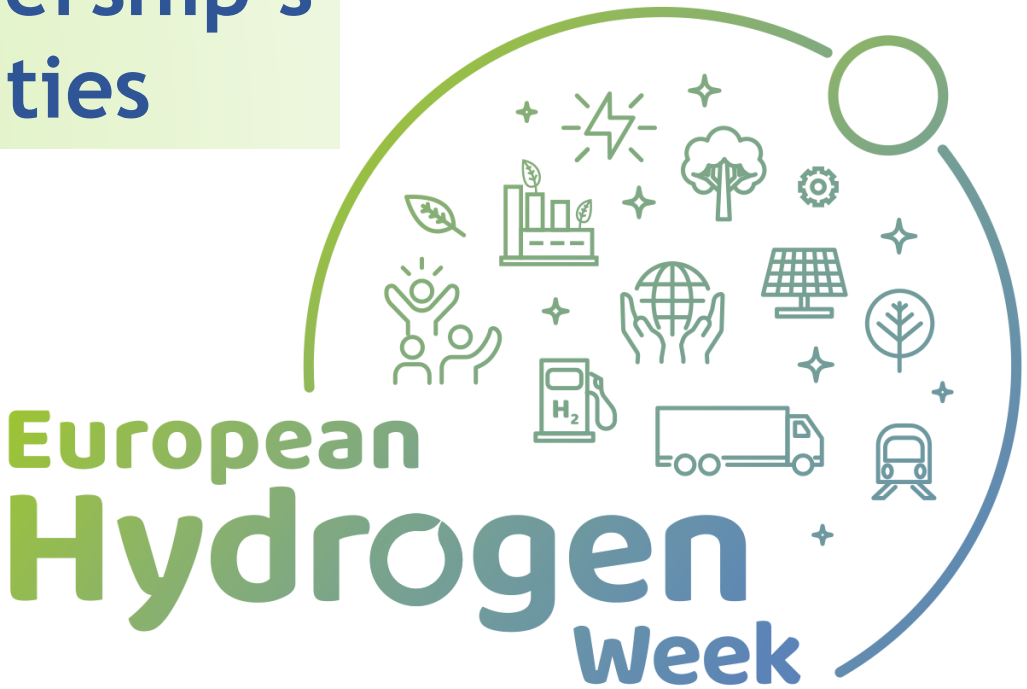
European Clean Hydrogen Partnership's Scientific Priorities



Mirela ATANASIU
Head of Unit Operations and Communications

European Hydrogen Research and Innovation Priorities
November 30th 2021

#EUHydrogenWeek
#CleanHydrogen

FCH

European Commission

Clean Hydrogen Partnership

Clean Hydrogen Partnership

- Council Regulation establishing the Joint Undertakings under Horizon Europe (adopted 19th November 2021);
- Addressing complex challenges that require partnership with industrial stakeholders.

