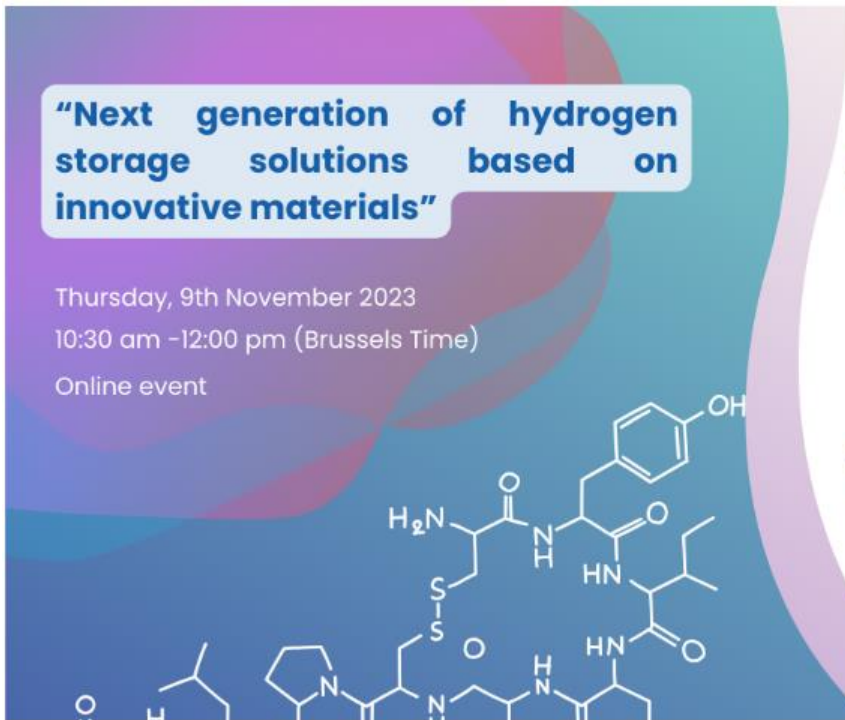


“Next generation of hydrogen storage solutions based on innovative materials”

Thursday, 9th November 2023
10:30 am -12:00 pm (Brussels Time)
Online event



Ammonia and MOF Based Hydrogen storageE for euRope (AMBHER)

www.ambherproject.eu

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- 1. Main Goals and S&T Targets**
- 2. Participants and Consortium Synergies**
- 3. Overall Approach and Methodology**
- 4. Expected Results (ER) and Key Exploitable Results (KER)**
- 5. Long Term Impact**



- Aims to provide quantum leap in the development of **hydrogen storage technologies**
 - ✓ **Short-term storage** – Metal Organic Frameworks (MOFs)
 - ✓ **Long-term storage** – Distributed generation of NH₃ using a CMR
- Sets the basis for commercialization of greener technological pathways
 - Designing and setting up a broad and complete network of value chains.
 - Developing a set of **flexible, cost-effective and environmentally friendly** technologies that can be easily tailored for the storage of H₂
 - Laying the foundations for new business opportunities
- Develop a full LCA, LCC and Health and Safety Analysis (HSE)
- Pave the way for future exploitation of Key Exploitable Results (KERs).
- Promote dissemination and communication of results and expand its impact



Storage Solutions

Short-term Storage (KER 1)

New pathway for storage through Novel ultra-porous Metal Organic Frameworks (MOFs)

- Scalable synthesis process for the manufacture of high surface area MOF with a gravimetric storage capacity of 6 wt%.
- To design and develop a MOF container for a storage hydrogen capacity of 40g/L at 100bar.

