be done primarily through the design and implementation of Horizon Europe's programme earmarked for clean hydrogen technologies. Several funding **instruments**, with specific characteristics, are to be used in order to respond to all the drivers identified in our problem definition. These instruments, while described in detail in the sections below, are also summarised in Table 3.

The achievement of the third objective will be done through the completion by the requested partnership of ancillary tasks and functions.

The activities contributing to each of the objective are described in detail the sections below.

2.1.1 General objective 1: Accelerate commercial maturity of clean hydrogen technologies

The first general objective is operationalised in 7 **Specific objectives**⁴³ organised along a **three-pillar structure**: (i) H₂ Production; (ii) H₂ Distribution and (iii) H₂ End-uses.

Several funding **instruments** applicable to all pillars are to be deployed:

- **Strategic research challenges** which focus on the long-term development of low TRL, yet key and promising technologies⁴⁴ whose development will take several years and will require *inter alia* long-term consortia performing basic theoretical and experimental research.
- **Research Actions** will also focus on relatively low TRL applications, but whose development is achievable within a shorter time-frame. This instrument is based on the standard grants provided under Horizon Europe.
- **Innovation Actions**, will aim to achieve the incremental development (and demonstration) of clean hydrogen applications which have not yet reached technological maturity but which are expected to do so by the end of (or shortly after) the intervention. Innovation actions include actions which aim to strengthen the capabilities of mature clean hydrogen applications in terms of efficiency, durability, functionality, etc.

As a contribution to the European Partnership, it is proposed that funding rates for Research and Innovation actions, and for Innovation Actions (see Table 3) are lower than the standard rate awarded under Horizon Europe. This will leverage higher private (industry and research) investment than what can be achieved without a European Partnership.

- **Flagships** whose main role is to demonstrate the viability of clean hydrogen solutions at scale.

A flagship project is an Innovation Action that focuses on one application and constitutes a first industrial deployment or demonstration at scale (e.g. 300 trucks, or a 100 MW electrolyser to decarbonize an industrial process). The impact of such project is that, after completion, the applications is fully demonstrated and can enter the market as a mature product. It is based on a normal grant with a

⁴³ Specific Objectives 1 through 7.

⁴⁴ E.g. low or free PGM catalysts for FC and electrolysers, Storage with special focus on materials (e.g. carbon fibers, hydrogen carriers...)

few special characteristics: a high budget to achieve volume and scale, a low funding rate (~30%) demanding a large co-investment from industry, the involvement of most of the industrial players supporting the concerned hydrogen application. The experience of the FCH 2 JU with what is proposed to be implemented as “flagships” is described further below in Figure 43.

Figure 43: Experience with flagship projects in the FCH 2 JU

Even if there were not always designated as “flagship project”, the current FCH 2 JU resorted successfully to this type of projects for cars, vans and H2 refuelling stations, buses and micro-CHP fuel cells. For instance, in the bus sectors the first partnership under FP7 supported several small-scale demonstration projects while in parallel building a coalition of 80+ interested bus operators, bus OEMs and infrastructure providers. Then in H2020, the FCH 2 JU supported a demonstration at scale with 300 buses in around 25 cities. The FCH 2 JU invested 60 million for an estimated total investment of 300M. The project led to synergies with CEF which supported some refuelling stations and members states which co-funded part of the buses. Now CEF is supporting a larger deployment of 600 buses with a small grant and EIB financing. As a result, public transport authorities can now purchase hydrogen buses from multiple European OEMs through regular public procurement. This supports compliance with the Clean Vehicle Directive.

This very positive experience should be successfully replicated in other transport applications (e.g. truck projects but also in the energy and industry application with demonstrations at scale

2.1.2 General objective 2: Enable at scale deployment capacity for key parts of the H₂ value chain

The second general objective is operationalized in **2 specific objectives which cut across all pillars** described above as well as **all applications** targeted within each pillar (horizontal and vertical integration).

GO2 will also be implemented, essentially, through grant financing. This objective complements the activities proposed under GO1 with two horizontal activities, each supported through a specific funding **instrument**:

1. The demonstration of sectoral integration through **hydrogen valleys** (SO8)
 - **Hydrogen Valleys** will seek to deploy, in a coordinated manner deployment of entire systems which integrate all three pillars, proving the technical and economic readiness of a hydrogen ecosystem, including production, distribution and storage, and final use in transport and stationary applications. Hydrogen Valleys represent a concrete tool to enable sectoral integration, as pursued by EU Energy policies to take shape in an accelerate manner.
2. Support to the scale-up of supply chain and EU manufacturing capacity achieved through **industrialization actions** (SO9)
 - **Industrialization Action** will be aimed at enhancing the manufacturing and scale-up capacity of European clean hydrogen supply chains. Such actions have a strong component for SMEs, which are best placed to take advantage of the opportunities offered by new technologies and grow by creating new jobs requiring advanced skills.

While GO 1 is organized around 3 separate pillars with different objectives and roadmaps, it is essential to keep in mind that one of the main advantages of the use of hydrogen in the energy transition is its ability to act as an energy vector linking sectors (e.g. from clean primary energy supply to final uses in

transport and stationary applications). Therefore, it is essential that the next programme supports hydrogen valley projects that showcase sectoral integration in practice by demonstrating the technical and economic readiness of hydrogen ecosystems, including production, distribution and storage, and final use in transport and stationary applications. This should be done in increasing steps in scale and complexity over time.

To be implemented at scale, H2 valleys will require large budgets (around €30 million) with a low funding rate (~25-30%). They will require massive co-investment from private partners (industry) and possibly regions and will involve numerous partners from a diversity of applications.

Figure 44: Experience with Hydrogen Valleys in the FCH 2 JU

The FCH 2 JU launched one call for a “hydrogen valley”. The call generated an unprecedented interest from various regions across Europe with proposals which would have leveraged more than 100M of co-investments.

Since the call was published, multiple regions/cities have expressed a strong interest to implement these concepts at larger scale. By 2030 we expect that these ecosystems or ‘H2 valleys’, as they are commonly known, will be proven. They will gather elements from the previous applications covered in the previous sections and will certainly include hydrogen generation from renewable sources, its distribution and storage and final use in a variety of applications. This concept will be implemented in different ways depending on local needs. They will include applications as varied as Ports, Industrial hubs, multimodal transport hubs

- **Industrialization Action** aimed at enhancing the manufacturing and scale-up capacity of European clean hydrogen supply chains. Such actions have a strong component for SMEs, which are best placed to take advantage of the opportunities offered by new technologies and grow by creating new jobs requiring advanced skills. They will also be focused on increasing the mass market readiness of hydrogen applications by supporting innovation in mass production of clean hydrogen technologies.

Industrialization actions will cover a wide range of activities in a broad TRL window (2-8), co-funding rates will reflect this broad window, with increasing levels of co-investment being required the closer the application / industrial process is to commercial readiness.

Without industrialization actions, there is a real risk that the efforts made to increase the commercial maturity of clean hydrogen applications will fail to have the desired impact if Europe does not decisively support the European supply chain. This instrument is tailored for SMEs, which are best placed to take advantage of the opportunities offered by these new technologies and grow by creating new jobs requiring advanced skills.

Industrialization actions will provide specific support to scale-up the manufacturing capacity, promoting innovations in supply chain, manufacturing and assembly of clean hydrogen technologies. The experience which has led to the need to include these actions within the scope of the requested partnership is described in Figure 45.⁴⁵

⁴⁵ Text Box contains reference to: *Investing in the European future we want*, Report of the independent High-Level Group on maximizing the impact of EU Research & Innovation Programmes, Luxembourg: Publications Office of the European Union, 2017

Figure 45: The need for Industrialization actions within Clean Hydrogen for Europe

The FCH sector includes a series of highly successful SMEs that have developed products and are eager to move to large scale manufacturing to enable cost reductions and market penetration. This requires typically investments between €10-40 million. When they turned to private European investors or financiers, these SMEs are met with hesitation and risk aversion. As a result, these SMEs often turn to Asian, North American or even Russian investors.

Private European investments can be facilitated by a combination of EU grants and debt. This does not require huge amounts of money: as an example, a series of 5 to 7,5 million-euro grants (i.e. based on 25% funding will leverage 20-30 M€ investments. This type of action would be in line with the objective of the framework programme and the recommendation of the Lamy report (the so-called “FAB” dimension).

Beyond the direct activities of the Institutionalised European Partnership described above, other activities will support this objective. These include the work that Hydrogen Europe and Hydrogen Europe Research contributes to EU and National authorities to design policies which support the deployment of hydrogen as a key element of their climate, energy and transport policies as well as the support given by Hydrogen Europe and its members in helping the Commission to set up Important Project of Common European Interest (IPCEI) where member states will be allowed to support hydrogen at scale.

2.1.3 General objective 3: Ensure a safe and frictionless deployment of clean hydrogen technologies

The unique advantage of a European Partnership is its ability to coordinate otherwise fragmented stakeholder landscapes and act in a concerted manner across research, innovation, deployment point as well as horizontal and societal aspects without which impacts will fail to materialise or will be severely delayed.

As a result, we believe it is crucial for the partnership to take on ancillary tasks which support the safe and frictionless deployment of clean hydrogen technologies, in addition to those associated with programme design and implementation (GO1 and GO2).

Contrary to the other general objectives, this GO is not mainly implemented by grant funding⁴⁶ but by diverse additional actions which include:

- (i) Work performed directly by the staff of the European Partnership
- (ii) In kind cooperation with members and project participants;
- (iii) Cooperation with the JRC;
- (iv) Occasional procurement or grants in the form of coordinated and support actions

Although not the unique enabler of this objective, **Cross Cutting actions** (SO 10) can also be used to address wider societal issues that risk delaying commercial roll-out, such as regulatory issues (e.g. Pre-normative research), standards, training and education and, importantly, safety aspects, etc.

These activities are of a horizontal nature and done across the three pillars and involve the following activities:

2.1.3.1 Communication and dissemination

Communication and dissemination are crucial for ensuring that the results of the partnership (and of the projects supported) are made known to the broader stakeholder community. This function should make sure that lessons learned within each project are taken up broadly (thus ensuring that the industry moves

⁴⁶ With the exception of cross cutting actions, as described in SO10.

forward together) and, when milestones are reached, that the community builds on them in order to reach the next goal. This function does not necessarily have to be taken up solely by the staff of the European Partnership but also embedded within each project funded (with support and coordination ensured by the staff), thereby enabling a multiplier effect to the communication activities.

The main groups targeted by dissemination activities should be the research and industry communities as well as public authorities and clean hydrogen end-users (customers), with a secondary focus on the broader public. Communication towards institutional actors (e.g. policy makers, member states, regions, etc.) should mainly take place in a more formalised approach as described in sections 1.4 and 2.3.

Large scale events, focused on the partnership itself, its projects and their results (e.g. such as the yearly programme review days and Stakeholder Forum) are examples of communication activities which balance the need to provide detailed results (which is to be done by the projects themselves) and the need to cover the broad range of activities pursued by the partnership. Web presence and social media engagement, together with participation in events focused on hydrogen (other than those organised by the European Partnership itself) aim to maximise exposure.

The EU dimension stemming from the fact that progress has been achieved with EU support is an important part of the communication drive. The visual identity and dissemination activities should strongly emphasise the EU's role in advancing hydrogen technology in support of wider climate, energy and economic objectives.

2.1.3.2 Knowledge management

Knowledge management activities play a crucial role in (i) programme monitoring and evaluation, (ii) programme (re) design and adaptation to changing needs/situations (iii) communication and dissemination, (iv) accountability and much more.

The FCH 2 JU has already build a strong capacity in knowledge management, (some of the activities are described below). Clean Hydrogen for Europe should build on the work already undertaken and continue to deploy a strong knowledge management structure in support of the objectives of the partnership.

