Innovation eco-system including gender data

Project title	sHYpS - sustainable HYdrogen powered Shipping		
Project acronym	sHYpS		
Project number	GA 101056940		
Call	Clean and competitive solutions for all transport modes	**Call ID**	HORIZON-CL5-2021-D5-01
Topic	Enabling the safe and efficient on-board storage and integration within ships of large quantities of ammonia and hydrogen fuels (ZEWT Partnership)	**Topic ID**	HORIZON-CL5-2021-D5-01-07
Funding scheme	HORIZON Action Grant Budget-Based		
Project start date	2022/06/01	**Duration**	48

Due date	2022/09/30	**Delivery date**	2022/10/28
Work package	8		
Responsible Author(s)	PNO		
Contributor(s)	-		
Version	V1		

Dissemination level

Please select only one option according to the GA			
☐	PU: Public	☐	PP: Restricted to other program participants
☐	RE: Restricted to a group specified by the consortium	☒	SEN: Confidential, only for members of the consortium

Version and amendments history

Version	**Date** (MM/DD/YYYY)	**Created/Amended by**	**Changes**
V1	2022/10/28	Marco Molica Colella (PNO), Antonio Invito (PNO), Maryam Mirpourian (PNO),	Integration of data and elaboration

Table of Contents

List of figures

List of tables

List of Abbreviations (not explained in the text)

Acronym	Definition
C&I	Commercial and Industrial
CAGR	Compound Annual Growth Rate
CPC	Common Patent Classification
D&C	Dissemination & Communication
D&C&E	Dissemination, Communication & Exploitation
DoA	Description of Action
DoW	Description of Work
EC	European Commission
ETS	Emissions Trading Scheme
EU	European Union
FEED	Front-end Engineering
GHG	Green House Gas
IACS	International Association of Classification Societies
IEA	International Energy Agency
IMO	International Maritime Organisation
IP	Intellectual Property
IPO	Initial Public offering
IPR	Intellectual Property Right
LH2	Liquid Hydrogen
LNG	Liquid Natural Gas
M&A	Merge & Acquisition
PE	Private Equity
PESTLE	Policy, Economic, Societal, Legal, Environmental
R&D	Research & Development
R&D&I	Research, Development & innovation
RTO	Research & Technology Organisation
SME	Small Medium Enterprise
TIC	Testing, Inspection and Certification
UK	United Kingdom
US	United States
VC	Venture Capital
WP	Work Package

INTRODUCTION

The purpose of this report is to complete a multi-criteria stakeholders' analysis in the context of the sHYpS project's innovation landscape. Within this scope, a mixed network of innovative companies, investors, financiers, and public institutions is explored, therefore defining a proxy of the project's related *ecosystem*. Literature's definition to analyse different types of ecosystems are diverse and based on different sets of criteria: elaborating on some of them, such as (1), it is possible to extrapolate the following definition, which suits this work:

Innovation ecosystems are here considered as the set of actors that pursue business, technology, and innovation development in specific similar fields.

In contrast to many ecosystems' definitions, it should be noted that the ones analysed in this work are not necessarily locally connected, while networks are established by looking for R&D&I collaborations and topics. On top of that, an intelligence work is carried out to connect the dots and investigate their activities.

The overarching scope is supporting the sHYpS project to establish a functional knowledge of emerging opportunities and competing solutions, helping the development of targeted engagement and outreach strategies.

1 AIM, APPROACH AND CONTENT OF THE REPORT

1.1 AIM OF THE REPORT AND APPROACH

1.1.1 Relation to other tasks

The stakeholders' analysis included in this work is intended to be a tool to support:

i) ***project's dissemination*** - to customise and target the messages that the sHYpS consortium will cast to each specific group of players involved in the project's fields of interest, to ensure project's acceptance and uptake of its innovations, and get reactions and relevant feedbacks thereof.
ii) ***project's exploitation*** - identifying each specific group of players involved in the market sectors targeted by the project, and spot potential competitors or partners for future RD&I activities or business ventures.

To this aim, the stakeholder characteristics and motives have been analysed, to develop a provide an overview of the relevant players in and outside EU, with which the consortium could potentially build synergies. To support the EC's new directives, a gender mapping has been also developed.

The work in this deliverable is also the first step in the context of WP8, paving the way to the D&C&E tasks during the project. A concept workflow is shown in the next Figure 1-1.

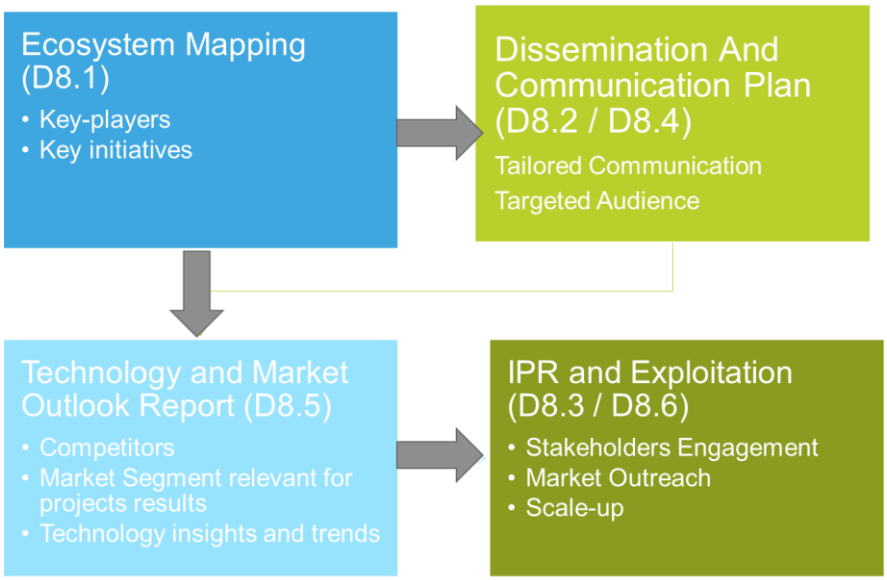


Figure 1-1: Approach to D&C&E through different deliverables

1.1.2 General methodology outline

The first step has been ***assessing the framework of the project, based on its KERs*** (Key Exploitable Results) map, as preliminary established at proposal stage. A PESTLE analysis has been then performed to identify the sHYpS value chain and the main keywords representing the project domain and consortium interests, which have then been validated with some of the project's partners.

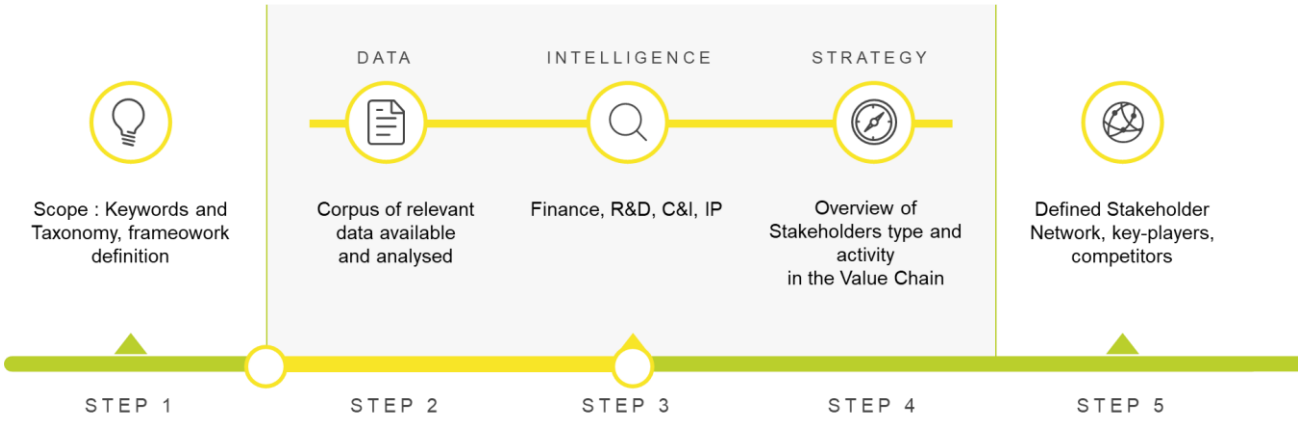


Figure 1-2: methodology concept

Based on the established framework, the core activity has been carried out by a thorough ***desktop analysis by PNO's analysts and consultants***. ***Multiple databases have been used to tap into public as well as not public data.*** Such data represent a unique combination of information – *an innovation scoreboard* – which have been then collected and elaborated according to PNO's methodologies, to present networks and innovation maps.

Special attention has been specifically paid to the ***production, logistics and use in maritime projects of liquid hydrogen***. Besides, it was decided to retain any possible information about R&D&I initiatives focussing on ***risk-based assessment***.

The key stakeholders include potential investors and funding agencies, as well as other stakeholders related to sHYpS. Further, organisations (both research centres and industries) active in transnational RD&I projects and publishing patents in the project domains have been investigated, to identify the high-level innovation trends in the targeted sectors.

1.2 CONTENT OF THE REPORT

This report includes 4 chapters, whose content is anticipated in the following:

- ***Chapter 2*** – a PESTLE analysis has been developed, to position sHYpS in the context of the market, regulatory and technical challenges related to the usage of liquid hydrogen as a fuel.
- ***Chapter 3*** – the sHYpS innovation ecosystem is described, starting from its value-chain's definition and building on R&D&I projects, mature private C&I initiatives, IP registrations and finance (private as well as public). Topics, maturity and general trends are elaborated, including a gender perspective.
- ***Chapter 4*** - key players (in and outside the EU) mapping and insights, with a view of feeding the D&C&E strategy and planning in the following of the sHYpS project

2 SHYPS CHALLENGES AND BACKGROUND – A PESTLE ANALYSIS

2.1 POLICY BACKGROUND AND ENVIRONMENTAL TARGETS FOR THE MARITIME INDUSTRY

The policy strategies related to sHYpS are pushed by global climate challenges and the fight against pollution. Therefore, sHYpS will respond to key directives from EC, IMO and the pioneering deadlines in Norway to protect fjords from air pollution and fulfil pollutants removal requirements in ports. The project can contribute to the evolution of the environmental legislation/directives and meeting their targets.

On the road to meet ***challenging climate targets for 2030 and 2050***, the shipping sector's contribution is of uttermost importance and faces great challenges ahead. Based on the European Green Deal, all emissions from EU transport needs to be reduced by 90 % by 2050. In this regard, from January 2018, large ships over 5,000 gross tonnage cargo or passengers at ports in the European Economic Area (EEA) need to report their CO_2 emissions. As a result, ***from 2019, ships calling into EEA ports have to report under both the EU Monitoring and Reporting Verification Regulation*** (MRV[1]) ***and the IMO Data Collection System***. Each year IMO shall produce an annual summary report to the IMO Marine Environment Protection Committee, while the Commission publishes a report to inform the public about the CO_2 emissions and energy efficiency information of the monitored fleet.

On the other hand, regulations concerning air pollution are not targeted by IMO yet, however, the port communities are increasingly addressing this issue. Norway, as already anticipated, is introducing a local air pollution regulation to protect the UNESCO world heritage fjords. It is foreseen that within a few years, this kind of legislation will be implemented in other European countries too.

[1] Monitoring and Reporting Verification Regulation - here

To sustain the change, in 2021, the EU has adopted a series of synergic legislative proposals, which include extending the Emissions Trading Scheme (ETS) to the shipping sector for vessels larger than 5,000 gross tonnage and calling at EU ports, boosting their use of renewable fuels and setting mandatory targets supporting an alternative fuel/energy infrastructure[2]. In the enlarged EU continental spectrum, Norway, has decided to push even further, by introducing ***zero emission requirements for cruise ships by no later than 2030.***

For the EC, 2021 has also been the year introducing a H2 Strategy for a climate-neutral Europe[3] to support decarbonizing various sectors including the maritime industry. In addition, the Commission will continue supporting research and innovation towards the decarbonisation of maritime transport, also through Horizon Europe (with a focus on the *Clean Hydrogen* JTI and *Zero Emission Waterborne Transport platform (ZEWT)*) and the *Innovation Fund* funding instruments.

This strategy, alongside continuing to push for global action at the International Maritime Organization (IMO)[4], is supposed to accelerate the use of H2 as an alternative fuel in Europe. The hydrogen push, however, is global. For instance, Japan and Australia are pushing forward to build a H2 economy and aim at H2 as a key source of power. Several companies, industrial clusters, and financial associations are therefore starting to invest in the H2 market. Some ***global companies have launched their net zero emission strategy through the application of hydrogen (H2) on board.***

2.2 HYDROGEN ECONOMY AND MARKET

The sHYpS' solution can effectively support the development of a hydrogen economy and bring new knowledge, jobs, and capitals in EU.

Europe's economy is experiencing a major shock. The rising price of oil & gas has been severely affecting the global economy and increasing energy prices. ***As of May of 2022, Europe's Inflation rate was recorded as 8.8%,*** which is higher than the prior peak in 2008 (4.4%) (2). This economic condition calls for an urgent action to end the dependence on fossil fuels and support the usage of clean energies in various sectors.

Besides, as implication of the Ukraine war, ***Europe is finally convinced to reduce its energy import*** (3). It is very likely that in the mid-term the war will accelerate the clean energy transition and adoption of alternative fuels. ***As a result, hydrogen momentum is expected to increase, with more financiers possibly engaged in the H2 market.*** This assumption seems to be confirmed in Chapter 3 of this report.

[2] Reducing Emission from the Shipping Sector – European Commission, here
[3] H2 Strategy for a climate-neutral Europe - COM(2020) 301 final
[4] The International Maritime Organization (IMO) set a target to reduce the average carbon dioxide (CO2) emissions by at least 40% within 2030, and 70% by 2050 compared to the 2008 level (12).

