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Mapping of Zero Emission Pilots and Demonstration Projects

Third Edition | March 2022



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Authors

Heidi Kilemo, Project Associate, Global Maritime Forum

Robert Montgomery, Project Advisor, Global Maritime Forum

Ana Madalena Leitão, Project Assistant, Global Maritime Forum

This report is based on analysis by the Global Maritime Forum on behalf of the Getting to Zero Coalition. The Getting to Zero Coalition is a partnership between the Global Maritime Forum and the World Economic Forum.



About the Getting to Zero Coalition

The Getting to Zero Coalition is an industry-led platform for collaboration that brings together leading stakeholders from across the maritime and fuels value chains with the financial sector and other stakeholders committed to making commercially viable zero-emission vessels a scalable reality by 2030.

The views expressed in this report are those of the authors alone and not the Getting to Zero Coalition or the Global Maritime Forum or the World Economic Forum.

Summary of key takeaways

The third edition of the Mapping of Zero Emission Pilots and Demonstration Projects for the maritime industry showcases global action from across the value chain, and increased efforts focusing on ship technologies, fuel production, as well as bunkering and infrastructure. Pilots and demonstration projects are essential to accelerate the shipping industry's energy transition, and the third edition illustrates how key parts of the value chain are collaborating on the development and implementation of zero-emission technologies.

The third edition of the study includes 203 projects, having grown from 106 projects in the **second edition** which was released in March 2021. While some of this growth can be attributed to better data collection, 86 of the projects included were initiated during 2021 and Q1 2022. For comparison, 60 projects in the mapping were initiated during 2020. This project increase illustrates that there is a clear acceleration in industry activity targeting zero-emission solutions. Some of the key takeaways in this year's mapping include:

- More detailed information has been collected on vessel types and fuels used, allowing the mapping to track potential future trends and specializations.
- The mapping now tracks participation of actors across the value chain and has identified broad collaboration on projects, as well as a potential gap in the value chain resulting from only a small number of demand-side actors involved in projects.
- An increased focus on hydrogen-derived fuel production, with a clear trend towards green hydrogen electrolysis and green ammonia synthesis.
- A higher number of projects targeting large vessels running on ammonia and methanol.
- More bunkering and infrastructure projects, as well as the emergence of fuel production in Oceania.
- Hydrogen and battery projects are the most likely to receive public funding, with more than half receiving public funding.

Overall project developments and expansion

Since the second edition of the mapping, more than 20 percent of the projects in the mapping have publicly announced that they are developing or continuing into a new project phase. These developments include moving from a concept study to a demonstration in normal operations, receiving Approval in Principle (AiP), signing a Memorandum of Understanding (MOU), receiving funding, or adding new partners to the project.

What is included in the mapping?

The *Mapping of Zero Emission Pilots and Demonstration Projects* includes projects focusing on zero-emission pathways for the maritime industry. The study covers projects focused on ship technology, fuel production, as well as bunkering and infrastructure. Since the first and second editions of the study, the scope of the information collected has been continuously developed and expanded to include more details on each project. The projects have been categorized based on the project focus, geographical focus, type of project, fuel choice, size and type of vessel, the technology used, the existence of public funding, and the parts of the value chain represented by project partners.

The mapping does not claim to offer an exhaustive list of efforts taking place, but the best endeavors have been made to identify as many projects as possible. Analysis of the metrics listed above provides valuable insights into industry action and trends emerging in shipping's decarbonization pathway. The scope of the mapping study is based on the Getting to Zero Coalition's **definition of zero-emission fuels**, and therefore, although an important part of the transition, energy efficiency projects are not included in this study.

Emerging project and fuel trends

Industry action on zero-emission shipping is gathering momentum, with the total number of projects growing significantly over the past year. Projects are underway across several fuels and a variety of technologies, showing that a wide portfolio of solutions is becoming increasingly available. Within this broader portfolio, trends are emerging. Figures 1, 2, and 3 below illustrate fuel focus across projects focusing on ship technology, fuel production, and bunkering and infrastructure. The figures show that new fuels, particularly hydrogen and ammonia are increasingly taking a larger share of the industry's focus.