Following its successful development and first use in 2017 (to collect project data generated in 2016), FCH 2 JU projects were requested to provide their data every year concerning results generated in the previous year, allowing to benchmark projects' progress against the targets defined in the MAWP and related AWP. Each project active in a certain year (previous year to the exercise) was thus asked to complete one or several questionnaires concerning the research data generated within the activities foreseen in the description of action/work. An annual iteration of the data collection exercise enabled the development of a time-dependent database of FCH 2 JU project results. Via the FCH 2 JU website, information on projects is already supplied to the general public (c.f. Link to communication and dissemination activities). This data complements other sources (EC CORDIS; TRIMIS and SETIS) and serves as a repository of the results obtained by projects (e.g. by giving access to public deliverables). Technology monitoring should continue with data collection from projects on annual basis. Going forward, the knowledge gained by the partnership should be better valorised in the new partnership in order to keep up with both technological developments and higher expectations of stakeholders regarding the potential of hydrogen technologies.

The fuel cells and hydrogen market and policy observatory, will collect systematically, comprehensive and publicly available market statistics, including information on the policy framework at national level and at regional level when relevant coupled with data on jobs creation, employment and education needs of FCH industry, national and regional R&D programs supporting FCH technologies in Europe.

The development of the European Media Monitoring (EMM) for FCH technologies (with support from JRC) provides a more comprehensive press screening mechanism and can be seen as strong input to communication and dissemination activities going forward.

2.1.3.3 Regulation, codes and standards coordination

The implementation of a Regulation, Code and Standards Strategy Coordination (RCS SC) is crucial for the market deployment of FCH systems. As mentioned in the different recent reports from IEA, IRENA, CEM and HEM through the Tokyo statement, regulations currently limit the development of a clean hydrogen industry. Project developers face hurdles where regulations and permit requirements are unclear, unfit for new purposes, or inconsistent across sectors and countries. Sharing knowledge and harmonizing standards is therefore key. Trade will benefit from common international standards.

Pre-normative research (PNR) is key to ensure **scientifically and technological based** standards and regulations.

RCS activities target the development as well as the actual use of harmonised performance-based standards for FCH appliances and systems, together with their safety in energy and transport applications that can:

- (a) facilitate access to the market and
- (b) serve as mandatory references in regulatory documents at EU level.

The FCH 2 JU Strategy on RCS therefore aimed at deploying the activities needed to enable meeting the interests of the European FCH-community in:

- Developing science-based, fit-for-purpose European and international standards that promote and enable market deployment by providing the technical requirements to achieve safety and build public confidence;
- Establishing compliance/certification criteria within the EC and UN regulatory framework;
- Guiding authorities and other stakeholders in the application of RCS.

To enable coordinated implementation of the above tasks, industry-led regulations, codes and standards strategy coordination group (RCS SCG) has been created, composed of representatives of Hydrogen Europe and Hydrogen Europe Research assisted by JRC and with the support of the Programme Office.

The RCS SCG is tasked with the following activities:

1. Identification of strategic themes for RCS development and proposed follow-up,
2. Contribution to the definition of the consecutive FCH 2 JU Multi Annual Work Programme (MAWP) and Annual Work Plans to best address RCS needs,
3. Transfer and ensuring actual use of PNR results in RCS developments,
4. Establishing an approach to enhance European participation and influence in European and international RCS bodies, including inputs to Annual Union Work Plans for Standardisation

A practical implementation of the RCS SCG tasks relying on the rationale, the inputs that need to be considered, the required actions, the resulting outputs and the follow-up to be performed by the new European Partnership, Clean Hydrogen for Europe, should be continued and strengthened.

The RCS and PNR identified priorities by the RCS Strategic Coordination Group should serve as reference for new topics to be processed in the Annual Working Plans. Any topic proposal related to RCS and/or PNR activities must be in explicit coherence with the set of priorities.

2.1.3.4 Safety

The hydrogen industry has immense experience, built up in an industrial setting, in handling large amounts of hydrogen safely. However, the relative lack of general experience with introducing hydrogen in settings where it was not traditionally located (in people's cars, buses, homes, fuelling ships or in refuelling stations alongside conventional fuels) increases the time necessary for products to be rolled-out commercially. A culture of safety (including effective yet sensible rules and regulations) needs to be built up alongside the technology itself. The mass scale introduction of hydrogen technologies beyond their traditional industrial setting should be built on a strong foundation of safety.

Recent safety related events have shown that more efforts are required to embed such a culture within this fast-growing sector.

This need was recognised by the FCH 2 JU and should continue to be a major focus in the next financial period, especially as projects move higher in TRL and commercial deployment, at scale is expected. This area should become a priority in the new partnership, building on the activities already conducted (see below), but significantly expanding them in scope and ambition.

The European Hydrogen Safety Panel (EHSP) was established at the end of 2017 and has assisted the FCH 2 JU at both programme and project level in ensuring that hydrogen safety is adequately handled.

The EHSP provides the PO with a unique, practical and direct access to state-of-the-art expert judgment for all issues regarding hydrogen safety. It is anticipated that this panel will collaborate with IPHE (RCS&S working group coordinated by JRC and US DoE) and similar global initiatives (e.g. US DoE safety panel) for more consistent, European and worldwide harmonized approach to hydrogen safety and an improved education, training and public outreach.

One of the objectives of the EHSP is to coordinate a package of measures to avoid any accident by integrating safety learnings, expertise and planning into FCH 2 JU funded projects, by ensuring that all projects address and incorporate the state-of-the-art in hydrogen safety appropriately. Besides answering urgent questions related to hydrogen safety in an independent, coordinated and consolidated way, the EHSP activities could include the offer of basic short introductions to hydrogen safety review of safety plans, laboratory visits to conduct site inspections and safety assessments and monitoring the appropriate safety performance of all relevant publicly co-funded projects. One of the tasks foreseen for the EHSP is related to the analysis of existing events already introduced in the European hydrogen safety reference database (HELLEN) and of new information from relevant mishaps, incidents or accidents. The EHSP interprets these data together with the involved parties, derive lessons learned and provides further general recommendations to all stakeholders.

Regarding public outreach and framed within the context of the intended broad information exchange, the EHSP offers a newsletter and a regularly updated website, containing the lessons learned and links to other important safety related information. As an additional value proposition, the EHSP contributes to the development of a comprehensive outreach, education and training programme for the safety component of FCH 2 JU projects to ensure complete and effective information dissemination from all FCH 2 JU demonstration projects.

The proposed European Partnership “Clean Hydrogen for Europe” should continue to build on the relationship of the FCH 2 JU with the EHSP, but also build in-house capacities for enhancing safety related aspects within own projects and more broadly in the hydrogen community.

2.1.3.5 Regional and International cooperation

One of the success of the existing FCH 2 JU has been to organise coalitions of end users (e.g. bus operators) and later of regions and cities acting both as

- end users (they purchase, operate or request to operate) many hydrogen applications
- promoters as part of their regional development policies for which they can mobilise resources, notably the EU structural funds.

This coalition of regions has been formalised as a “smart specialisation platform” S3⁴⁷ supported by the European Commission.

Indeed, short- and medium-term issues can vary from one country to another or from one region to another: while some regions require immediate improvements to air quality, others wish to focus on climate change adaptation and mitigation. In this context, it is important to note that regions (and cities) as well as other international partners are not only end-users (customers) of the hydrogen technologies and solutions being developed by the programme, but are also potential sources of complementary

⁴⁷ <https://s3platform.jrc.ec.europa.eu/hydrogen-valleys>

funding which support further uptake and deployment. This dual-role makes cooperation and coordination even more important to the effectiveness of this partnership. Targeted cooperation and coordination at programme and, when possible, at project level through appropriate co-funding schemes or via Joint Calls, can considerably expand the scope and impact of the Institutionalised European Partnership's activities.

Given the importance of international cooperation in science and technology, explicitly recognised in the EU's Innovation Union flagship initiative, the FCH 2 JU has worked in close cooperation with the Commission with Mission Innovation⁴⁸ and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)⁴⁹ countries, the US DoE, Japan METI/NEDO (Ministry of Energy and Transport) in order to align with, facilitate and accelerate the worldwide market introduction of FCH technologies.

It is therefore a key objective of Clean Hydrogen for Europe to strengthen the alignment with and leverage additional innovation investments within Member States, Associated Countries and Regions. Clean Hydrogen for Europe must collaborate with Regions involved in or planning significant clean hydrogen activities in order to align strategy and coordinate research and demonstration activities (for example, exploring opportunities for joint public outreach actions).

This cooperation should build on the existing activities and fora established by the FCH 2 JU, (e.g. the S3 smart specialisation platform on hydrogen valleys) and enhanced in the next financial period.

The proposed partnership will also establish coordination and cooperation with Member States in the context of the States Representative Group (SRG) given the importance to align European and national policies and optimise the basic European principle of additionality. Formal actions to improve cooperation during the new financial period are explained in section 2.3, on Governance.

2.1.3.6 Funding and financial engineering

As presented in detail in section 1.2.3, there are several funding and financing schemes for complimentary projects to the ones directly to be supported by Clean Hydrogen for Europe.

Coordinating the funding and financing sources can significantly leverage the impact of projects and enhance the achievement of the partnership's objectives.

Supporting synergies between funding sources should deliver additional gains in terms of innovation results, closing the innovation gap in Europe and promoting economic growth. With the aim of accelerating the market introduction and deployment of the technologies stemming from the projects, the Clean Hydrogen for Europe should work closely with the industry, academia and research, the European Commission, Member States, Regions and Cities, other EU bodies and Financial Institutions to create synergies between different funding and financing sources.

The FCH 2 JU has been addressing these funding sources on a case-by-case basis but it is now time to initiate a structured approach to it.

In addition to the coordination and information exchange mechanisms described in section 1.2.3, the requested Institutionalised European Partnership should leverage past experiences and the work of the FCH 2 JU on funding and financial engineering. This should include the lessons learned from already supported projects benefiting from the combination of funds, highlighting specific requirements that potential beneficiaries must address to ensure EU funds' blending is fully compatibility with EU rules (e.g. compliance with the non-cumulative principle and the co-financing principle). A detailed analysis of existing grant funding opportunities on a simple and user-friendly platform should be maintained in this respect.

⁴⁸ <http://mission-innovation.net/>

⁴⁹ <https://www.iphe.net/>

Activities in this area should enhance cooperation with the Commission and its proposed Research & Innovation Investment Agenda for Hydrogen to work with other forms of Commission support outside of Horizon Europe and financing/investments coming from outside the Commission such as the EIB departments and advisory services as well as other financial investors in view of defining the right structures (e.g. special purpose vehicles -SPV) to aggregate demand and raise the bankability of fuel cell and hydrogen technologies with higher TRLs.

Furthermore, aggregation of demand will enable the development of more market driven and aggressive business models for deploying technology directly related with demonstration projects receiving support from the partnership, especially in relation to flagship projects and hydrogen valleys.

The proposed partnership will capitalise on the best practices and experiences of FCH 2 JU , other Joint Undertakings and the JRC in terms of developing synergies with countries and regions, notably in the context of the European Structural and Investment Funds (ESIF) for optimising their Research and Innovation Strategies for Smart Specialisation (RIS).

The partnership should contribute to leveraging the outcomes of this work to ensure higher leverage of Horizon Europe funds with other instruments and reinforce the collaboration with policy makers in the European Commission and Executive Agencies in charge of managing other EU funds.

2.1.4 Funding instruments proposed to be used under the partnership

The partnership will be fully in line with the funding rules of Horizon Europe. In order to maximise the effectiveness of the programme, a number of specific instruments which are based on existing Research Actions and Innovation actions are proposed. These are:

- **Strategic research challenges**
- **Research Actions**
- **Innovation Actions**
- **Flagships**
- **Hydrogen Valleys**
- **Industrialization Action**
- **Cross Cutting actions**

We propose to distinguish four levels of TRL with decreasing funding rate corresponding to higher industry investment for the instruments outlined above:

Table 3: Funding rate of the different instruments proposed in Clean Hydrogen for Europe

H2020 equivalent	Type of project	TRL	Industry	Research
RIA	1. Strategic research challenges	TRL 2-3	100%	100%
	2. Research Actions	TRL 3-6	70%	100%
IA	3. Innovation Actions	TRL 5-7	50%	TBD
	4.1. Flagship project	TRL 7-8	30%	TBD
	4.2. Hydrogen Valley	TRL 7-8	30%	TBD
	5. Industrialization Action	TRL 2-8	30-70%	TBD
RIA / CSA	6. Cross Cutting	n/a	70-100%	100%

These proposed funding rates are conditional on the consideration of the full CAPEX (equipment costs) rather than depreciation⁵⁰. Otherwise the funding rates cannot be reduced to these levels.