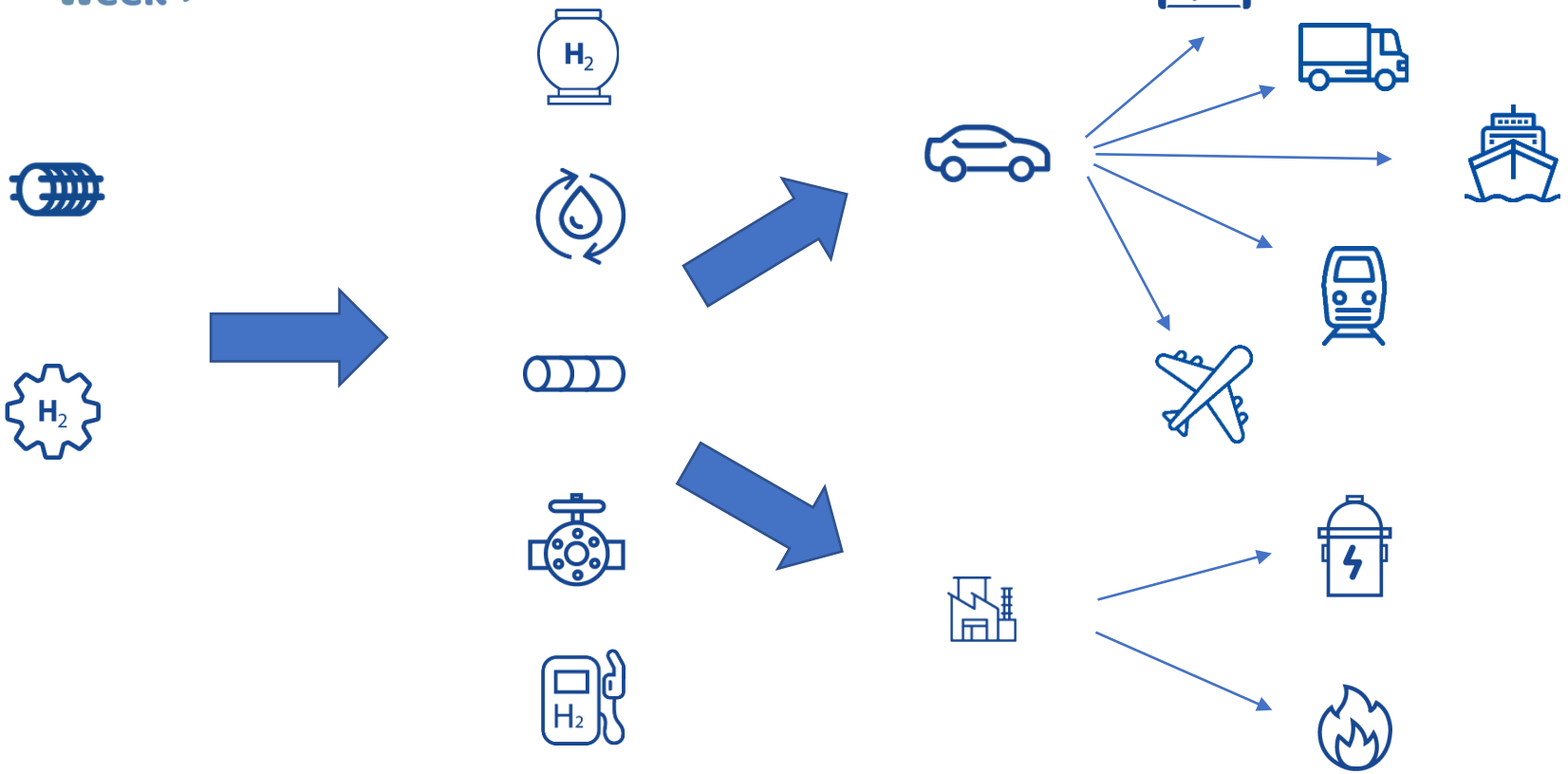
Research & Innovation Activities

- Renewable hydrogen production;
- Hydrogen transmission, distribution and storage;
- End-use technologies in transport, buildings and industry (with fuel cells, burners, boilers etc).

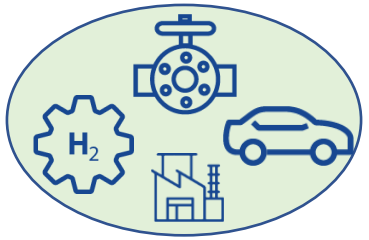
Extensive Consultation with Stakeholders

- Already extensively discussed with JU Partners and Member States Representatives;
- To consult other stakeholders via the Stakeholders Group;
- *But also to collect independent opinons of the wider scientific community, through a scientific advisory workshop (during H2 Week).*

Research & Innovation Activities



Cross-cutting



Hydrogen Valleys

Supply Chain

Strategic Research challenges

Production | **Distribution and Storage** | **End-use** | **Horizontal Activities**

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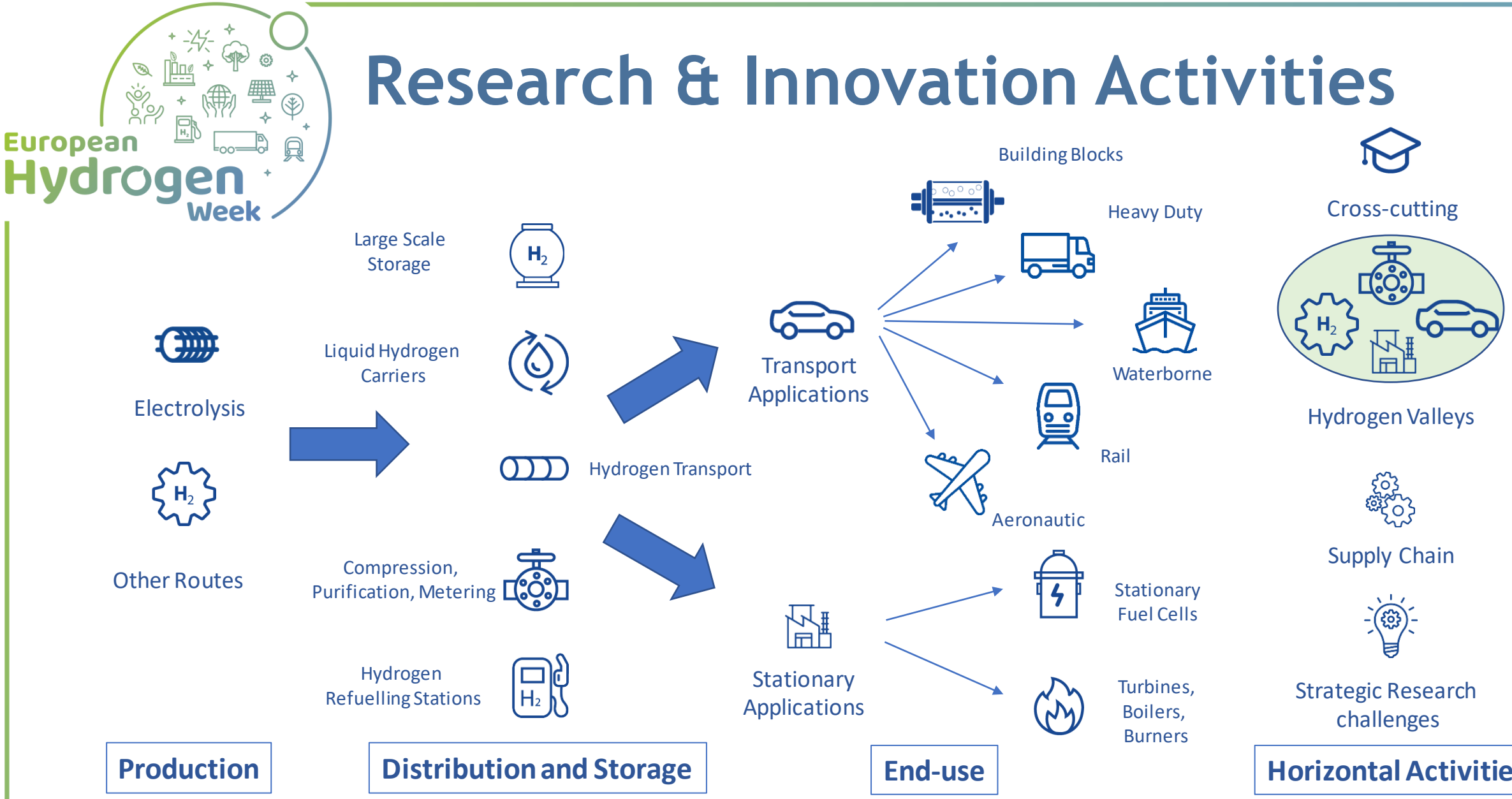
Research & Innovation Activities