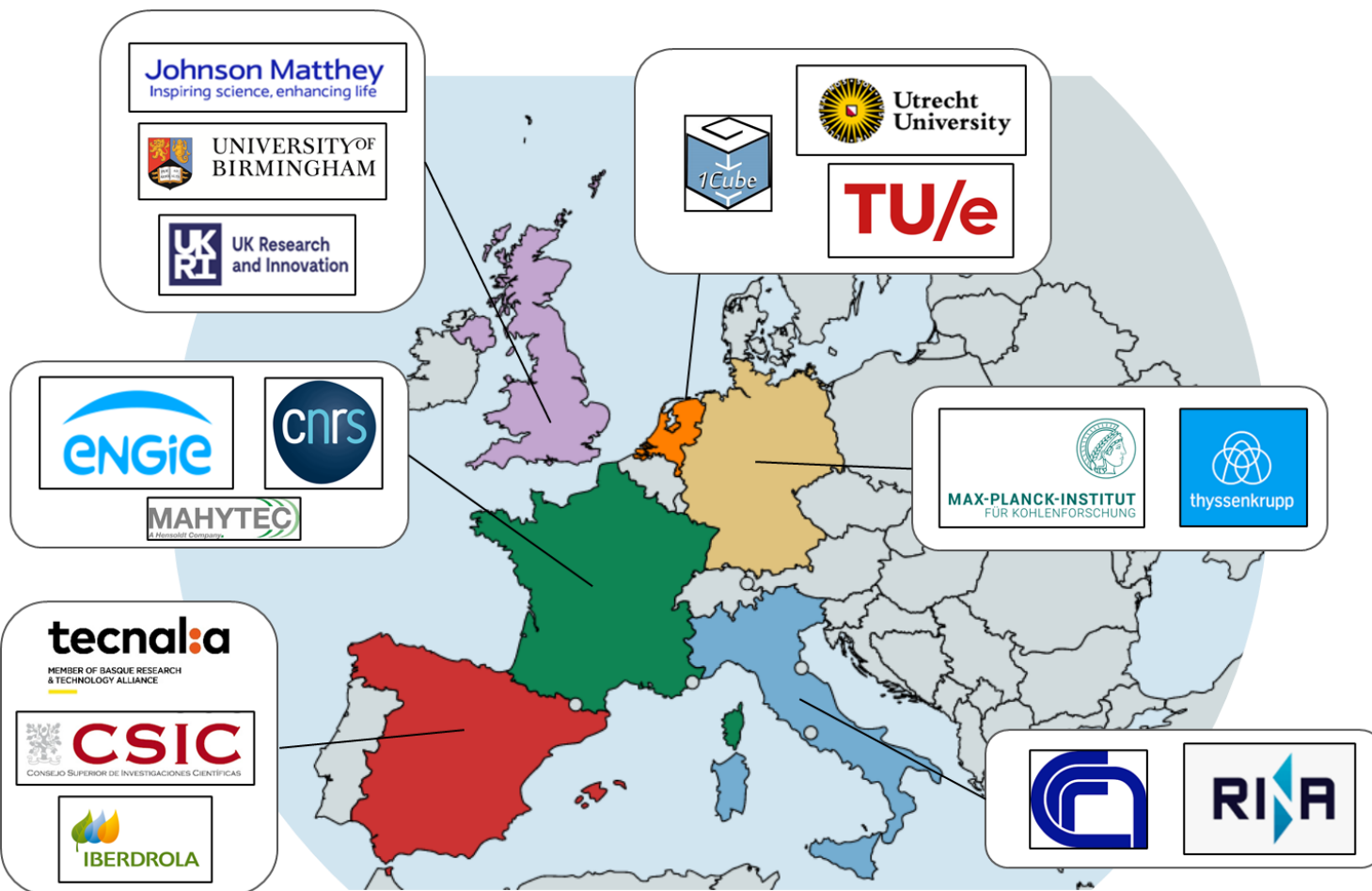
Long-term Storage (KER 2)

An innovative Catalytic Membrane Reactor (CMR) to produce green ammonia, with production rate 4 times higher than conventional reactors operated at the same conditions.

- New environmentally friendly catalyst materials
- Highly conductive 3D printed Periodic Open Cellular Structures (POCS) with optimised heat and mass transfer.
- Carbon Molecular Sieve Membranes with selectivities of $\text{NH}_3/\text{N}_2 > 50$ and $\text{NH}_3/\text{H}_2 > 10$ with an NH_3 permeance $> 5 \times 10^{-7} \text{ mol}\cdot\text{Pa}^{-1}\text{m}^{-2}\text{s}^{-1}$