Figure 1: Total number of ship technology projects by fuel focus 2016 to Q1 2022

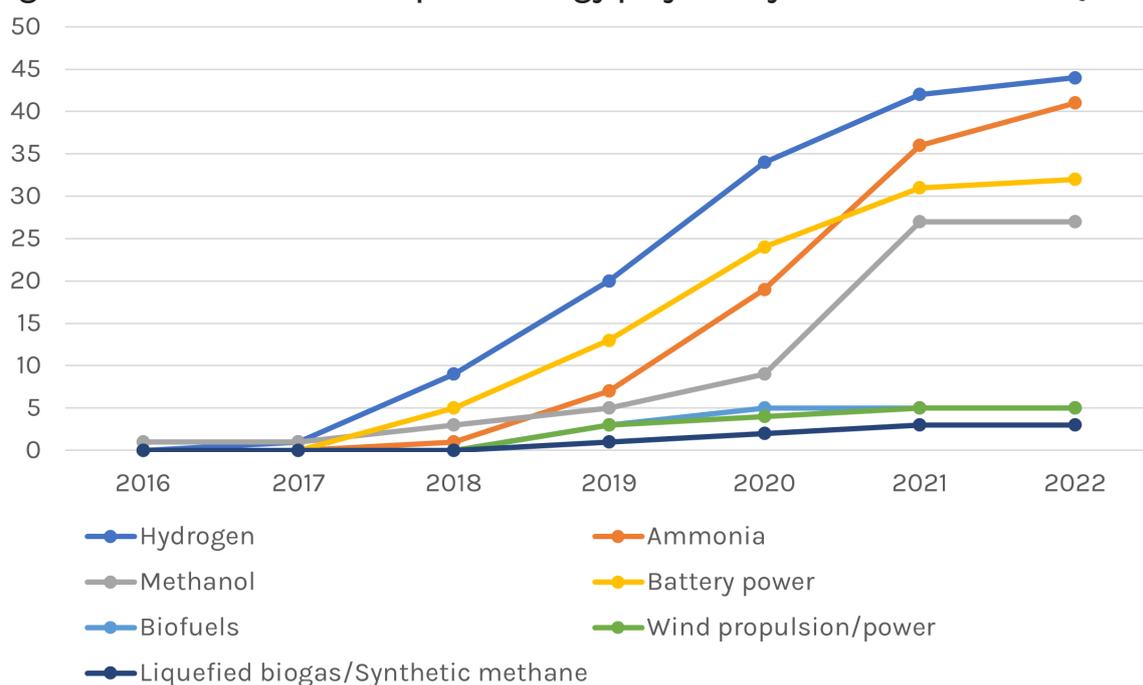


Figure 2: Total number of fuel production projects by fuel focus 2016 to Q1 2022

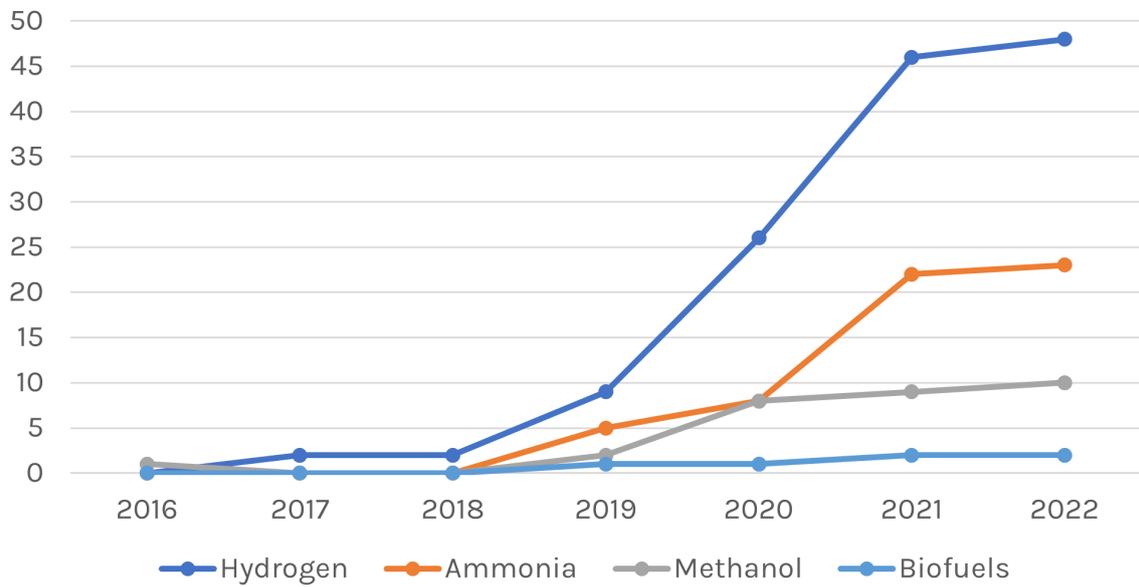
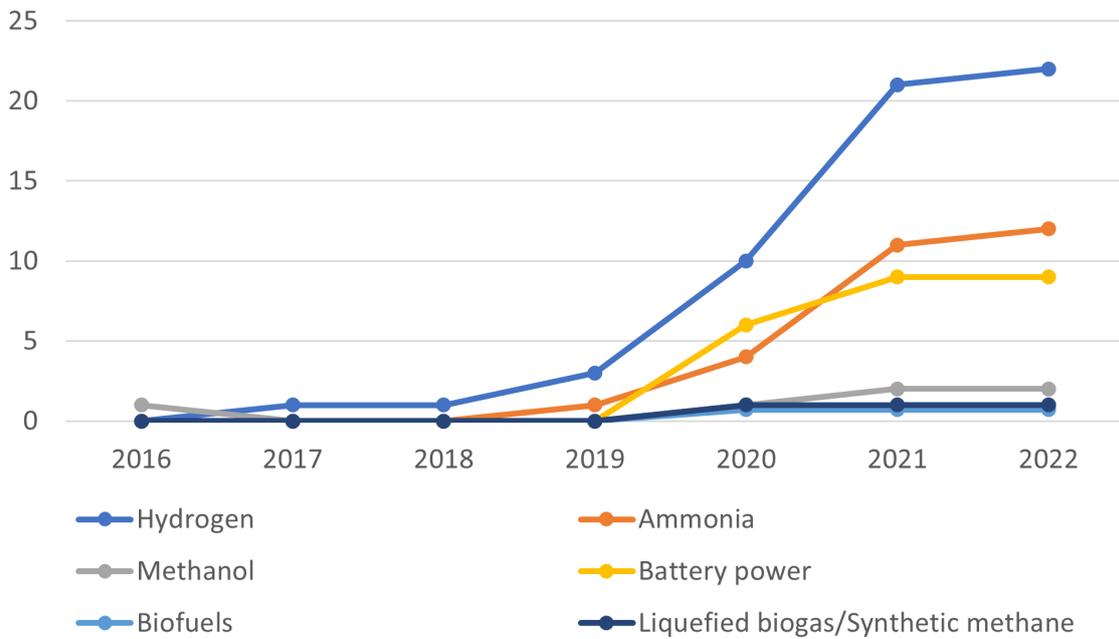


Figure 3: Total number of bunkering and infrastructure projects by fuel focus 2016 to Q1 2022

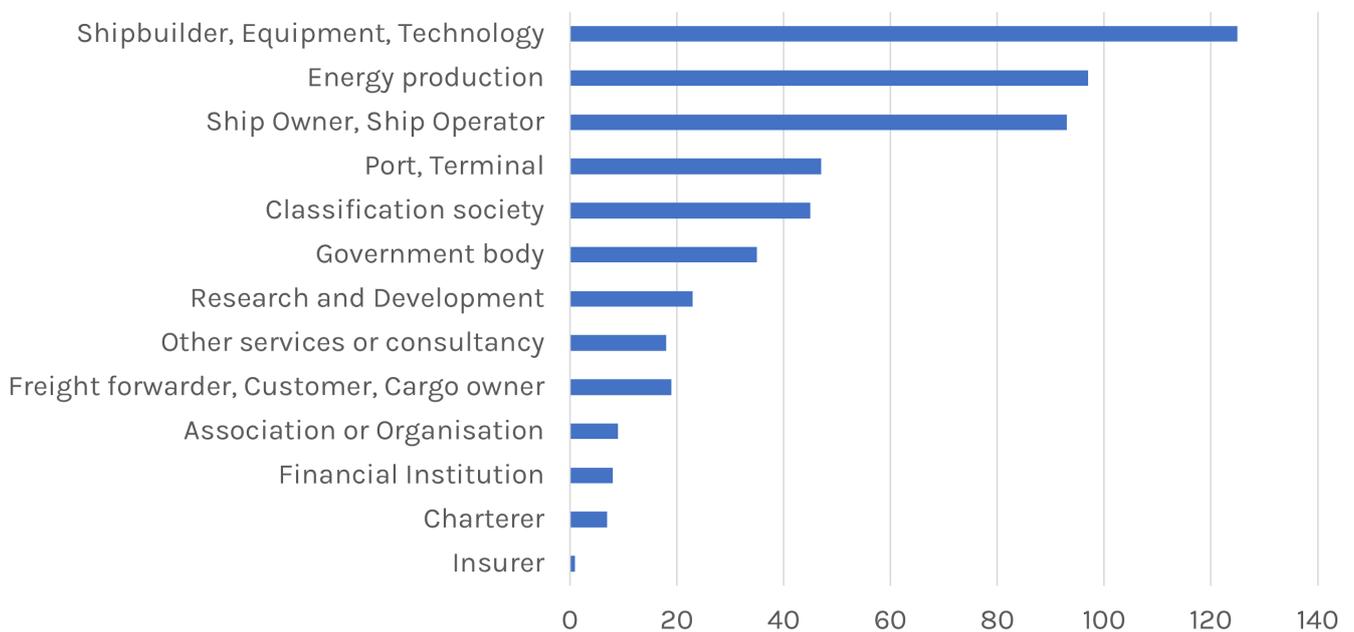


Cross-value chain projects

The Getting to Zero Coalition’s recent report **The Next Wave: Green Corridors**, identified cross-value chain collaboration as one of the key building blocks to establish green corridors and for implementing viable demonstration projects. In this context, the mapping study has been expanded to include a new category focused on the parts of the value chain involved in each project.

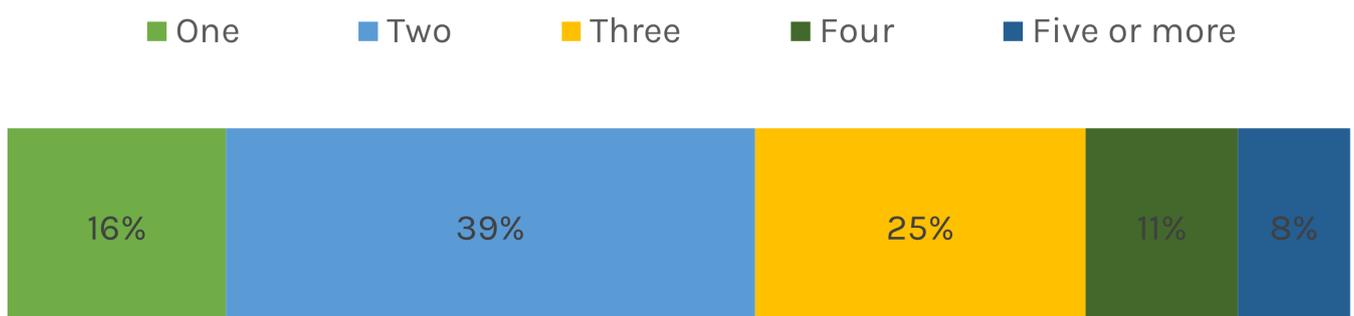
Almost all projects included in the mapping study involve multiple stakeholders and parts of the value chain. The most active stakeholders come from five categories; Shipbuilder, Equipment, Technology; Energy production; Ship owner, Ship operator; Port, Terminal; and Classification society (see Figure 4).