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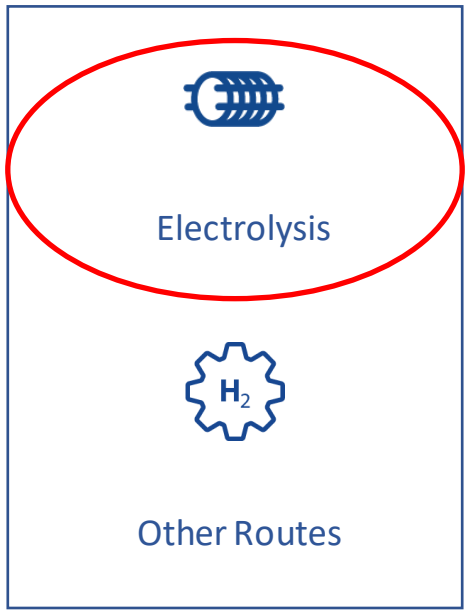
Pillar 1:
Renewable Hydrogen Production

1.A Electrolysis

OBJECTIVES

1. Reducing electrolyser costs;
2. Improving dynamic operation, durability, reliability and efficiency;
3. Increasing current density and decreasing footprint;
4. Demonstrate their ability to provide flexibility to the electricity system;
5. Ensure circularity by design for materials and for production processes;
6. Increase the scale of deployment;
7. Improved manufacturing for both water and steam electrolysis.



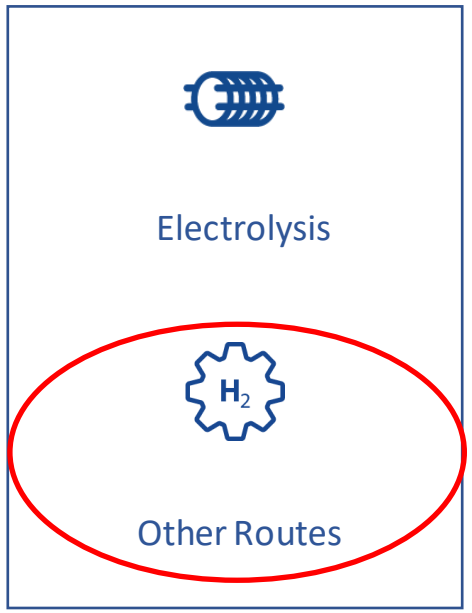
Production

Pillar 1:
Renewable Hydrogen Production

1.B Other Routes

OBJECTIVES

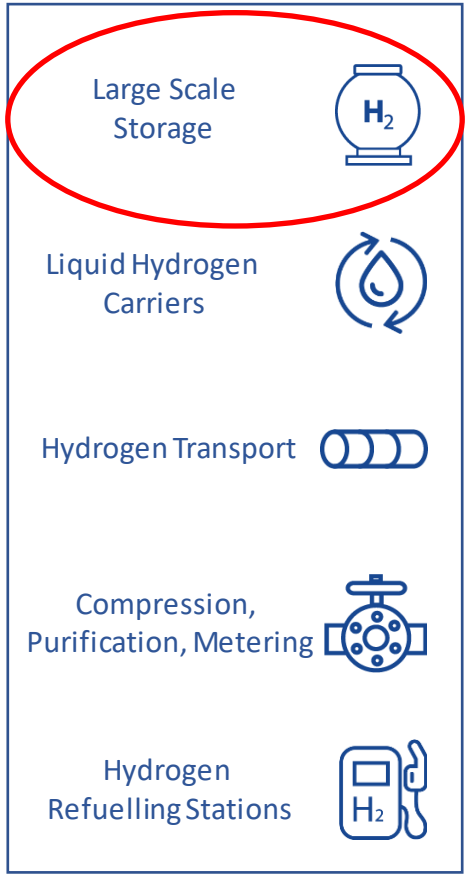
1. Reducing costs;
2. Improving the efficiency of the process;
3. Increasing carbon yield for processes based on biomass/raw biogas;
4. Increase the scale of deployment;



Production

Pillar 2:
Hydrogen Storage and Distribution

2.A Large Scale Storage



OBJECTIVES

1. Improving cost and efficiency of aboveground storage solutions;
2. Demonstrate distributed aboveground storage solutions available at a low capital cost;
3. Validate the performance of underground storage in different geologies, to identify better materials and to encourage improved designs;
4. Demonstrate the large-scale underground storage across various media at a low capital cost.

