

Appendix

DETERMINATION AND PRIORITISATION OF CLEAN HYDROGEN MISSION ACTIVITIES

Background

Results from one of the first Clean Hydrogen Mission member and stakeholder feedback sessions in early 2021 are discussed below. Feedback was obtained through an online session that included experts and ministry representatives from over 17 countries and the EC, including Australia, Austria, Canada, Chile, China, France, Germany, India, Italy, Japan, Korea, Morocco, Norway, Saudi Arabia, United Kingdom, and United States.

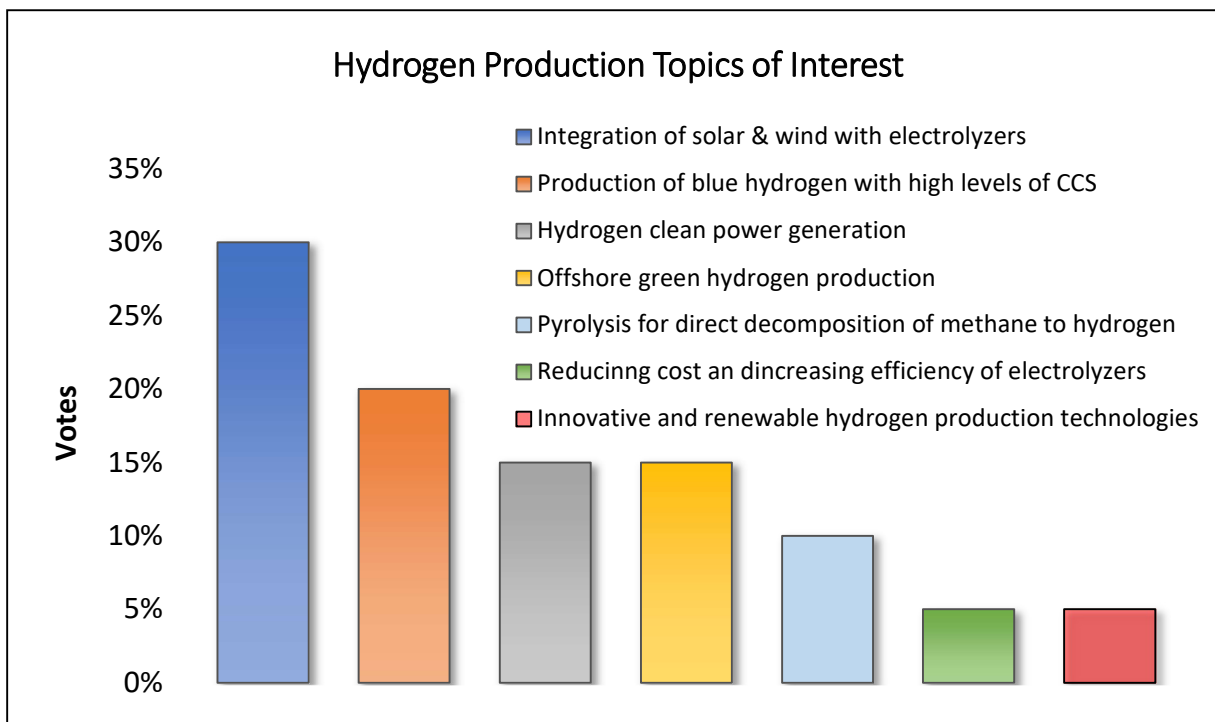
Members were requested to provide input during the web-based session on any topic of interest and participants voted on their highest priorities, real time using an online tool. These topics and votes by participants are shown below and organized by pillar: Research and Innovation, Demonstrations, and Enabling Environment. Although participation may not have been exhaustive and these topics are not necessarily the highest priority for all MI members or stakeholders, they are presented as a snapshot of preliminary feedback. Additional topics of interest and priority should be submitted in response to the draft summarized below.

Pillar 1: Research and Innovation Hydrogen Production

Workshop participants provided the following specific topics of interest that could be considered for collaborative work within MI and members voted on each to represent their priorities. The highest priority was for additional activities on integration of solar and wind plants with large-scale electrolyzers, including planning and operation, such as addressing load following, capacity factors, siting, controls, etc. The distribution of votes by topic is shown in Figure 1.

