Clean Hydrogen Partnership

Summary of the opinions collected from the wider scientific community on the work Programme of the Clean Hydrogen JU

October 2022

The Clean Hydrogen JU continued its effort to increase the openness of its Programme, by widening the scope of its Programme Review Days (PRD). In 2022, this part of the Hydrogen Week, traditionally presenting the progress of the Programme and achievements of selected projects, was opened to the wider scientific community for consultation (as required by the SBA – see above too). These days were thus renamed as EU Hydrogen Research Days and included discussion panels for each Pillar with scientists / researchers from the wider scientific community, along with the audience, freely exchanging their views and opinions on the Clean Hydrogen JU Programme, the achievements of its projects and the way forward.

A number of repetitive themes and conclusions (to the precedent year exercise) arose from the different panels during the EU Research Days, which are summarised below:

1. One important conclusion that can be drawn from the JU projects is that most barriers are not so much technological or financial, but arise from the cross-cutting areas of regulation and education. Complex permitting procedures and lack of regulations and standards are observed at national and local level, which are combined with limitations in skilled labour.

2. In parallel, increasing public awareness is critical for the public acceptance of hydrogen technologies. Communication and dissemination of project results and the benefits of hydrogen can help bring these technologies closer to the public and also allow facilitate the collaboration with regulatory and local authorities. This can then lead to the desired increase of uptake.

3. The availability of resources and components in Europe must be ensured, especially considering the great challenges faced the recent years (during COVID-19 pandemic especially) in terms of supply chain disruptions and lack of materials. Manufacturing capacity in EU must be supported strongly in the coming years, while also working more on materials and related sustainability aspects.

4. Hydrogen Valleys can accelerate technology progress and the uptake of hydrogen technologies, while also facilitate the collaboration between the sector stakeholders (industry, research, SMEs), as they provide an energy ecosystem where all stakeholders can become part of it and see the benefits of hydrogen. They can help to identify regulatory and standards bottlenecks, increase public awareness and provide a “platform” for the collaboration of different stakeholders. If set up appropriately, based on the hydrogen demand needs of the valley participants, then they can ensure hydrogen uptake and address these additional bottlenecks. The Hydrogen Valleys can gradually be replicated or linked among themselves or even with other independent projects, thus further enlarging these ecosystems. In turn they could then provide for the creation of the necessary demand in EU for equipment and components to support in-house manufacturing.

5. Although there is a gradual shift within the hydrogen sector of the focus towards deployment of current technologies, it is important not to stop working on the next generation technologies, for EU to keep its competitive advantage at international level. The research at low TRL should always be in line with the priorities of the industry, so that these technologies can be then exploited and be implemented in the different hydrogen applications. In parallel, research should continuously look

into the current technologies and see how it can further improve their performance, while lowering their cost.

6. Synergies will be a key to succeed the above. The national programmes and the Clean Hydrogen JU SRIA should be aligned to avoid unnecessary overlaps but mostly to ensure complementarities and by using the available tools that have been set up, like the ERA Hydrogen Pilot and the SET Plan, to achieve synergies both at the level of research and in deployment. In parallel the Clean Hydrogen JU should collaborate with the end-use related European Partnerships (such as Clean Aviation JU, EU-RAIL JU, Zero waterborne, 2ZERO etc) by discussing with them and identifying the needs of their sectors. Nevertheless, research should not be restricted just to these areas, as hydrogen is an enabler and it is important not to limit it beforehand. In this aspect also collaboration with CETP could be beneficial.

In terms of specific scientific priorities, several priority areas were proposed by the participants (including scientific community), as follows (presented by Pillar):

A. Hydrogen Production

Although the industry technology is maturing with PEM electrolysers becoming a reliable solution for the production of hydrogen with very low contamination, it is important to continue bringing together large mature industries with small and medium enterprises (SMEs) in projects to deliver the necessary impact and increase the manufacturing scale and technology uptake, including pushing the work on standards and improving the permitting process.

A significant impediment for the projects and the increase of their operational hours, especially for demonstration projects, is the high level of electricity prices, which is the main cost element of hydrogen production. Auxiliary services like electricity grid balancing shall support the financial viability of the hydrogen production installations and the integration of hydrogen technologies in the energy system. On the other hand, the 1-2 €/kg cost of grey hydrogen that used to be the point of reference has moved to 6, 8 or even 10 €/kg following the NG price hikes. To avoid the high cost of electricity and be competitive with grey hydrogen, investors should consider complete renewable hydrogen projects, whereby electrolysers would use directly renewable electricity from renewable energy technologies that are part of the green hydrogen production investment.