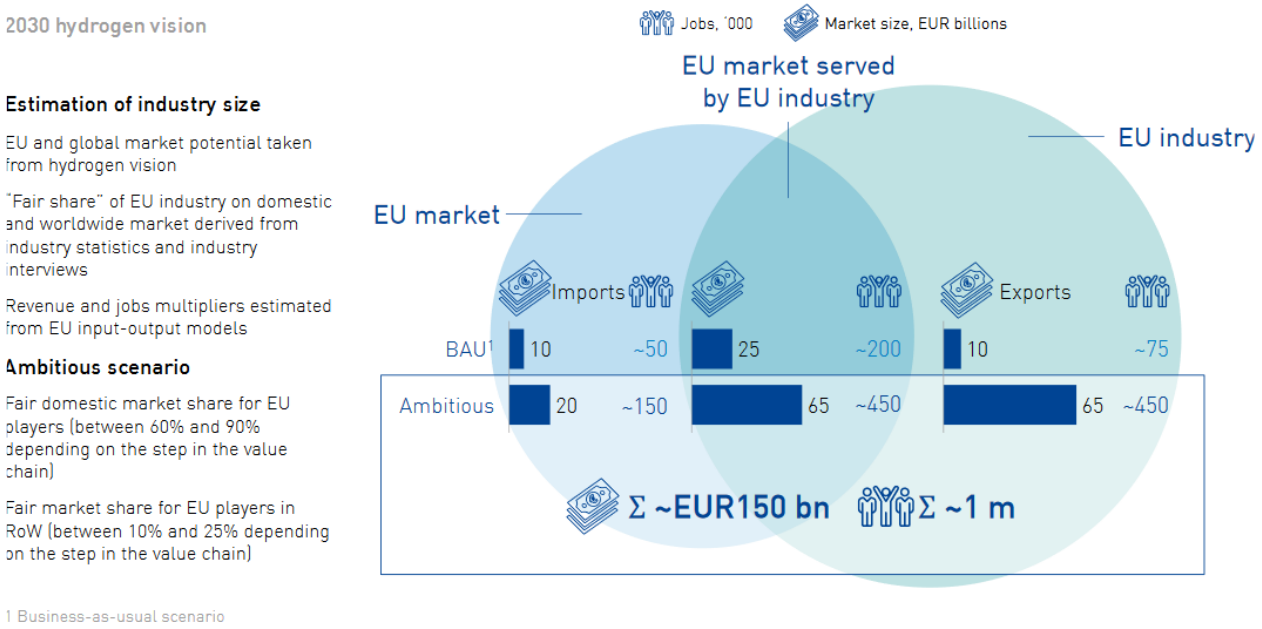


Figure 2-1 : Revenues And Employment In The Hydrogen Economy, 2030 (Hydrogen Roadmap Europe)

The ***demand for clean energy and a climate neutral economy has kept rising*** (4) (5) (6). *The market size of the global green H2 was US$ 445 million in 2021 and is projected to increase to US$ 4,377 million by 2027. This portrays that the green H2 market is expected to grow at the Compound Annual Growth Rate (CAGR) of 58.1% in 2022-2027* (7).

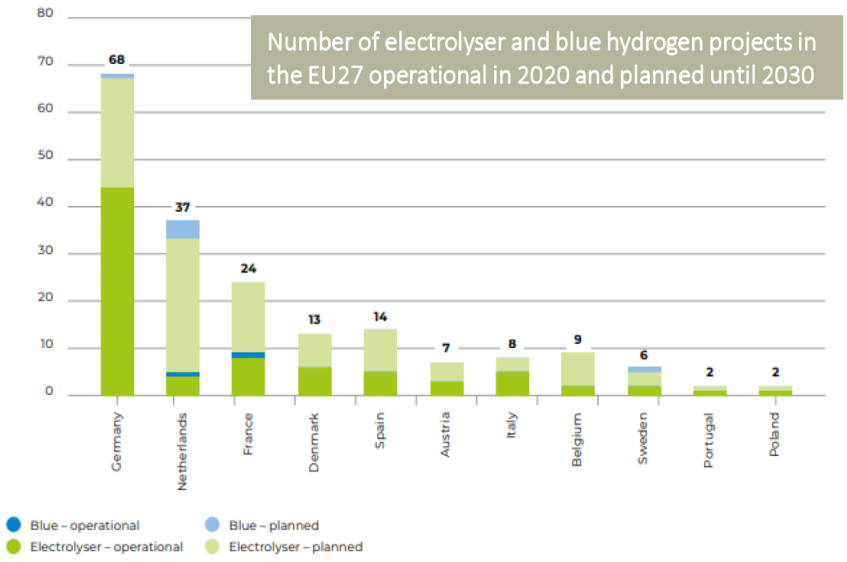


Figure 2-2: PNO elaboration from (13)

The maritime industry can make no exception and all the actors involved in the maritime value chain will need to take corporate responsibility and expedite towards a green transition, not to risk that its profits can be affected. sHYpS can support the industry, by establishing a green brand image opportunity and business case. As a matter of facts, the containerized ISO container developed by the project will provide an opportunity for a broad application of LH2**,** in maritime as well as other industries, such as pharma, chemical, and food. On the other hand, the project can contribute to scale up the logistic value-chain.

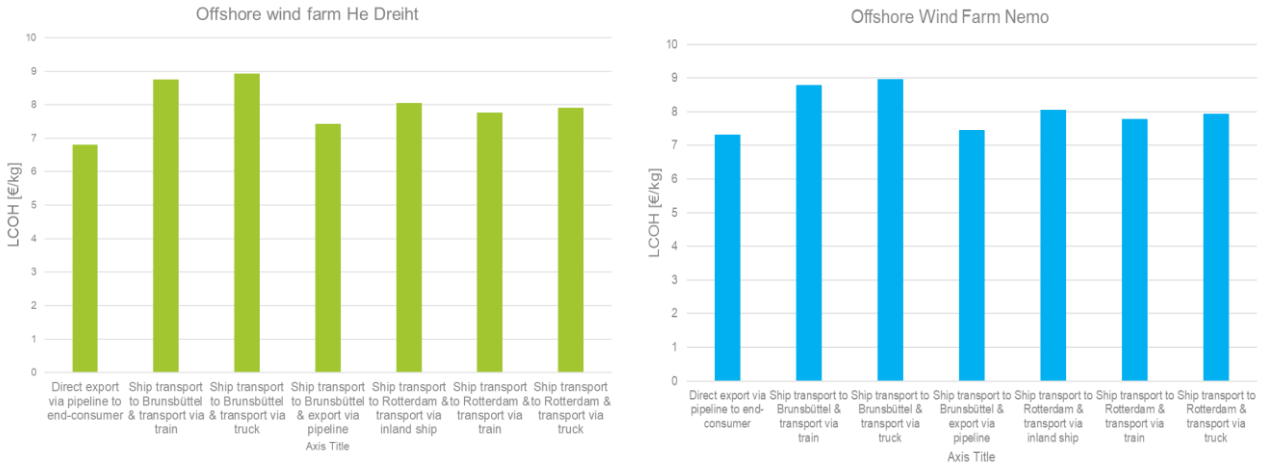


Figure 2-3. Cost comparison of the green H2 transportation scenarios between Offshore Wind Farm He Dreiht and Nemo (8)

The ***main market barrier to green H2 is its relatively high cost*** (7). Currently, ***the production cost of green H2 (ca. 4.65€/kg) is three times higher than that of grey H2*** (ca. 1.4€/kg). Green H2 is still significantly more expensive than blue H2, and the key variables defining its price are the electrolysers costs as well as the renewable energy costs and availability. On the other hand, logistics and transport affect costs as well, and they are an important barrier to the application of H2 in the maritime industry: ***LH2/CH2 transport cost is relatively expensive due to the absence of a structured value chain***, their transport can take place via pipelines, ships, trucks, and trains. Currently, the lowest H2 transport cost examples are registered when pipelines are used, taking LCOH (Levelized Cost of Hydrogen) between 6.81€/kg to 7.31 €/kg. These numbers can vary depending on distance, infrastructure, and logistics (Figure 2-3).

However, green hydrogen projects are the majority in the current pipeline in EU (Figure 2-2): the situation is foreseen to change within 3 decades, depending on technology, finance, and economy of scale through significant demonstrations as well as the increase in carbon taxes, likely pushing to invest in this market.

2.3 Technology. Practical And Regulatory Aspects

The technical, logistics and legal aspects necessary to use hydrogen on board are still immature, hindering investments. sHYpS can set the standard for future handling and transport of LH2 in containerized tanks, since it will study all aspects of the design with no compromise on safety and reliability, defining a full logistics value-chain.

From a technological standpoint, the application of ***LH2 onboard is challenging*** due to several reasons.

- ***hydrogen is liquid at very low temperatures, -253 °C.***
- it has a ***large volumetric expansion*** when passing to the gas state (ratio of gas/liquid volume is about 850).
- ***hydrogen is explosive in a wide interval of concentrations*** (4.7-75%), while this interval for fossil fuel is 1-6%, and for LNG is 5%-15%.
- ***LH2 leakages*** can damage the hull of the ships. When LH2 spills, a fast cooling of the deck surface occurs, due to evaporation of the liquid in the ambient, rendering the surface brittle. In addition, the vapor clouds formed with evaporation are perilous for humans.

- Finally, ***the effect of ships motion on LH2 container*** is another challenge for its use onboard[5].

There are no IACS[6]-approved rules or safety guidelines for the Hydrogen installation onboard. Due to these immature aspects, many financiers are still hesitant to invest in hydrogen projects in the shipping industry.
According to IMO: *Draft interim guidelines aimed at providing international standard provisions for ships using fuel cell power installations have been agreed by IMO's Sub-Committee on Carriage of Cargoes and Containers (CCC 7). The draft interim guidelines cover issues including fire systems and gas/vapour detection. The guidelines are intended to ensure the safe and reliable delivery of electrical and/or thermal energy through the use of fuel cell technology. The development of these interim guidelines for safety of ships using fuel cells is part of the important work being carried out by the Sub-Committee in the context of shipping's need for new fuels and propulsion systems to meet decarbonisation ambitions set out in the Initial IMO GHG Strategy.*

On the other hand, one of the main challenges is the lack of an established supply chain**.** The project will provide evidence that the upscaling of the solution is achievable by 2025, if supply is in place. Thanks to sHYps, different stakeholders (designers, transportation companies, regulatory bodies, port authorities, port operators, vessel operators, and especially crews) will gain the experience and confidence necessary to deal with hydrogen during its transport and use onboard. Establishing logistics and supply is a key target for the project exploitation.

To address these issues sHYps will also study the correct choice of construction materials and design a container that can withstand the effects of ship motions.
[6] International Association of Classification Societies

3 SHYPS INNOVATION ECOSYSTEM

This chapter aims at describing and mapping the ecosystem of actors that is currently engaged in the challenges of the sector and concurring to their solution. The project value-chain has been modelled below as a basis to define the ecosystem's actors. The sections of the chain covered by the partners are highlighted in greenish.

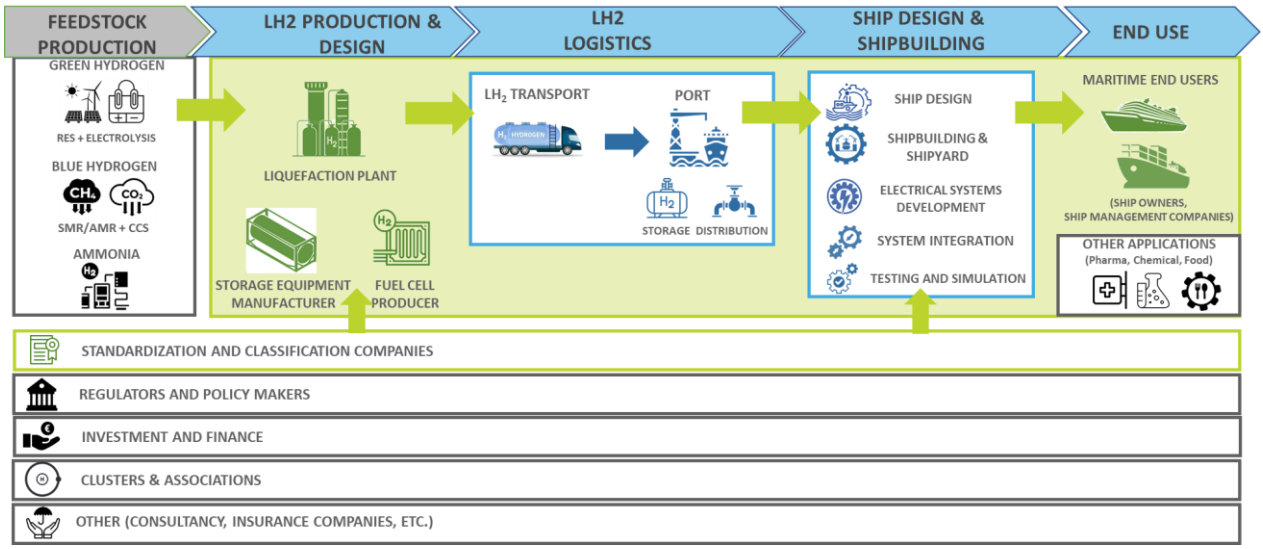
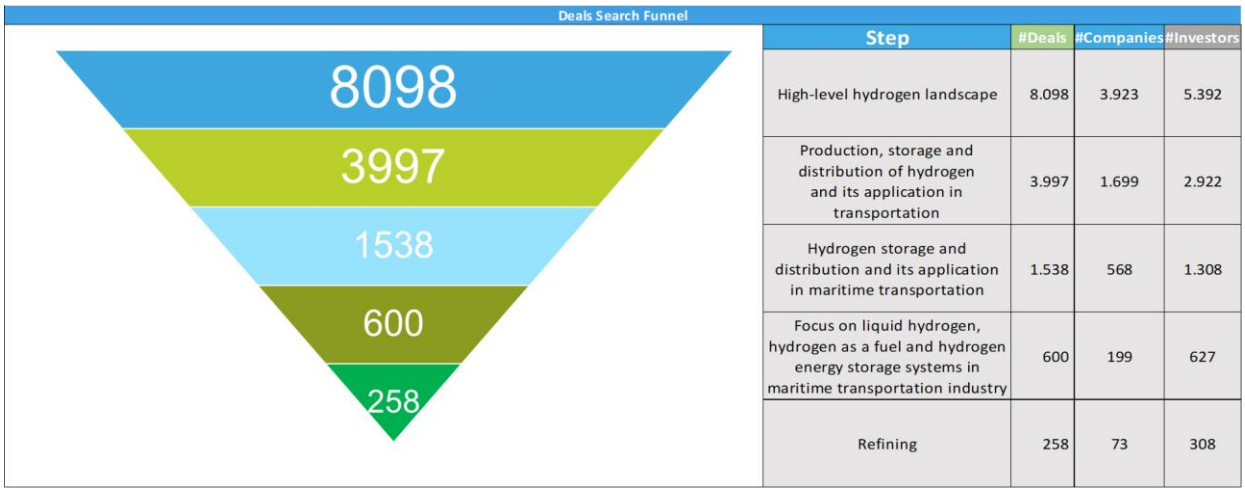


Figure 3-1: sHYpS value-chain model

3.1 THE FINANCIAL PERSPECTIVE

Hydrogen financing is an increasing trend, and this statement applies to both private and public funding. This report has investigated both dimensions.