2. Participants and Consortium Synergies

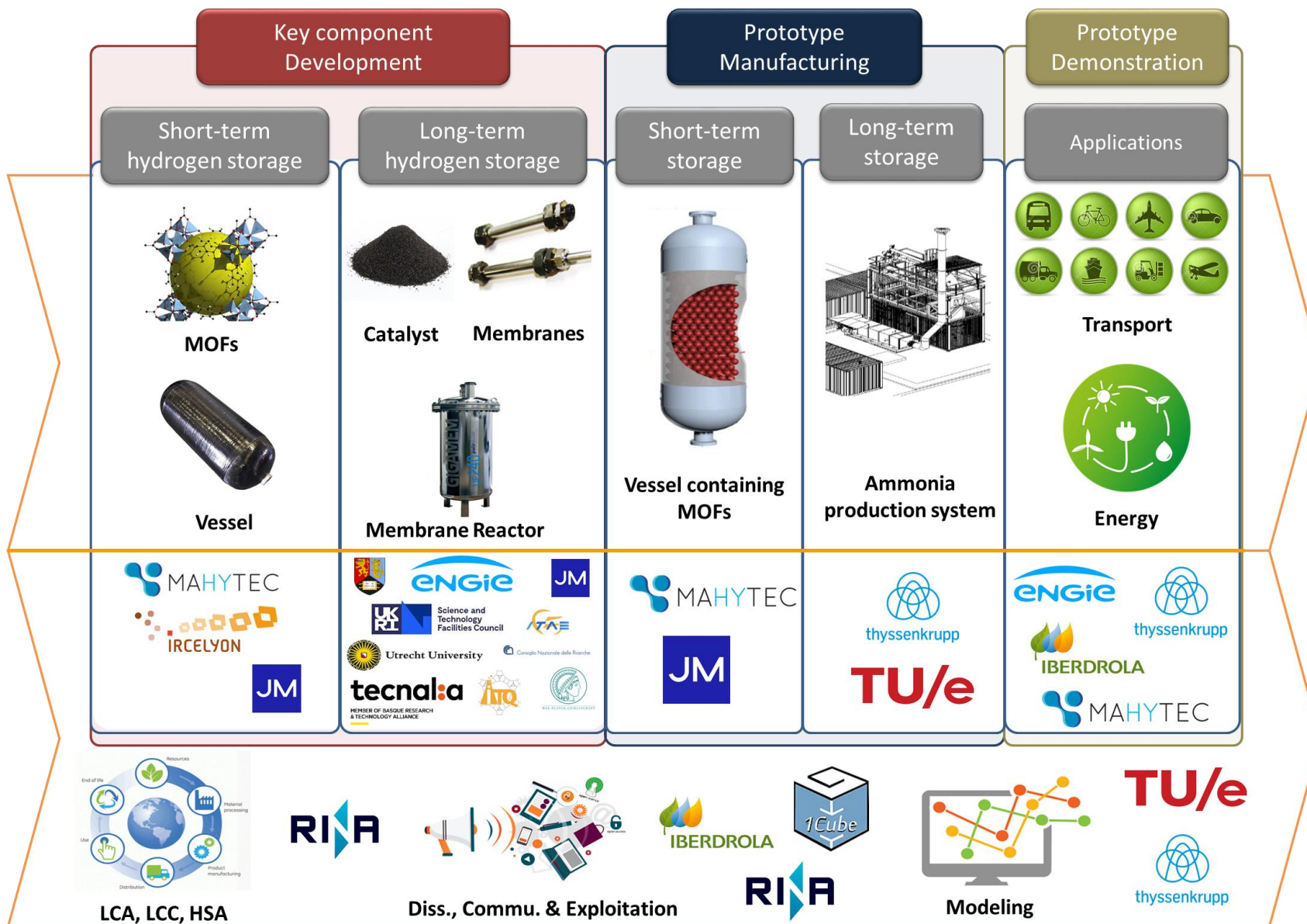
16 partners from 6 countries



SME/IND (7)		
Materials Development	Johnson Matthey	
Vessel Design	Mahytec	
Process Design, Plant Construction And Operation	Thyssenkrupp	
Multinational Energy Companies	ENGIE, Iberdrola	
LCA, LCC And HSA	RINA-C	
Dissemination And Communication	ICUBE	
European Research Public /Private Institutes And Universities (9)		
TUE CNR UU	UoB CNRS CSIC	TEC MPI UKRI

