areNH$_3$a

Comisión Europea

# *Advanced material and Reactor for ENergy storage tHrough Ammonia*

## Newsletter – October 2020


## Editorial

Welcome to this first ARENHA project newsletter. ARENHA is a European four-year project with global impact seeking to develop, integrate and demonstrate key material solutions enabling the use of ammonia for flexible, safe and profitable storage utilization of energy. Ammonia is an excellent carrier due to its high energy density, carbon-free composition, industrial know-how and relative ease of energy storage. ARENHA demonstrates the feasibility of ammonia as a dispatchable form of large-scale energy storage.

The present newsletter is the first release and it is presenting the progress on the project and highlighting information related to the R&D fields addressed. Hope you will find the info in this newsletter interesting. On our website www.arenha.eu you will find public presentations, all the public information of the project and many other interesting news. Stay tuned!

## In this Issue:

# What is ARENHA?

## The concept

For decades, utility-scale energy storage has been used to balance load and demand within an energy generation system composed mainly of base load power sources enabling thus to large nuclear or thermal generating plant to operate at peak efficiencies. Energy storage has contributed over the time to meet peak demand and regulate frequency beside peak fossil fuel power plants that usually provided the bulk of the required energy. In the aforementioned context where inherent variability of the power generation asset was mainly a minor issue, energy storage capacity remains nevertheless limited for economic reasons storing electricity during low electricity demand and releasing it back into the grid during high demand, typically over a daily cycle.

In the current context of global momentum in favour of renewable electricity catalysed by spectacular levelized production cost decrease, higher storage capacity is required to ensure security and flexibility providing a portfolio of services from grid services to the decarbonization of energy intensive sectors like the transport, industry or heating and cooling sector.

For that purpose, hydrogen produced from electrolysis reveals to be a key pathway to unlock the full potential of renewable and especially for seasonal energy storage of large energy quantity and more specifically for all situations dealing with a large energy-to-power ratio situation. Hydrogen having a low volumetric energy density, it has to be compressed to high pressure, liquefied or combined as hydrogen carrier. Among all possibilities, ammonia is a carbon-free and dispatchable energy carrier allowing storing large quantities of renewable electricity. It is a primary candidate to allow a secure and clean supply of renewable energy for various stationary or mobile applications and with ability to provide a wide range of energy storage services using existing infrastructures and both well-defined regulation and acceptable safety history for over 75 years. If state-of-the-art ammonia production plants produce between 3,000 and 6,000-ton $NH_3$/day, its well-known process involves $H_2$ production from natural gas reforming. Technical challenges remain to be overcome in order to ensure a flexible and cost comparable production of ammonia from intermittent renewable electricity sources. In addition to that, efficient energy discharge processes from NH3 must be developed in order to best leverage the clean energy produced upstream by the renewable asset.

The ARENHA project aims at using ammonia as a green hydrogen carrier and for that purpose it develops its main activities around the green hydrogen production, ammonia synthesis, storage and dehydrogenation (Figure 1). Innovative materials are

developed and integrated into ground-breaking systems in order to demonstrate a flexible and profitable power-to-ammonia value chain but also several key energy discharge processes. Specifically, ARENHA is developing advanced SOEC for renewable hydrogen production, catalysts for low temperature/pressure ammonia synthesis, solid absorbents for ammonia synthesis intensification and storage, catalysts and membrane reactors for ammonia decomposition for pure hydrogen (>99.99%) production. Energy discharge processes studied in ARENHA tackle various applications from ammonia decomposition into pure $H_2$ for FCEV, direct ammonia utilization on SOFCs for power and ICEs for mobility.