Figure 4: Project participation by different parts of the value chain



Examining the overall value chain data shows that 170 projects (84 percent) involved at least two parts of the value chain, indicating a broadly collaborative environment. However, only 40 projects (20 percent) involve at least four value chain categories (see Figure 5 below).

Figure 5: Number of value chain segments covered in projects



Drilling down into the frequency of the individual value chain categories highlights a lack of projects where the demand side of the industry is involved. The Freight forwarder, Customer, Cargo owner category; and Charterer categories are only involved in 21 projects (roughly 10 percent of projects tracked in the study). These two categories are of particular significance, as the Getting to Zero Coalition analysis has also identified that customer demand will be a key factor in achieving scale for zero-emission shipping projects. Of the 21 projects, Freight forwarder, Customer, Cargo owner, and Charterer are involved in, 16 of the projects focus exclusively on ship technology.

In addition to the demand side stakeholder categories - Freight forwarder, Customer, Cargo owner and Charterer - other key actors in the value chain include Ship owner, Ship operator; Energy production; Government body; Port, Terminal; and Classification society. In total there are 41 projects (20 percent) in the mapping that include at least three of the key value chain actors as a partner to the project. Of these projects, 30 focus on ship technology, 13 focus on bunkering and infrastructure, and eight focus on fuel production (several projects have multiple focus areas). Geographical areas and fuel focus are widely distributed.

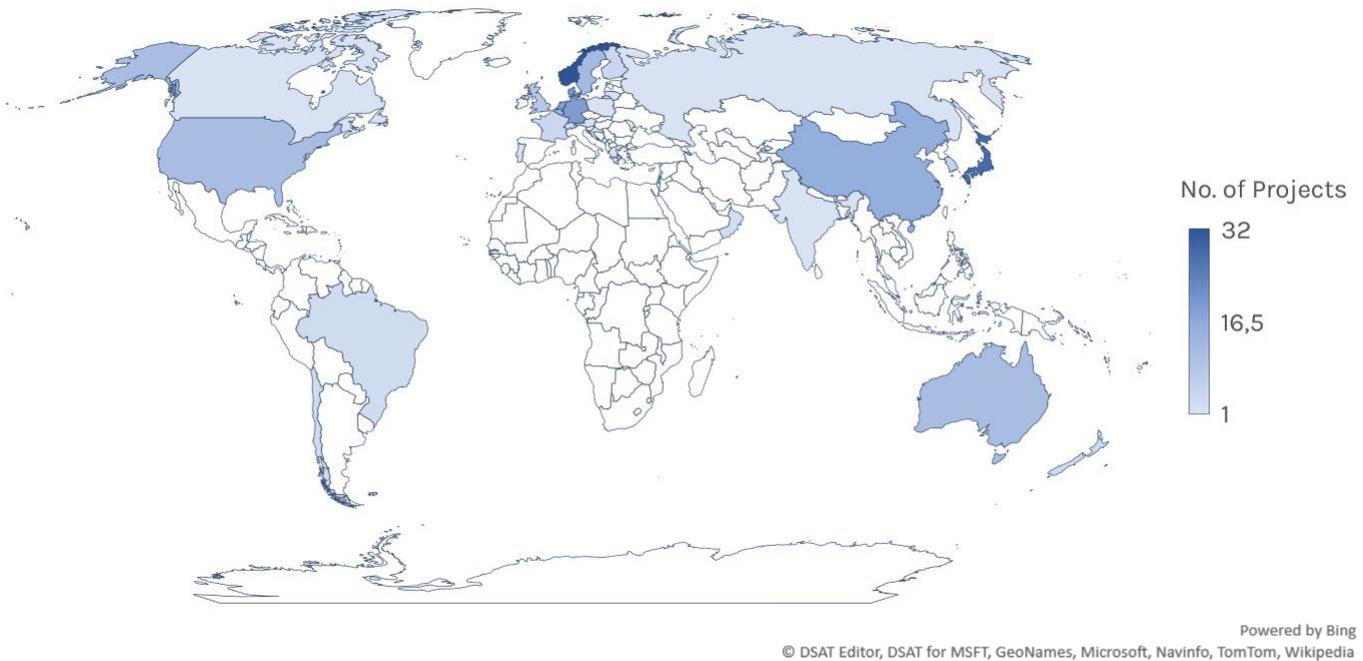
The most common partnership between key parts of the value chain is between Ship owners, Ship operators and Energy production. However, when it comes to the basic operational value chain which comprises; Ship owner, Ship operator; Energy production; and Port, Terminal there are only five projects in the mapping with all of these stakeholders.

Geographies

In terms of geography, a majority of the projects are connected to Europe (114), followed by Asia (60), Oceania (14), North America (13), and South America (8).¹ Figure 6 below illustrates where the projects are taking place. The most significant development since the last edition of the mapping is that the number of Asian projects has increased from 31 to 61, with most projects taking place in Japan (29) and China (15), followed by Singapore (8) and South Korea (5).

¹ Some projects span multiple countries and continents.

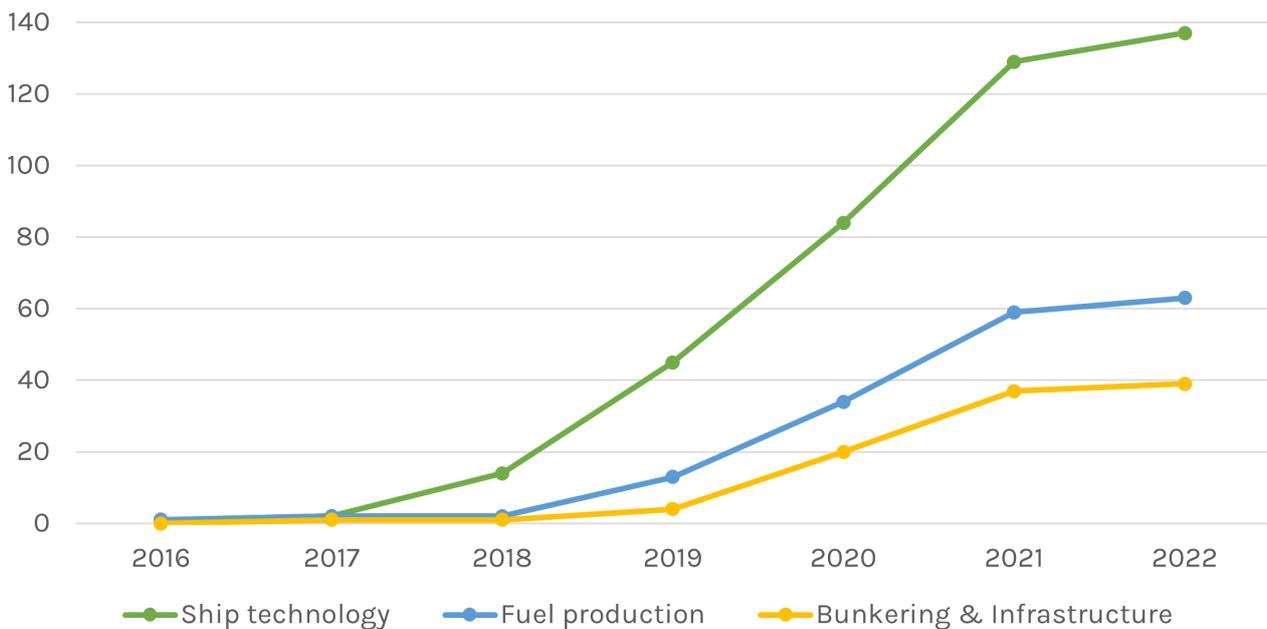
Figure 6: Number of projects in each country



Project type and focus

The project focus is divided into ship technology, fuel production, and bunkering and infrastructure. Approximately 67 percent of the projects in the mapping focus on ship technology, 31 percent of the projects focus on fuel production, and 19 percent focus on bunkering and infrastructure.²