- Planning and operation of integrated solar and wind plants supplying power to large-scale electrolyzers

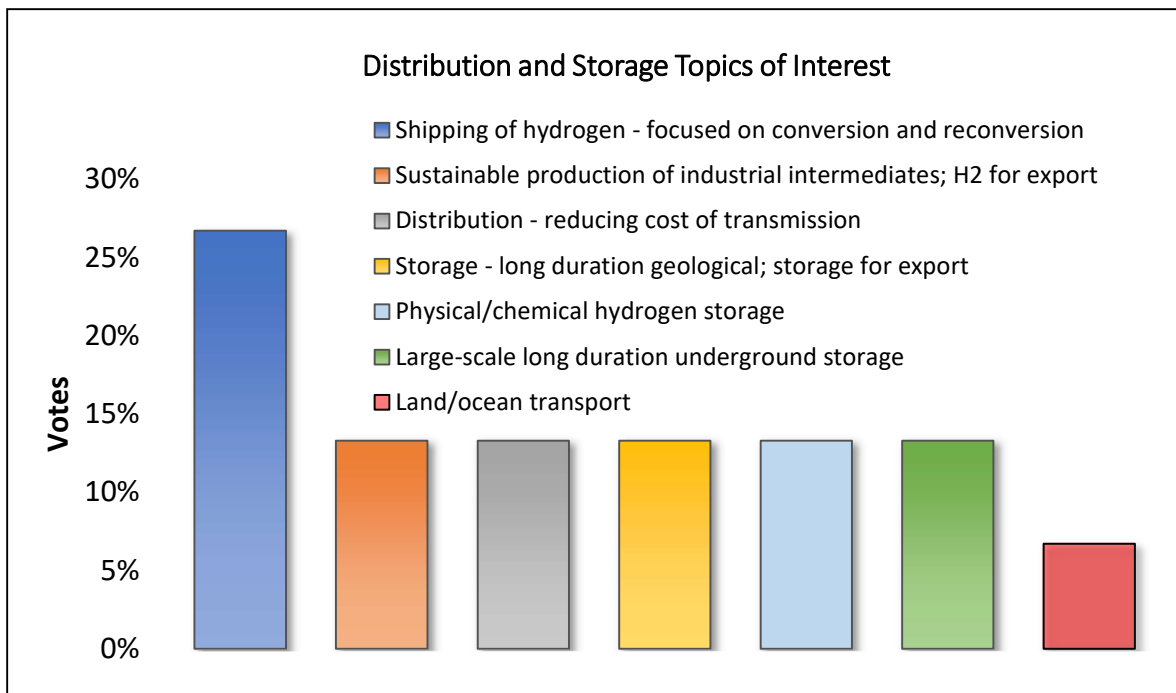
- Production of hydrogen via methane reformation with very high levels of CCS, as well as fossil based hydrogen production in general with CCS
- Hydrogen clean power generation, in relation to hydrogen production
- Offshore green hydrogen production via electrolyzers
- Pyrolysis for direct decomposition of methane to hydrogen and solid carbon (reducing the cost of production and producing a valuable co-product)
- Electrolysis - specifically reducing the cost and improving efficiency of electrolyzers
- Innovative renewable hydrogen production technologies



Distribution and Storage

The list below and Figure 2 show results and prioritization from members on topics related to hydrogen distribution and storage, with the highest priority identified as the shipping of hydrogen, with a focus on conversion and re-conversion (e.g., hydrogen and dehydrogenation) of hydrogen carriers such as LOHCs. All other topics were of lesser interest at the feedback session although there is some overlap among topics. With recent global interest in international trade of hydrogen and in the use of chemical carriers for low cost, high density hydrogen transport, this is clearly an area of potential interest to multiple MI members and stakeholders.