⁵⁰ This is the case when the partners build themselves the pilot that will be demonstrated. When the demonstrating partners purchase the pilot this is not automatically the case. When publishing the call, for Flagship and Demonstration projects, CHE should use the equivalent Horizon Europe to the H2020 option provided in the Grant agreement (Article 6.2.D.2 option 2) and explained in the Annotated Model Grant Agreement (p. 82 and following), to make the full purchase costs of capitalised equipment, infrastructure or other assets used for the action (not only the depreciation costs for the relevant periodic report) eligible for funding. This H2020 special

2.2 Resources

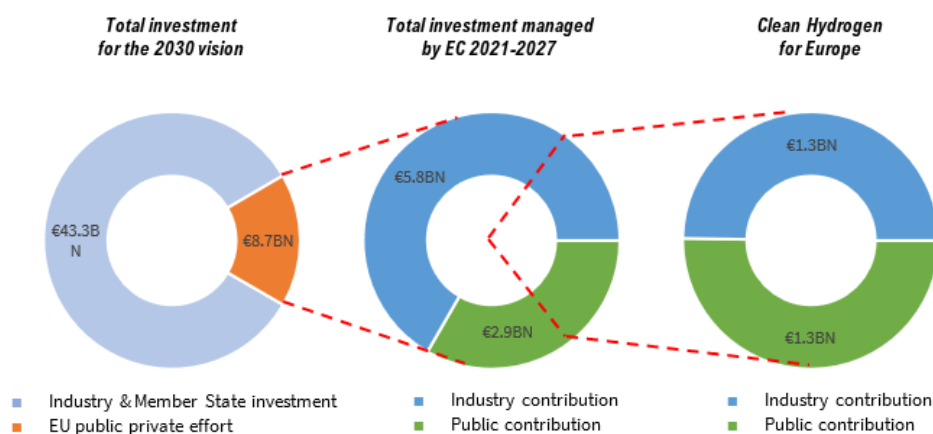
Even through the many challenges, we are confident that this vision for hydrogen's role in the 2030 energy system is achievable. With the right support, hydrogen technologies can be competitive and mature by 2030, and play the pivotal role as mentioned by Vice-President Frans Timmermans to meet some of Europe's key policy aims of the Green Deal:

5. Deep cuts of CO₂ in hard to decarbonise sectors: heavy duty transport (road, rail, ship), heat and industry
6. Reducing air pollution
7. Ensuring energy security
8. Providing energy to citizens at an affordable price
9. Ensuring European competitiveness

We estimate that, **overall, €52 billion of investment will be needed** to realize this vision in the decade 2020-2030. While the bulk of this investment will come from private investors and must be triggered by proper regulation and Member States support. It is necessary to trigger **8.7 billion investment by EU funding and financing action**, with roughly 1/3 third coming from EU public contribution and 2/3 from private investment. 70 % of the €8.7 billion programme could be provided through existing or planned EU support funds like CEF Transport and Energy or the ETS Innovation Fund (mostly market deployment actions).

It is estimated that **€2.6 BN (30%) would be needed for the partnership on Clean Hydrogen to deliver its targets**. It is expected that contributions will be **shared equally by the partners (industry and research) and the European Commission**.

Figure 46: Estimation of Public Private investment in Clean Hydrogen for Europe and its leverage effect



The overall budget of €2.6BN is broken down in the SRIA. Our set of roadmaps includes a **detailed justification** of the budget with a list of projects justifying the amount. They are based on the following simplified calculations:

1. The need for overall public and private investment in Hydrogen in the next decade is estimated between €50 and €60 billion⁵¹
2. €8 billion can be triggered by EU actions with a focus on R&I and first deployment with roughly €3 billion of public investment and €5 from private investment. This corresponds to the roadmaps comprising our SRIA
3. Out of this €3 billion is needed for the next partnership (the rest should be triggered via the ETS innovation fund, CEF, some structural funds and EU invest).

clause was written specifically to cover this type of situations. The investment expenses will take place during the project and will be easily identifiable and auditable in the accounts (balance sheet and general ledger) of the project partner.

⁵¹ Based on estimation by the Hydrogen Council Study and the FCH JU Roadmap for Europe

2.2.1 Private contribution

As we highly value the possibility to have an institutional partnership rather than other forms of funding, the private partners (the European Hydrogen Industry and Research community) are ready to make a substantial commitment to the goals of the partnership.

Resources contributed by the private side will be:

- In-kind contributions to the projects funded by the Union contributions (on the basis of non-reimbursed eligible costs);
- In-kind contribution for additional activities foreseen in the SRIA not covered by Union funding;
- Investments in operational activities that is spend beyond the work that is foreseen in the SRIA;
- in cash contribution used to finance the administrative costs, in case of an Institutionalised European Partnership (Joint Undertaking).

First, we are willing to accept lower funding rates for some types of actions than in Horizon Europe. This commitment will further increase the impact of each EUR of public money spent within the partnership beyond what is already achieved currently. In other words, the industry commits itself to bring in projects much higher private financial investments within the funded projects of an Institutionalised European Partnership than it would outside of one. This reduction in funding rates under the proposed European Partnership is illustrated in Figure 44.

Second, the members of Hydrogen Europe and Hydrogen Europe Research also commit **to bring in additional investments or activities (AA)** which will be made outside of partnership funded projects but supporting the objectives of the partnership (defined in the SRIA). In other words, the industry and research commit themselves invest in projects and equipment which support the goals of the partnership even when not receiving EU funding to do so. AA should demonstrate leverage of the partnership, which implies that there should be a certain causal effect between the creation/existence of the PPP, its strategic objectives and the activities reported. When submitting the annual AA plan, Members will clearly explain:

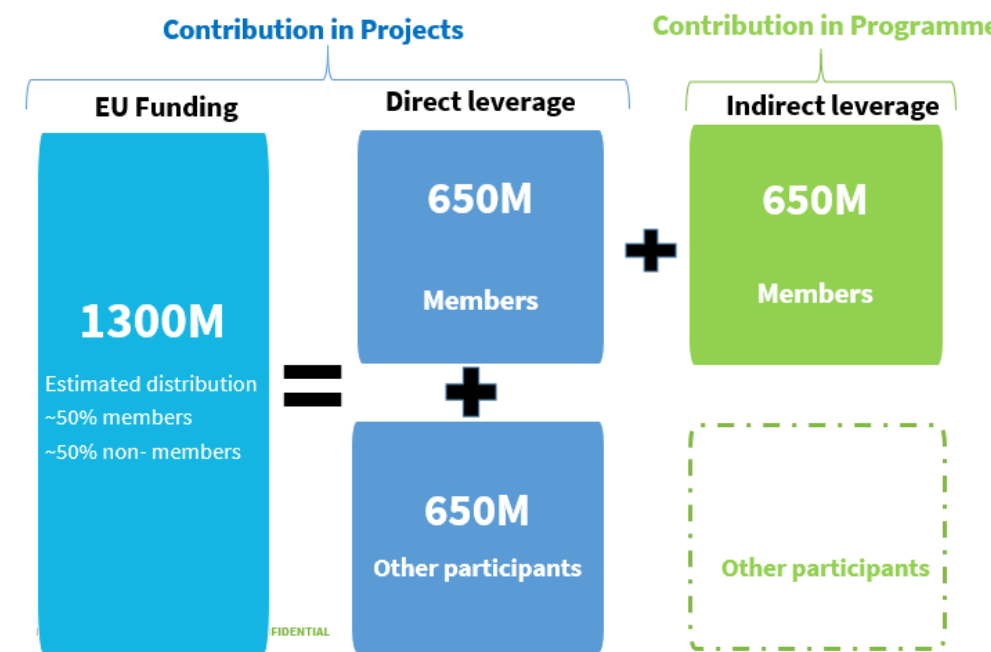
1. how these contribute to the objectives of the partnership
2. AND indicate
 - a) EITHER a link between the AA and a past or existing projects of the FCH JU or a new partnership (e.g. the funded project was part of a large investment, the project activity is continued and expanded after the project, the use of projects results.
 - b) OR a link between the AA and wider strategic European initiatives on hydrogen. These strategic European Initiatives should be would be listed upfront in the SRIA (e.g. IPCEI on Clean Hydrogen; 2x40GW initiative; EU-Africa Partnership, Mission Innovation, Regions' initiative) and could be further updated in its mid-term review.

Non-member participants will be expected to at least match the contribution received from the EU (Direct leverage); however, it is also estimated that they will make similar investments as members⁵².

Therefore, based on the current H2020 IKOP and IKAA evaluations, the total reported private contribution to the Institutionalised European Partnership will be of 150% of the total EU funding received in the programme, with an estimate total leverage effect of the IEP (when considering non-members indirect leverage) being 200% of the total EU Funding.

⁵² The indirect leverage effect of non-member participants may not be fully verifiable as reporting of such figures will be voluntary.

Figure 47: Leverage effect of the Clean Hydrogen for Europe Institutionalised European Partnership



Two important principles should be considered in designing the approach for contributions from private partners under Horizon Europe:

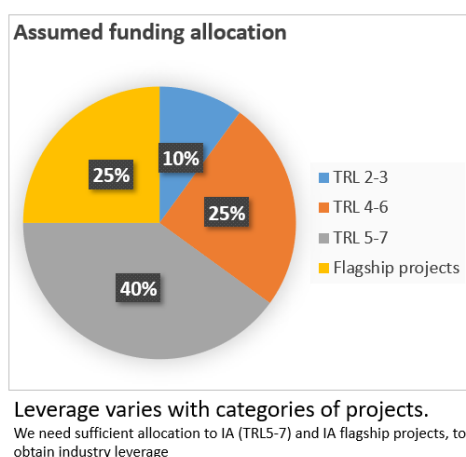
1. A fair balance of obligations and rights between members of HE and HER and other participants in projects (non-members).

The balance of rights and obligation should be such that organisations are incentivized to become active and become members of the partnership rather than being incentivized to stay passive or, worse, to renounce to membership of Hydrogen Europe or Hydrogen Europe Research in order to avoid certain obligations while still reaping the benefits. Imposing in-cash contribution on members only, while non-members have full, un-restricted access to all programme funding is a clear example of an obligation that upsets this fair balance and cannot be implemented as such.

In that sense it is proposed that:

- Reduction of funding rate should apply equally to members and non-members
 - Certain parts of the programme should be open only to members of HE and/or HER (and/or non-members should be requested to become members and to contribute)
 - Only members would commit to additional activities
2. Sufficient funding (2/3 of budget) given to demonstration projects and flagship projects as they are the ones where large industry contributions are to be made. This not only maximises the impact of the partnership but significantly increase leverage effects (in particular direct leverage) as the funding rates are much lower. This is illustrated by the figure below, which shows an indicative split of the budget, according to the various instruments proposed at different TRLs.

Figure 48: Indicative split of funding to various instruments in order to obtain the required industry leverage.



In addition, in order to ensure the proper implementation of the Partnership’s Strategic Research and Innovation agenda and to ensure that projects contribute adequately to the ambitious goals of the partnership, projects should be coordinated by a member of the partnership.

Our conviction is that we can bring substantial private contributions provided the modalities are well-thought and encourage the active involvement of the sector, however the commitments of private partners expressed in this document should be understood in the context of the principles expressed above.