3.1.1 Private Funding



Step	#Deals	#Companies	#Investors
High-level hydrogen landscape	8.098	3.923	5.392
Production, storage and distribution of hydrogen and its application in transportation	3.997	1.699	2.922
Hydrogen storage and distribution and its application in maritime transportation	1.538	568	1.308
Focus on liquid hydrogen, hydrogen as a fuel and hydrogen energy storage systems in maritime transportation industry	600	199	627
Refining	258	73	308

Figure 3-2: Private investment analysis' key results (deals, companies, investors)

We have analysed the investments trends looking at deals from VC to IPO and M&As (Figure 3-2). The first level of investigation focussed on a bird's view over the hydrogen field. It shows that in the last 10 years there have been more than 8.000 traceable deals, equal to ca. 300 billion euros.

With the following steps in our analysis, we have gone deeper, up to highlighting that the specific use of hydrogen and liquid hydrogen as fuel in maritime transportation, together with H2/LH2 storage systems has led to almost 1.200 deals for investments of about 30 billion euros in the last 10 years. In the final close-up we have further restricted the field, *involving only companies and deals related the maritime application, H2 and LH2 supply chain and LH2 containment systems*. According to our analysis, ***the application of the technologies related the use of hydrogen and liquid hydrogen as alternative fuels in the maritime sector has led to investments of almost 20€ billion in the last 10 years, with about 530 deals in our radar*** (Figure 3-3).

The general trend highlights predominant VCs funding rounds, which indicates early financing and thus a "young", growing sector. On the other hand, strategic M&As and PE are visible. The investments have peaked in 2021, probably also due to a re-start after the pandemic (Figure 3-4), on top of the immediate follow-up of the Paris Agreement.

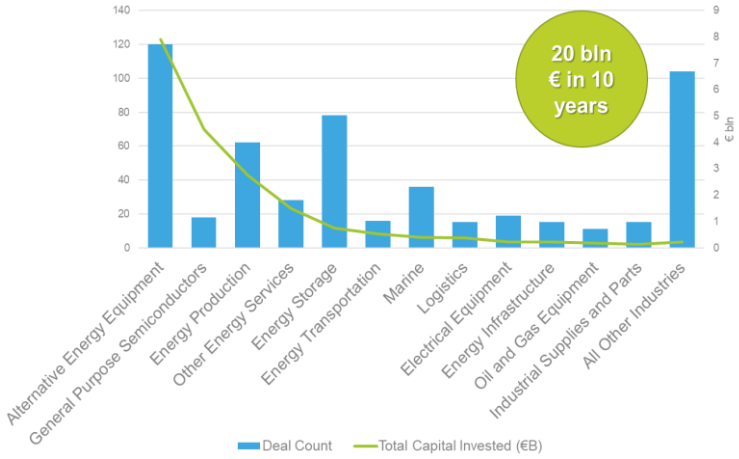


Figure 3-3: Investments and deals by industry

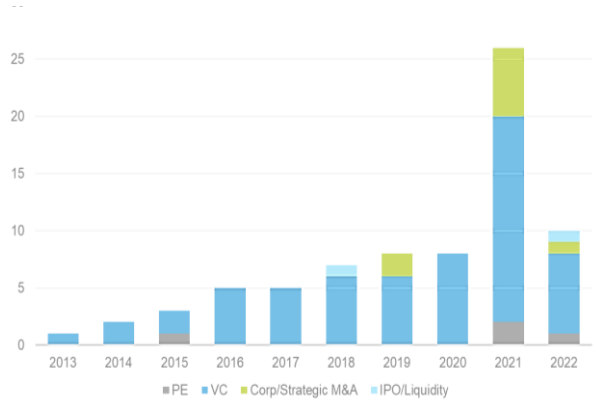


Figure 3-4: Deals by type

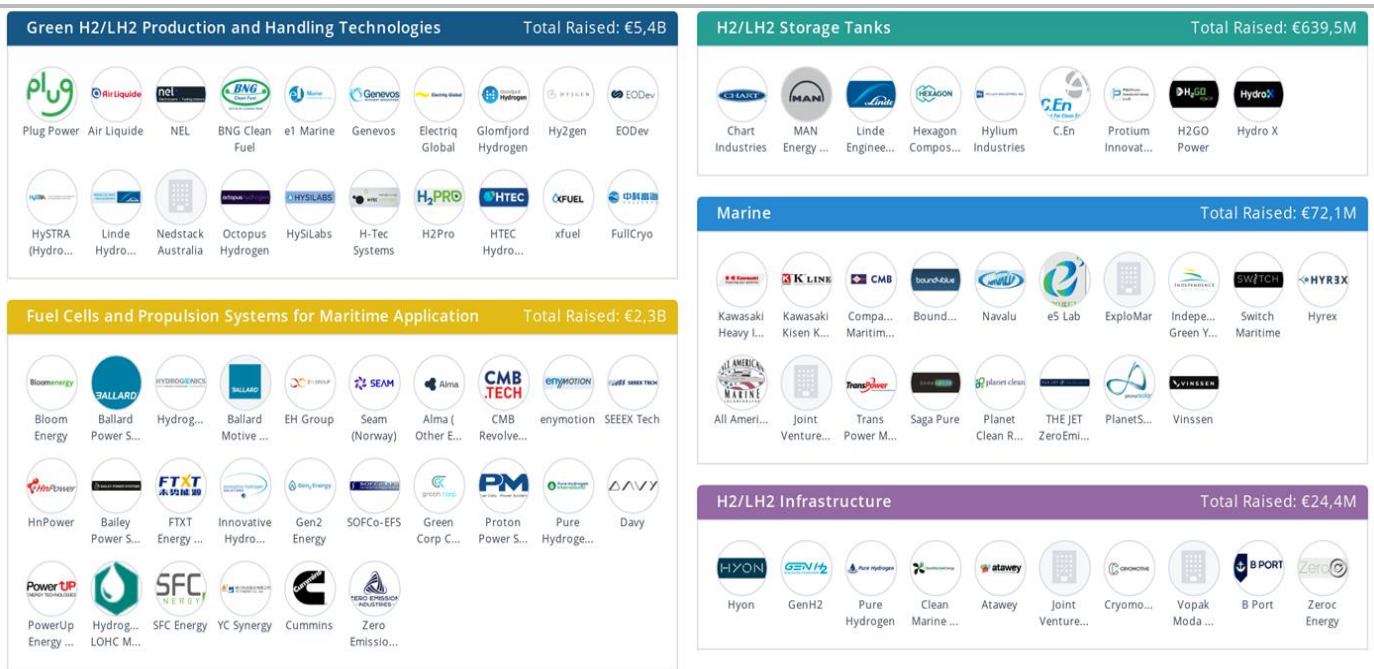


Figure 3-5: Relevant players identified looking into private investments

A general overview of the key players emerging from this analysis is summarised by Figure 3-5. The final iteration has identified 73 relevant companies and 308 private and institutional

investors. The footprint is global, involving US, Korean and Chinese companies that are developing business and investing. The picture divides different organisations by expertise and highlights the total raised funding. A focussed description of different the *Emerging Players*, including acquirers (of other companies), investors and top companies in terms of capital raised is reported in Chapter 4.

3.1.2 Public Funding

Public funding includes a series of policy measures (grants, incentives) that are compliant to the policy background described in Section 2.1. In this paragraph, the focus goes on public money to fund hydrogen-related projects.

All in all, we tracked more than 100 M€ funding since 2016, provided to R&D&I in the sHYpS domain by EU, Norway, Germany, Italy, The Netherlands and other Nordic countries.

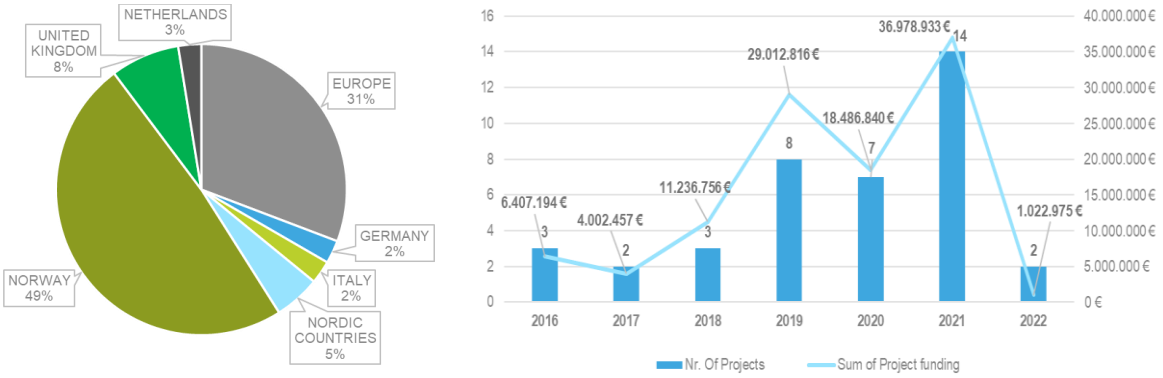


Figure 3-6: public funding from R&D&I programmes in EU addressing sHYpS thematical areas

As a matter of facts, hydrogen-related funding supports production (green), logistics, grid networks, and new technology developments. These aspects are addressed by different programs at EU and national levels. sHYpS will monitor and clarify these funding opportunities to support the establishment of a supply-chain. In the following, an introductory scheme is reported, that will be the base for a detailed analysis in the next months (Figure 3-7). They include Horizon Europe (the large R&D programme that also funded sHYpS), LIFE (the European programme for environment), CEF (Connecting Europe Facilities), Innovation Fund, PCIs (Project of Common Interest) and IPCEI (Important Project of Common European Interest)

All in all, the ***landscape and quantity of funding is growing, since new programmes are massively addressing hydrogen***. For example, since the creation of the *Innovation Fund* (2020), the first 2 rounds of funding have delivered almost 3 billion Euros only considering the 24 large scale approved projects (small scale projects have been financed too on a separate call). Hydrogen is involved primarily in terms of production (with funding per project in the order of hundreds million) in the large-scale projects, as well as in some maritime applications with smaller budgets in the order of 10 million for small scale projects. Notably, electrolysers have been included as a separated category of the European PCI (Projects of Common interest), whose lists allow to access to CEF Energy funding (Connecting Europe Facility). The RePowerEU plan will also reinforce these contributions.

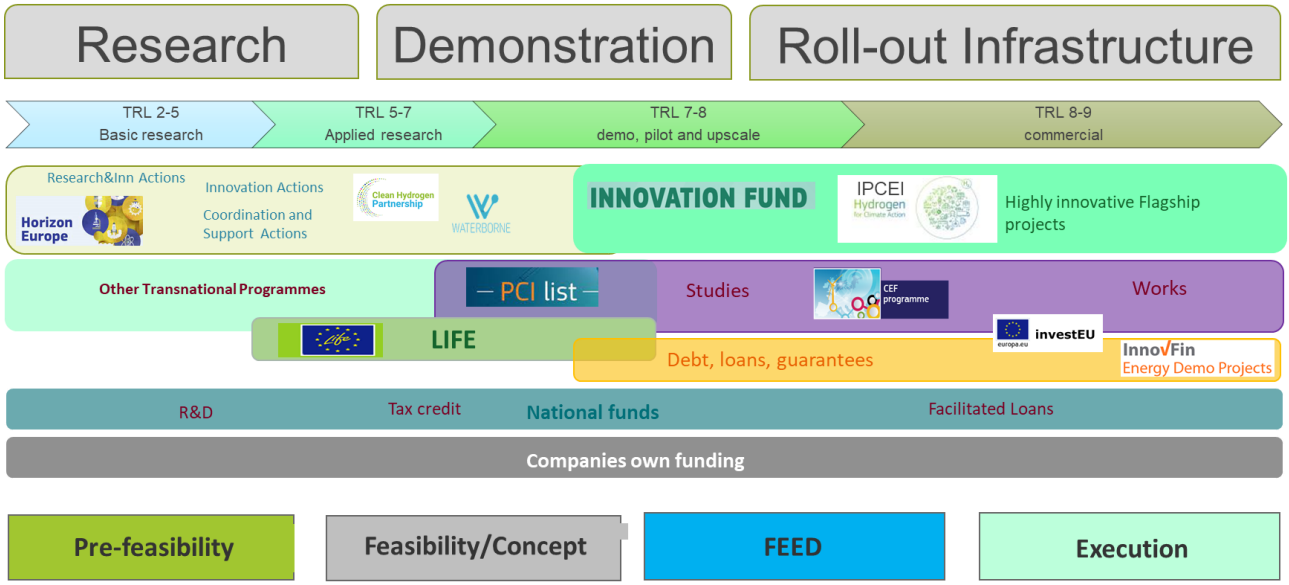


Figure 3-7: EU funding map sketch showing different schemes compared to TRL (Technology Readiness Levels) and stage of development

3.2 The Technology And Innovation Arena

3.2.1 Projects and Innovation benchmarks

As explained in Chapter 2, the innovation and business focus of sHYpS concerns production, logistics and use in maritime projects of liquid hydrogen, including risk-based assessment. Therefore, we retained these areas of interest in our analysis in the first place, but also considered H2 production and supply to spot possible hubs for production which can be interesting for logistics.

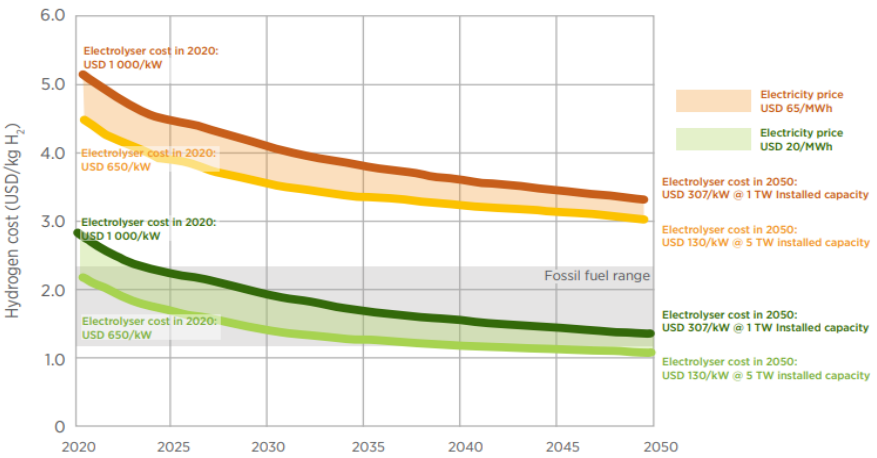


Figure 3-8: Hydrogen costs overview, parametrised by electrolysers cost (source IEA (14))

As a matter of facts, there is a vast pipeline of green hydrogen projects expected in the next years, which is supposed to progressively integrate and then replace the current majority of blue hydrogen production (Figure 2-2). The RePowerEU programme has set a target of 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of imports by 2030. The main techno-economic barriers for this are the cost and abundance of renewable energy, as well as the costs of electrolysers. While the latter one is a technology issue, the former also depends on geography, with countries like the Netherlands and Sweden at the first places for low prices (9).