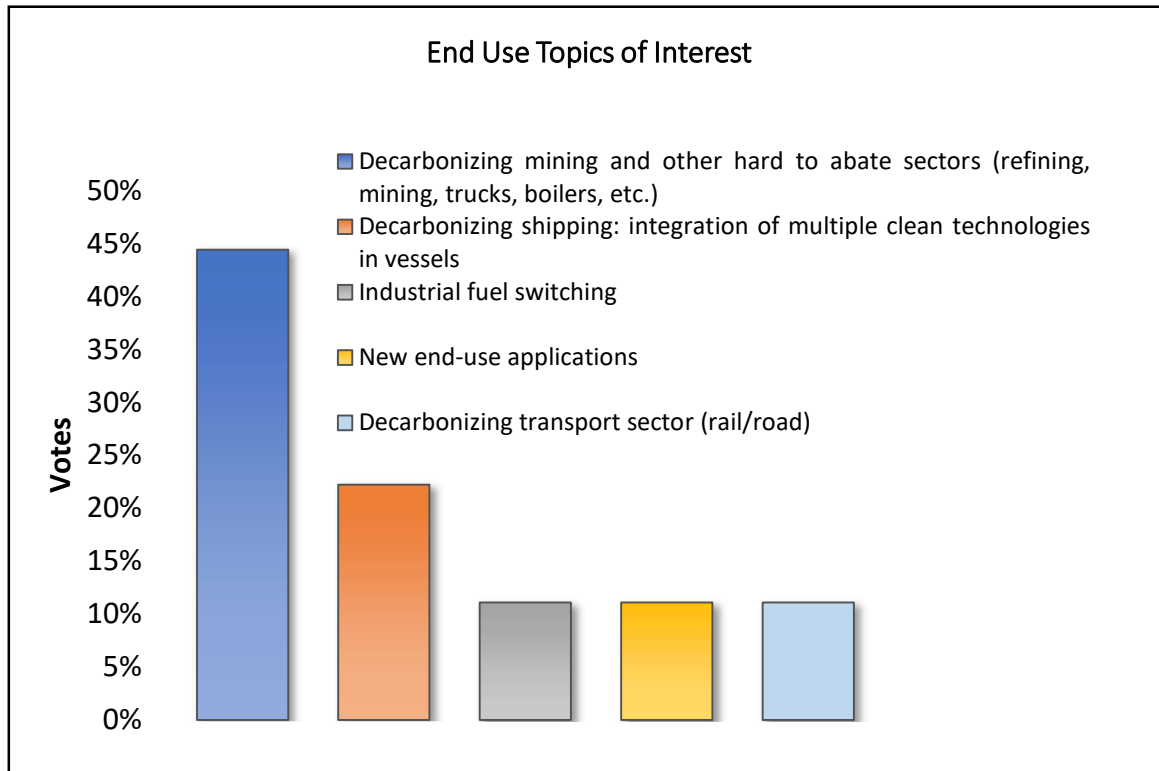
- Shipping of hydrogen, focusing on conversion and reconversion elements, i.e., hydrogen transport and transport vectors such as ammonia, methanol, e-fuels, LOHCs, etc.
- Sustainable production of industrial intermediate products, such as green ammonia or green steel, and hydrogen for export using renewable energy sources
- Distribution – specifically reducing cost of transmission and a greater understanding of technical opportunities and/or limitations of blending hydrogen in natural gas pipelines
- Storage – specifically storage in geological formations and storage for long range export
- Physical or chemical hydrogen storage
- Large-scale long-duration (underground) hydrogen storage
- Land/ocean transport



End Use Applications

Specific end use applications and requirements for hydrogen delivered to the end use, such as purity, pressure, etc., will dictate the conditions and thus cost of the hydrogen, and will be directly related to the Mission's overarching goal is to achieve 2 USD/kg hydrogen from production to end use. The list below and Figure X show results and prioritization from members on topics related to various end uses of interest. The highest priority selected was decarbonizing heavy duty applications such as in the mining industry, as well hard to decarbonize industries such as refining. Some topics were overly general and duplicative though consistent with multiple studies, it is not surprising that focus on hard to decarbonize sectors for the use of hydrogen is considered a priority.