2.3 Governance

The Governance structure of the FCH 2 JU has proven to be, overall, fit-for-purpose and effective. For this reason, this partnership request limits itself to briefly present the current situation and to suggest, based on past experiences and evaluations, potential changes and adaptations to the governance structure.

The current bodies of the FCH 2 Joint Undertaking comprise of (i) the Governing Board, (ii) the Executive Director, (iii) the Scientific Committee, (iv) the States Representatives Group and (iv) the Stakeholder Forum. The last three bodies are advisory. Responsibility for the strategic orientation and the operations of the FCH 2 JU is assigned to the Governing Board. The Governing Board formulates the strategic orientation within the Multi-Annual Work Plan (MAWP) which is then implemented through Annual Work Plans (AWP). The Governing Board appoints the Executive Director.

The interim evaluation of the FCH 2 JU stressed that the implementation of the partnership has been successful in most relevant aspects: *“roles and responsibilities of the FCH 2 JU bodies are clearly defined in the founding regulation and in the MAWP and, [as a result], the JU has successfully created an active FCH community “.*

However, despite this positive assessment, issues have been highlighted in relation to the role and participation of the advisory bodies (Scientific Committee, States Representative Group and Stakeholder Forum). The evaluation of the FCH 2 JU recommended a reassessment⁵³ and potentially updated role for the advisory bodies, an improved relationship with Member States based on strategic exchanges and synergies and a better alignment between the FCH JU and other Commission activities.

⁵³ As the research community, well represented now through Hydrogen Europe Research, is fully integrated in the governance of the Institutionalised European Partnership, a scientific committee appears less useful for this new period.

As a result, while retaining the core elements of governance, changes are welcome to improve the functioning of the advisory bodies.

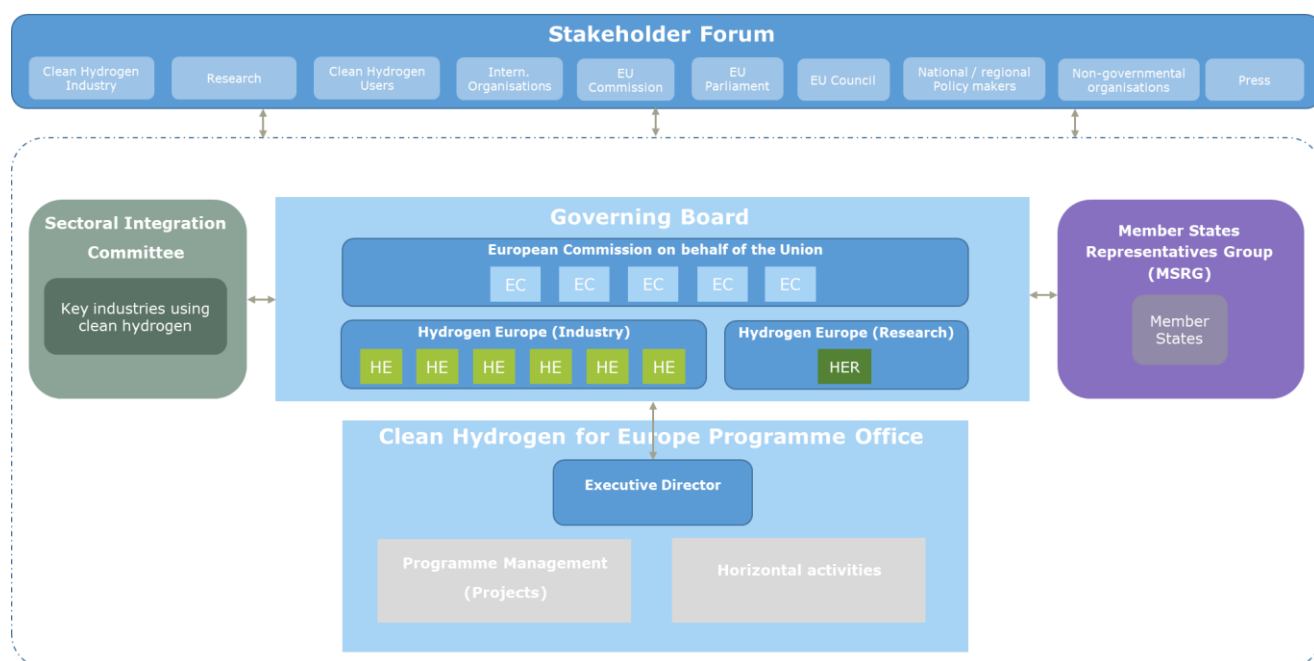
In our view, the governance structure of the “Clean Hydrogen for Europe” partnership should be based on the following principles:

- The “Clean Hydrogen for Europe” partnership should be based on a long-term commitment, including a balanced contribution from all partners.
- Partners should be accountable for the achievement of their objectives and be aligned with the Union’s strategic goals relating to research, development and innovation.
- The governance and functioning of the partnership should be open, transparent, effective and efficient and give the opportunity to a wide range of stakeholders active in their specific areas to participate.

The sections below outline a potential governing structure for “Clean Hydrogen for Europe” that the European Commission may consider. This proposed structure would be based on the following bodies:

- the Governing Board (GB);
- the Executive Director (ED);
- Advisory bodies
 - the Sectoral Integration Committee (SIC).
 - The States Representatives Group (SRG);
 - the Stakeholder Forum (SF).

Table 4: Illustration of potential governance structure of the Clean Hydrogen for Europe partnership



2.3.1 Governing Board

Given the positive evaluations of the existing bodies, we propose that the Governing Board (GB) and the Executive Director (ED) retain the same role as performed in the FCH 2 JU.

The main principles for the composition⁵⁴, functioning⁵⁵ and tasks⁵⁶ of the Governing Board may remain, broadly, the same and the GB should consist of representatives from (i) the Commission on behalf of the Union, (ii) Hydrogen Europe and (iii) Hydrogen Europe Research.

⁵⁴ Article 5, Regulation (EU) No 559/2014 of 6 May 2014 establishing the Fuel Cells and Hydrogen 2 Joint Undertaking

⁵⁵ Article 6, Regulation (EU) No 559/2014

⁵⁶ Article 7, Regulation (EU) No 559/2014

However, in order to reflect the growing ambition of the partnership and the expanded stakeholder community, we propose that the representation of the EU Commission on the governing board should be expanded.

2.3.1.1 European Commission on behalf of the Union

It goes without saying that we fully acknowledge and respect that the European Commission is the sole decision maker when it comes to its representation in the partnership; nevertheless, we take the freedom this opportunity to express some suggestions.

Given the growing role that clean hydrogen can play in the implementation of multiple Union objectives and the larger sets of funding instruments that could support the hydrogen sector in synergy with Horizon Europe, we believe it would be beneficial to expand the representation of the European Commission services within the Governing Board. The representation of multiple Commission services could further ensure that the broad array EU public interest are adequately defended in the framework of the Partnership and strengthen the synergy between the various funding instruments at the disposal of the Commission.

Private members (Industry and Research)

The industry grouping (Hydrogen Europe Industry) has six representatives on the FCH 2 JU Governing Board (one representing SME's) while the Research Grouping (Hydrogen Europe Research) has one representative.

Despite the fact that the membership of HE and HER has considerably evolved⁵⁷, both in terms of number of members, as well as the number of applications and value chains represented, we believe that the current composition of the private members is still fit for purpose going forward.

Six representatives from the Industry Grouping (Hydrogen Europe Industry) can reflect well the proposed intervention logic⁵⁸ for Clean Hydrogen for Europe. This number of representatives can adequately cover the various specific objectives proposed for the partnership. Five of the representatives will have a close connection with one or several specific objectives, as follows: (i) Hydrogen production, (ii) Transport, Storage and Distribution of hydrogen (iii) Hydrogen use in Transport, (iv) Hydrogen use in heating, cooling and industry and (v) Cross cutting issues, hydrogen valleys and hydrogen supply chains. The sixth representative will be the president of the Hydrogen Europe.

Based on current experience, one representative from the research grouping (Hydrogen Europe Research) is considered adequate.

2.3.2 Advisory bodies

As hydrogen technologies and, more broadly, clean hydrogen as an energy vector, can contribute to a broad array of industries and enable multiple pathways for the decarbonisation of Europe, it becomes increasingly important to build synergies with connected sectors, ensure a coordinated roll-out and contribute to an adequate regulatory framework that is fit-for purpose.

As a result, the main role of the advisory bodies should be to ensure structured, coordinated and timely synergies with the broader stakeholder community.

While the stakeholder community is very broad, we consider that the most important stakeholders to be involved in a formal capacity within the advisory bodies are: (i) the related sectors which can directly benefit from the deployment of Clean Hydrogen technologies and which are supported, at EU level,

⁵⁷ The membership of FCH Industry Grouping (the Industry side of Hydrogen Europe) has grown from 65 entities in 2008 to 173 entities, around 40% of which being SMEs, covering 22 countries. The membership of the Research Grouping (the research arm) has grown from 45 members in 2009 to 78 research institutions and universities today (covering 22 countries).

⁵⁸ See Figure 25

through an EU private public partnership (PPPs) and (ii) Member State representatives responsible for national (and regional policies) and roadmaps.

Given the particular setup of the partnership, (which incorporates, by design, the scientific community within its core management structures), the role of the Scientific Committee, as currently defined by the FCH 2 JU can be viewed as somewhat redundant. This opens up an opportunity to streamline and enhance the governance structure of the future partnership by replacing the Scientific Committee with another body, the Sectoral Integration Committee.

2.3.2.1 Sectoral Integration Committee

We propose to set-up a Sectoral Integration Committee (SIC) that would consist of representatives of sectors which need or use clean hydrogen, in including other relevant candidate European Partnerships. (see Figure 37 and Annex I – Synergies with other partnerships)

The SIC would be able to provide input on the strategic and the technological priorities to be addressed in the Clean Hydrogen for Europe partnership (e.g. as laid down in the SRIA and associated detailed technological roadmaps) taking account the progress and needs in related sectors the group's main aim would be to enable concrete synergies to take place between the partnership and the adjacent sectors.

Given the work that has already been conducted in the preparation of the SRIA and this partnership request, we propose that Hydrogen Europe continues to play a role in the context of the SIC.

Should the Commission consider not to be opportune to envision a formal role for the SIC within the governance structure of the partnership (even in advisory capacity) Hydrogen Europe can offer to set-up and maintain an informal group that can achieve a similar function as the one proposed for the SIC.

2.3.2.2 States Representatives Group (SRG)

Coordination with Member States policies, roadmaps, deployment strategies and funding remain important for the effectiveness of the programme. As a result, we propose to maintain the role of States Representatives Group (SRG) with strengthened focus on synergies. The SRG may consist of representatives of each Member State and of each country associated to Horizon Europe whose main role would be to ensure coordination and alignment between the European and the National and Regional strategies and policies on clean Hydrogen. It would be highly beneficial for representatives within the group to be responsible of (or at least strongly familiar with) national funding programmes targeting similar objectives as Clean Hydrogen for Europe, which would ensure that funding activities are complementary.

If considered appropriate by the European Commission, representatives of regions with a strong focus on Clean Hydrogen deployment and/or funding can also be integrated within the functioning of this group to enhance the level of coordination. However, this can be achieved by other means outside the formal setting of the SRG.

2.3.2.3 Stakeholder Forum (SF)

The Stakeholder Forum has been highly successful during the FCH 2 JU and has demonstrated the value of stakeholder involvement in the framework of the partnership. Under the proposed partnership it will continue to enable the broader form of coordination. It will be used as a tool for two-way communication between the broader stakeholder community and the partnership. On one side, it may *inter alia* enable policy makers (at EU, National and Regional level) to assess the work of the partnership and propose strategic actions going forward, as well enable the partnership itself to share its results and achievements.

The Stakeholder forum will remain open to all public and private stakeholders, international interest groups from Member States, associated countries as well as from other countries and allow multiple stakeholder groups to provide comments on the activities of the partnership. In addition to the

Governing Board, the Stakeholder forum can act as an additional mechanism for defining and defending the EU public interest in the framework of the Partnership.