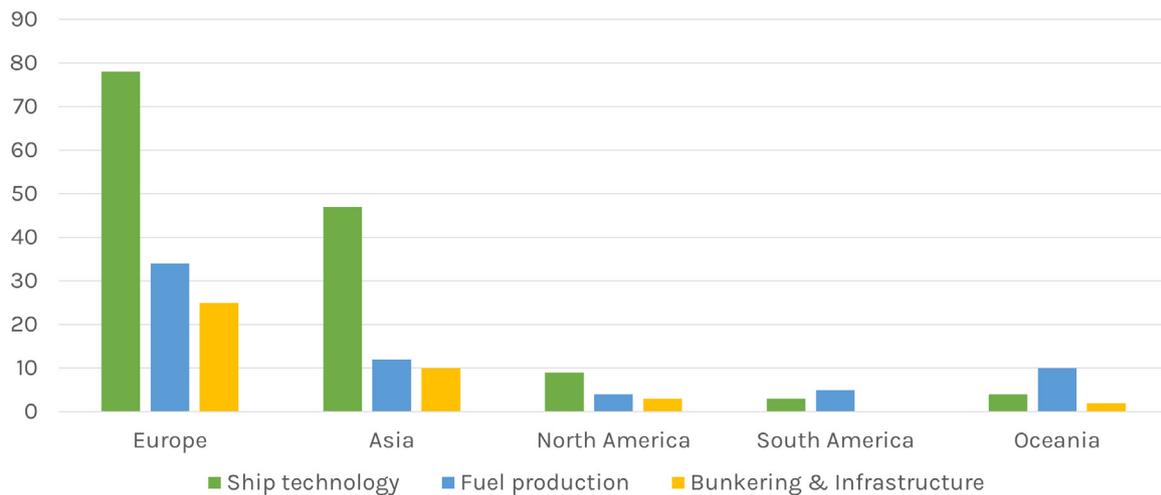
Figure 7: Project focus increase from 2016 to Q1 2022



² Some projects have multiple focus areas meaning that percentages sum to more than 100.

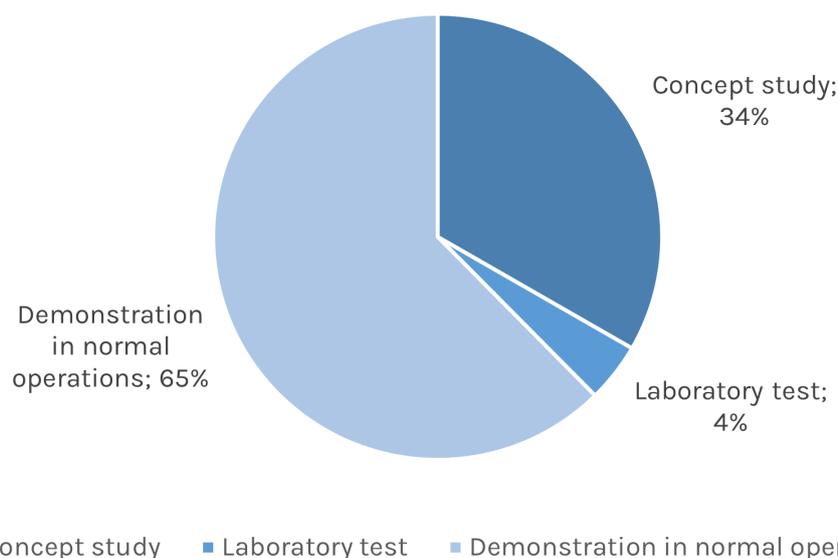
At a regional level, the data shows Oceania and South America focus primarily on fuel production, whereas Asia, Europe, and North America have projects spread across the categories, with the largest number of projects in these regions focused on ship technology (see Figure 8). This can be explained in the context of each region’s natural strengths, such as abundant renewable energy resources in Australia and Chile, or advanced shipbuilding industries in Japan, China, Norway and Denmark.

Figure 8: Project focus in each region



The mapping differentiates between projects demonstrating technologies in normal operations, concept studies, and testing in a laboratory setting. Demonstrations in normal operations make up 65 percent of all projects, with concept studies accounting for 34 percent and laboratory tests representing only four percent of all projects (see Figure 9).³ The ratio between the three categories has not changed significantly since the second edition of the mapping study.

Figure 9: Percentage of projects by project type

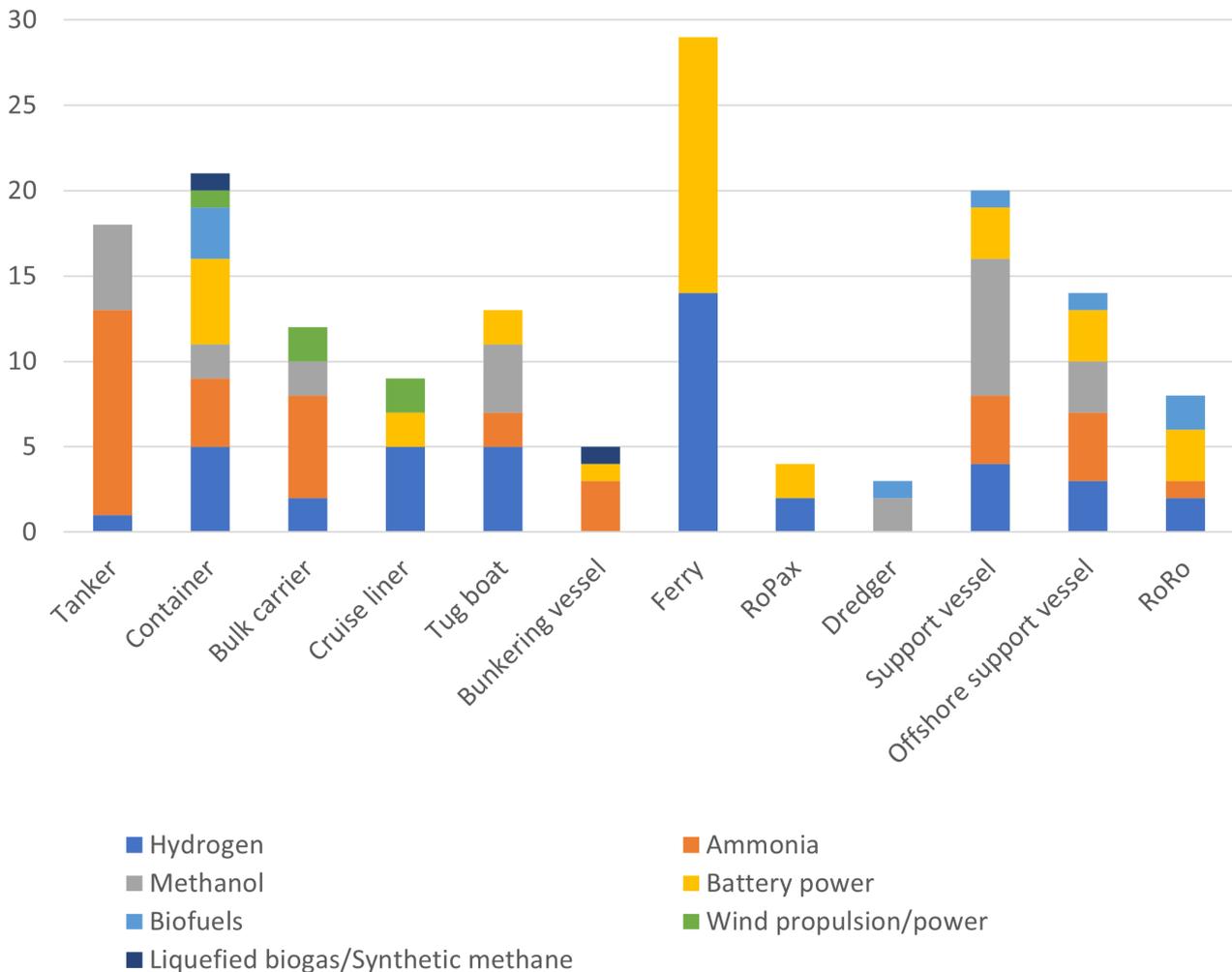


³ A project can have multiple project types meaning the percentages sum to more than 100.