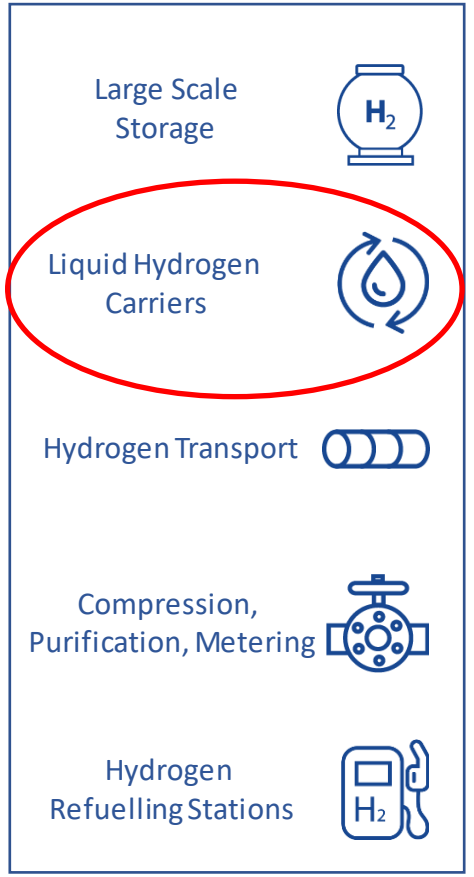
Distribution and Storage

Pillar 2:
Hydrogen Storage and Distribution

2.B Hydrogen in the Natural Gas Grid

OBJECTIVES

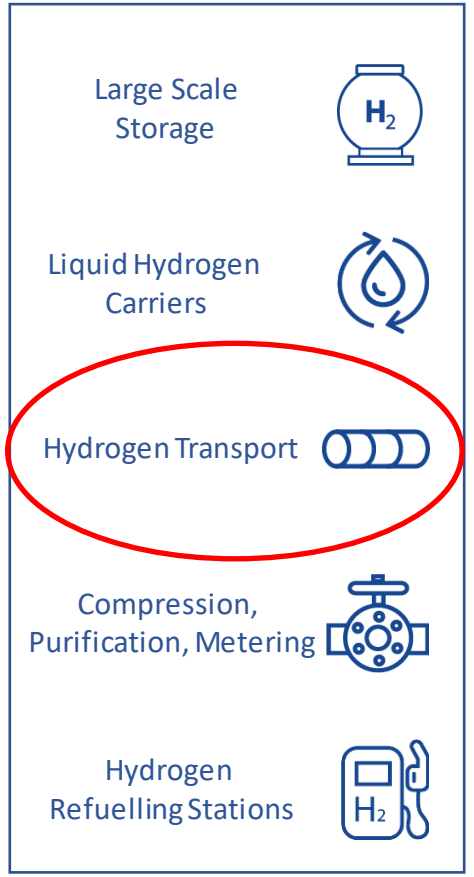
1. Development of technologies and materials to explore and support the transportation of H2 via the natural gas grid.
2. Enable through research and demonstration activities the transportation of hydrogen through the natural gas grid either by blending or via repurposing to 100% hydrogen.



Distribution and Storage

Pillar 2:
Hydrogen Storage and Distribution

2.C Liquid Hydrogen Carriers



OBJECTIVES

1. Increase efficiency and reduce costs of hydrogen liquefaction technologies;
2. Contribute to the roll-out of next generation liquefaction technology;
3. Continue research on carrier cycling performance, chemistries, catalysis and reactors, which show potential for improved roundtrip efficiency and life cycle assessment;
4. Develop a range of hydrogen carriers that will be used commercially to transport and store hydrogen, while improving their roundtrip efficiency and lowering their cost.

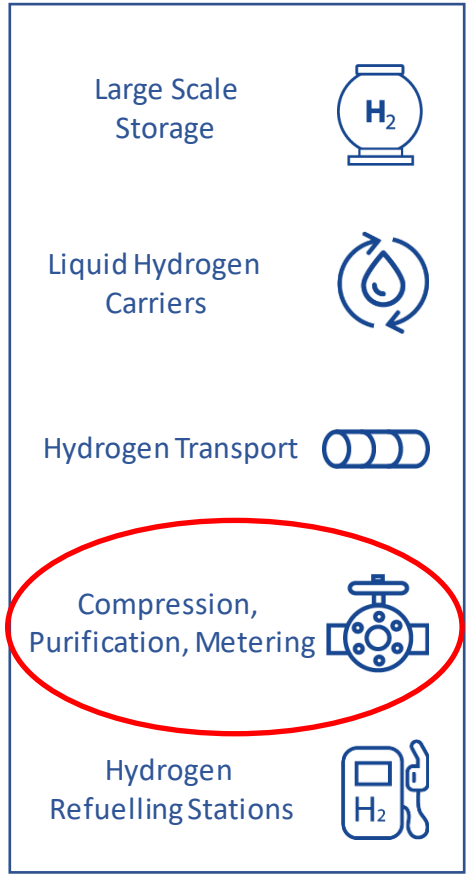
Distribution and Storage

Pillar 2:
Hydrogen Storage and Distribution

2.D Improving Existing Hydrogen Transport Means

OBJECTIVES

1. Increase the pressure and capacity for new built pure hydrogen pipelines, while reducing their cost;
2. Reduce road transport costs of compressed hydrogen by increasing the capacity of tube trailers;
3. Improve the efficiency of road transport of liquid hydrogen, while reducing costs;
4. Enable scale-up of solutions for shipping of bulk liquid hydrogen and support its commercialisation.