2.3.2.4 Regions and RCS Strategy Committee

As mentioned in previous sections, the hydrogen sector and the FCH 2 JU have developed strong ties with regions with a hydrogen strategy. We would like to explore with the Commission how this link could be strengthened in the future partnership by giving an official role to the current S3 platform or a regions committee, or even a joint regions and member states committee.

As we also mentioned in previous sections, regulations, codes and standards (RCS) are key to accelerate the deployment of hydrogen technologies and instrumental in the competition with other geographies. The FCH 2 JU created an informal RCS strategy group. We believe this work should be expanded and made official. We would like to explore with the Commission how this could be best done.

2.3.3 Implementation

The main instrument to guide operations of the Clean Hydrogen for Europe partnership will be the Annual Work Plans (AWPs). It would be constructed annually, based on the multi-annual work plan.

The strategic multiannual planning of research and innovation activities of the Clean Hydrogen for Europe Partnership should be based on a further operationalisation of the Strategic Research and Innovation Agenda (SRIA) presented in this partnership request. It should be adopted by the Governing Board of the partnership and address the strategic objectives of the programme as well as specific objectives concerning techno-economic aspects with quantitative KPIs related to the successful deployment of the Clean Hydrogen technologies.

The SRIA should include the state-of-the-art of Clean Hydrogen technologies and define in great detail, through technology roadmaps, future targets covering both 2025 and 2030.

To take into account quick market and technology evolutions, annual strategic orientation provided by the Governing Board may complete the development and/or revision of the technology roadmaps.

Annual work plans which implement the SRIA will continue to be developed following a similar process as the one employed within the FCH 2 JU. This process will involve technical committees coordinated by Hydrogen Europe and Hydrogen Europe Research. The number, structure and composition of the technical committees, however, will be revised in order to reflect the proposed intervention logic of the partnership.

2.4 Openness and transparency

As described in section 1.4, the proposed European Partnership will be represented, on the private side by Hydrogen Europe and Hydrogen Europe Research, which currently consists of:

- 173 industry companies from 23 countries representing the entire clean hydrogen value chain (equipment manufacturers, integrators, OEM's, energy companies, utilities, as well as current and future end-users of hydrogen)
- 78 research organisations from 22 countries representing universities and research technology organisations (RTO) covering all the R&I topics from materials to systems and from H₂ production to consumption.

The membership is constantly growing and will continue to do so in the next financial period. Active recruitment of *inter alia* additional renewable /clean energy producers and electricity system operators will take place in order to further expand the stakeholder base and enable large-scale deployment of clean hydrogen technologies in line with EU goals and targets. Furthermore, engagement with central and eastern European countries will continue to be a priority area for the partnership, in order to ensure a wide and balanced geographical coverage.

Clean Hydrogen for Europe has already and will continue to involve all relevant partners and stakeholders **beyond the narrow composition of core partners** in all stages of preparation and implementation of the partnership for the next financial period.

Participation in the calls issued within the scope of the partnership may remain **open**, on a fair and non-discriminatory way **to all beneficiaries**⁵⁹ eligible for funding under Horizon Europe rules if adequate mechanisms related to financial contributions which do not dissuade active participation in the partnership are put in place.

At the same time, **participation** within Hydrogen Europe Industry and Hydrogen Europe Research is and will remain open, on a fair and non-discriminatory way to companies, associations and research institutions from EU, EEA, associated or candidate countries.

Active participation and engagement by private actors are essential for the success of the partnership, which is why implementing rules must avoid disincentivising actors from engaging with the partnership (e.g. by placing unreasonable financial burden on them, in contrast to other beneficiaries, not associated with the partnership).

All **newcomers** are and will be provided with a comprehensive briefing on the functioning of the partnership and are/will be encouraged to become involved in development of the annual plans and the implementation on the programme.

The **Strategic Research and Innovation Agenda** and associated technology roadmaps have been developed in close collaboration with current Hydrogen Europe and Hydrogen Europe research members. This process has included a thorough consultation with associations' members to identify which roadmap they individually support. Following this first step, a further refinement will be performed to assess the extent to which each member will be involved in the implementation of a roadmap, from being an Observers to being a roadmap Leader working in close cooperation with the Technical Committee Leader. KPIs will be set up to monitor the openness and outreach of the partnership and its activities.

The **relevant sectors**, for which development and deployment of clean hydrogen technologies can play an important role, in particular those who will benefit from a PPP in the context of the next financial period (see section 1.4.3) have been consulted on a bilateral basis and Memoranda of Understanding (MoU) or common papers are or will be in place to formalise processes for ensuring complementarity and synergies and, avoiding duplication of work.

The SRIA, as well as the partnership's problem definition and intervention logic have been presented to stakeholders at the FCH 2 JU Programme Review Days, put up for **open public consultation** (see www.cleanhydrogenforeurope.eu).

To ensure openness and transparency in the course of **implementation** of the partnership, the **SRIA** shall be further defined through **technical committees**, which serve as the fora through which the members of Hydrogen Europe and Hydrogen Europe Research members can contribute and mobilise their knowledge and expertise. The SRIA should be revised periodically in consultation with the "**sectoral integration committee**" and may reflect changes in priorities brought about by changing circumstances, in particular, by technical progress achieved by the partnership or internationally. In addition, **an element of open public consultation** which will include the general public as well as Member State actors will complement the internal review process described above.

To ensure the same openness and transparency for the definition of the **Annual Working Plans** (AWPs), an overall written process plan shall be established to describe how the AWP is prepared. This process must be based on consensus jointly between Industry and Research and the European Commission and also integrate the recommendations from advisory bodies. Annually updated strategic priorities shall be provided by the GB as an overall guideline for the coming AWP to focus on topics/areas where hydrogen can offer a unique value proposition.

⁵⁹ Provided the rights and obligations of members and non-members are balanced as described in section 2.2.2. "Private contributions"

The definition of AWP will be guided by priorities defined in the SRIA and taking into account the State of the Art, projects being currently developed, synergies with others partnerships, published calls and views from relevant stakeholders. Participation within **technical committees** will be open to all members of Hydrogen Europe Industry and Hydrogen Europe research.

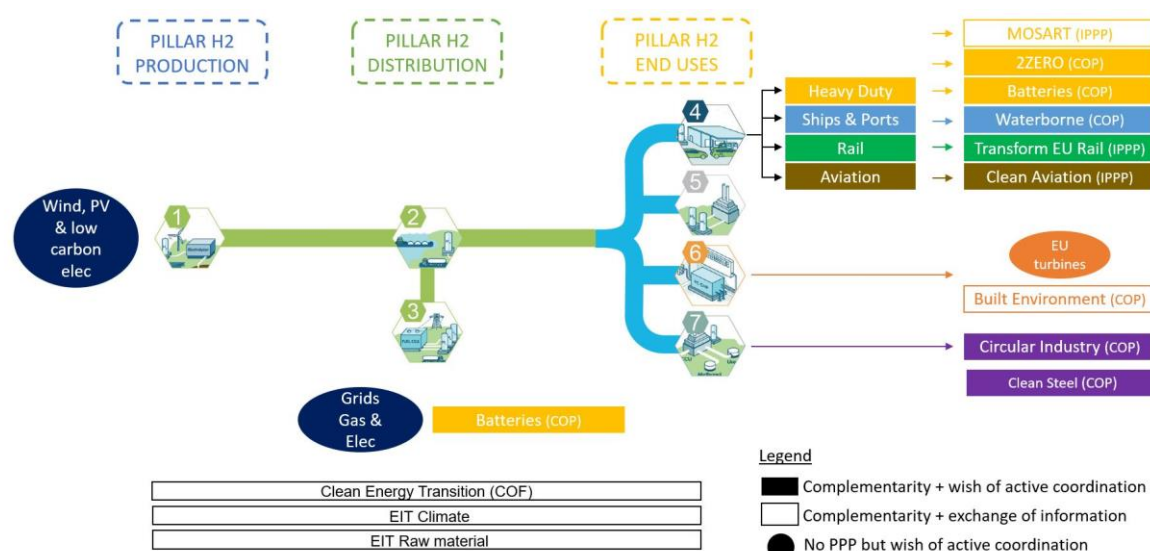
The rules of **procedure of the bodies** of the partnership **will be made publicly available**. The partnership will prepare and publish yearly annual reports which will include, *inter alia* information on the level of participation in the programme of members and non-members within the calls issued under the partnership.

The Partnership will also **provide all relevant information** in a timely manner to its appropriate bodies as well as promote its activities, including information and dissemination activities to the wider public. In particular, annual programmes (calls for proposals) will be widely and openly promoted by the Programme Office, in order to reach as many stakeholders as possible. The Partnership will continue to organise yearly “Info Days” and organise brokerage events to facilitate access to partners and consortia to newcomers and small players (including by taking into account geographical balance and inclusion across Europe).

3 Annex I – Synergies with other partnerships

There is a potential for synergies and need of coordination with a number of partnerships. This is depicted in the picture below:

Figure 49: Synergies with other partnerships



In a nutshell, synergies are essentially linked with the “Pillar End-Uses” with a group of 5 partnerships related to transport applications and 2 partnerships related to industry.

Transport partnerships

- The battery partnership is a special case. Batteries and hydrogen technologies are both technology inputs for end-use applications. The cooperation between us is focused on the design of hybrid systems combining battery and hydrogen technologies.
- Road transport, Waterborne, rail and aviation are clearly end-uses applications for which hydrogen technologies can play a role for their emission reduction objectives.

Industry-related partnerships

- Process4Planet - Clean and Circular Industry
- Clean Steel

How to organise synergies: division of tasks

When identifying the division of tasks, it is essential to check if the above-mentioned partnerships will indeed work on the integration of hydrogen in their application. We are aware that hydrogen technologies appear in the SRIA of all the mentioned partnerships. However, hydrogen technologies are not their sole priority and once the budgets are allocated, difficult choices will be necessary. These partnerships may then prefer to “(partly) leave hydrogen technologies” within the responsibility of the Clean Hydrogen for Europe Partnership.

Synergies needs to be organised in two ways:

- In identifying a basic **division of tasks / scope** between the partnerships and
- Designing a **coordination** process.

In terms of division of tasks, hydrogen and fuel cells technologies can be seen as technology bricks to be integrated into end-uses application.

A line could handily be drawn between partnerships that develop technology “building blocks” (Clean Hydrogen for Europe) and partnerships that design vehicles (e.g. transport partnerships) or processes (e.g. steel). In this line of thinking, the latter would provide the former with specifications regarding the required technology “building blocks” developers. This simple division may work for very mature technologies where the “end use” sector has very clear and stable requirements.

For new and disruptive technologies, this clear division of roles can be counterproductive and will not yield positive results. To overcome this, there is a **clear need for cooperation to demonstrate the technology and co-define specifications**.

Accordingly, a correct division of tasks must rely on three zones or three sets of actions:

- (i) **activities** which are **clearly in the remit of Clean Hydrogen for Europe** (technology “building blocks” such as fuel cells, tanks, refuelling infrastructure, etc.)
- (ii) **activities** which are **clearly in the remit of the end-use partnerships** (e.g. the design of new vehicles such as aircraft or ships adapted to the new technologies or new industrial processes for steel making or chemistry)
- (iii) **activities which requires a close cooperation**: The first integration and demonstration, certification and standardisation.

The table below provides a first analysis defining **division of roles** between Clean Hydrogen for Europe and other partnerships, as well as those activities which will have to be conducted in close cooperation. Relevant activities that would normally fall outside the remit of Clean Hydrogen Europe, but which will not be taken-up by any other partnership have been assumed by Clean Hydrogen for Europe and are also depicted in yellow. The division of tasks in Table 5 is our proposal which is still being discussed, coordinated and fine-tuned with the European Commission and other partnerships. All partnerships have committed to a close co-operation during Horizon Europe.