Research & innovation priorities to be considered in next calls:

- A number of challenges still remain to be addressed for the hydrogen production plants: cooling systems, reduction of critical materials, balance of plant, degradation, improved fast response services, heat exchangers, etc;
- To address the cost issue, focus may be given on the connection of electrolysis plants with off-grid renewable energy plants;
- Continued focus on purity for example by incorporating purification units in existing and future production installations;
- Further improvements in the automation of stack production at manufacturing level.

B. Hydrogen Storage and Distribution

Storage in salt caverns and depleted gas fields is at a low TRL, requiring support to continue gaining knowledge and experience especially at large scale, but also to investigate further critical issues (e.g. microbiological aspects for the porous reservoirs).

Regarding research on hydrogen mixtures into the gas grid and separation, RCS and hydrogen strategies are incomplete. Another critical factor is the limited awareness of the impact of hydrogen mixtures in the gas grid from the side of the gas transmission grid operators; one reason for this is their limited collaboration with relevant hydrogen projects (like project HIGGS).

Repurposing of gas pipelines and blending are both considered in the Programme, but the focus should be in repurposing as the more permanent long-term solution. In the short to medium term, the choice between the two is more dependent on what options are actually available to serve the customer needs. In refuelling, many synergies can be achieved with hydrogen valleys, heavy duty transportation and other end-uses.

Research & innovation priorities to be considered in next calls:

- Hydrogen Storage in salt caverns and evaluating the storage potential in porous reservoirs;
- For LOHCs low PGM catalysts for dehydrogenation are expected to be a critical element to reduce/eliminate the use of critical materials;
- For LOHCs reducing the required energy to hydrogenate and dehydrogenate;
- Significant work needed to improve the RCS framework; collaboration with regulatory authorities is advisable.

C. Hydrogen End-uses: Transport

Overall, it was agreed that the Programme is well structured and covers all transport areas sufficiently.

C.1 Building Blocks

The funded projects show that the developments in the building blocks for transport applications (fuel cell systems and on-board storage) is progressing smoothly. Building blocks are an essential area of research and will continuously require to invest in it to improve different aspects, like in components, materials and performance. More importantly though it is recommended that they are developed for all (if possible) transport applications, and then only to be customised accordingly to each specific application, as the optimal approach will differ in each case (e.g. different performances required by aviation compared to other modes of transportation).

Many new material developments warrant further research on this area. Moreover, there is already competition in materials, especially carbon fibres for tanks/on-board storage. This is expected to become further intense moving to mass-production. So it is critical to further work on materials and their sustainability aspects. Recycling should also be considered, as it has the potential to reduce costs.

Research & innovation priorities to be considered for next calls:

- Further research on materials as a priority, as for example components must be made more compact and lighter;
- More work is required to improve building blocks in terms of power density, durability, fuel efficiency. To progress more efficiently though it is important that all related components and aspects are developed in parallel, altogether;
- As degradation is better understood, more focus should also be placed on mitigation strategies to reduce it;
- High temperature applications should be considered more in the Programme;
- The work on building blocks should not exclude cars and buses; these will always need to be supported if we want to remain competitive and not fall behind international developments;
- Modelling should be used in combination with empirical methods to analyse project results.

C.2 Transport Applications

So far the different transport modes were addressed separately. This should gradually change, in combination with the research on the building blocks, so that a more integrated view on how to move ahead on hydrogen in mobility can be developed.

FCEV car and FCB demos have demonstrated that they are a competitive solution. It is important now to invest more in fleets to scale up and reduce costs. In parallel it is important to invest in supply chains, so that mass-production can be enabled and the FC can be built in EU, especially considering the low TRL of European FC suppliers and the supply chain issues that are observed the recent years. This is probably where EU lacks the most compared to its global competitors, not in technology readiness.

Another solution is to invest in hydrogen ecosystems, ranging from the vertical integration of the transport supply chain to setting up hydrogen valleys like ports, enabling the technology to be further developed and integrated in the economic sectors.

Two main problems identified in most demonstration projects were the low availability of HRS and the lack of regulations. Therefore, more attention is required on these aspects.

Research & innovation priorities to be considered in next calls:

- EU needs to put in place its own supply chains for the mass production of fuel cells for transport applications (and not only);
- For demonstration projects data monitoring remains a challenge to be addressed.

D. Hydrogen End-uses: Clean Heat and Power

Significant technological progress has been achieved over the past 15 years as shown by the projects, from the initial few hundred hours of operation achieved in the first projects to the several thousands of operational hours, with high efficiency and low degradation in the most recent ones.