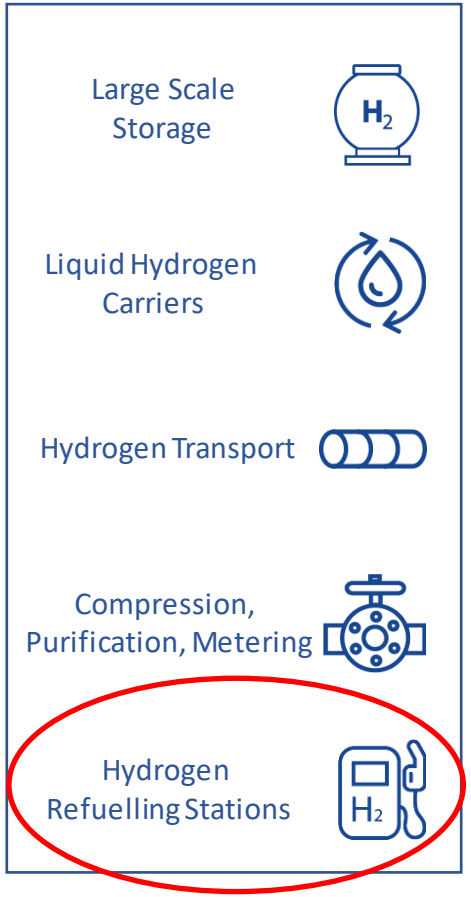
Distribution and Storage

Pillar 2:
Hydrogen Storage and Distribution

2.E Compression, Purification and Metering Solutions

OBJECTIVES

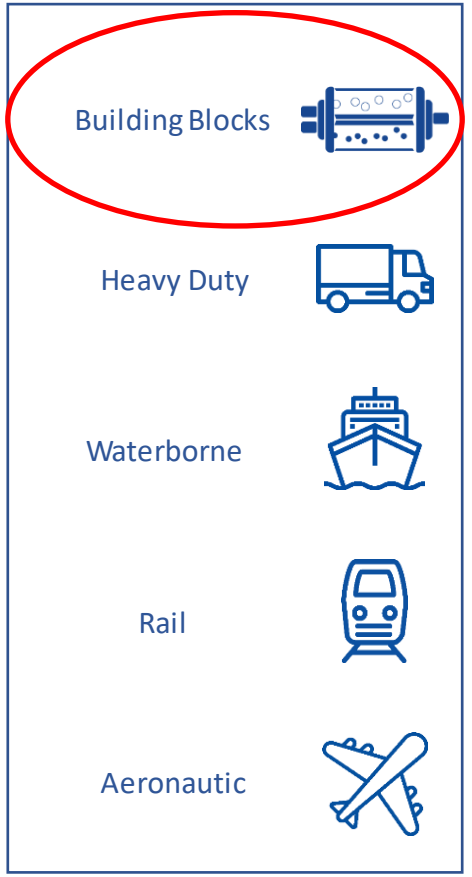
1. Develop more efficient compressor and purification technologies;
2. Reduce total cost of ownership of compression and purification technologies;
3. Reduce energy consumption and increase the recovery factor of purification technologies;
4. Increase the reliability and lifetime of compression and purification technologies;
5. Improve metering technologies and standards, especially in terms of accuracy and protocols.



Distribution and Storage

Pillar 3:
Hydrogen End-Uses: Transport Applications

3.1.A Building Blocks



End-use:
Transport Applications

OBJECTIVES

1. Improving overall system performance for fuel cell stack technology in terms of power density, reliability and durability;
2. Reduction or replacement of PGM loadings and development of new materials advancing the performance of on-board storage technology;
3. Improvements in design, health monitoring and manufacturability of core components for fuel cell stacks and on-board storage technology;
4. Extending the EU leadership on FC production from automotive to maritime and aviation, given the high pressure for decarbonisation of these sectors.

Pillar 3:
Hydrogen End-Uses: Transport Applications

3.1.B Heavy Duty Vehicles Applications

OBJECTIVES

1. Reducing the cost of core components ,such as modules and stacks, in order to foster the competitiveness of FC heavy-duty applications;
2. Improving overall system performance of FC systems, in order to improve the availability and durability and meet the needs of FCH HDV end users;
3. Improvements in design and monitoring procedures of FC systems;
4. Supporting and accelerating the wide roll out of FC HDVs.

End-use:
Transport Applications

Pillar 3:
Hydrogen End-Uses: Transport Applications

3.1.C Waterborne Applications

OBJECTIVES

1. Scaling up FC designs towards commercially relevant applications;
2. Reducing the CAPEX of PEMFC or SOFC systems for maritime applications;
3. Improving overall system performance for FC and stacks, especially in terms of power density, bunkering rate and operational flexibility;
4. Improvements in ship design and safety procedures, both for ships and ports bunker terminals;
5. Supporting the wide roll out of FC ships.

End-use: Transport Applications

Pillar 3:
Hydrogen End-Uses: Transport Applications

3.1.D Rail Applications

OBJECTIVES

1. Reducing the cost of stacks;
2. Improving reliability and durability at stack and FC system;
3. Improving power output while reducing weight and dimension of the module;
4. Improvements in train design and safety procedures;
5. Supporting the roll out of FC trains, by providing the viability of the FCH solution in the train transport segment.