Table 5: Division of tasks and roles within the scope of Hydrogen Europe and "End-use" partnerships

Applications	Clean Hydrogen for Europe	Cooperation zone	“End use” Partnerships
Transport	Development of technology bricks such as: -Fuel cell systems -Tanks -Refueling infrastructure	• Demonstration of the technology in existing vehicles • Demonstration of first fleets⁶⁰ • Regulations, codes and standards • Safety	New design of vehicles or vessels able to integrate the new clean technology
Hydrogen for heat and power	Fuel cells Turbine Burners, boilers	• Regulations, codes and standards⁶¹ • Safety	• Retrofitting end-users’ appliances⁶² • Integration into existing processes
Clean Steel (Hydrogen as energy and reducing agent)	Hydrogen production, distribution and storage	• Integration of H2 and steel processes • Regulations, codes and standards • Safety	New steel making plant (DRI)
Clean and circular industry	Hydrogen production, distribution and storage	• Integration of H2 and new industrial processes	New industrial processes.

⁶⁰ More details provided below for each partnership

⁶¹ This role is assumed by CHE as no other partnership exists in this area

⁶² This role is assumed by CHE as no other partnership exists in this area

(hydrogen as a feedstock)		• Regulation, codes and standards • Coordination within “H2 valleys” and the “Clean and circular hubs”	
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The division presented above is **built on existing success stories**. It has already been employed within the existing Hydrogen partnership (i.e. the FCH 2 JU) which not only developed technology “building blocks” but also demonstrated end-use applications, including:

- First fleets of cars
- First fleets of buses
- First demonstration of trucks (starting)
- A couple of demonstrations of H2 ship (starting)
- An electrolyser in a steel plant
- An electrolyser in an ammonia plant (starting)

The FCH 2 JU was successful in bringing in within its projects, representatives of the end-uses applications. Moreover, **Hydrogen Europe membership includes the representatives of all end-uses applications for which synergies are explored** (i.e. cars, vans, trucks, ships, aircrafts, trains, steel, refineries, chemical industries). These “bridging” members are those which are the **most active** in testing hydrogen technologies within their areas. In addition, the FCH 2 JU has successfully built a large network of cities and regions, gathering them around large procurement projects (JIVE, JIVE2). These entities are **customers of hydrogen end-use applications** as described here. This existing foundation ensures a broad, coordinated, approach, necessary for effective implementation of actions that require close collaboration between different partnerships.

Detailed application of cooperation principles in the transport area.

It is important to remain aware that hydrogen technologies are not necessarily the single or first priority of many of the end-use partnership for which we seek to establish cooperation. It is therefore useful to specify and agree on synergies with each partnership in the transport sector.

• Road transport and synergies with 2Zero Partnership:

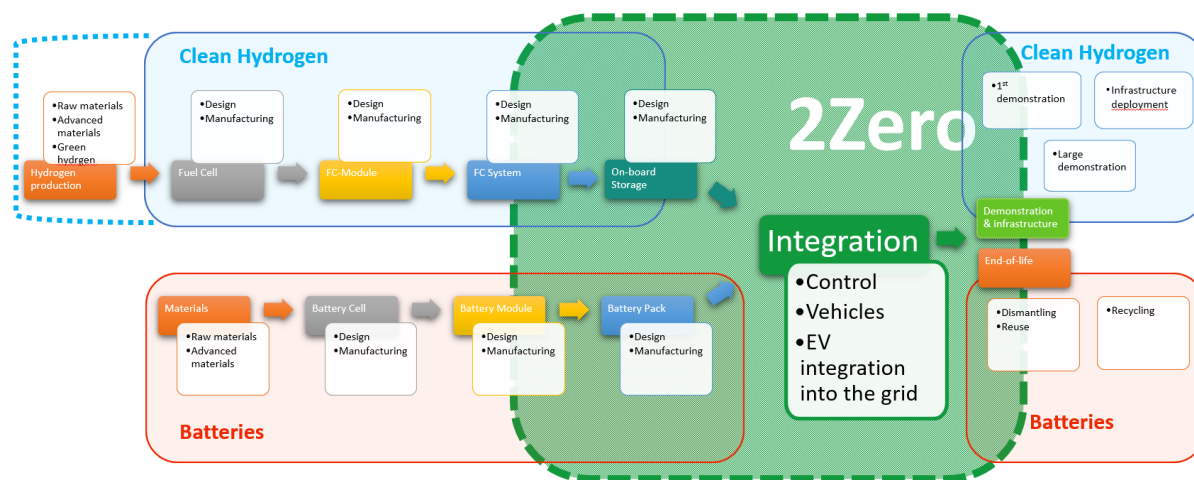
- Applications which are considered **mature** and already demonstrated by the FCH 2 JU (e.g. passenger cars and buses). Should **NOT** fall within the demonstration remit of Clean Hydrogen for Europe. Instead, the focus should be on the new generation of technology building blocks (fuel cells and tanks) that can adapt to new automotive platforms developed in 2Zero.
- **New** applications (e.g. trucks and coaches) which still require a lot of development and demonstration efforts should be a priority in the transport part Clean Hydrogen for Europe partnership, both in terms of technological development as well as demonstration.

Existing links (common statement paper published in 2017⁶³) with EGVI will need to be reinforced and reorganised to ensure a smooth transfer of information between the two initiatives and avoid any duplication of activities. Indeed, the Clean Hydrogen initiative will enlarge its activities to clean hydrogen production pathways, technologies for safe and cost-efficient distribution and storage as well as demand-side technologies (including fuel cells) to produce power and / or heat for mobile and stationary applications, therefore bringing an important technological contribution to the 2Zero partnership for the integration into the transport and mobility system. A strong coordination of efforts and activities will be needed to ensure a smooth transfer of information between the two partnerships, both for the integration at vehicle levels and for the interface between vehicle and infrastructure and

⁶³ <https://egvi.eu/mediaroom/battery-and-hydrogen-electric-vehicles-for-zero-emission-transport/>

deployment activities. Synergies between Clean hydrogen for Europe and 2Zero are still at proposal stage and are described in the figure below.

Figure 50 Detailed interaction of 2Zero with the Clean Hydrogen and Batteries partnerships⁶⁴



- **Zero-emission Waterborne Partnership** is a special case because it has to deal with:
 - Many categories of ships: for some⁶⁵ gaseous or liquid hydrogen is the optimal solution while others (e.g. ocean-going ships) will face a number of difficult choices in terms of fuels and powertrains
 - Several emission reduction pathways
 - Energy efficiency
 - New fuels: H2 and H2 made fuels such ammonia, e-LNG, e-methanol, e-diesel
 - New powertrains (different type of Fuel cells or even combustion engines adapted to new fuels).

Given this complexity, it makes sense for Clean Hydrogen for Europe to take a role, in the context of coordinated calls, on the demonstration of ships most fitting with hydrogen (gaseous or liquid) as a fuel whereas the zero-emission waterborne partnership would focus on the other solutions.

In addition, ports (combining ships, material handling, logistics and use of hydrogen in the industrial hinterland) are a privilege location for “H2 valley” projects, as foreseen by Clean Hydrogen for Europe. This type of project maximizes the efficiency of an eco-system and can only be achieved by the hydrogen partnership since it requires a broad expertise that clearly goes beyond the remit of the shipping industry.

Proposed Scope of the cooperation: While each partnership should develop its own activities, both HE/HER and Waterborne TP agree that there is an important potential for synergies and cooperation in particular in the following fields:

- Alternative fuels: Hydrogen and hydrogen made fuels (ammonia, methanol, others)
- Power conversion: fuel cell / turbines / ICE
- Emission reduction (Non-GHG): Fuel cells;
- Input to regulatory and standardization processes

⁶⁴ This graph is a first attempt to sketch the coordination between 2Zero, Clean Hydrogen and Batteries partnerships and reflects the first discussions between the three partnerships. Further exchange will be needed to reach a final agreement.

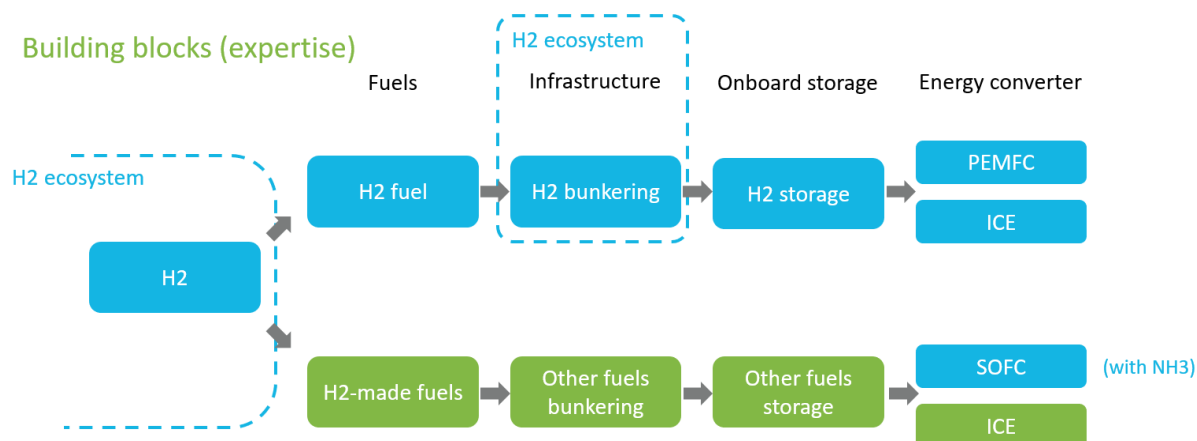
⁶⁵ e.g. short and medium distance ships, inland vessels, but also other types of vessels with specific use patterns and power requirements.

In these fields, the division of tasks and cooperation can be developed as follows:

Technology building blocks

HE/HER can work on the development of the following building blocks (in blue) which are clearly in its field of expertise. This should be reflected in CHE priorities.

Figure 51 Proposed division of responsibilities between CHE and ZEWT⁶⁶



- ZEWT should explore how other technology building blocks can be developed in the respective Partnership.
- It is mutually understood that
 - H2 technologies exist for land transport and stationary applications but the objective is now that CHE develops customized and up scalable technologies with a view to deliver waterborne fit-for-purpose solutions for the main ship types and services of the waterborne transport sector before 2030;
 - ZEWT should ensure there is a real prospect to demonstrate these technologies at scale in waterborne transport conditions and
 - ZEWT should share with CHE its analysis about the demand for the different technologies.

Integration and Demonstration

Integration of the technology building blocks (on board aspect of bunkering, on board energy storage, power converter, etc.) is the core competence of the ZEWT Partnership and should be at the core of ZEWT activities.

This however does not prevent cooperation in integration and demonstration. Indeed, while ZEWT should play a leading role in demonstrating the possibility to integrate such technologies in ships, it is useful to distinguish different categories of ships as HE/HER and CHE may take the initiative of demonstration for some ships.

For (large) ships, which account for the overwhelming majority of waterborne GHG emissions:

- There is a need to develop waterborne transport specific building blocks: “waterborne transport scale” (e.g. multi-MW FC or ICE, hybrid solutions, multi-tons of fuels storage and bunkering).

⁶⁶ This graph is a attempt to sketch the coordination between Clean Hydrogen and ZEWT and reflects the discussions between the two partnerships so far, and close to final agreement.

- ZEWT is the best placed to find the right large demonstrators since onboard integration represents a major challenge due to its complexity.
- The choice of the future fuel(s) remains open

ZEWT should be responsible for organising the demonstration of solutions developed for the main ship types and serves as aforementioned.

When it comes to the bunkering infrastructure, CHE should be responsible regarding bunkering for the incoming pipeline, land storage, distribution and bunkering (land side) of H2 and hydrogen carriers such as ammonia, while ZEWT should be responsible for bunkering (sea side), onboard distribution and storage.

Both parties should coordinate their activities to ensure that the development of technology building blocks by CHE and the demonstration by Waterborne are well synchronised.