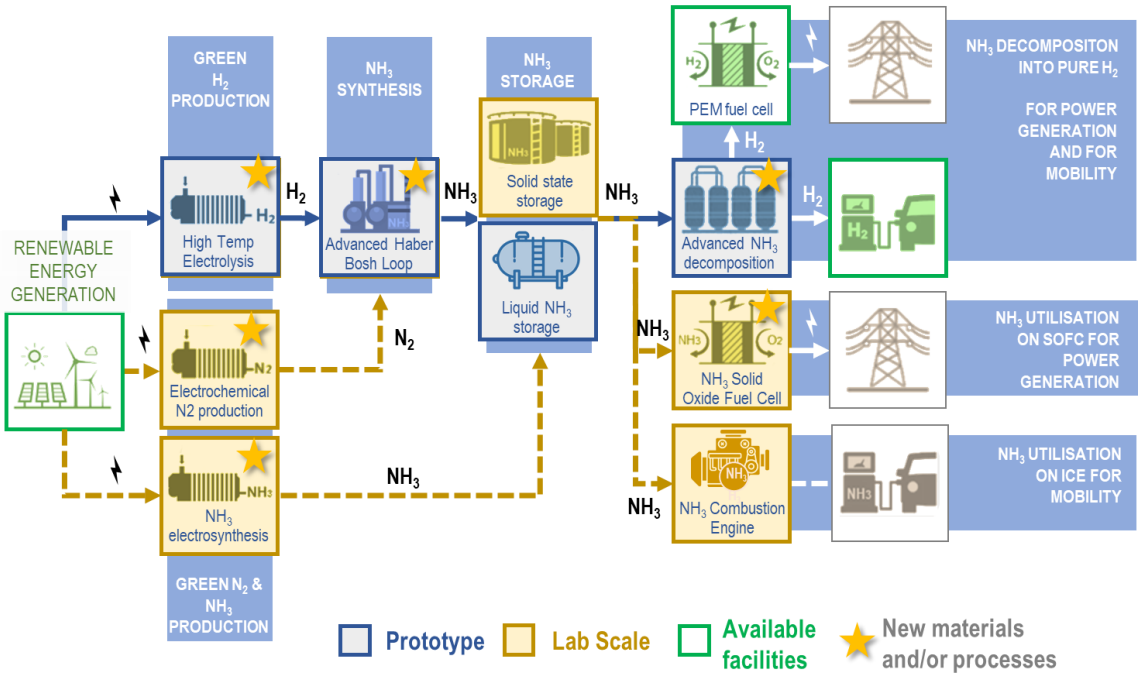


***Figure 1. Power-to-ammonia-to-usage value chain in ARENHA***

## Project objectives.

ARENHA will demonstrate the full power-to-ammonia-to-usage value chain at TRL 5 and the outstanding potential of green ammonia to address the issue of large-scale energy storage through LCA, sociological survey, techno-economic analysis deeply connected with multiscale modelling. For this purpose, breakthrough technologies will be developed and integrated along the overall value chain. The main technical objectives on material and system level are the following:

- To develop and integrate innovative solid oxide cell materials into a flexible high temperature electrolysis demonstration unit producing 1.5 $Nm^3/hr$ hydrogen at ambient pressure to be connected on a real PV plant.
- To develop and integrate innovative materials into a synthesis loop enabling to operate a flexible Haber Bosch production unit of 10 $kgNH_3$/day at lower pressure (<50 bar) and temperature (<450 °C).

- To develop and integrate innovative materials into a decomposition reactor able to generate 10 $Nm^3/hr$ of pure hydrogen (>99.99%) from green ammonia.
- To develop and test innovative materials and solutions for the alternative direct synthesis and utilization of next-generation green ammonia.
- To demonstrate ammonia as a flexible energy carrier through the development of a fully integrated prototype for green ammonia synthesis and decomposition.
- To assess the social acceptance, techno-economic-environmental feasibility, and replication potential of the developed value chains.

## Partnership

The ARENHA consortium gathers 11 organisations from 7 countries (Netherlands, Denmark, Germany, Estonia, France, United Kingdom and Spain). The consortium has been set-up in order to form a new complete Ammonia supply chain from European resources: i) Energy and Transport key players: ENGIE being the number one independent power producer in the world and PSA ID, part of Groupe-PSA, number 2 Europe's vehicle manufacturer; ii) 3 Hi-tech SMEs, ELCOGEN, Proton Ventures (PV) and HYDROGEN 2 SITE (H2SITE), focused on innovative solutions for hydrogen generation through Solid Oxide Cells, decentralized ammonia production and membrane reactors for hydrogen production and purification, respectively; iii) 5 Top European Research centres (TECNALIA, FhG-IKTS, DTU, STFC and TUE), all with a strong record of research and innovation covering the field of materials, electrolysers, reactors, process design in the ammonia value chain; and iv) Other key organisation such as CNH2 with extensive expertise around hydrogen value chain.