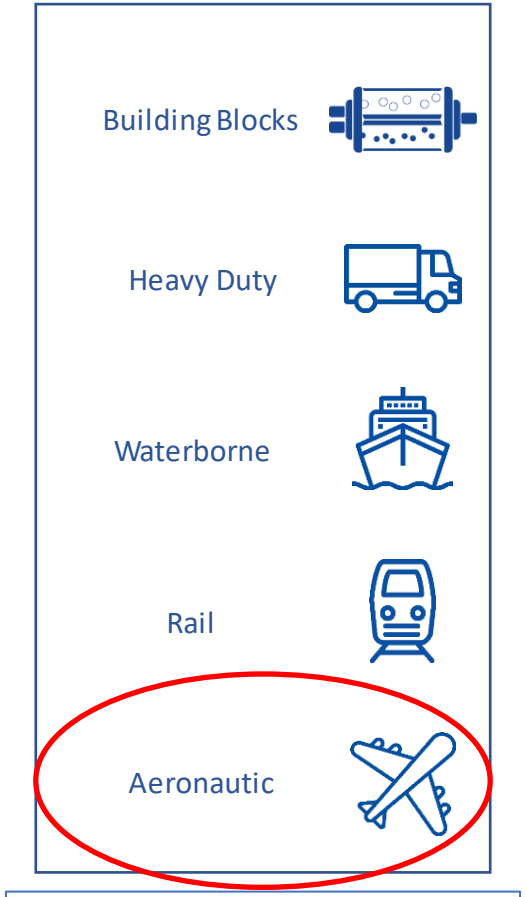
End-use: Transport Applications

Pillar 3:
Hydrogen End-Uses: Transport Applications

3.1.E Aeronautic Applications

OBJECTIVES

1. Improving overall system and stack performance for scalable FC in terms of power density, durability and availability;
2. Reducing NOx emissions of turbines;
3. Addressing Airport infrastructure (of both liquid and compressed hydrogen) and refuelling tech / procedures;
4. Developing aviation dedicated technological bricks, focusing on on-board storage, distribution components and systems of liquid hydrogen.
5. Addressing safety and regulation, specific to hydrogen for aviation applications



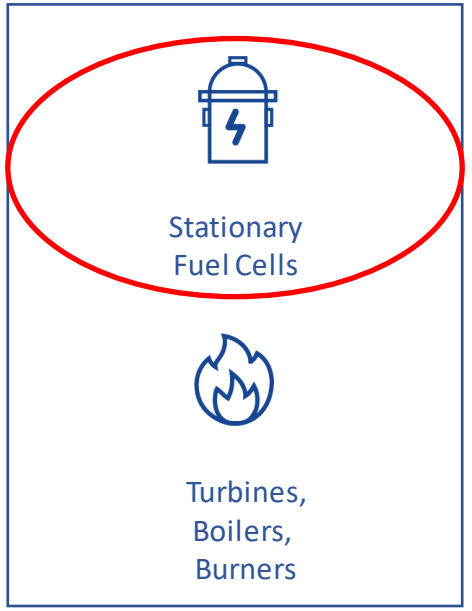
End-use:
Transport Applications

Pillar 3:
Hydrogen End-Uses: Clean Heat and Power

3.2.A Stationary Fuel Cells

OBJECTIVES

1. Reducing costs of stationary fuel cells;
2. Prepare and demonstrate the next generation of fuel cells for stationary applications, able to run under 100% H_2 and other H_2-rich fuels;
3. Improve flexibility of systems in operation, in particular with reversible fuel cells and integration with thermal storage;
4. Reducing use of critical raw materials and recycling them for further usage;
5. Support development of processes suitable for mass manufacturing.



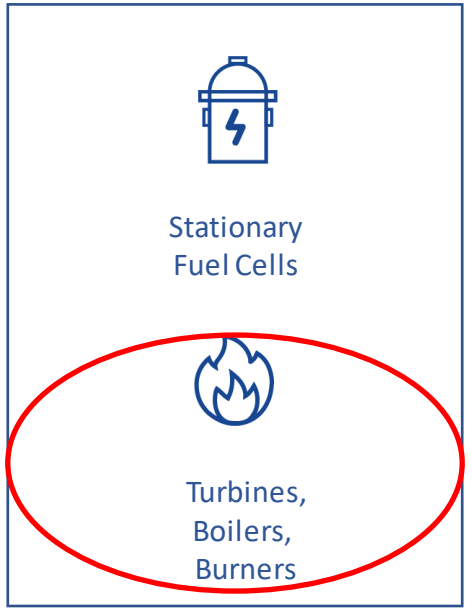
End-use:
Stationary Applications

Pillar 3:
Hydrogen End-Uses: Clean Heat and Power

3.2.B Turbines, Boilers and Burners

OBJECTIVES

1. Allow turbines to run on higher admixtures of H_2, up to 100% whilst keeping low NOx emissions, high efficiencies and flexible operation.
2. Develop concepts on safety and plant integration and demonstrate the retrofitting of turbines, boilers and burners, so that they are able to run up to 100% H_2.



End-use:
Stationary Applications

Horizontal Activities (1)

1. Cross-cutting issues

1. Sustainability, LCSA, recycling and eco-design

a) Develop life cycle thinking tools addressing the three dimensions of sustainable development: economic, social, and environmental.

b) Develop eco-design guidelines and eco-efficient processes.

c) Develop enhanced recovery processes in particular for PGMs/CRMs and per- and polyfluoroalkyl substances.