Ship technology and ship types

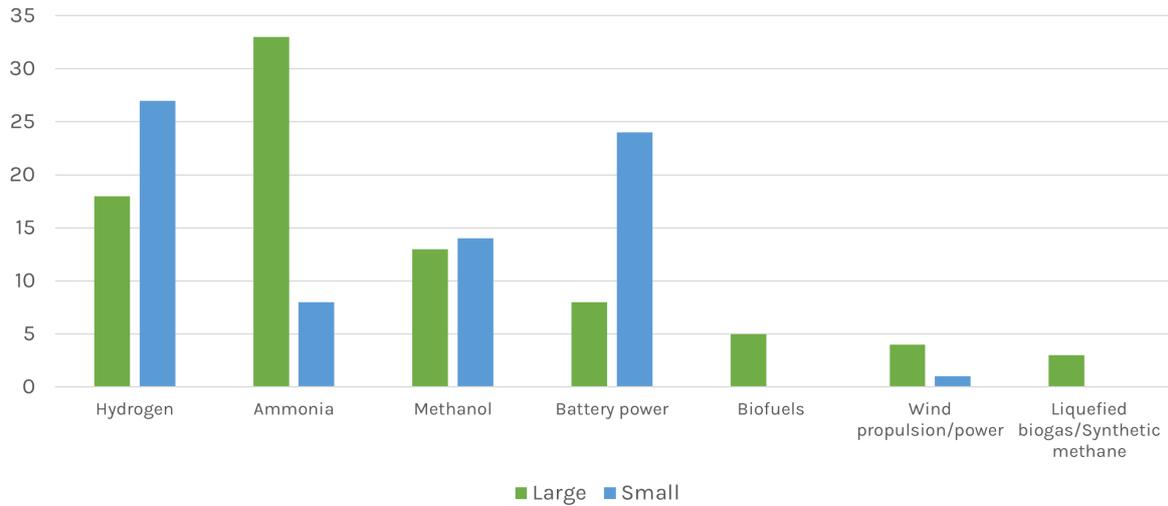
Roughly two-thirds of the projects included in the mapping study focus on ship technology. Ship technology projects are occurring across a diverse range of fuels and vessel types (see Figure 10).

Figure 10: Number of projects by ship type and fuel focus



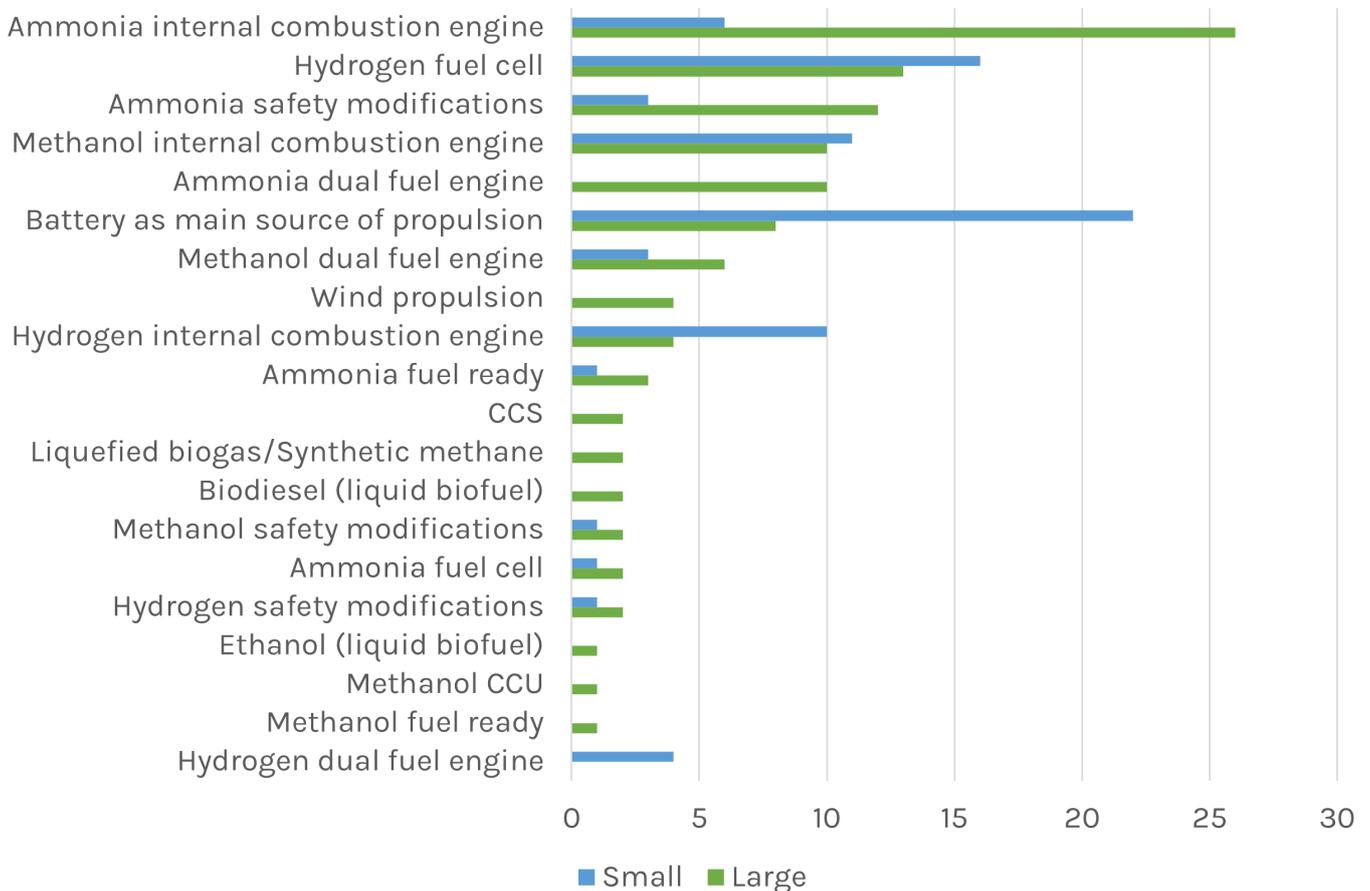
By aggregating the different ship types into small and large vessels, differences in fuel focus become clear for the two ship sizes (see Figure 11). Ammonia is the clear leader for large vessels, with hydrogen used across both ship sizes and battery power a popular fuel in small ship projects.