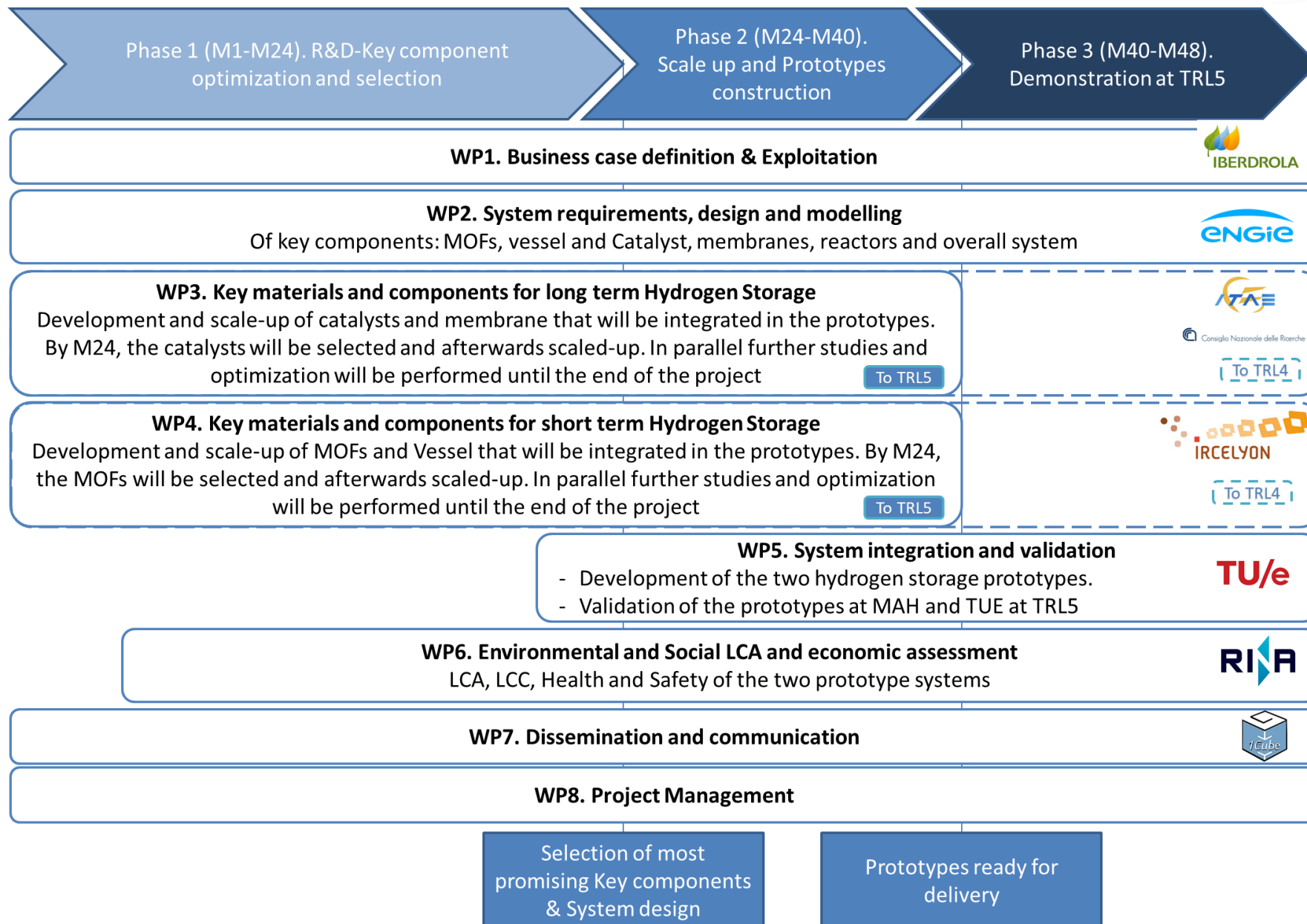


3. Overall Approach and Methodology





3. Overall Approach and Methodology



4. Expected Results (ER) and Key Exploitable Results (KER)

Short-term Hydrogen Storage (MOFs)

ER1: Novel nanoporous materials MOFs

- With high surface ($> 2.500 \text{ m}^2/\text{g}$) and competitive cost with a gravimetric storage capacity of 6 wt%.