2. Education and public Awareness

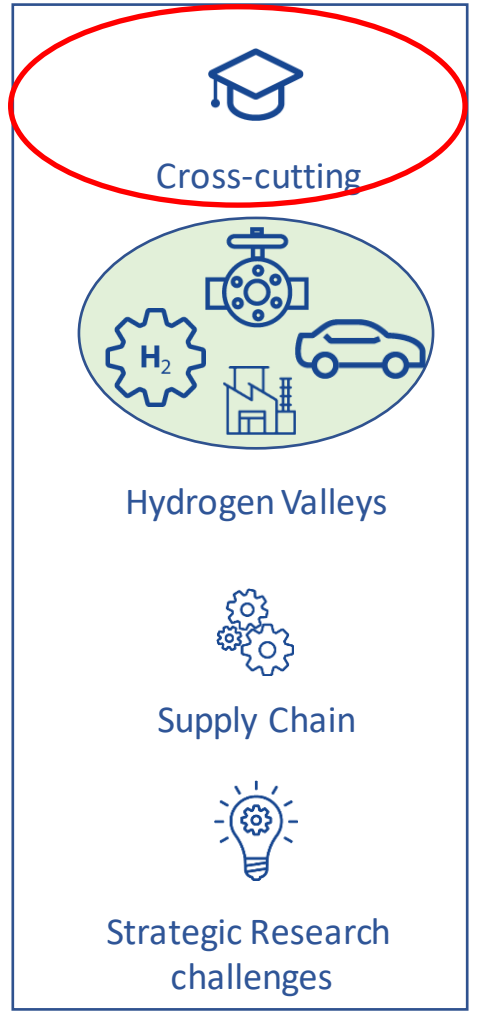
a) Develop educational and training material and building training programs for professionals and students on hydrogen and fuel cells.

b) Raise public awareness and trust towards hydrogen technologies and their system benefits.

3. Safety, Pre-Normative Research and Regulations, Codes and Standards

a) Increase the level of safety of hydrogen technologies and applications

b) Support the development of RCS for hydrogen technologies and applications, with the focus on standards

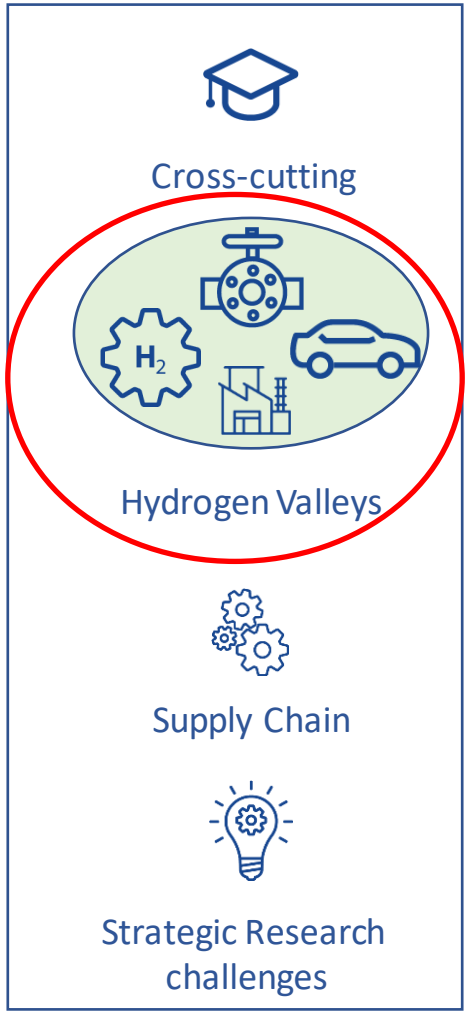


Horizontal Activities (2)

2. Hydrogen Valleys

MAIN OBJECTIVES

1. Innovation in integrating several technology elements together to improve overall synergies, facilitate sector coupling and improve energy and economic efficiency of the whole system;
2. Improved security and resilience of the energy systems;
3. Demonstration of new markets for hydrogen;
4. Complementarity of the development of hydrogen with RES, integration with other technologies, existing infrastructure, etc;
5. Assessment of the availability and affordability of clean energy provision for industry and city uses.

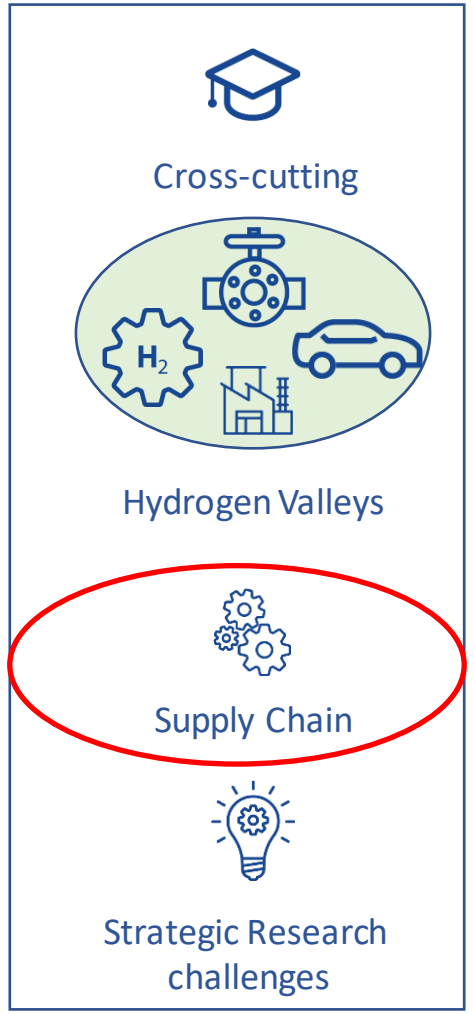


Horizontal Activities (3)

3. Hydrogen Supply Chains

OBJECTIVES

1. Identification of potential vulnerabilities in EUs hydrogen supply chain;
2. Development of new and improved manufacturing technologies and production processes that facilitate the safe and sustainable use of non-critical (raw) materials, as well as the adoption of the circular economy principles;
3. Reducing the use of critical (raw) materials with sustainability or environmental concerns, such as for instance those deriving from poly/perfluoroalkyls.