Therefore, on the one hand, ***we have looked into emerging technology developments (R&D&I) and on the other hand into current – privately financed – C&I projects, exploring the complete spectrum of maturity.***

The selected projects have been mapped and categorized based on the **type of feedstock** (compressed hydrogen, ammonia or liquid hydrogen) and on the main objective in relation to sHYpS.

R&D&I projects objectives	C&I projects objectives
• ***Logistics and transportation*** - If the selected project involves the optimization of supply chain via innovative bunkering, storage and distribution solutions for the maritime sector; • ***Technology development*** **-** If the selected project is focused on the development of fuel cells and containment systems for the storage and use of LH2/hydrogen/ammonia for maritime sector; • ***On-board containment + propulsion system*** **-** If the selected project provides the entire integrated system for on-board storing and using LH2/hydrogen/ammonia for vessel propulsion.	• **Production and Supply** (no maritime sector specified) - If the selected project focuses on the production and/or supply without mentioning the application in maritime transport (to understand where possible distribution hubs are emerging); • **Maritime transport application** - If the selected project is focused on the production and / or distribution of hydrogen or LH2 for maritime transport; • **On-board technology development** (fuel cell, propulsion system, etc.) - If the selected projects is focused on the development of fuel cells, propulsion or containment systems for the usage of LH2/hydrogen/ammonia in maritime sector; • **Vessel on-board integration** - If the selected project provides the on-board vessel demonstration of the use of LH2/hydrogen/ammonia.

3.2.1.1 Used Databases

We have started data collection from the original benchmark provided by partners at proposal stage and we have then considered ***PNO's intelligence tools and four additional public databases: NOW GmbH***, the National Organisation Hydrogen and Fuel Cell Technology, which has mapped the German-funded projects in the field of hydrogen and fuel cells; ***EntsoG***, (European Network of Transmission System Operators for Gas) that launched a hydrogen projects platform; ***Innovation Fund***, the funding programmes for the large scale demonstration of innovative low-carbon technologies, managed by the EC and ***NextGEN***, the IMO's platform mapping all the projects aiming to decarbonise the maritime transportation.

We have opted to retain all the projects related the use or potential use of hydrogen in maritime transportation and those related to the storage and distribution of liquid hydrogen. The only exception is represented by the projects from *Innovation Fund*, from which we also retained the ones with the main aim of establishing a hydrogen hub / distribution centre.

3.2.1.2 C&I projects map

***A total of 64 C&I projects were selected, leading to 172 different potential stakeholders**, **most of which are large companies (90) and SMEs (51)**.*

By geography, 35 stakeholders are from Germany, 18 from the Netherlands, 17 from the United States and 15 from Norway and Japan (Figure 3-10).

Figure 3-9: C&I projects concept map

By type, as expected, ***C&I projects are dominated by the private sector***, with large corporates and SMEs being a prominent share. We found evidence that, out of the 172 emerged stakeholders ***66 are also project developers /investors / financiers, followed by feedstock producers (36) and end-users (30).*** The represented value-chain (Figure 3-11) is thus concentrated on the construction side and the provision of supply. The project finance is mostly consolidated by the large corporates involved, but banks are also explicitly presented among projects promoters. ***The most active players are presented with details in Chapter 4, but a snapshot is visible in Figure 3-11***, where they are shown with respect to the number of relevant projects in which they appeared.

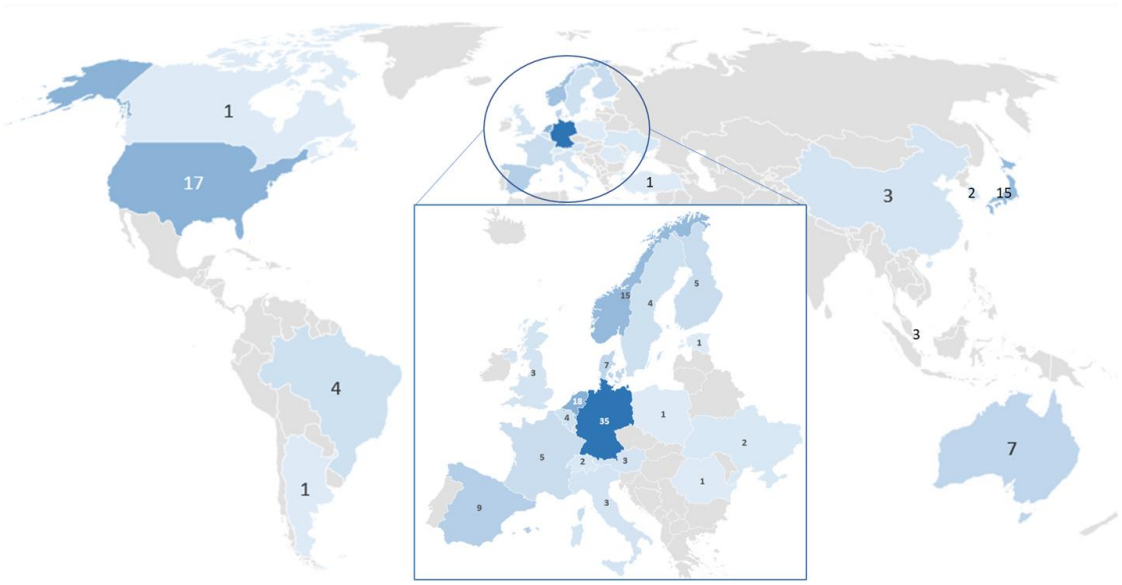


Figure 3-10: C&I projects stakeholders' geography

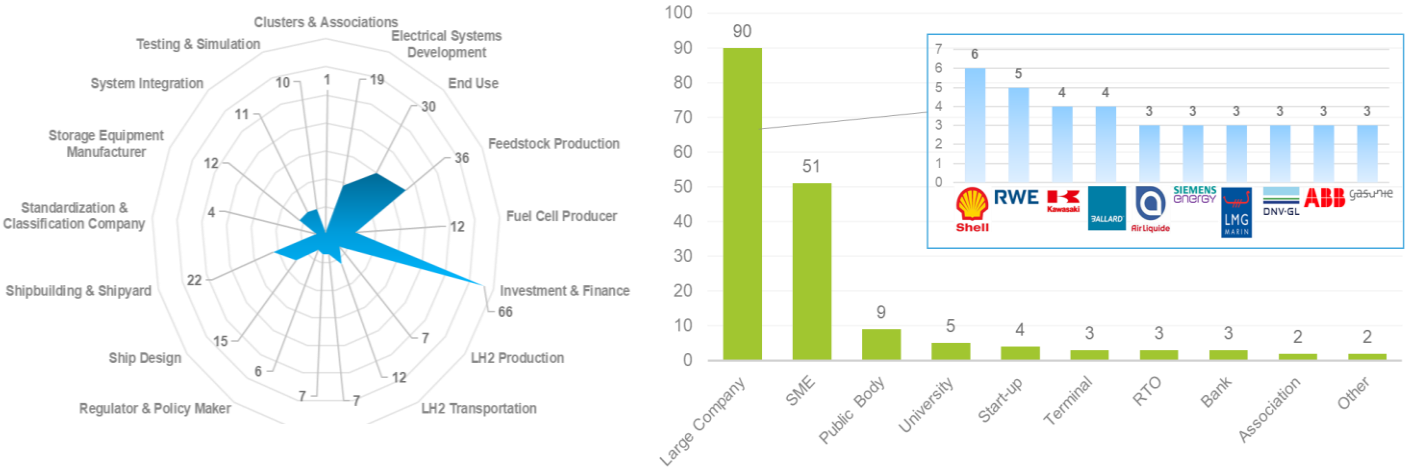
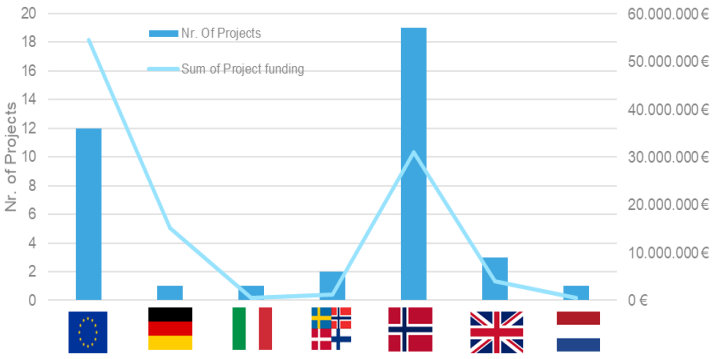


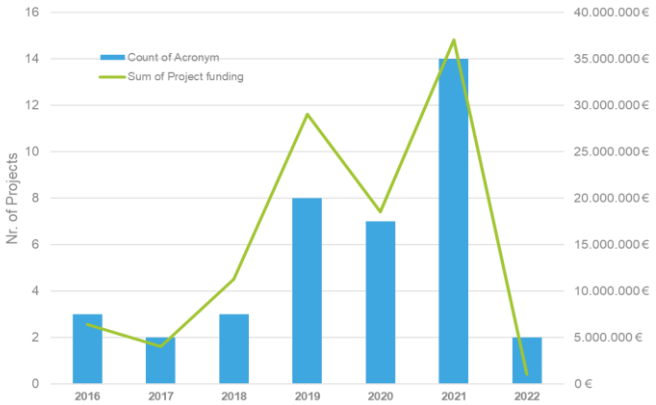
Figure 3-11: C&I projects stakeholders' classification by value-chain positioning (left) and organisation type, including top promoters (right)

3.2.1.3 R&D&I projects map

40 relevant public funded projects were finally selected[7], all started after 2016, showing a sharp growth trend from 2019 (

). 19 of these are funded by Norway with around 31 Million €, while 12 belong to various programmes





funded by the European Commission with 54.5 Million €.

[7] 39 + 1, considering the project NH3CRAFT, funded on the same call as sHYpS. Information about this project was not available at the time the data were analysed. So, even if included in the map, it is not included in the statistics. The numbers also don't consider sHYpS.

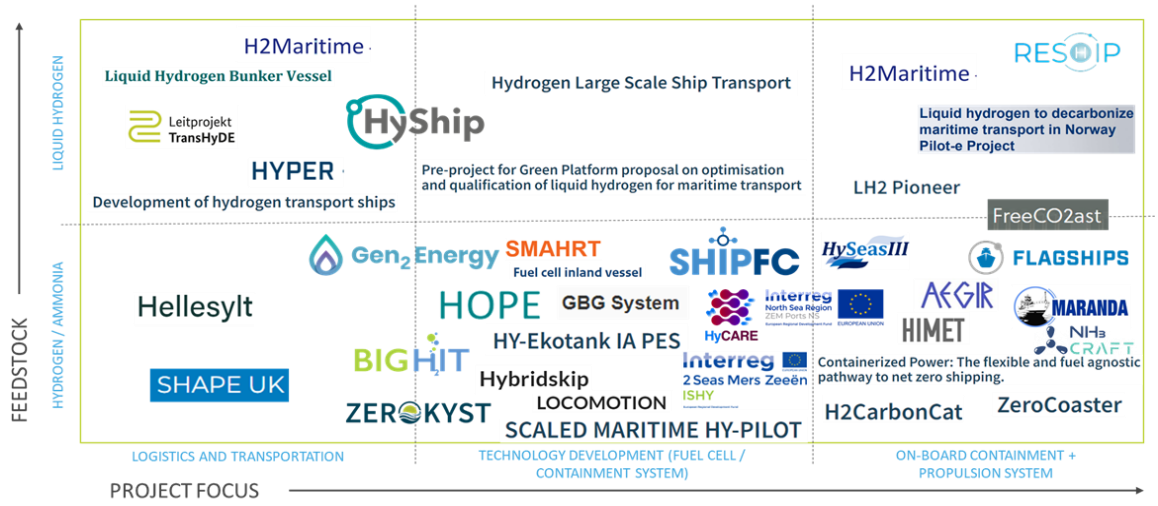


Figure 3-12: R&D&I projects concept map

Based on their belonging to the sHYpS value-chain, ***146 different stakeholders (corresponding to ca. 270 project participations) were identified, of which 56 are SMEs, 41 large companies, 15 RTOs and 11 universities***.
By geography, 60 of these come from Norway, followed by the UK with 27 and Germany with 11 organisations.

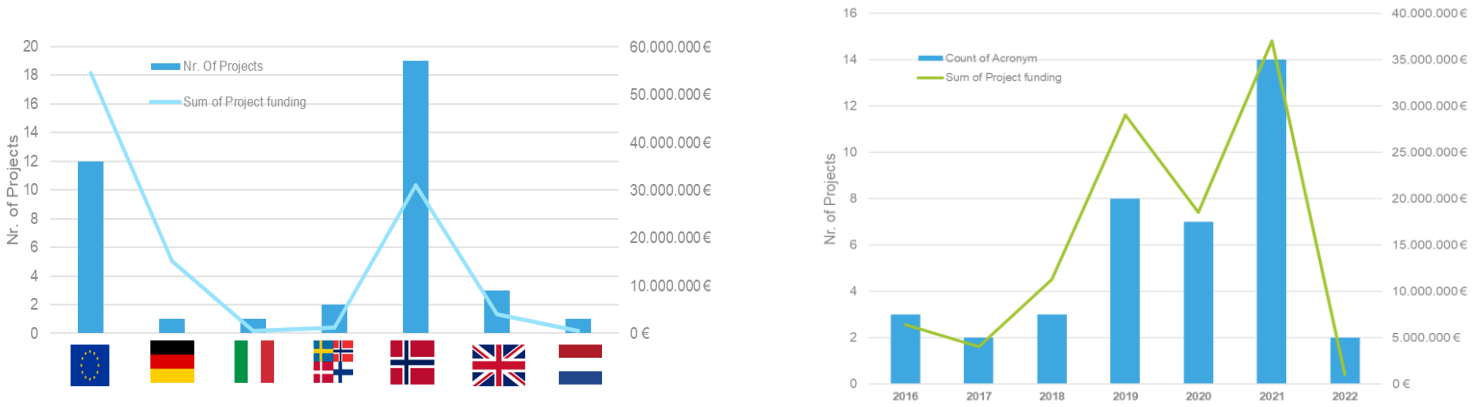


Figure 3-13: Number of selected projects and funding per funding country (left) and year (right)

The 146 stakeholders that have been identified represent the entire value-chain, differently from the C&I case. ***Projects partners and promoters include many more technology developers, class societies and TICs, ports, and R&D institutions***. ***Associations, public bodies and infrastructure management companies are also included.*** From the technology standpoint, the expertise includes storage equipment manufacturers, electrical systems developers, shipyards and end-users. It should also be noted that different stakeholders can have different roles for each participation, therefore 30 participations include a role also supporting further investments/scale-up. For example, players like AirLiquide stand out, which can integrate a strong vertical value-chain from hydrogen production to project development and finance. All in all, there is a high end-users' participation, highlighting a large interest and possibly a fast development to market stage and real applications. More details are presented in Chapter 4.