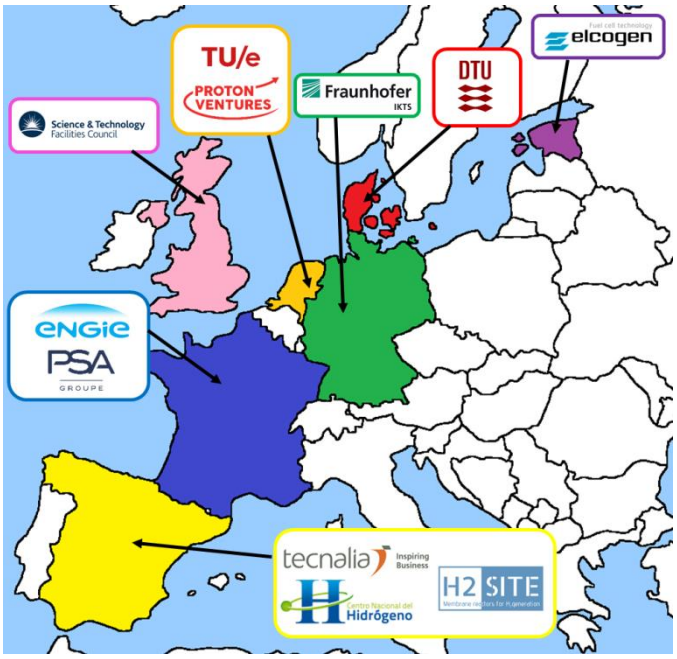


***Figure 2. Partnership of ARENHA***

In ARENHA, the total industrial participation is around 45% of the consortium, while innovative SMEs represent 27% of the participants.

## Project structure and work planning

The project scheduled work plan comprises activities related to the whole value chain and it will be implemented in 48 months. It is broken down in eight work packages following the focus on using ammonia as green hydrogen carrier and for that purpose it develops its main activities around green hydrogen production, ammonia synthesis, ammonia storage and ammonia dehydrogenation. Finally, the novel materials and systems will be integrated into a testing infrastructure combined with an ammonia storage tank for proof of concept and validation to demonstrate the full power-to-ammonia-to usage value chain at TRL 5.