From a technology point of view, it is important now to work on the development of different performance aspects to cover the diverse needs of end users. The requirements to cover these complex operations require

more developments, in particular in relation to the flexibility of the systems and their adaptability to different clean fuels (hydrogen, ammonia, renewable gases).

The main challenges now are less technological, as the maturity has increased, but more related to the business models, especially when consumers are gradually transformed to prosumers. The biggest problem is finding on one hand hydrogen to operate the systems and on the other hand, customers willing to invest in such applications. It is important to look at collaboration with other sectors, e.g. in the context of hydrogen valleys. Moreover, the regulatory framework needs to evolve.

Research & innovation priorities to be considered in next calls:

- FC technology must become more adaptable and flexible to end-use, while allowing the input of a wider range of clean fuels;
- Further research is required on materials to increases lifetime of stacks, reversibility, as well as improving degradation, modularity, stability of the system;
- Develop and automate processes for mass manufacturing of FC systems to reduce costs of components;
- It is important to address the aspects of openness and make results from projects accessible to the public and especially to the research community and the industry.

E. Cross-cutting Topics (focus: PNR)

Synergies and even the inclusion of European/national (and regional) standardisation bodies/technical committees in projects could facilitate the exchange of information and the uptake of project results in the updates of standards. Clean Hydrogen JU can further contribute to standardisation through its PNR activities.

Regulators are sometimes not aware of the existence of relevant standards, which should be addressed by future projects aiming at increasing their awareness and capacity building.

Contribution of JU in the mapping and awareness of the specific standards missing to the relevant authorities might identify gaps and accelerate adoption of the necessary legislative measures. Also, preserve the knowledge and maintain a repository to support the projects as well, in addition to its support on pre-normative research.

Research & innovation priorities to be considered in next calls:

- It is necessary for pre-normative research to address the gaps with existing standards. In terms of storage and distribution, large scale hydrogen storage needs to be studied and analysed further, but also LH_2, LHOC, metering of hydrogen, quality control. In mobility, focus should fall more on homologation of new vehicle and vessel types, refuelling protocols, etc.;
- Increase the awareness and support the capacity building of regulators and local authorities in terms of RCS;
- Experience from demonstration projects should be shared / collected to further support RCS development.

F. Hydrogen Valleys

The participants agreed that although funding is important, it is not the main issue for (at least these) hydrogen projects. More important is identifying the consumers of the hydrogen, and specifically the ones that are ready and able to consume it.

Dissemination of valley's experiences (both at European and International level) is critical. All valleys 'learn by doing'; thus, it is important to share this knowledge quickly and effectively to facilitate leapfrogging. H2V platform under the Mission Innovation can support this transfer of know-how, including at international level.

Permitting issues are faced by all projects, mainly due to limited awareness of local administration. Also, co-operation with national authorities like NOW[73] could be a topic to continue working on.

There should not be a single approach to support valleys. Large-scale and small-scale types are both relevant, it all depends on the local context and the actual needs for hydrogen. Small valleys are important, in particular for replication and further expansion.

Funding support to CAPEX is needed (like in the valleys topics/grants), but it is not the only useful instrument to accelerate Hydrogen Valley deployment. Current JU support to PDA is a useful instrument aiming to initiate a pipeline of projects. Moreover, funding synergies among EU and national programmes do not always work. There is a need to work at both European and national level to streamline complementarities of funding programmes.

Research & innovation priorities to be considered for next calls:

- Already from existing projects salty marine environments have proven to have their unique challenges; worth to further fund similar projects and identify best solutions;
- Hydrogen Valleys can benefit from projects like HyLaw, which can facilitate the collaboration with the local authorities. Moreover, transferring the know-how from other valleys, e.g. via JU projects or the H2V platform, can help create faster the necessary understanding and raise public awareness in relation to hydrogen and the hydrogen valleys.

G. Supply Chain

Projects have shown promising results as regards the technologies to enable massive production of the necessary components to scale-up supply of FC. However, high volume demand that will allow these technologies to be further applied in continuously working production lines is still missing. Mass production would require also progress on other relevant aspects, like quality control, recycling etc.

Volume commitment in every single part of the supply chain will be decisive to develop EU's manufacturing capacity. European manufacturers need to be supported; the mistakes of the past should not be repeated, e.g. with PV manufacturing.

Standardisation of FC types and features/sizes and wider use of the same types depending on the application could reduce drastically the deviation and complexity in terms of supply chain response, quality control and standardisation maintenance in the large scale.

Research & innovation priorities to be considered in next calls:

- Focus should be in automation and quality control when manufacturing large volumes of products.