Figure 11: Fuel focus preference for small and large vessels



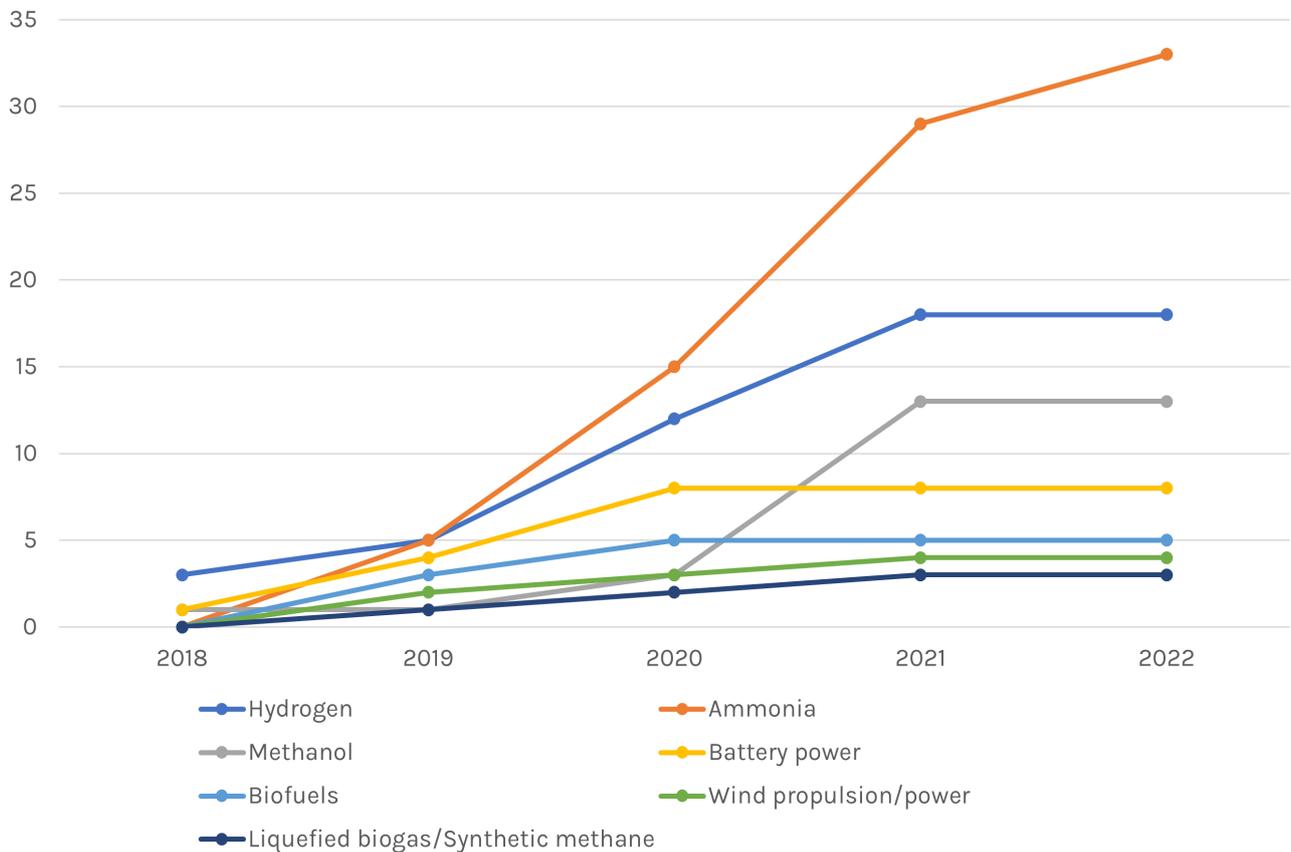
Examining the specific ship technologies used in small and large vessel projects shows emphasis on internal combustion engines, dual-fuel engines, and safety modifications for large vessels. For small vessels the focus is on hydrogen fuel cells, hydrogen combustion engines, and battery propulsion (see Figure 12).

Figure 12: Ship technology for small and large vessel projects



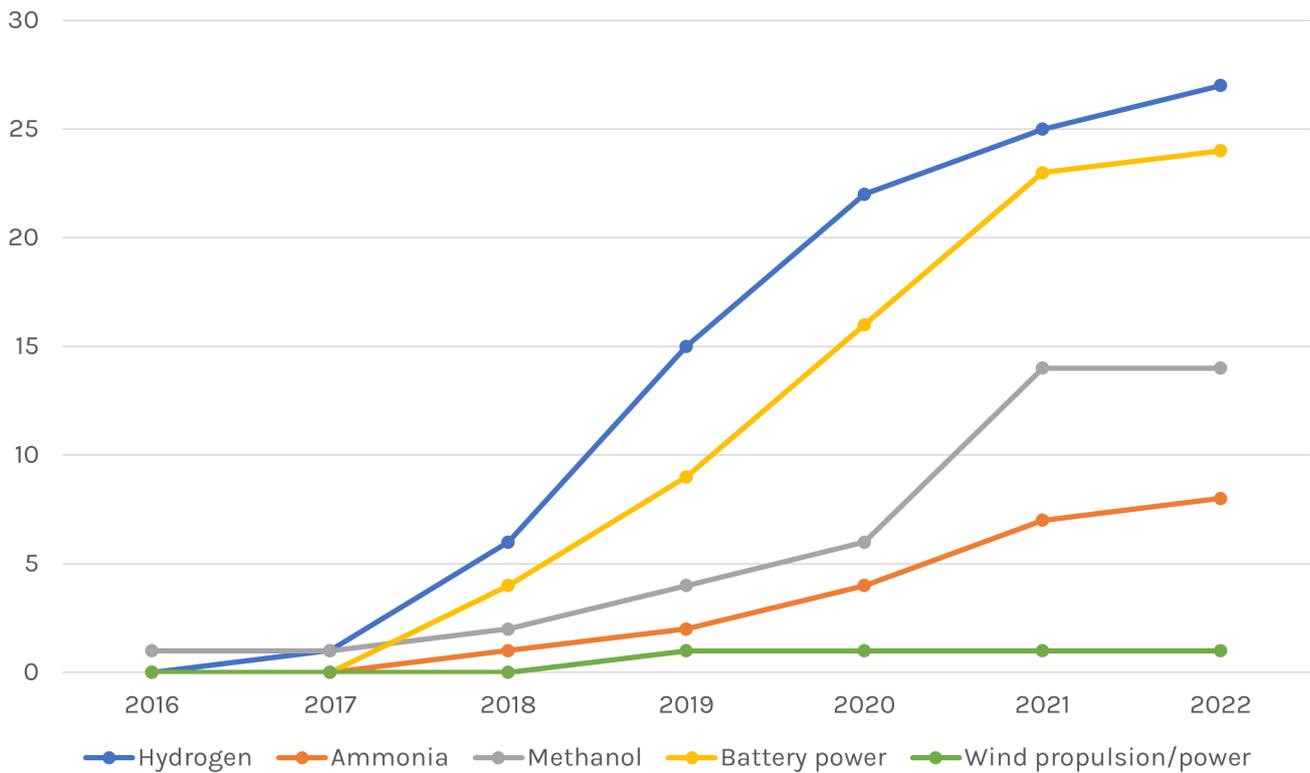
The focus on different fuel types also seems to be changing over time, with ammonia only emerging in recent years as a preferred solution for large vessel ship technology projects (see Figure 13). The number of projects focusing on methanol also experienced significant growth over 2021.

Figure 13: Fuel focus of ship technology projects for large vessels from 2016 to Q1 2022



Small vessel ship technology projects show hydrogen and battery power as the dominant fuels overall, but the data also shows that seven new methanol projects were commenced during 2021 (see Figure 14). It is worth noting that almost 60 percent of small vessel hydrogen projects involve hydrogen fuel cells, which offer another method of electrifying ships in addition to battery power.

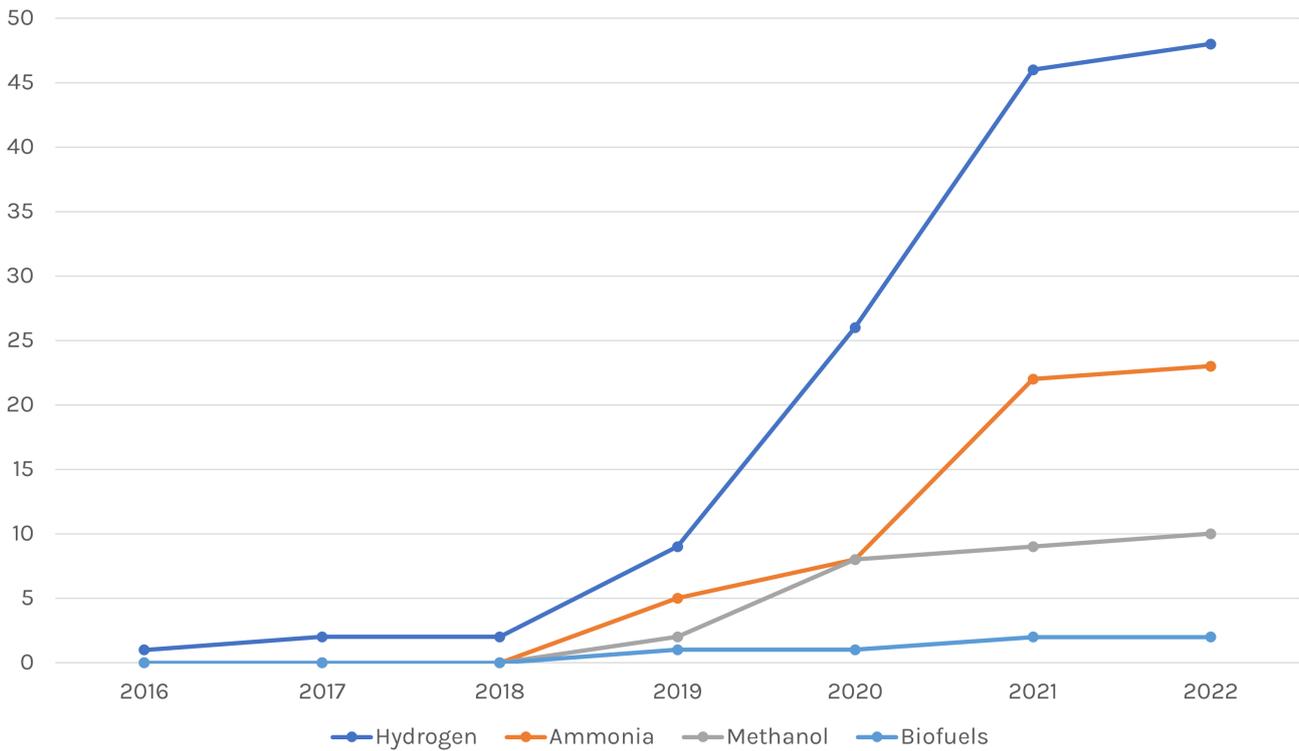
Figure 14: Fuel focus of ship technology projects for small vessels from 2016 to Q1 2022