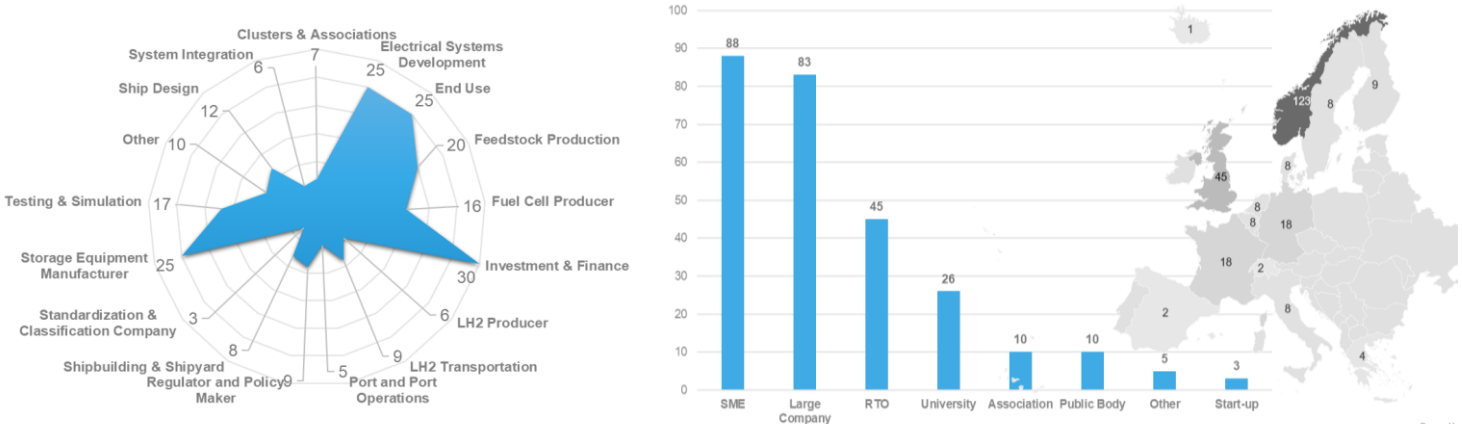


Figure 3-14: R&D&I projects stakeholders' classification by value-chain positioning (left) and organisation type, and countries (right)

3.2.2 Patenting and IP benchmark

To complete the innovation & technology mapping and benchmarking, a patent analysis has been carried out to integrate the projects investigation. Consistently, the focus of the intelligence was on the application of LH2 as alternative fuel in the maritime sector and the LH2 storage systems for maritime applications.

The investigation was carried on through PNO's specific intelligence tools, on a database of tens of millions of patents from a global portfolio. The queries funnel was very steep, starting from 44k documents, which were then limited to ca. 600, by refining the keywords, retaining publications dates from 2012, and identifying a set of relevant CPCs as shown in Table 1.

Table 1: relevant CPC for the sHYpS case

List of relevant CPC	
CPC	**Description**
B63	SHIPS OR OTHER WATERBONER VESSELS; RELATED EQUIPMENT
F17	STORING OR DISTRIBUTING GASES OR LIQUIDS
F25J	LIQUEFACTION, SOLIDIFICATION OR SEPARATION OF GASES OR GASEUS
H01M	BASIC ELECTRIC ELEMENTS: PROCESSES OR MEANS (E.G. BATTERIES OR FUEL CELLS)
Y02E	TECHNOLOGIES OR APPLICATIONS FOR MITIGATION OR ADAPTATION AGAINST CLIMATE CHANGE
Y02T	CLIMATE CHANGE MITIGATION TECHNOLOGIES RELATED TO TRANSPORTATION

A total number of ***14 top-relevant patents*** has been eventually shortlisted, most of which have as their objective the storage or distribution of gases or liquids, the development of fuel cells and their application in the naval sector. ***From the selected patents, 11 top applicants have emerged. They are mostly (7 out of 11) large-size companies. 3 are from South Korea and 2 from Japan*** (see Figure 3-15). More details are reported in Chapter 4.

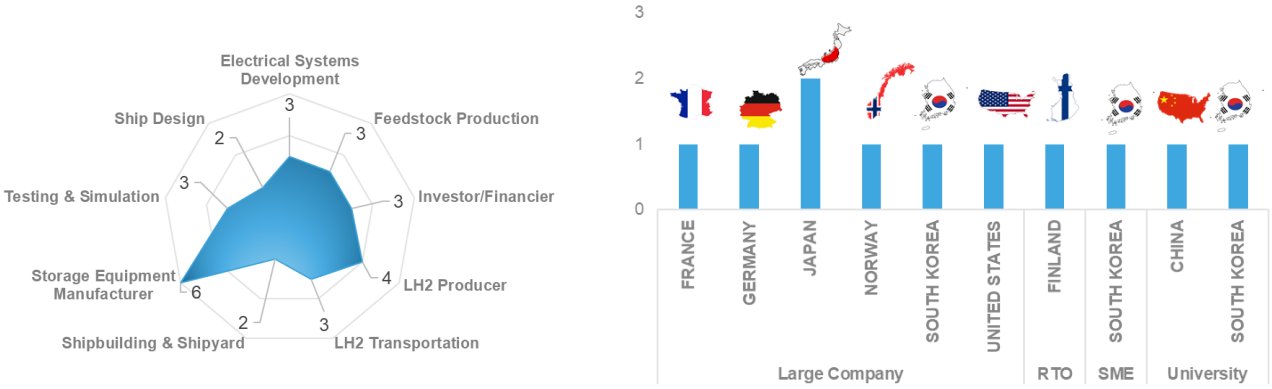


Figure 3-15: key applicants expertise (left); country and type (right)

3.3 GENDER PERSPECTIVE

According to IEA, women's participation in the energy sector is below that of the broader economy and varies widely across energy sub-sectors. ***In this report, a gender analysis was carried out to complete the characterization of the sHYpS ecosystem which confirms this underrepresentation, with only few exceptions.***

A sample of 40 organisations (whose selection is explained in the next chapter) was considered, which was made of 25 large enterprises and 8 SMEs (incusing a start-up), the rest being research organisations.

Both for **SMEs and research centres,** we looked for the gender profiles of the project managers and/or inventors of the analysed patents. These were completed by looking at the top management figures (for SMEs) or at the administration and management charts, together with the decision-makers of the interesting departments when available (for research centres).

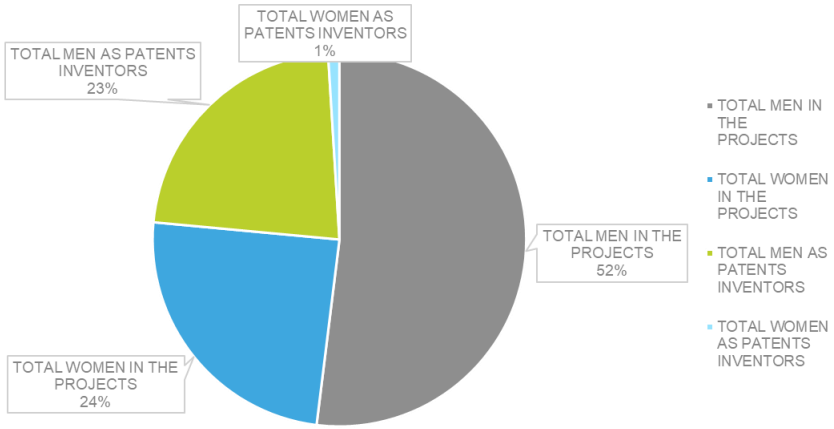


Figure 3-16: Gender balance in the R&D&I activities analysed for 40 sHYpS stakeholders

Looking at the R&D&I level - we counted 53 males and 25 females as referents of the funded projects. This numbers drop when we considered patents, where females are 1 against 23 males.

Looking at the management level – as far as the 8 SMEs are concerned, our review showed that in there is an average of 83% male presence at managerial level compared to 17% female presence. Among those present, the only one to have a female CEO is the French PERS-EE. On the 7research centre's side, the administration and management charts, together with the decision-makers of the interesting departments, showed an average of 54% male presence compared to 46% female

presence. In particular, NTNU and VTT are the only ones to have a greater female than male presence.

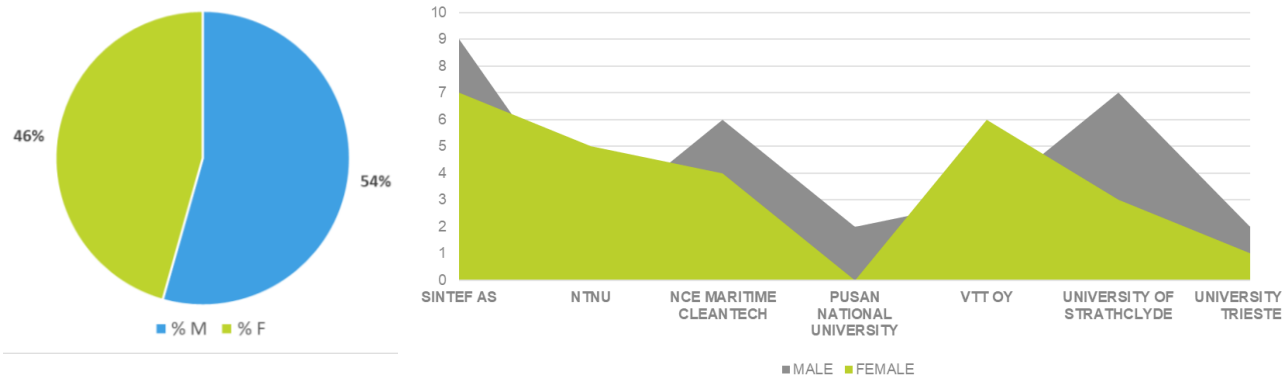


Figure 3-17: Gender Distribution in the TOP R&D Organisations at Administration and Management Level

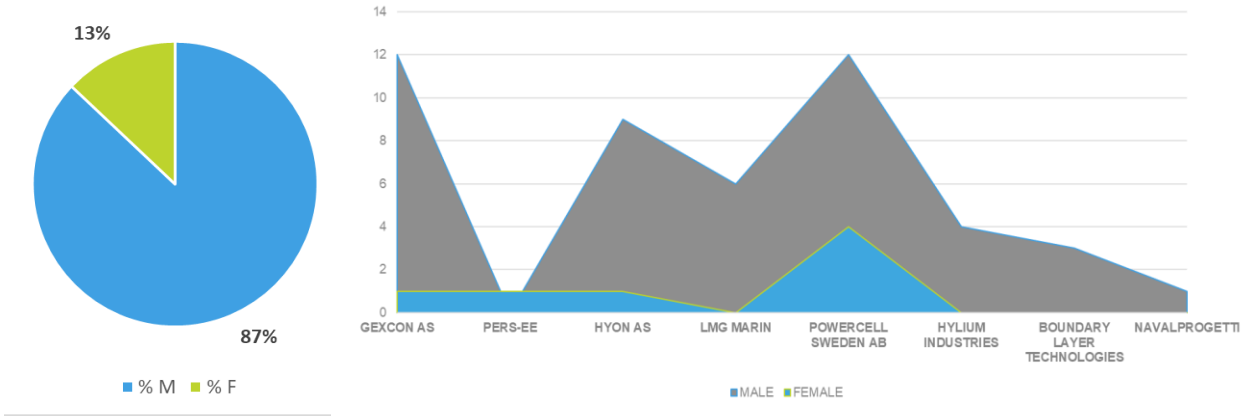


Figure 3-18: Gender Distribution of the TOP Small and Medium Size Companies at Management Level

In order to study the gender balance of the **large industries** in our sample, we directly considered the gender equality information inside their company reports, where diversity and inclusion are discussed. We have then looked at both the men/women ratio in terms of total employees and in terms of management.

The analysis has shown a clear prevalence of men both in terms of total employees and managerial figures, with the only exceptions of Lloyd's which has a ratio of men to women of 57/43 in terms of total employees and Norled AS who has 55/45 in terms of managerial figures.

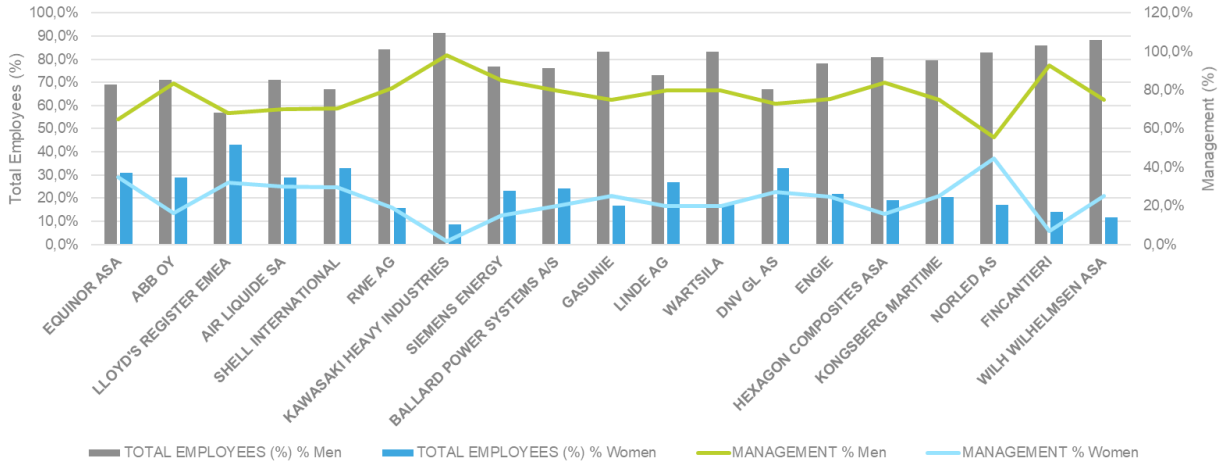


Figure 3-19: Gender Distribution of the Most Relevant Large Companies in both Overall Employeement and Management Areas

4 KEY STAKEHOLDERS

4.1 OVERVIEW AND INSIGHTS

All in all, almost 300 unique stakeholders were identified as described in the previous chapter. A value-chain representation of a significant part of them is reported in Figure 4-1