The specific case of small and short distance waterborne transport for which there is a possibility to have a technology transfer of H2 technologies from land application (FC, tanks or refuelling infrastructure) and for synergies with land transport, a clearer business case for H2 as a fuel and a prospect of rapid deployment (i.e. they can serve as early adopter building confidence in the technology), CHE shall have the possibility to initiate demonstration projects. Both Partnerships shall establish a cooperation in this area, to exchange information on the possibility of up-scaling the project for other waterborne transport applications.

CHE should shall have the possibility to initiate demonstration projects. Both Partnerships shall establish a cooperation in this area, to exchange information on the possibility of up-scaling the project for other waterborne transport applications.

Regulation

The development of new technologies and integration into a ship is subject to the development or adaptation of many technical regulations. The associations agree to cooperate actively in this matter considering their respective expertise and experience.

ZEWT should shall take the lead in the discussion with the relevant bodies (ESSF, IMO, CESNI etc) concerning applicable rules and regulations while CHE should shall support the regulation effort by providing all useful information and testing about H2 technologies. HE and HER will also support by sharing needed information about H2 technologies either through Waterborne or by a direct participation in these bodies.

HE, HER and CHE should shall take the lead when it comes to the standardisation and certification of H2 technologies (fuel cells, storage, etc) while ZEWT should shall support the effort by sharing all the requirements to ensure that they are considered in standards.

Ports

Beyond the ships and bunkering infrastructure ports are also an area of common interest.

For ZEWT, the Partnership shall develop and demonstrate solutions for port -based supply infrastructure (i.e infrastructure for bunkering of alternative fuels and electricity) needed to enable zero-emission waterborne transport, to be implemented by 2030 at the latest

For HE, besides ship bunkering, ports are promising hydrogen hubs: combining

- Ports operations (which can also resort to hydrogen technologies to reduce their emission),
- Multi-modal logistics
- International trade of H2
- Ports industrial hinterland with vast usage of hydrogen (e.g. Port of Rotterdam and Port of Antwerpen, both members of HE, are the biggest producers and users of hydrogen in Europe) and face the challenge to decarbonise this production

The associations have not yet identified precise common R&I actions on ports but will inform each other of developments in this field.

- **Clean Aviation Partnership** is also defined by several pathways to reduce emissions. Among which, only two are relevant for hydrogen.
 - Electrification and hybridization of aircrafts: In this context, fuel cells and Hydrogen provide ancillary or non-propulsion power. There is a need to develop adapted fuel cells, adapted storage, and H2 infrastructure. In this context, Clean Hydrogen for Europe could support the development of such products on the basis of requirements defined by the aeronautic industry.
 - New fuels for aviation. These fuels include biofuels (not relevant), synthetic fuels made from hydrogen (that can be used in existing aircrafts) or liquid hydrogen (that requires a completely new architecture). It is only the last option that is relevant for the cooperation between the two partnerships. It would be up to the Clean Aviation partnership to support the design of new aircrafts while Clean Hydrogen for Europe could support with the development of technology building blocks on the basis of requirements defined by the aeronautic industry.

Similar to ports, airports (combining aircrafts, material handling, logistics and use of hydrogen in the industrial hinterland) are a privilege location for “H2 valley” projects which can only be achieved by the hydrogen partnership since it requires a broad expertise going beyond the remit of the clean aviation partnership.

- **Rail Partnership.** The draft SRIA of the partnership on rail includes limited references to hydrogen. We propose a division of tasks and cooperation according to the general principles described in Table 5. Similar to ports and airports, rail hubs can be good candidates for H2 valleys, and it makes sense to see such hubs at close proximity from ports and/or airports.
- **Clean Steel.** As a major and general guideline, it is suggested that
 1. any technological development or innovation dealing with clean hydrogen production, distribution and storage be within the scope of CHE,
 2. any development of a new steel production plant or process will be within the scope of Clean Steel
 3. the integration of the production, distribution and storage of hydrogen in the steel making process is an area for cooperation between the 2 partnerships.

In the area of cooperation, the following cooperation scenario are envisaged:

- When a pure process-related development or innovation specific to the Steel sector (project addressing a challenge specific to the steel sector) would require a contribution from a partner of another sector (such as integration of means of producing, storing and dispensing hydrogen), the project will be entirely financed by Clean Steel and this upon invitation by the steel sector of the identified partner of another sector.
- Conversely a technological development or innovation of technology bricks not specific to Steel will be entirely financed by CHE. This would also include aspects such as safety and regulations codes and standards.
- If cases arise that a technological development or innovation cannot be clearly assigned to Clean Steel or CHE, both partnerships will investigate the possibility to have “aligned/complementary” calls. This could be the case especially in the integration of hydrogen technologies where the know-how might be equally split between stakeholders of both partnerships.
- Finally, it is also recommended that if difference in priorities exists between the vision of sectoral integration through hydrogen technologies and the steel sector specifically, for some

topics of common interest, each Partnership could launch a topic according to its roadmap prioritization while the other could complement in subsequent calls either at cross-sectorial level (CHE) or at steel value chain specific focus level (Clean Steel).

Both HE/HER and ESTEP/EUROFER are determined to ensure a smooth development of the two partnerships based on these initial recommendations and on further conversations and agreements in line with the above recommendations.

How to organise synergies: Coordinating Process

In addition to the division of tasks proposed above, synergies are a good part a question of coordination process. The Partnership request for Clean Hydrogen for Europe emphasizes the need for constant dialogue with partnerships in connected areas. The main elements of such a dialogue are summarized as:

- We suggest to formalize this continuous discussion with the proposal to replace the scientific committee of the FCH 2 JU by “a sector integration committee” which will have a formal role in the governance of Clean Hydrogen for Europe. Alternatively, a “PPP committee” could be established across several relevant partnerships to formalize this continuous discussion. If none of these proposals are retained by the EC, we can rely on bilateral dialogues to maintain coordination.
- Dialogue between partnerships could lead into coordinated calls. By coordinated calls, we do not refer to complex administrative mechanisms but a simple coordination between two partnerships on the definition of topics subsequent decisions that a certain topic will published by one of the partnerships and another topic by the other. This can be done call by call but it could also cover longer periods. Such coordination calls could follow the principles outlined in Table 5.
- Within the membership of Hydrogen Europe, we have designated bridging members⁶⁷, i.e. members of hydrogen Europe that are also very active in “end-use partnerships” with the aim of facilitating the coordination between partnerships and ensure the complementarities of our roadmaps.

⁶⁷ For instance, Airbus/Safran/Liebherr/DLR for aviation. Alstom/Siemens for rail. Fincantieri/ Chantiers de l’Atlantique for waterborne. Salzgitter/Voestalpine/Arcelor Mittal/Thyssen Krupp for steel, many OEMs, Tier 1 suppliers and other components suppliers for 2ZERO & Batteries, etc.

EU šalių narių pasiskirstymas prioritetizuojant vandenilio plėtrą

	Vandenilis			Harmonizavimas				Klasteriai	Sintetinis kuras
	AEI	Dujinis	Branduolinis	Sertifikavimas/ kilmės garantijos	Vandenilio CO2/EUR	Terminologija	Tech neutralumas		
DE	11 VN								
FR									
SE									
LU									
DK									
AT									
IE									
PT									
ES									
NL									
BE									
Lietuva	5 VN								
IT									
EE									
PL									
LV									
HR	11 VN								
MT									
CY									
EL									
FI									
HU									
BG									
RO									
CZ									
SI									
SK									

Lietuvos Respublikos energetikos ministerijos inicijuota diskusija vandenilio technologijų
vystymo potencialo Lietuvoje tema

ATMINTINĖ

2020 m. rugsėjo 18 d.

2020 m. rugsėjo 18 d. Lietuvos Respublikos energetikos ministerijos (toliau — Energetikos ministerijos) iniciatyva įvyko diskusija vandenilio technologijų vystymo potencialo Lietuvoje tema. Nuotoliniu būdu galimybės šioje srityje aptarė Energetikos ministerijos ir kitų valstybės institucijų, valstybės valdomų įmonių, pramonės, mokslinių tyrimų institutų ir asociacijų atstovai.

Lietuvos Respublikos energetikos atašė pavaduotoja Sandra Vainutė pristatė su vandenilio technologijomis susijusias iniciatyvas **Europos Sąjungoje** (toliau — ES), taip pat ES narių pasiskirstymą pagal vandenilio plėtros prioritetus. Šiame kontekste šalys turi įsivertinti, koks vandenilio gamybos būdas ar būdai jiems priimtinausi (iš atsinaujinančių energijos išteklių (toliau — AEI), dujų ar branduolinės energijos), kokie harmonizavimo aspektai priimtinausi, kiek šalims narėms aktualūs klasterių kūrimo ar sintetinio kuro gamybos klausimai (lentelė pridedama). Susitikimo metu taip pat pažymėta, kad didžiosios ES šalys, šiuo metu ES Tarybai pirmininkaujanti Vokietija bei Prancūzija parengė nacionalines vandenilio strategijas. Šiais metais patvirtintoje ES Vandenilio strategijoje numatyta siekti integruoti vandenilį dekarbonizuojant pramonės, transporto, energijos gamybos ir pastatų sektorius visoje Europoje. Strategijoje nagrinėjama, kaip esamą potencialą paversti realybe per investicijas, reguliavimą, rinkos kūrimą ir mokslinius tyrimus bei inovacijas. Šiuo metu jau yra paskelbtas ES Tarybos išvadų dėl jūrinio vėjo ir kitų atsinaujinančių šaltinių projektas, o artimiausiu metu, po 2020 m. spalio 5-6 d. vyksiančios neformalios Energetikos ministrų Tarybos, bus paskelbtas papildomas ES Tarybos išvadų projektas dėl vandenilio. Siekiant, jog šiose išvadose būtų įtraukiami Lietuvai svarbūs pasiūlymai, aktualu visoms suinteresuotoms šalims dalyvauti rengiant ir teikiant pastabas.

Energetikos ministerijos Inovacijų ir tarptautiškumo skatinimo grupės vadovas Žilvinas Danys pristatė pilotinį vandenilio projektą, kuris įtrauktas į Lietuvos ateities DNR ekonomikos skatinimo planą. Projekto tikslas yra praktiškai išbandyti pagaminto „žaliojo“ vandenilio maišymą ir perdavimą į esamą gamtinių dujų infrastruktūrą. Planuojama, kad 2,45 mln. Eur. vertės projektas bus užbaigtas 2021 metais.

Energetikos ministerijos Klimato kaitos valdymo grupės atstovas Aurimas Salapėta pristatė šiuo metu Lietuvos Respublikos Seime svarstomą **Alternatyviųjų degalų įstatymo** (toliau — ADĮ) projektą. ADĮ siekiama užtikrinti 15 proc. AEI dalies transporto sektoriuje pasiekimą. Tam tikslui nuo 2022 m. benzino ir dyzelino tiekėjai, o nuo 2025 m. ir gamtinių dujų transportui tiekėjai įpareigojami kartu su įprastais degalais patiekti ir atitinkamą dalį degalų iš AEI. Gamtinių dujų transporto sektoriaus tiekėjams nuo 2025 m. numatytas laipsniškas įsipareigojimų didėjimas iki 16,8 proc., kurį įgyvendinti galima panaudojant biometano ar vandenilio dujas. „Žaliojo“ vandenilis ADĮ projekte yra susijęs ir su mineralinių degalų tiekėjais, kurie vandenilio pagalba gali įgyvendinti pažangiųjų biodegalų tikslą. Sunkusis transportas pereinamuoju laikotarpiu turi nemažai potencialo vandenilio dujų panaudojimui.