Fuel production

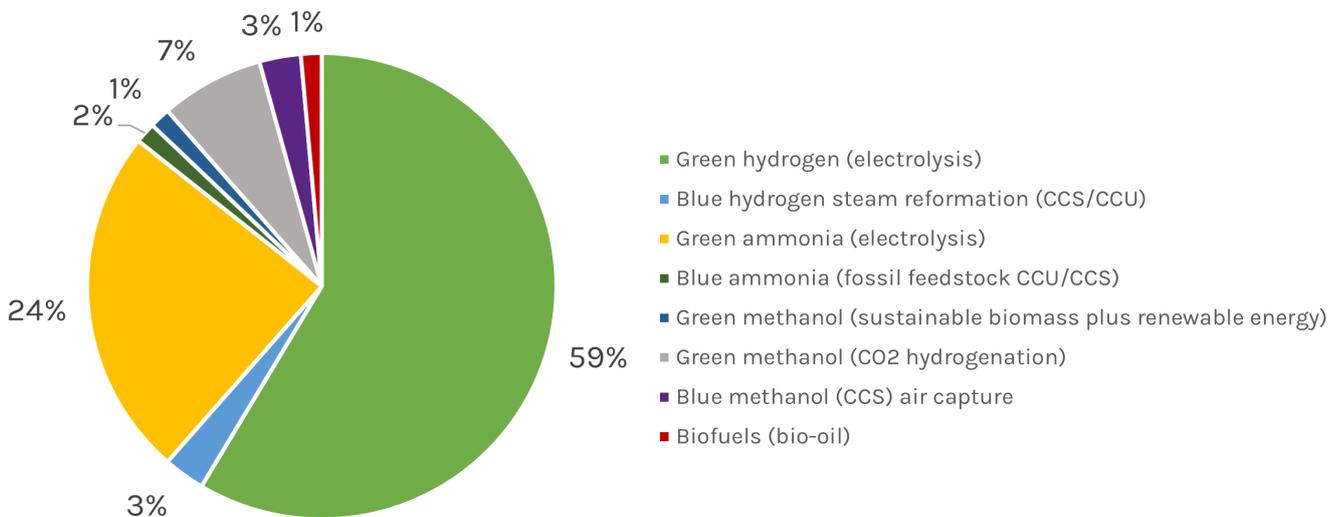
Almost one-third of the projects included in the mapping focus on fuel production. Looking at fuel production developments over time, there is a steady and significant increase in hydrogen production projects. From 2021 there has been a significant increase in ammonia production as well, with 13 ammonia fuel production projects announced in 2021. It is worth noting that fuel production projects were included in the mapping so far as they anticipate producing marine fuels or have a member of the Getting to Zero Coalition as a project partner.

Figure 15: Fuel production and development over time



In terms of fuel production technologies, there is a clear preference for green hydrogen electrolysis and green ammonia synthesis, with these two fuel production technologies making up 79 percent of all fuel production technologies in the study (see Figure 16).

Figure 16: Fuel production technology used



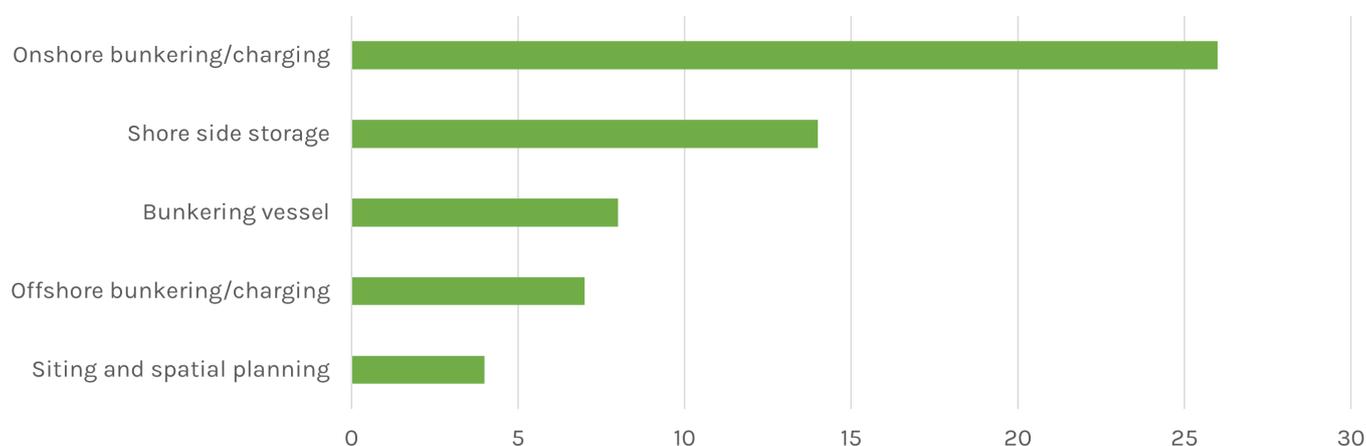
Part of the reason for the large number of hydrogen projects found in the study is that hydrogen is a production input for both ammonia and methanol. Thus many projects, particularly on the fuel production side, will show a hydrogen component in addition to another fuel. Despite this, the mapping still shows a strong preference for projects focusing on the production of hydrogen and hydrogen-derived fuels for the maritime industry.

Bunkering and Infrastructure

Bunkering and infrastructure is the focus of 19 percent of the projects in the mapping. Most of these projects focus on onshore bunkering, shore-side storage, and bunkering vessels. The projects take place in Europe (25 projects), Asia (10 projects, all taking place in Japan or Singapore), North America (3), and Oceania (2 projects).