ER2: Specially designed MOF container

- Hydrogen storage capacity of 40g/L at 100 bar whilst at competitive cost (600-1.000 euros/kg_{H2}).



KER1: Novel ultra-porous MOFs for newly designed and cheaper storage vessels for Hydrogen Refuel Stations

Value proposition

Innovative conformable cryo-vessel operating up to 100 bars to be used in Hydrogen Refuel Station for Heavy Duty Vehicles.



4. Expected Results (ER) and Key Exploitable Results (KER)

Long-term Hydrogen Storage (Green Ammonia)

ER3: Innovative environmentally friendly catalyst materials

- Operating at $P < 20 \text{ bar}$ and $T < 250 \text{ }^\circ\text{C}$ with NH_3 production rates $>$ to $8 \text{ mmol NH}_3 \text{ g}^{-1}\text{h}^{-1}$

ER4: Innovative membranes

- With selectivities of $\text{NH}_3/\text{N}_2 > 50$ and $\text{NH}_3/\text{H}_2 > 10$ and NH_3 permeance $> 5 \times 10^{-7} \text{ mol}\cdot\text{Pa}^{-1}\text{m}^{-2}\text{s}^{-1}$

ER5: Design and manufacture highly conductive Periodic Open Cellular Structures

- With optimised heat and mass transfer and thin struts.

KER2: Advanced catalysts and membranes integrated into CMR

Value proposition:

Advanced catalysts and membranes integrated into CMR for more efficiently and cheaper long-term energy storage in form of green ammonia.





Resilient, sustainable and secure (critical) raw materials, value chains for EU industrial ecosystems, in support of the twin green and digital transformations.

- **European Green Deal**
 - Reduce the EU's energy dependence
 - EU energy system more resilient by balancing the energy generation and consumption curve
- **An economy that works for people**
 - Secure and cheap electricity for the citizens – lower-priced renewable energy at times of high energy demand
- **Protecting our EU way of life;**
 - Generating a more decentralised and democratic economy – more choices for citizens
- **A stronger Europe in the world**
 - Increasing the competitiveness of the European energy industry
- **A Europe fit for the digital age**
 - Solutions proposed in AMBHER will be monitored remotely
 - Data management in the operation of the plants and in the balance of the grid.



5. Long Term Impact

New sustainable-by-design materials with enhanced functionalities and applications in a wide range of industrial processes and consumer products.

- For short-term storage
 - Novel nanoporous materials in the form of MOFs developed and integrated in a specially designed vessel for storing hydrogen at 100bar
- For long-term storage
 - Catalysts and Membranes are combined in an intensified and compact Membrane reactor (CMR)

Leadership in producing materials that provide solutions for clean, toxic/pollutant free environment, decarbonising industry, and safeguarding civil infrastructures.

- Radical innovations in MOFs nanoporous materials – surface area $> 2.500 \text{ m}^2/\text{g}$, low cost, innovative shaping processes such as 3D printing
- Development of two classes of catalysts NH_3 synthesis – 2-4 orders of magnitude higher production (at 300°C)
 - Couple additive manufacturing with the science of membrane reactors
 - Improved performance with increased conversion rate at lower temperature and pressure
- Significant contribution to the decarbonisation of industry, transport and the economy as a whole



Leadership in circular economy that strengthens cross-sectorial cooperation along the value chain and enable SMEs to transform their activities and business models.

- The use of short- and long-term renewable energy storage solutions enables the decarbonisation of sectors like transport sector.
- Impact on the entire value chain of these sectors and improve the overall competitiveness of the European economy.
- AMBHER will also contribute to the generation of wealth by creating around 20,000 jobs (direct, indirect and induced) accumulated (2030-2035).

Increased adoption of key digital and enabling technologies in industry value chains and strategic sectors, paying attention to SMEs and start-ups.

- Connect material developers with key players in the
 - hydrogen economy
 - additive manufacturing
 - chemical companies
 - end-users of ammonia
- Matching existing needs and new products
- Innovative organizations that develop advanced technologies meeting the challenges of the coming years.



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Thank you for your attention!

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