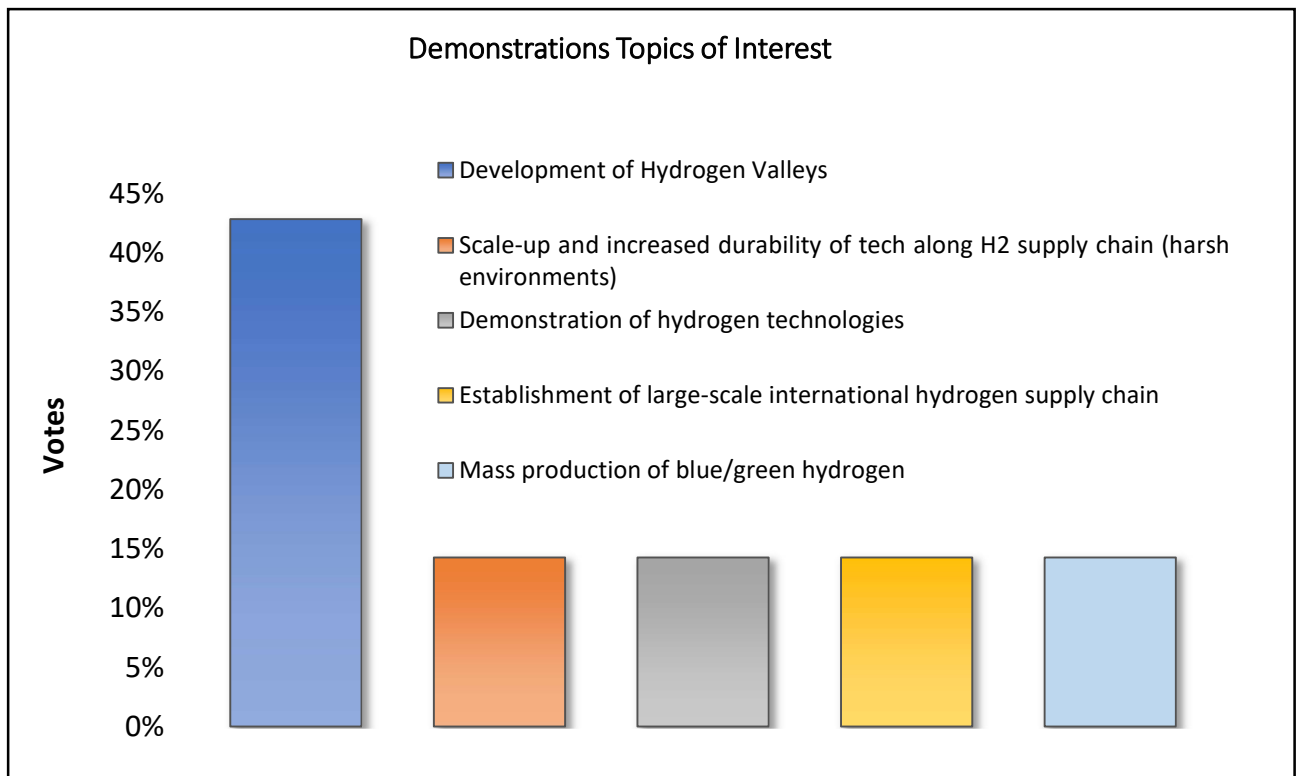
- Synthetic fuels and other technologies for decarbonising the mining industry as well as new technologies for green hydrogen use in machinery, trucks, boilers, and hard to abate industries, such as refining and smelting processes
- Decarbonizing shipping applications, including integration of multiple clean technologies (e.g., hydrogen, ammonia, methanol) in vessels; including supply, bunkering, and logistics applications
- Industrial fuel switching
- New end use applications
- Decarbonising the transport sector, specifically rail/road transport
- Hydrogen applications in multiple areas including mobility, direct iron reduction (DRI), grid stability, and power production



Pillar 2: Demonstrations

For demonstration activities, participants provided the following feedback on areas of priority, with the development of hydrogen valleys receiving the most votes. Given the previous focus on hydrogen valleys through the Mission Innovation Challenge 8, members anticipated a continued focus on demonstrating hydrogen valleys and applying lessons learned and best practices.