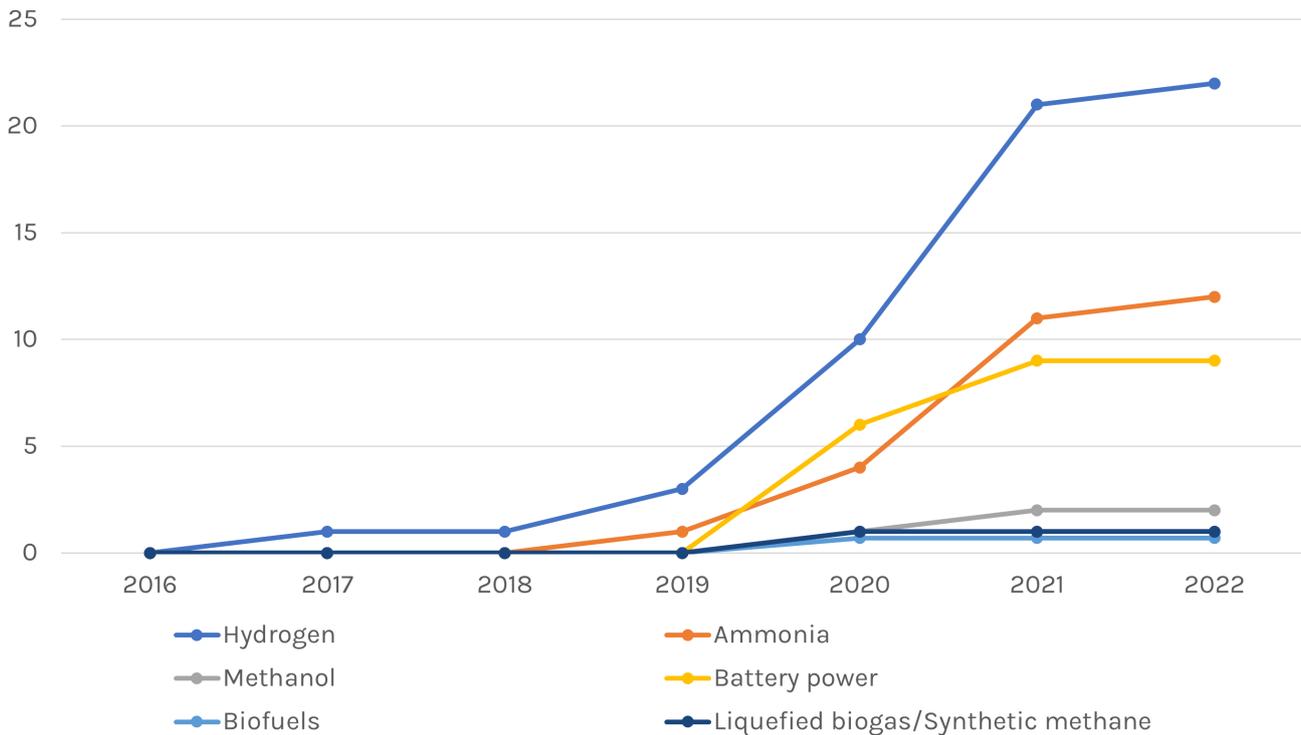
To enable green shipping along specific routes, investments in bunkering and infrastructure between major ports are necessary. The mapping shows that a significant number of projects focus on bunkering and infrastructure and involve ports and terminals in Europe and Asia. The Next Wave: Green Corridor report highlights the Europe/Asia containership route as a feasible option to create a high-impact green corridor, and the projects in the mapping indicate that necessary infrastructure for zero-emission bunkering is underway.

Figure 17: Bunkering and infrastructure



In terms of fuel focus, the bunkering and infrastructure projects are illustrating the same fuel trends as seen in fuel production projects with an emphasis on hydrogen and ammonia, with a high number of battery-related projects emerging as well (see Figure 18). Approximately half of the projects focus solely on bunkering and infrastructure, and the other half also focuses on fuel production.

Figure 18: Bunkering and infrastructure projects by fuel type



Multi-port projects

Out of the total 47 projects in the mapping where ports are involved as a partner, seven projects include multiple ports as project partners. These projects focus on regional and international routes.

Five of the multi-port projects focus on transport within Europe. The projects include relevant stakeholders and aim to develop the right conditions and infrastructure for zero-emission transport between ports. Three of the projects are regional ferry projects, aiming to decarbonize the ferry routes between Sweden/Denmark and Germany through battery as the main source of propulsion.

Two of the projects focus on cross-regional transport. A hydrogen project in Northern Australia focuses on delivering a fully integrated hydrogen production and export supply chain between Australia and the Asia-Pacific region. The last project is undertaken in Brazil and focuses on creating a hydrogen hub for production and export. Through the collaboration, green ammonia will be exported to Europe from the Port of Pecém to its trading partner, the Port of Rotterdam in the Netherlands.

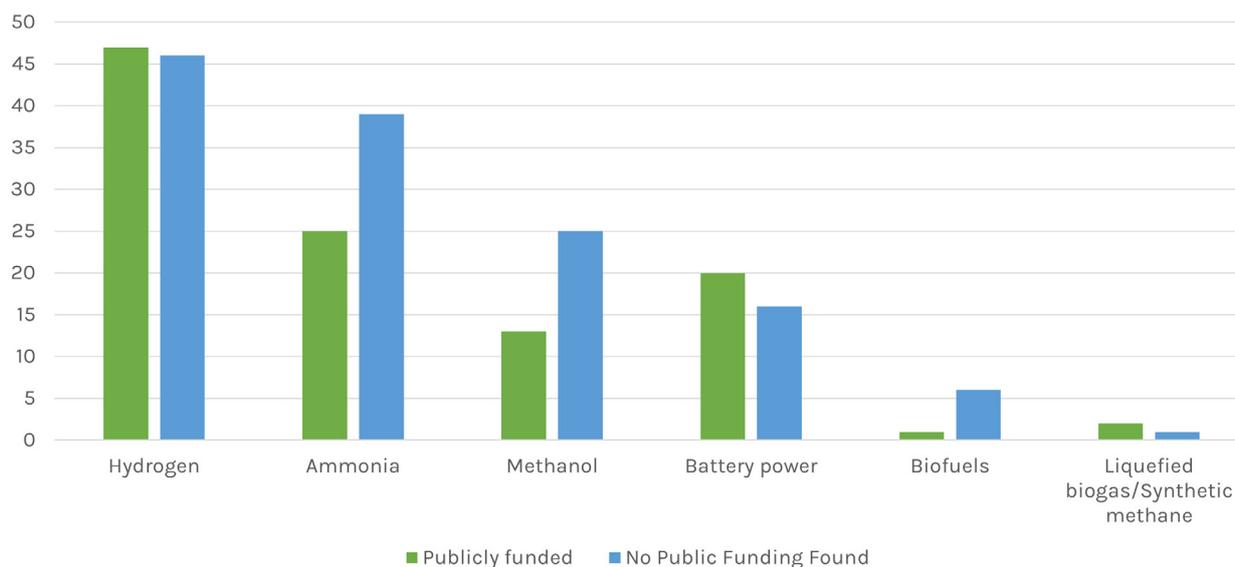
Funding of projects

The proportion of projects which have received some amount of direct public funding is just under half, with the mapping study identifying public funding for 88 projects out of the total 203. Of the publicly funded projects, 70 are found in Europe, with less public funding found for projects in other regions, particularly Asia.

It is worth noting that the existence of public funding was only counted where there was a direct award of funding to the project. This does not count public funding where one of the partners is a public entity or when the project was partially funded through other sources of funding like subsidies. This can partially explain the lower amount of publicly funded projects outside of Europe, which frequently have public support, but not necessarily direct funding awards in the same way as is done, for example, through the EU.

Bunkering and infrastructure projects and fuel production projects are more likely to receive public funding than projects focused on ship technology. When it comes to fuel focus, hydrogen and battery power projects attract the most public funding, with both fuel types receiving public funding on more than half of the projects included in this study (see Figure 19). The focus on public funding for hydrogen-related projects is understandable given that the EU and many countries have identified the development of hydrogen projects as a strategic priority.

Figure 19: Number of publicly funded projects for each fuel type



What next?

We hope that by continuing to develop a better understanding of the scale and diversity of zero-emission pilots and demonstration projects already underway, the mapping can continue to raise ambition in working towards a transition to zero-emission fuels for the maritime industry. In this way, we hope the mapping can provide some support to potential first movers in helping them to draw upon learnings from other projects and improving confidence in undertaking these projects.

The information in the mapping study is based on publicly available information which has not been verified, so we encourage stakeholders from across the maritime industry to send us information about new projects or projects we have missed so we can improve the quality and validity of the findings.

We would like to thank all the members of the Getting to Zero Coalition, who have provided us with information about the projects they are involved in. Without their contributions, the mapping could not have been produced.

The *Mapping of Zero Emission Pilots and Demonstration Projects* will be updated on a continuing basis by the Getting to Zero Coalition.

Details of the individual projects included in the study can be found on the [NextGEN website](#). NextGEN is a joint project between the Maritime and Port Authority of Singapore and the International Maritime Organization which seeks to develop a collaborative global ecosystem of maritime transport decarbonization initiatives, to ensure that the decarbonization journey remains inclusive for all.



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