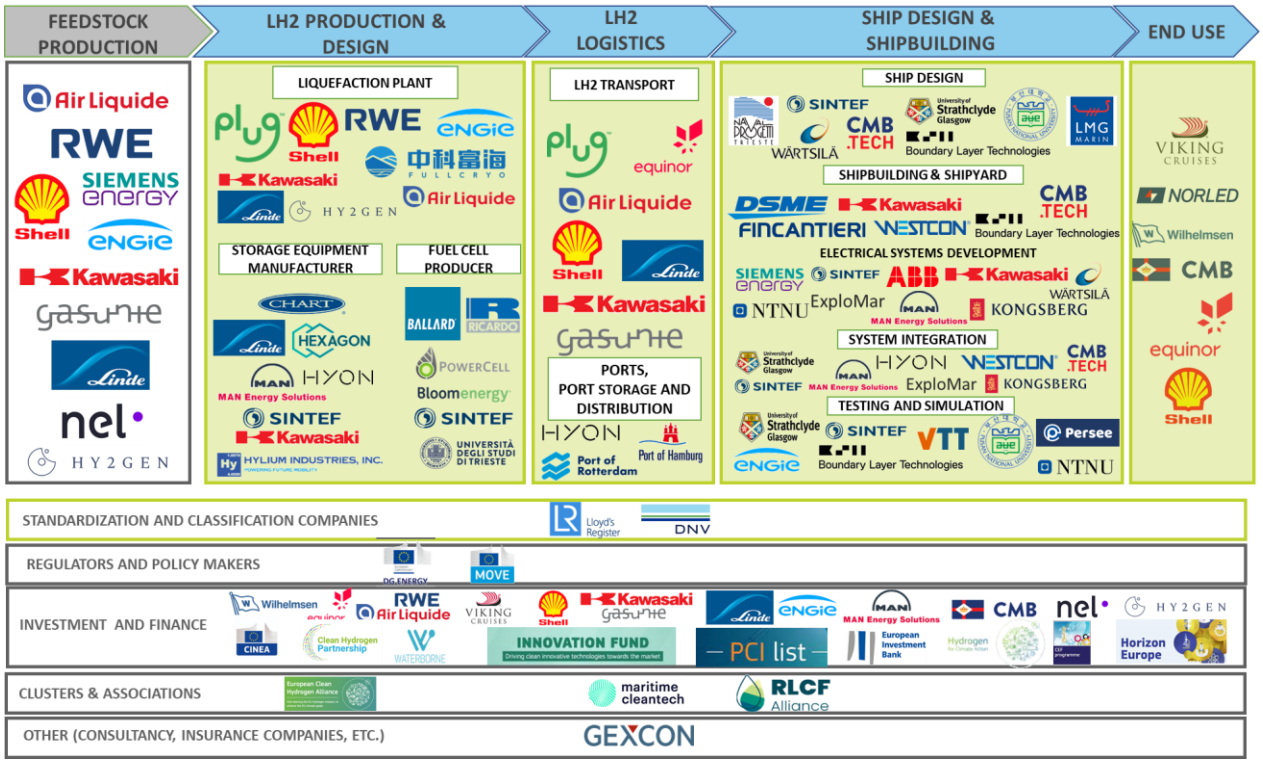


Figure 4-1: stakeholders'value-chain bird's view

Developing H_2 projects

Hubs' creation and Project Development - at a first glance one can note that there are significant overlaps of companies in more roles, for example: Shell, AirLiquide, Kawasaki, Engie, Equinor, Siemens, ABB, Gasuine. These large O&G, Energy companies and equipment manufacturers have in fact the capacity to vertically integrate different roles and are trying to build hydrogen hubs, which includes project development and project finance.

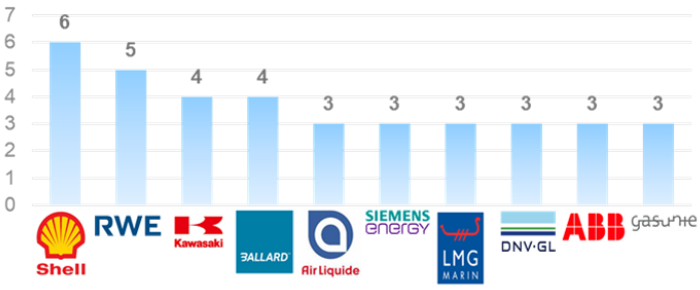


Figure 4-2: top companies emerged from C&I projects

Shell was primarily identified in 6 C&I projects, as leading producer of hydrogen and liquid hydrogen, with a division totally dedicated to marine application, which is dealing with various partners for the transportation of LH2 in containment systems. **RWE AG**, H2 and LH2 producer that is investing in numerous infrastructures to create real storage and distribution hubs, with 5 commercial projects. **Gasuine** is doing the same in The Netherlands.

On the ports' side, the **Port of Rotterdam** (appearing in 1 C&I project) has been signing several MoU with international partners to import hydrogen into Europe and to become a crucial hub (10). Since 2017 these MoUs' signatories include the Brazilian State (1 Mt/year), the Chilean Minister of Energy (potentially unlocking 1.4 Mt/year by 2030) and the Western Australian government to develop a common supply-chain. 3 projects in the state are possibly establishing a 4Mt/year supply. In 2022, the Port signed a MoU with Chariot Energy Group to secure off-take contracts (0.7 Mt/year). The overall supply potential is 6.7 Mt/year, but uncertainties can decrease this volume by 60 %

Developing technologies

Technology leadership and know-how - stepping into the equipment and ship design domains, **Kawasaki Heavy Industries** and **Ballard** are leading manufacturers of fuel cells systems, both appearing in 4 commercial projects. **Kawasaki** seems indeed to cover the entire supply chain of LH2 and shipbuilding and built the first LH2-propelled vessel: the Suiso Frontier. It is also emerged as the company with more patents (82) in the sector corresponding to our search (liquid hydrogen and maritime transportation), followed by **Linde AG**, market leader in the production and distribution of liquid hydrogen and in the manufacturing of containment system of gases, owner of 34 patents.

All the top patent applicants and IP owner are reported in Figure 4-3. Most of them (6) have expertise in the manufacturing of storage equipment, followed by liquid hydrogen producers (4). Among them on can again find **Air Liquide**, worldwide leader in production and distribution of liquid hydrogen. Besides, the group includes **Daewoo Shipbuilding & Marine Engineering Company**, one of the biggest three South Korean shipbuilders, and **Pusan University**, which has a department specialised in naval design: they own two out of 11 selected relevant patents each.

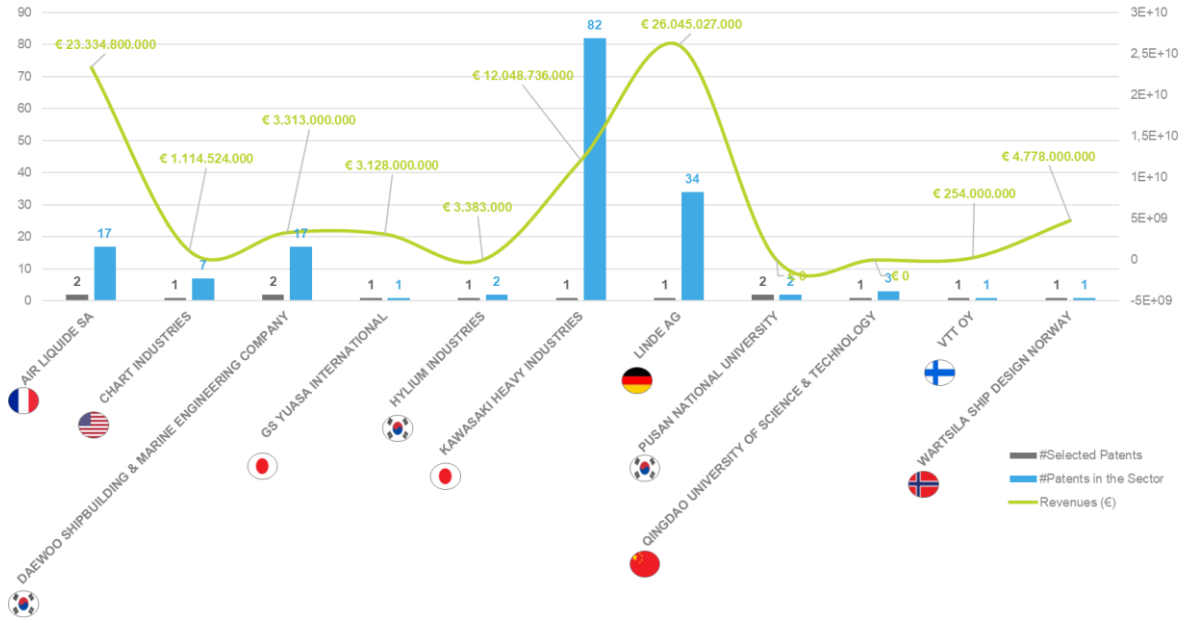


Figure 4-3: Top applicants and patents owner in the domains od sHYpS (nr. of patents in the sector in blue, number of top-related patents among the 11 retained in grey and turnover in green

R&D&I networks in public funded projects – Out of 270 participations related to 40 R&D&I projects, 14 are from the Norwegian RTO **SINTEF Energy**, which has consolidated expertise in energy conversion technologies and is investigating optimal methods and processes for the application of liquid hydrogen as an alternative fuel for maritime transport. SINTEF is followed by the

Norwegian O&G **Equinor**, which has 7 participations and is heavily investing in the creation of a liquid hydrogen supply chain also for its gas transport vessels. With 5 participations we then have **ABB**, leading provider of electrical power distribution and automation for the marine industry, and **Gexcon AS**, a world-leading company in the field of safety and risk management and advanced dispersion, explosion, and fire modelling.

A network analysis of the selected funded projects has also been realised, to highlight the key nodes among the most active organizations (represented by their respective logos in the figure below). The core network is highlighted in the central part of the figure, where the most active organizations with the most collaborations emerge. More precisely, **we can highlight four networks** of organizations that endure in several selected projects:

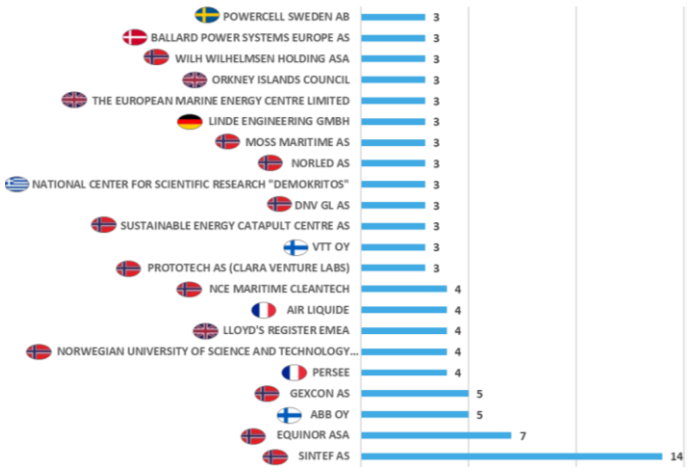


Figure 4-4: most active organisation in projects participation

- **Equinor ASA, NCE Maritime Cleantech, Air Liquide, DNV GL, Wilhelmsen and Norled** have collaborated in three different selected projects mainly focused on creating a LH2 supply chain and its demonstration for use in maritime transportation;
- **Sintef, NTNU, Gexcon and Moss Maritime** have collaborated in three different selected projects mainly focused on LH2 handling, storage technologies and fuel cells systems for maritime application;
- **Equinor ASA, PERSEE and DEMOKRITOS** have collaborated in three different selected projects mainly focused on the optimization of processes for using LH2 in maritime sector;
- **ABB, PERSEE and VTT OY** have collaborated in three different selected projects mainly focused on the development of PEMFC powertrain and mobile H2 containment system for application in maritime transportation.

New entrants and investing companies

The analysis of the deals in the last years has confirmed some of the results obtained from the technological perspective, as many of the resulting companies (already shown in Figure 3-5) had already been identified in the previous analyses. This includes *the main manufacturers of LH2 storage containment systems for on-board applications.*

Expanding companies – in terms of scale-up and growth, **Plug Power (sHYpS partner)** has shown a leading role in the production and distribution of hydrogen and liquid hydrogen, being the company with the highest capital raised. They are followed by **Bloom Energy**, a US-based solid-oxide fuel cell systems, **NEL**, a Norway-based hydrogen company delivering optimal solutions to produce, store and distribute hydrogen from renewable energy, and **Ballard Power Systems**, producer of fuel cells systems for maritime application.

Private funding for emerging companies and new entrants – By only considering private equity and venture capital investments, the company that raised the most is **Hy2gen**, a German producer of green hydrogen and hydrogen-based e-fuels intended for mobility, followed by **FullCryo**, a China-

based manufacturer. of refrigeration and cryogenic equipment to liquefy hydrogen. Among the new entrants Asian located businesses seem to be prominent in the sector: we can mention **ExploMar**, a Chinese company founded in 2021 that has developed the first generation of hydrogen boats with the application of zero-emission hydrogen fuel cell technology, and **Linde Hydrogen Energy**, a South Korean manufacturer of liquid hydrogen for mobility, formed as a joint venture between Hyosung Heavy Industries and Linde as major shareholder.

Deals by Investors & Acquirers – **Chart Industries (**sHYpS' partner)**,** appeared on the top of the deal count, with three investments. **Kawasaki Heavy Industries**, **Air Liquide** and **Ballard** also have an active deal count in the sector. Interesting investment activities have also been tracked for **CMB (Compagnie Maritime Belge)**, a provider of cargo transportation and shipping services in Belgium, and the aforementioned **NEL**: both have two investments appearing in our data.

In terms of M&As, **Man Energy Solutions**, a provider of systems and services for shipping and energy generation, has completed two acquisitions: **H-Tec Systems**, a German developer of hydrogen fuel cells, and the **Marine Fuel Gas Supply System business of Cryo AB,** a manufacturer of cryogenic equipment for the storage, distribution and handling of liquefied gases.

Relevant EU public bodies, agencies and platforms

Section 3.1.2 refers to key funding schemes at EU level to support the establishment of scaled-up hydrogen projects. The corresponding EU bodies to be considered as relevant stakeholders are therefore:

DG Energy (EC's Directorate General for Energy): this Directorate-General develops the EU energy policy and is responsible for the supervision of projects and programmes that provide financial support to technological development and innovation in the energy sector. Reference schemes under their policy area include the PCI (Project of Common Interest), that support the transnational energy corridors (TEN-E), related to cross border initiatives for -e.g. - renewables, CO2 transport, energy storage, gas networks and electrolysers. The access to a PCI list (upon application) and the award of the status of PCI, also grants access to the application for CEF-energy program to fund works and studies in these domains. In particular, *CEF 2021-2027 emphasises synergies between the transport, energy and digital sectors and promotes cross-sectoral work in areas such as connected and automated mobility and alternative fuels.*

DG Move (EC's Directorate general for transport) is in charge of EU's policies related to transport and logistics. In its mission's statement, DG MOVEs has also connections to hydrogen, *to develop initiatives for the reduction of greenhouse gas emissions and air pollution from ships, including legislation for the promotion of renewable and low carbon fuels in maritime transport (FuelEU maritime), coordinate the activities of the European Sustainable Shipping Forum (ESSF)*, develop *the policy priorities for supporting maritime transport, sustainable logistics and intermodal transport through EU financial instruments (TEN-T/CEF2, Recovery and Resilience Facility, InvestEU, ESIF, Horizon Europe and Taxonomy for sustainable finance)*

CINEA (The European Climate, Infrastructure and Environment Executive Agency) is the key delegated funding agency responsible to manage the funding that is agreed to fund specific programmes and calls. CINEA is in charge of energy and transport **projects in** the Horizon Europe programme (the same that funded sHYpS), as well as Innovation Fund, LIFE CEF and EMFF (European Maritime Fisheries and Aquaculture Fund)

The **EIB** (European Investment Bank) is one of the key financial promoters of many EU funding instruments. On top of that, the EIB provides to mature projects different blended finance instruments to support climate related projects.