Energetikos ministerijos Inovacijų ir tarptautiškumo skatinimo grupės atstovas Daumantas Kerežis trumpai pristatė būsimos 2021-2027 m. ES tyrimų ir inovacijų programos Europos Horizontas kontekste, energetikos mokslinių tyrimų ir inovacijų srityje telkiamas

partnerystes. Šiais bendradarbiavimo formatais siekiama, kad moksliniai tyrimai būtų aktualūs tiek mokslo institucijoms, tiek verslui. Detaliau pristatyta **Švara** **vandenilio Europai partnerystė** (pridedamas dokumentas), į kurią kviečiami verslo ir mokslo atstovai. Šią iniciatyvą koordinuoja asociacija „Hydrogen Europe“.

Lietuvos energetikos agentūros vadovas Dr. Darius Biekša pristatė Lietuvos energetikos sektoriaus raidos tendencijas iki 2030 m. ir vandenilio technologijų vaidmenį šiame kontekste. Kol kas į esamą modeliavimą priemonės, susijusios su vandenilio technologijomis, nėra įtrauktos, tačiau Lietuvoje esama potencialo ir tolimesnės diskusijos yra labai reikalingos ir svarbios. Svarbu harmonizuoti transporto elektrifikavimo ir dujų elektrifikavimo kryptis, kad jos nekonkuruotų tarpusavyje.

AB „Klaipėdos nafta“ atstovė Jurgita Šilinskaitė-Vensloviienė trumpai pristatė „mėlynojo“ vandenilio (gaminamo iš gamtinių dujų) gaminimo Lietuvoje galimybes. Atsižvelgiant į tai, kad Lietuvoje Klaipėdos gamtinių dujų terminalo veikla numatoma iki 2044 m., būtina atsižvelgti į pasaulines energetikos technologijų tendencijas, kurios bus aktualios ateityje. „Mėlynojo“ vandenilio gaminimas iš gamtinių dujų su CO₂ sugavimu ir saugojimu galėtų padėti Lietuvai ne tik patenkinti vidaus vartojimo poreikius, bet ir tapti šio produkto eksportuotoja. Lietuvoje galėtų derėti tiek „žaliojo“, tiek „mėlynojo“ vandenilio gamyba. Šiuo metu AB „Klaipėdos nafta“ domisi CO₂ saugojimo komerciniu pagrindu galimybėmis Norvegijoje, Danijoje ir Jungtinėje Karalystėje.

AB „Klaipėdos nafta“ atstovė taip pat atkreipė dėmesį į prognozę, kad 2050 m. amoniakas kaip kuras turėtų sudaryti 20-25 proc. dalį jūriniame transporte. Šiuo metu pasaulyje vykdomi pilotiniai projektai, kurių metu testuojamas amoniako pritaikymas jūriniame transporte.

UAB „EPSO-G“ atstovas Laurynas Mereckas trumpai pristatė AB „Litgrid“ užsakymu vykdomą studiją „Raida 2050“ ir pakvietė į rugsėjo 24 d. vyksiantį viešą renginį – dirbtuves, kurių metu bus diskutuojama apie galimas priemones integruoti didelius AEI kiekius į Lietuvos energetikos sistemą.

Lietuvos energetikos instituto (toliau — LEI) atstovas Dr. Darius Milčius pristatė dar vieną į Lietuvos ateities DNR ekonomikos skatinimo planą įtrauktą projektą, kurio tikslas yra įrengti demonstracinį centrą, kuriame vandenilio technologijos būtų vienos iš pagrindinių. Projekto apimtyje bus įrengta saulės elektrinė, elektrolizės būdu išgaunamas vandenilis vėliau būtų panaudojamas transporte. Taip pat bus atliekami bandymai, susiję su galimybėmis vartotojams saulės energiją perkelti iš vasaros į žiemą. Taip pat buvo pristatytas projektas, pateiktas finansavimui per Šiaurės ir Baltijos šalių energetikos mokslinių tyrimų programą, kurio tikslas yra nagrinėti galimybes vandenilį naudoti kaip kurą elektromobilių įkrovimo stotelėse, pritaikant turimus modeliavimo įrankius.

LEI atstovas taip pat informavo apie Lietuvos vandenilio energetikos asociaciją, kuri yra įsteigta nuo 2006 m., o šiais metais tapo „Hydrogen Europe“ asociacijos nare. Kol kas asociacijai priklauso mokslo bendruomenės atstovai: Vilniaus universitetas, Kauno technologijos universitetas, Vytauto Didžiojo universitetas ir LEI. Dr. Darius Milčius Lietuvos vandenilio asociacijos vardu pakvietė į ją jungtis ir vandenilio technologijomis suinteresuotas įmones, dalyvauti bendruose projektuose.

AB „Achema“ atstovas Juozas Tumaitis pasidalino informacija apie tai, kad įmonė plačiai naudoja vandenilį amoniako gamyboje, apie milijoną tonų per metus. AB „Achema“ tikėtų iki 5 proc. „žaliojo“ vandenilio įmaišymas, kadangi būtent tokiems pajėgumams yra pritaikyti katalizatoriai. Jei šalyje atsirastų nuolatinis „žaliojo“ vandenilio srautas, jis būtų naudingas įmonei siekiant mažinti CO₂ emisijas. Šiuo metu elektrolizei naudoti „žaliąją“ elektrą dar yra per brangu. AB „Achema“ atstovas taip pat atkreipė dėmesį į amoniaką kaip trūkstantį grandį „žaliojo“ vandenilio sistemoje.

AB „Amber Grid“ atstovas Vytautas Ruolia informavo, kad įmonė šiuo metu ieško galimybių vykdyti demonstracinius projektus, vandenilio maišymus su gamtinėmis dujomis. Tokiems projektams būtina parama, kadangi nėra investicinės grąžos. AB „Amber Grid“ aktualu sulaukti Valstybinės energetikos reguliavimo tarybos Energetikos įstatymo pakeitimus įgyvendinančių teisės aktų, kuriais būtų nustatyta galimybė reguliuojamą energetikos veiklą vykdančioms įmonėms dalį reguliuojamos veiklos pajamų nukreipti inovacijoms skatinti. Įmonė dalyvauja REGATRACE projekte, kurio tikslas yra sukurti biometano ir kitų dujų, pagamintų iš AEI, prekybos, perdavimo ir konversijos (elektra-vandenilis-metanas) europinę sistemą bei metodinę pagalbą, kuriant nacionalines dujų iš AEI politikos kryptis. AB „Amber Grid“ šiuo metu yra pasirengę į dujų tinklą patiekti iki 2 proc. vandenilio.

AB „Ignitis grupė“ atstovas Paulius Kozlovas pažymėjo, kad AB „Energijos skirstymo operatorius“ gamtinių dujų skirstymo tinklas didžiąją dalimi yra nepritaikytas vandeniliui. Tačiau egzistuoja galimybė šalia esamos dujų infrastruktūros tiesti naujus vamzdžius, pasinaudojant esamais servitutais. Šiame kontekste svarbu iš anksto ir aiškiai identifikuoti poreikį. AB „Ignitis grupė“ šiuo metu turi 90 KW elektrolizės pajėgumus Lietuvos elektrinėje Elektrėnuose. Vilniaus termofikacinė elektrinė taip pat galėtų tiekti elektrolizės pajėgumus bandymams. P. Kozlovas pažymėjo, kad investicijų į „žaliąjį“ vandenilį galima tikėtis tik matant platesnę ateities perspektyvą; reikėtų aiškumo, kaip galėtų būti sumažinta „žaliojo“ vandenilio kaina lyginant su vandeniliu, pagamintu iš iškastinio kuro.

AB „ORLEN Lietuva“ atstovas Kęstutis Starkus pažymėjo, kad vandenilio gamyba yra energijai itin imlus procesas; ši bendrovė būtų suinteresuoti galimybėmis jo įsigyti. „Žaliojo“ vandenilio gamybos procesuose leistų labai sumažinti CO₂ emisijas. AB „ORLEN Lietuva“ taip pat matytų potencialą naudoti „žaliąjį“ vandenilį degalų gamyboje, taip vandenilis galėtų būti netiesiogiai panaudojamas transporte. Šioje srityje reikėtų aiškesnio reguliavimo ir skatinimo.

Apibendrindama diskusiją energetikos viceministrė Lina Sabaitienė pasidžiaugė dideliu verslo ir mokslo atstovų susidomėjimu ir aktyvumu aptariant vandenilio technologijų pritaikymo energetikoje potencialą. Tolimesnis šios technologijos vystymas galėtų padėti mažinti CO₂ išmetimų kiekį ir padėtų įgyvendinti Nacionalinėje energetinės nepriklausomybės strategijoje ir Nacionaliniame energetikos ir klimato srities veiksmų plane užfiksuotus tikslus, bei bendrą ES klimato neutralumo siekį iki 2050 metų. Ateityje galėtų būti vykdomi reguliarūs susitikimai vandenilio panaudojimo transporto sektoriuje, dujų perdavimo tinkluose, pramonės procesuose, laivyboje. Siūlymai dėl reguliaraus bendradarbiavimo formato steigimo ar esamų bendradarbiavimo platformų išplėtimo ir pritaikymo bus aptarti kito susitikimo metu.

Parengė:

Ieva Visockienė, Energetikos ministerijos Inovacijų ir tarptautiškumo skatinimo grupės patarėja

DETALŪS METADUOMENYS	
Dokumento sudarytojas (-ai)	Lietuvos Respublikos energetikos ministerija, Gedimino pr. 38, LT-01104, Vilnius, LT-01104 Vilnius, Lietuva (2020-09-30 15:09:08)
Dokumento pavadinimas (antraštė)	SUSITIKIMO DĖL VANDENILIO TECHNOLOGIJŲ PLĖTROS GALIMYBIŲ ATMINTINĖ IR PASIŪLYMAS DĖL TOLIMESNIŲ VEIKSMŲ
Dokumento registracijos data ir numeris	2020-09-30 Nr. 3-1543
Dokumento gavimo data ir dokumento gavimo registracijos numeris	-
Dokumento specifikacijos identifikavimo žymuo	ADOC-V1.0
Parašo paskirtis	Pasirašymas
Parašą sukūrusio asmens vardas, pavardė ir pareigos	Lina Sabaitienė, Viceministras
Parašo sukūrimo data ir laikas	2020-09-30 14:33:09 (GMT+03:00)
Parašo formatas	XAdES-T
Laiko žymoje nurodytas laikas	2020-09-30 14:33:29 (GMT+03:00)
Informacija apie sertifikavimo paslaugos teikėją	ADIC CA-A,Asmens dokumentu israsymo centras prie LR VRM,2.5.4.97=#1609313838373738333135,LT
Sertifikato galiojimo laikas	2018-02-06 11:00:05–2021-02-05 11:00:05
Parašo paskirtis	Registravimas
Parašą sukūrusio asmens vardas, pavardė ir pareigos	Greta Lukoševičiūtė, Vyriausioji specialistė
Parašo sukūrimo data ir laikas	2020-09-30 15:01:39 (GMT+03:00)
Parašo formatas	XAdES-C
Laiko žymoje nurodytas laikas	2020-09-30 15:01:58 (GMT+03:00)
Informacija apie sertifikavimo paslaugos teikėją	ADIC CA-B,Asmens dokumentu israsymo centras prie LR VRM,2.5.4.97=#1609313838373738333135,LT
Sertifikato galiojimo laikas	2019-09-30 12:18:10–2022-09-29 12:18:10
Informacija apie būdus, naudotus metaduomenų vientisumui užtikrinti	
Pagrindinio dokumento priedų skaičius	3
Pagrindinio dokumento pridedamų dokumentų skaičius	-
Programinės įrangos, kuria naudojantis sudarytas elektroninis dokumentas, pavadinimas	DocLogix v12.8.5.0
Informacija apie elektroninio dokumento ir elektroninio (-ių) parašo (-ų) tikrinimą (tikrinimo data)	Tikrinant dokumentą nenustatyta jokių klaidų (2020-09-30 15:09:08)
Elektroninio dokumento nuorašo atspausdinimo data ir ją atspausdinęs darbuotojas	2020-09-30 15:09:08 atspausdino Greta Lukoševičiūtė
Paieškos nuoroda	-
Papildomi metaduomenys	-