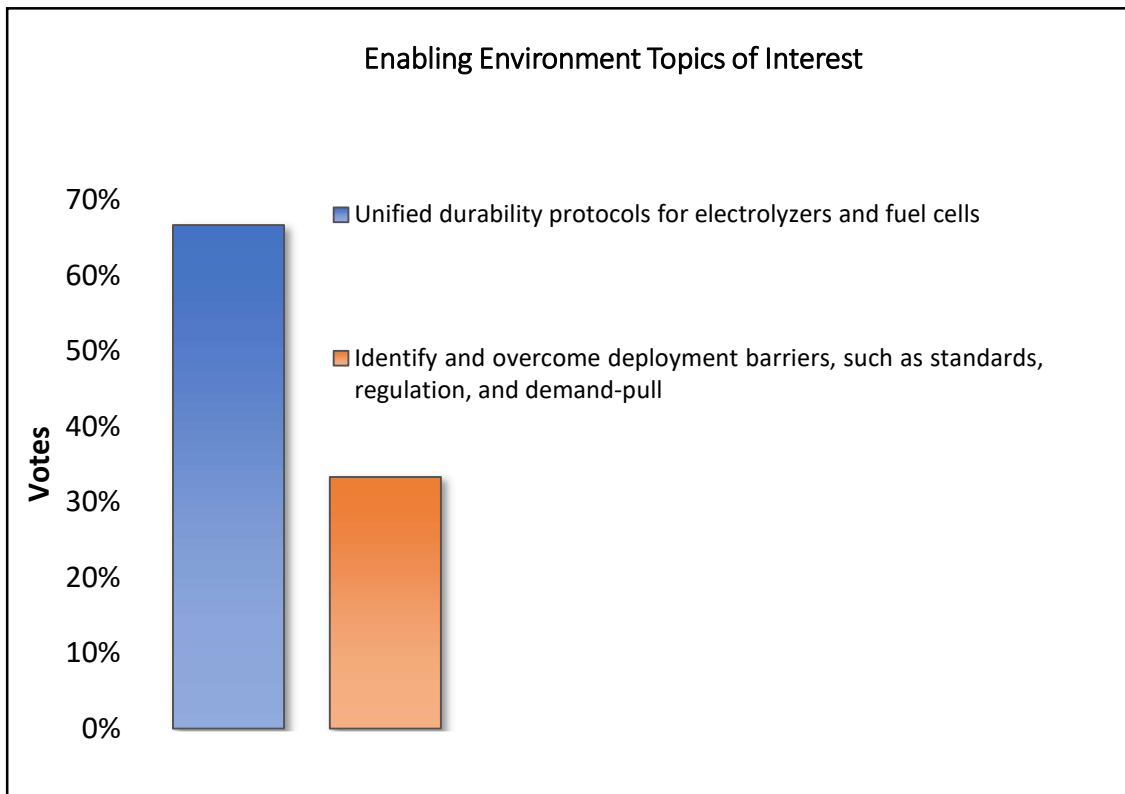
- Development of hydrogen valleys
- Scale-up and increased durability of technologies along the green hydrogen supply chain and applications in stressing geographies: extreme solar irradiation and exposure, high altitudes, dust-filled settings/environments, exposure to vibration, etc.
- Demonstration of hydrogen technologies (this is presumably specific to hydrogen production and not included in the broader hydrogen valley context)
- Establishment of a large-scale international hydrogen supply chain on a commercial basis; specific comments include without limiting the use of hydrogen carriers
- Mass production of blue/green hydrogen



Pillar 3: Enabling Environment

In this category, participants provided a limited number of specific topics of interest. However, there was discussion about the importance of coordinating with broader global activities. A key area of interest was safety, codes, and standards, and recognition that such activities were also underway through other international hydrogen partnerships

- Unified durability protocols for electrolyzers and fuel cells; codes and standards (aligned with the third pillar, this included coordinating with other initiatives to facilitate an enabling environment for hydrogen solutions)
- Identify and overcome deployment barriers, such as standards and regulations, and enable demand-pull



The topics and priorities listed in this Appendix are not considered exhaustive but provide some insight into the early perspectives of members and stakeholders as the Mission was being established in early 2021. As stated in the main section of the Discussion Paper, members and stakeholders should provide feedback on these and other topic areas of interest to be included in the Mission. In developing the Action Plan, feedback will be considered to help identify and prioritise key activities appropriate within the scope of MI and to avoid duplication with other initiatives. Coordination and leveraging of resources will be critical in accelerating progress towards a clean hydrogen economy.