The **Clean Hydrogen Joint Undertaking (JU)** is a public private partnership supporting research and innovation (R&I) activities in hydrogen technologies in Europe. The three members of the JU are the European Commission, Hydrogen Europe (industry) and Hydrogen Europe Research (RTOs, Universities). The JU oversees implementing a specific agenda with measurable KPIs. The grants from the JU are managed inside the Horizon Europe framework, besides, the platform supports the definition of business models and financial engineering of large projects. Notably, the JU's calls include the Hydrogen Valleys that support the development of hydrogen ecosystems.

ZEWT - the Co-Programmed Partnership on Zero-Emission Waterborne Transport is a partnership in the framework of Horizon Europe, whose scope is *providing and demonstrating zero-emission solutions for all main ship types and services before 2030, which will enable zero-emission waterborne transport before 2050. Notably, sHYpS was funded under the ZEWT programme*

The **ECHA (European Clean Hydrogen Alliance)** *brings together industry, public authorities, civil society and other stakeholders.* Its role of facilitator, also includes creating liaisons with investors. Besides, on the technical side the ECHA is working to support faster standardisation, permitting and procurement. In the attempt to reach the ambitious 10 Mt/year target of RePowerEU, the alliance has recently created an Electrolysers Partnership (10). *The alliance is open to all public and private actors with activities in renewable or low-carbon hydrogen. In 2022, ECHA has been pursuing the implementation of an established pipeline of 750 projects (many of which have been considered in this analysis).*

In April 2022, the **RLFCA** (Renewable and Low Carbon Fuels Value Chain Alliance) was formed under the steering of the DG-MOVE, supported by Hydrogen Europe and Fuels Europe, on top of aviation and waterborne stakeholders like Safran and Fincantieri in its governance. The scope of the alliance is to set up renewable fuels feedstock and supply, fostering the needed enabling conditions and structuring a project pipeline including high-TRL and R&D initiatives. Its missions is composed of 4 elements: feedstock and supply, aviation, waterborne and financing. The synergies of multimodality will be a key element of its programme.

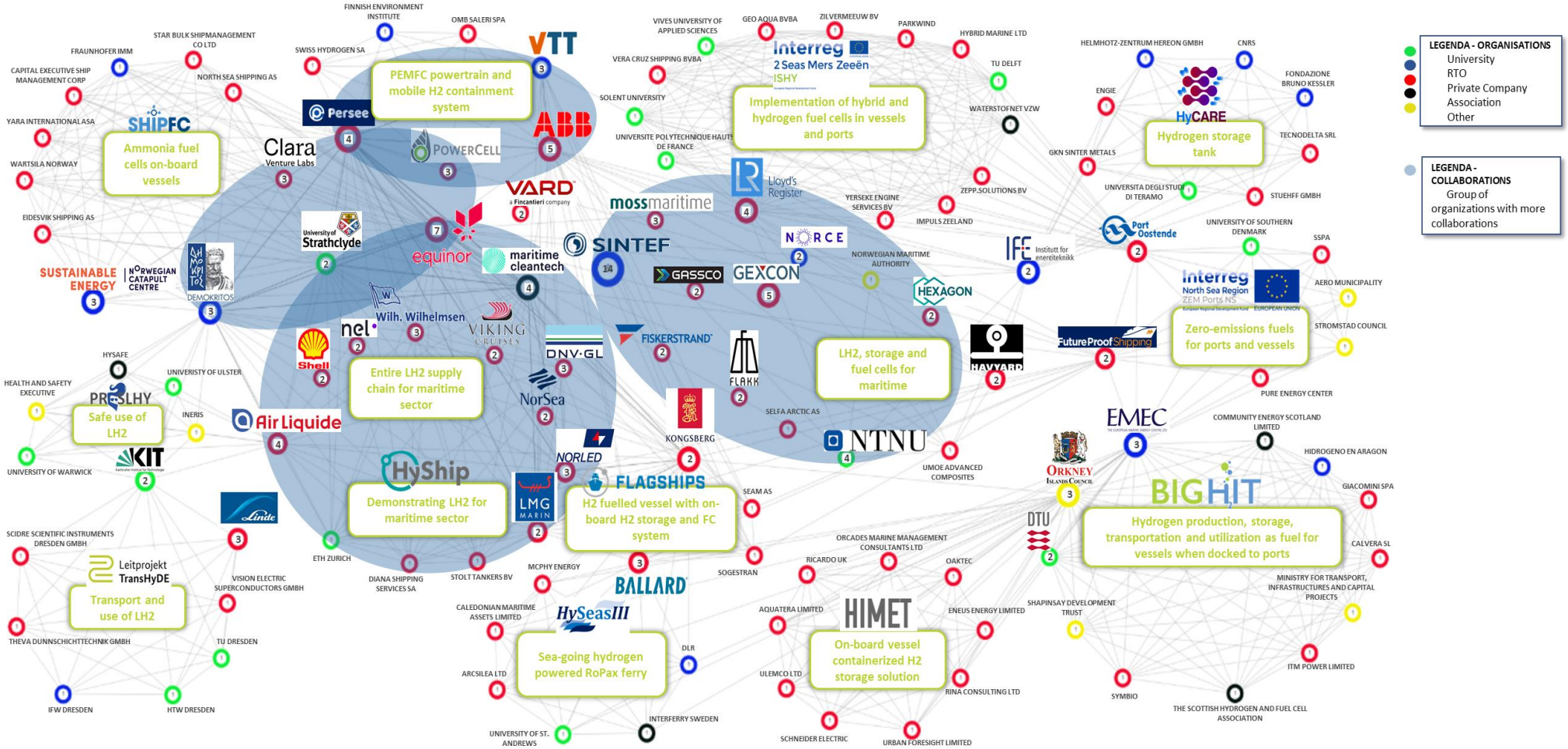


Figure 4-5: R&D&I networks map showing projects and related partners and cooperations

4.2 KEY-PLAYERS AND INNOVATORS FROM THE SHYPS ECOSYSTEM

After completing the analyses described above, in this paragraph we suggest a selection of the top 40 stakeholders from the sHYpS ecosystem (Figure 4-7***)***

4.2.1 Identification criteria

The following criteria were taken into consideration to make them stand out:

1. **Presence in the LH2 technology and innovation arena,** which highlighted
   a. the organisations emerged in all the three completed steps (C&I projects, R&D&I projects, IP) and not mentioned later: Linde AG, Wärtsilä
   b. the organisations involved in at least 3 selected commercial projects, and not mentioned before: Shell International NV, RWE AG, Kawasaki Heavy Industries Ltd., Air Liquide SA, Siemens Energy, Ballard Power Systems A/S, ABB OY, Gasunie, LMG MARIN, DNV GL
   c. the organizations emerged in at least two funded projects and one commercial project or vice versa, and not mentioned before: DNV GL AS, ENGIE, Hexagon Composites ASA, Hyon AS, Kongsberg Maritime, LMG MARIN AS, PowerCell Sweden AB, Viking Cruises, Norled AS
   d. the organizations emerged in at least two funded projects or commercial projects and that have published one selected patent, and not mentioned before: VTT OY

2. **Research and innovation champions, in R&D&I or IP, which included**
   a. the organisations with sufficiently high R&D&I projects participations compared to the best in class: SINTEF AS, Equinor ASA, ABB OY, Gexcon AS, PERS-EE, Norwegian University of Science and Technology (NTNU), Lloyd's Register EMEA, Air Liquide SA, NCE Maritime Cleantech
   b. organisations that have published at least 2 of the top 11 selected patents, and not mentioned before: Daewoo Shibuilding and Marine Engineering Company, Pusan National University, Air Liquide SA

3. **Highly focussed technical knowledge related to sHYpS, but not included into the previous criteria, therefore**
   a. companies which provide tanks for storing and distributing liquid hydrogen on-board vessels, and not mentioned before: MAN Energy Solutions; Hylium Industries
   b. companies which design/build/operate LH2-propelled vessels and on-board LH2 propulsion systems, and not mentioned before: Wilhelmsen ASA, Fincantieri, Boundary Layer Technologies, Westcon Group, University of Strathclyde

4. **The sHYpS partners emerged from one of the analyses done, and not mentioned before:** NavalProgetti, Ricardo UK, Università di Trieste, Chart Industries

4.2.2 PNO's Market and Innovation Positioning Map (MIPM©)

As a wrap-up of this ecosystem's analysis, the top-40s have been used to ***populate PNO's Market and Innovation Positioning Map (MIPM©)***. The MIPM is a 4-quadrants matrix defined in the last 8 years. It is built in such a way to:

1) Spot noticeable companies working on a particular technology topic

2) Evidence those key – smaller/emerging - players with a very specific knowledge on the analysis subject matter.

The analysis is qualitative but based on a quantitative weighted measurement of a mixed scoreboard. More in detail.

- ***Innovation Vision and Specific Knowledge (x-axis)*** – take into account both the R&D capacity in the field (including funding and IP) and a specific Affinity Index which weights the proximity to the specific project technology at the centre of the analysis
- ***Investing Capacity (y-axis)*** – considers the capacity and structure to invest (e.g. turnover), considering the nature of the organisation.

The organisations with growing investing capacity are positioned from the bottom to the top. Going from the left to the right instead, the organisations with increased specific domain/market knowledge and innovation capacity can be found. Therefore, the upper quadrant defines organisations most likely to be market incumbents/entrants, whilst in the lower one relevant expert, technology providers or "visionaries" can be found, with most specific knowledge with respect to the analysed topic.

For the sHYpS case, the MIPM (Figure 4-6) identifies the "position" of an organisation with respect to LH2 storage with applications for the maritime transportation, allowing vessels to be fuelled by LH2. As a note, sHYpS is not included in the analysis not to move all partners on the right.

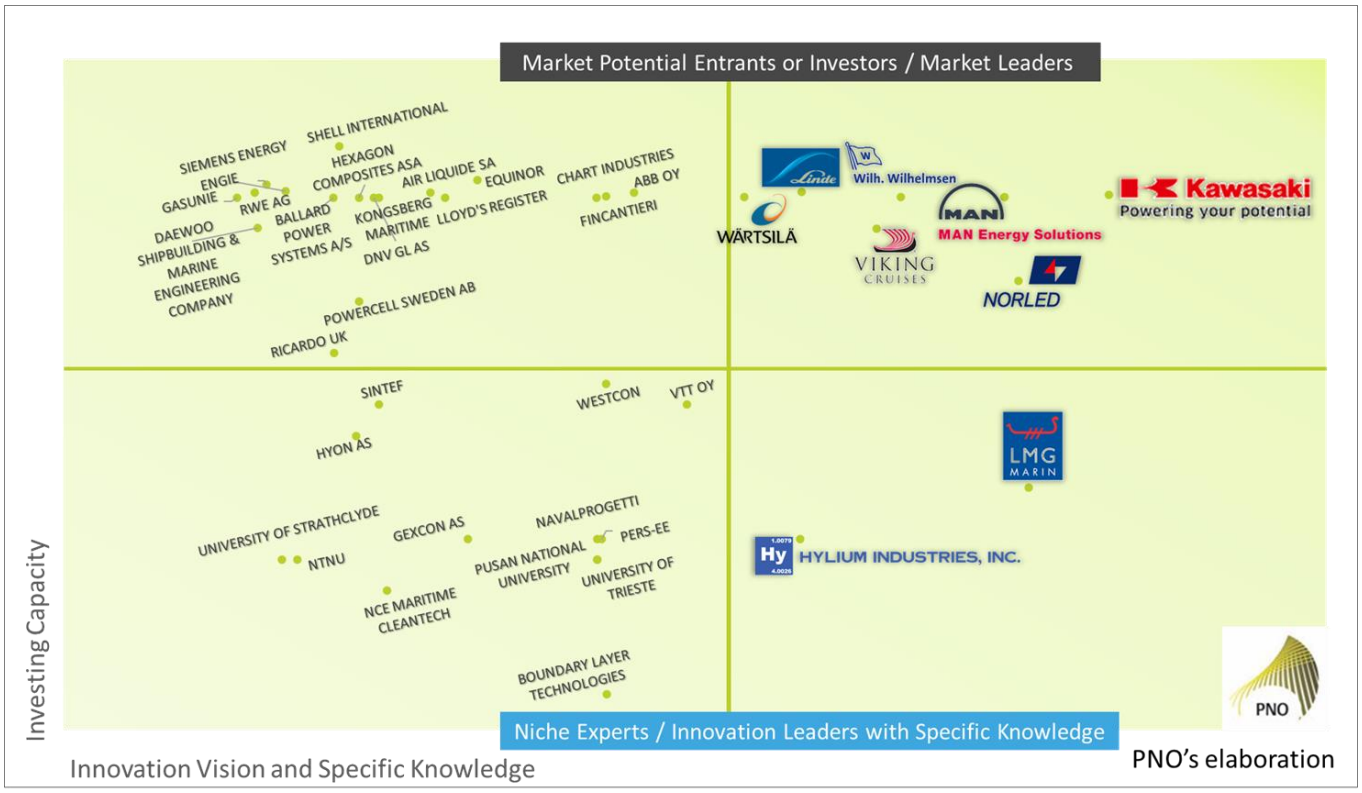


Figure 4-6: sHYpS MIPM

The **key headlines** from the map are as follows:

Kawasaki Heavy Industries (KHI) appears to be in a prominent market position in the LH2 for the maritime sector, as it covers the entire value chain, comprising the LH2 production and storage systems, as well as leading the construction of LH2-fuelled vessels. Its Suiso Frontier was the first ever vessel to be fuelled by liquid hydrogen.

KHI is followed by **Norled AS**, a Norwegian ferry and cruise ships operator, which owns MF Hydra, the world's first liquid hydrogen-powered ferry, operational from 2022.