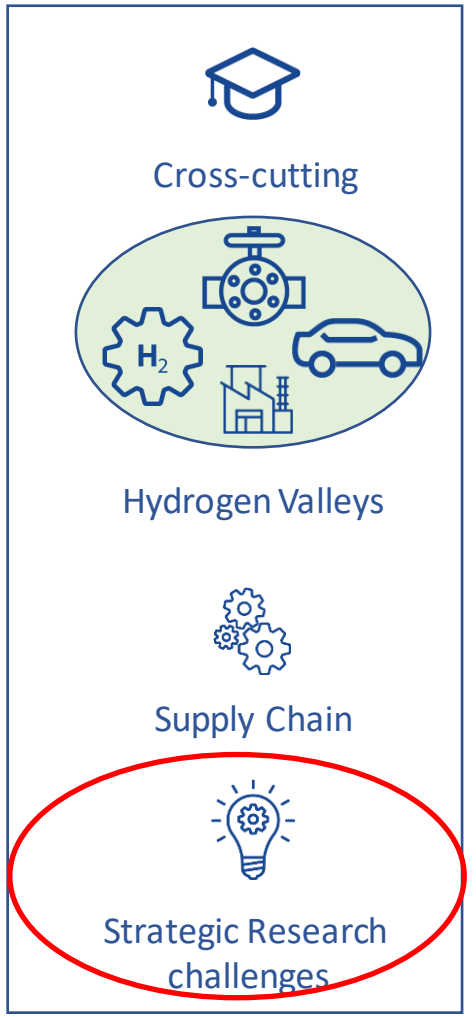


Horizontal Activities (4)

4. Strategic Research Challenges

OBJECTIVES

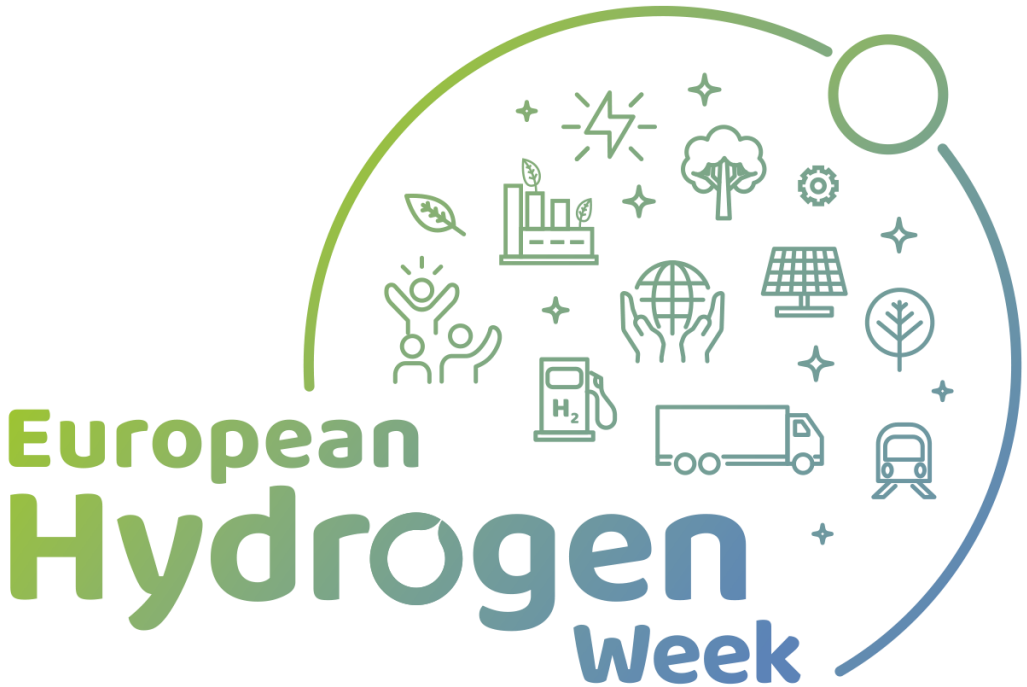
- To ensure a continuous generation of early stage research knowledge, the above actions will be supplemented by multidisciplinary investigations, gathering expertise at different technology scale (materials, component, cell, stack and system).
- The considered approach will gather the required expertise from European Research and Technology Organisations (RTO).
- The result will lead to a comprehensive strategy investigating new design, characterisation and testing, accelerating the developments in basic low-TRL research and innovation actions.



Scientific Priorities

Reaching out to the wider scientific community

- The research and innovation activities of the Clean Hydrogen Partnership range from early research actions to large scale demonstrations.
- All actions though entail complex scientific challenges.
- The Clean Hydrogen Partnership relies on the wider scientific community (in addition to its member, Hydrogen Europe Research) to provide its expertise and suggestions on its research and innovation agenda.
- Its independent opinions and advice will be gathered annually during H2 Week/Stakeholders Forum therefore further explored in the upcoming partnership.



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