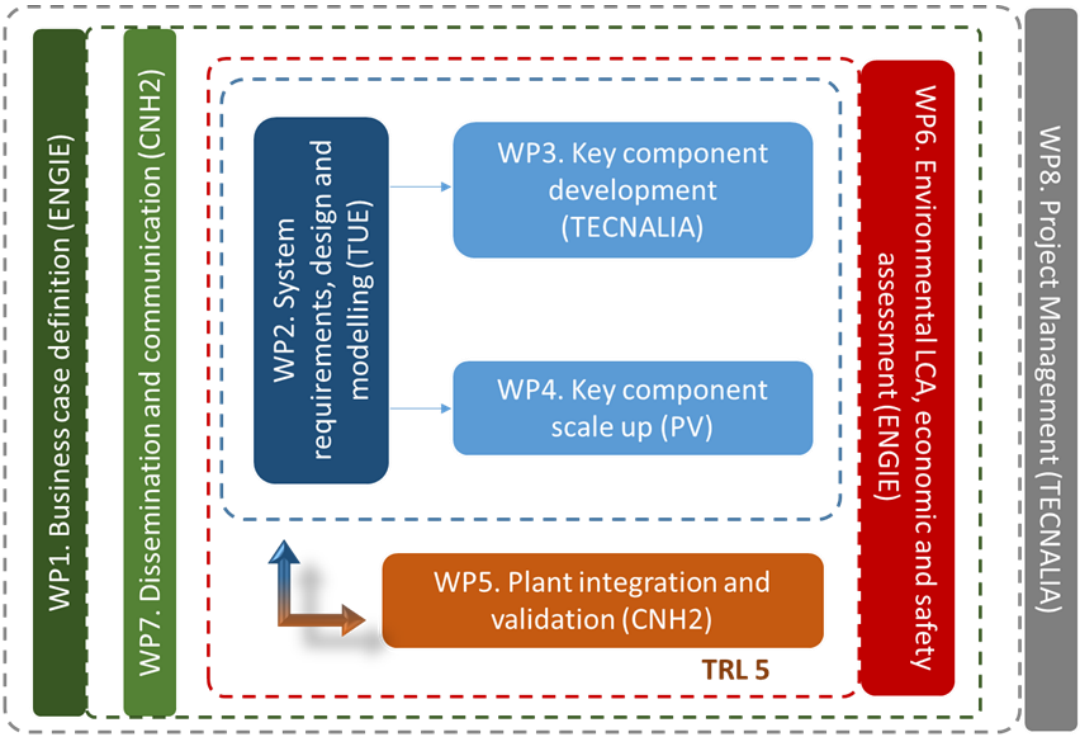


***Figure 3 ARENHA work structure and synergies among partners***

# Latest news from the project

## ARENHA online Kick-off Meeting

Due to the current situation and our responsibility to limit the spread of COVID-19, the kick-off meeting was celebrated online with success on May 5th. It was the first-time consortium was in contact all together. Besides presenting the groups, the consortium made a review of the long-term goal of the project and discussed on the short-term specific activities to be carried out in the next months. Further information on the project can be found at the following link: https://arenha.eu.


***Figure 4. Kick-off meeting***

## ARENHA online M6 Consortium Meeting

Due to the current situation the month 6 consortium meeting was celebrated also online with success on October 23rd. Progress has been made since the kick-off meeting. Activities in the frame of the active WPs: business case definition, system requirements, design and modelling, key component development, environmental LCA and safety assessment and dissemination and communication have started. Internal and external communication tools have been developed to facilitate the project execution and dissemination of the progress and project results. Public website and first video have been released. Further information on the project can be found at the following link: https://arenha.eu.

# Highlights

## Dissemination activities, publications and presentations:

ARENHA public presentations as well as open access articles and public reports are available online in the dissemination section of the project website: www.arenha.eu.

## Peer Reviewed Articles.

1. V. Cechetto, L. D Felice, A. Arratibel Plazaola, F. Gallucci. Ammonia inhibition on $H_2$ produced via ammonia decomposition in a catalytic membrane reactor. Submitted.
2. Jaysree Pan, Heine Anton Hansen, Tejs Vegge. Vanadium oxynitrides as stable catalysts for electrochemical reduction of nitrogen to ammonia: the role of oxygen. Submitted to Journal of Materials Chemistry A

## Conference proceedings or presentations.

1. C. Mounaïm-Rousselle, P. Brequigny, S. Houillé, C. Dumand. Potential of Ammonia as future Zero-Carbon fuel for future mobility: Working operating limits for Spark-Ignition engines. Presented to the International Congress on Energy and Powertrains (Rouen, France, November 2020). https://www.sia.fr/evenements/193-sia-powertrain-energy-rouen-2020
2. Valentina Cechetto, Luca Di Felice, Jose Medrano, Camel Makhloufi, Jon Zuniga, Fausto Gallucci. $H_2$ production via ammonia decomposition in a catalytic membrane reactor. Submitted to the World Online Conference on Membrane Processes.

## Upcoming events

**November 16-29, 2020** International Congress on Energy and Powertrains (Rouen, France, November 2020).
https://www.sia.fr/evenements/193-sia-powertrain-energy-rouen-2020

**March 17-19, 2021** World Online Conference on Sustainable Technologies (WOCMP 2021). https://www.wocst.org/

**May 17-18, 2021** - 7th Edition of International Conference on Catalysis, Chemical Engineering and Technology (CCT2021) in Tokyo, Japan.
https://catalysis-conferences.com/

**2021** – European Hydrogen Energy Conference (EHEC-2021), Madrid, Spain.

**ARENHA in figures:**

11 partners (6RES, 2 IND, 3 SME)

7 countries

5,684,325 € project

Start: April 2020

Duration: 48 months

**Key milestones:**

April 2023 - Ammonia synthesis and decomposition prototypes ready

April 2024 - Ammonia- based energy storage system integrated and validated


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More information about ARENHA (including a non-confidential presentation of the project) is available at the project website: https://arenha.eu/


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