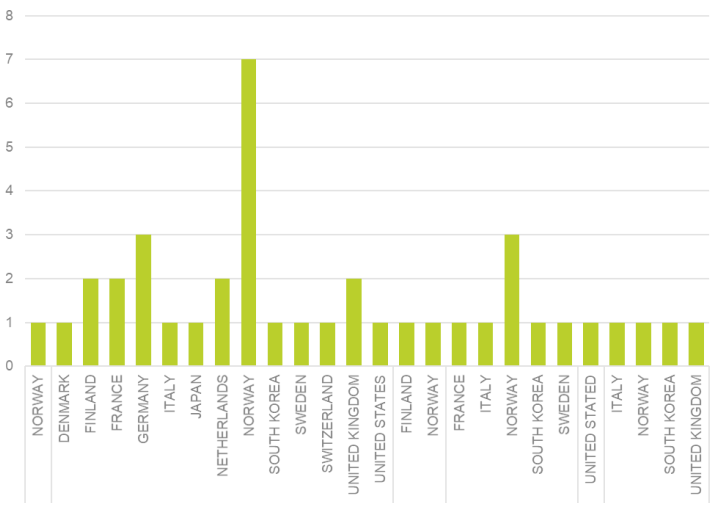


Figure 4-7: top -40s by country and type

Wilhelmsen and Viking Cruises are keeping the pace, carrying out numerous projects for the development and use of liquid hydrogen as fuel for their ships.

Regarding the manufacturers of on-board LH2 containment systems, **MAN ES (Man Energy Solutions)** has shown the highest affinity with the technology developed by sHYpS, as it is already producing and commercializing an integrated LH2 containment system equipped with TCSs (tank connection spaces) for vessel on-board applications.

Other manufacturers of on-board LH2 containment systems that have shown such a level of affinity that they appear on the right side of the map are **Linde AG**, and **Hylium Industries**, a South Korean SME company specialized in liquid hydrogen handling, which is also developing containerized tanks.

As for naval architects able to design LH2-fueled vessels, **LMG Marin** has shown the highest affinity with sHYpS. It is an SME with offices in Norway and France that is contributing to the design of numerous liquid hydrogen ships in various projects around Europe.

Looking at the propulsion and electrification for running a ship to LH2, **Wartsila**, the European leader in ship propulsion and automation systems, is the company that has achieved the highest score. It also owns a ship design division for converting vessels in hydrogen-based fuel.

The bottom-left quadrant contains the R&D and industrial experts in systems and technologies related the application of liquid hydrogen in maritime sector as a fuel. In this quadrant, one can find most active R&D organizations related the topic and small and medium enterprises specialized in naval design and optimization of the electrification processes applied to the maritime transportation. Among the companies in this quadrant, **Boundary Layer Technologies** is an American start-up that has designed and is developing LH2-fueled hydrofoil vessels for both freight and passengers. It deserves particular attention, and it is assumed that it can move to the right side in the next few years.

Eventually, the top-left quadrant, contains the potential entrants or investors in the specific sector of the use of liquid hydrogen for maritime transportation. Notably, large project developers like **AirLiquide**, **Engie** or **Shell** are there and they should be duly considered.

As a final remark, the map does not contain future emerging players still in their infancy, meaning, before any achieved project or practical result. A dedicated analysis should be performed to spot

possible technologies to be adapted from adjacent technical areas and complete a different intelligence.

4.3 RELEVANCE FOR sHYpS STAKEHOLDERS' ENGAGEMENT

sHYpS is built around 8 WPs on top of project management.

- WP1 - Development of the LH2 ISO Storage Containment
- WP2 - Fuel Gas Handling System Design and Integration
- WP3 - Fuel Cells Integrated Design and Overall Energy Management
- WP4 - Logistics & Handling Design
- WP5 - Overall Electrical Design & Ship Integration
- WP6 - LH2 Storage Ship Integration, testing and Demonstrator
- WP7 - Upscale of the Solution - Road to 2027 Demonstration
- WP8 - Dissemination, Communication and Exploitation

Project Activity	Stakeholders type															
	Feedstock Production	Production and Design			LH_2 Logistics		Shipbuilding and Ship Design					End Use	Horizontal			
		LH_2 Production	Storage Equipment Manufacturer	Fuel Cell Producer	LH_2 Transportation	Port and Port Operations	Shipbuilding & Shipyard	Ship Design	Electrical Systems Development	System Integration	Testing & Simulation		Standardization & Classification Company	Regulator and Policy Maker	Investor / Financier	Cluster & Association
WP1																
WP2																
WP3																
WP4																
WP5																
WP6																
WP7																
WP8 Approach																

Engage for exploitation and replication
Keep informed through dissemination, liaise and evaluate collaboration
Just inform and watch their activities - potential competitor

Figure 4-8: Value-chain roles compared to sHYpS WPs activities and WP8 priorities identification.

A list of almost 300 stakeholders has been rebuilt, along a shortlisted top-40 group. As described in Chapter 1 of this report, the overall analysis can support a fine-tuned approach to Dissemination, Communication and Exploitation activities, as well as directly feeding following reports in the project (Figure 1-1). The suggested approach is visible in Figure 4-8. This is intended to be dynamic and shared with the partners along the project. The colours in the grid from WP1 to WP7, illustrate the relevance of certain stakeholder types for each WP, while the bottom line for WP8, finally shows 3 levels of approach.

Engage for exploitation and replication

These stakeholders are the ones relevant for replicability, for scale-up and whose role is not covered by any partner in the consortium (Figure 4-9). They primarily include end-users, shipping companies or companies which are looking at hydrogen to fuel their ships (e.g. the Norwegian O&G Equinor), They are mostly relevant for WP7. On top of them, ports and port operations/storage/infrastructure[8] companies are also a good match. On the shipbuilding side, the

[8] This may change a bit if a new partner for cranes and containers movement is included in the consortium

only category not included in the consortium is shipyards, although some pre-existing business relations may exist. It is however advised to keep them in the loop. Finally, regulators and policy makers, clusters and associations as well as investors should be included. About investors, we have seen how large corporates take also care of the project development and finance, integrating the value-chain (e.g. AirLiquide). Since this concerns the establishment of hydrogen supply, which is potential business relevance for the consortium (e.g. Plug Power), an internal discussion will be needed to identify which kind of investors can be interesting. Further analyses are possible on a later stage.

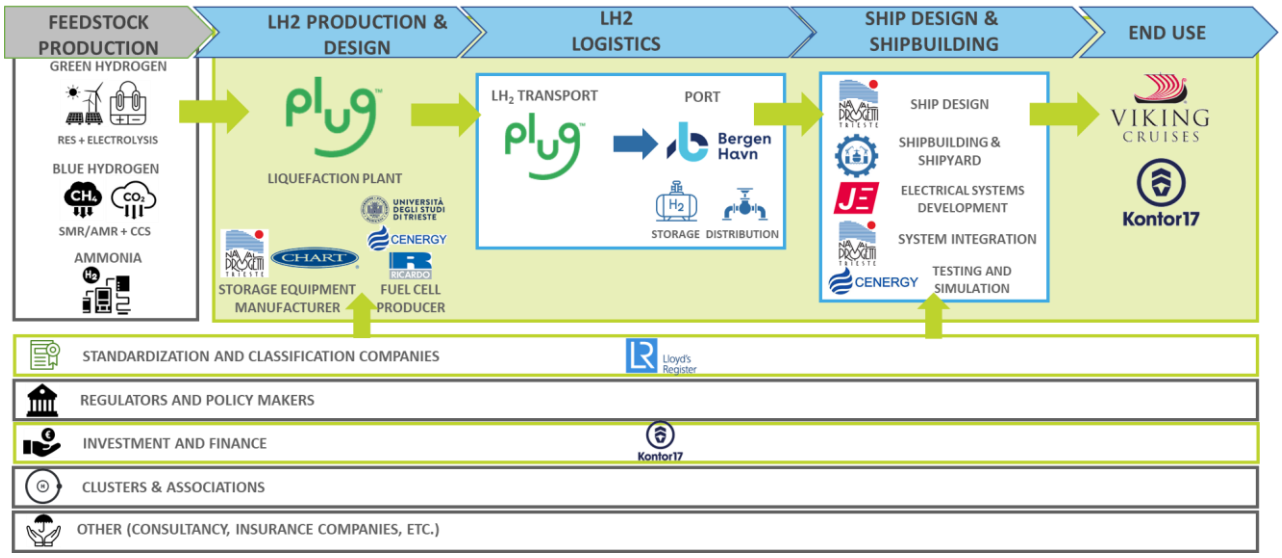


Figure 4-9: sHYpS partners in the value-chain

Keep informed through dissemination, liaise and evaluate collaboration

These stakeholders include all those roles where there is a potential coverage by the consortium but are also very important for dissemination and liaison. They will be reached through the dissemination of results, which may include joint seminars or workshops and may be relevant for most of the WPs. Again, a particular attention should be given to some of the actors needed to establish the supply-chain, like feedstock/hydrogen providers and transport operators.

This category also includes the so called “sister projects”, meaning other EU funded initiatives on similar topics. The consortium will identify the best candidates. The first project in this list is NH3CRAFT, funded on the same call as sHYpS (link), which focusses on the alternative ammonia storage route.

Just inform and watch – potential competitors

This category includes organisations with the same key technical expertise in the sHYpS consortium. Stakeholders in this category should be kept informed, but also be watched since they are potential competitors. A list of ca. 70 competitors of sHYpS partners have been drafted whose “treemap” is reported in Figure 4-10. Once assessed by the partners, they will be watched with a view to the project technology and market watch report.

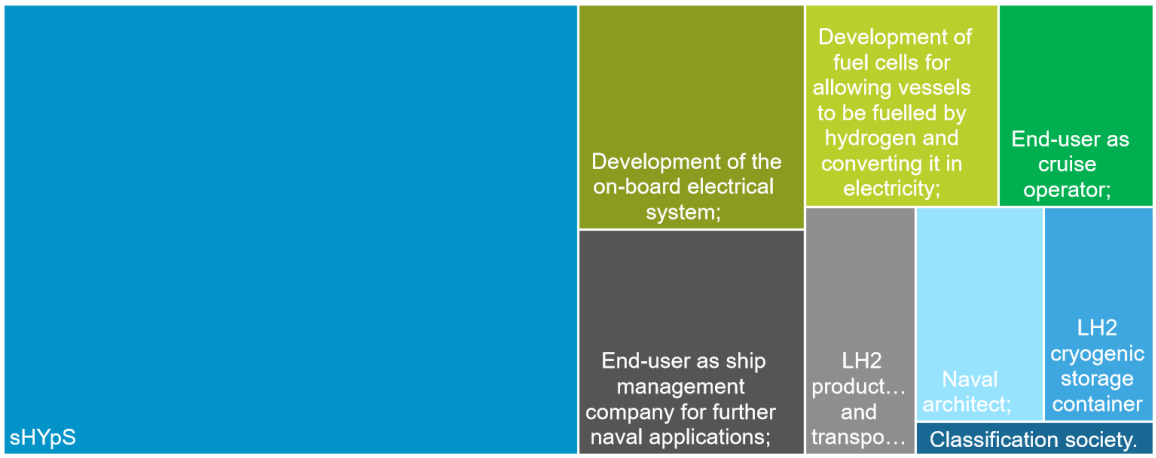


Figure 4-10: sHYpS competitors mapping (the squares on the right represent the nr. of competitors for each category compared to the total on the left)

5 CONCLUSIONS AND NEXT STEPS

This report identified a large innovation ecosystem, including:

- 299 stakeholders relevant for sHYpS
- 70 competitors of different sHYpS partners to be watched
- A top-40 list of key-players

Their knowledge will support tailoring the outreach activities of the project.

A key conclusion of this report is that hydrogen usage as a fuel is being increasingly and fast developed and funded with many projects on the map in the last 5 years, pushed by regulatory bodies. Moreover, there is an evident trend of private capital's financing, which delivered 20 billion Euro in 10 years. The primary project promoters in the current C&I scenario have been identified. They are developing hubs which can be very useful to sHYpS to establish its supply-chain.

Some of sHYpS partners are quite prominent in this business, with recent investments and evident growth. Besides, sHYpS seems to keep a potential first place concerning the maturity, with a first-of-a-kind application to a cruise ship in real operations.

Finally, from the gender standpoint, the ecosystem is strongly unbalanced, with few exceptions.

The next steps include:

- Revisions and assessment of the stakeholders list by the partners
- Definition of the D&C engagement plan
- Initiation of the technology watch (including specific players and competitors) to define its content and roadmap.
- Preliminary analysis of specific funding programmes

6 WORKS CITED

1. **IMEC, SMIT, VUB.** *INNOVATION ECOSYSTEMS IN EUROPE: First outline of an innovation ecosystem index.* 2019.

2. **statista.** Harmonized index of consumer prices (HICP) inflation rate of the European Union in May 2022, by country. *statista.* [Online] 2022. https://www.statista.com/statistics/225698/monthly-inflation-rate-in-eu-countries/.

3. **Eurostat.** Energy production and imports. *https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_production_and_imports.* [Online] 2022.

4. *Signaling can increase consumers' willingness to pay for green products. Theoretical model and experimental evidence.* **Berger, J.** 2019, Journal of consumetr behavior.

5. *Green product supply chain contracts considering environmental responsibilities.* **Hong.Z. and Guo, X.** 2019, Omega.

6. *Going green to be seen: Status, reputation, and conspicuous conservation.* **Griskevicius, Vladas Tybur, Joshua M. Van den Bergh, Bram.** 2010, Journal of Personality and Social Psychology.

7. **marketdataforecast.** Green Hydrogen Market. *https://www.marketdataforecast.com/market-reports/green-hydrogen-market.* [Online] January 2022.

8. **umlaut: Patrick Wienert, Petja Stöver, Philipp Wiener ; KONGSTEIN: Thore Schreiber, Bonke Jensen.** *Production and transportation costs for green hydrogen from an offshore wind farm to an industrial end-user onshore.* 2021.

9. **ICCT.** *COST OF RENEWABLE HYDROGEN PRODUCED ONSITE AT HYDROGEN REFUELING STATIONS IN EUROPE.* 2022.

10. **Hydrogen Europe.** *Clean Hydrogen Monitor 2022.* 2022.

11. *The relationship between the development of global maritime fleets and GHG emission from shipping.* **Chen, J., Fei, Y. and Wan, Z.** 2019, Journal of Environmental Management.

12. *Decarbonization and sustainable development goal 13: a reflection of the maritime sector.* **Ezinna, P., Nwanmuoh, E. and Ozumba, B.** 2021, Journal of International Maritime Safety, Environmental Affairs, and Shipping.

13. **Guidehouse.** Market state and trends in renewable and low-carbon gases in Europe. 2020.

14. **IEA.** *Green Hydrogen Cost Reduction -SCALING UP ELECTROLYZERS TO MEET THE 1.5° C CLIMATE GOAL.* 2020.

"Co-Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or of the European Climate, Infrastructure and Environment Executive Agency. Neither the European Union nor the granting authority can be held responsible for them."