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First Workshop ARENHA project: "Introduction to novel technologies related to ammonia-based energy storage"

Advanced materials and Reactors for ENergy storage tHrough Ammonia (ARENHA)

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Website project: https://arenha.eu/

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1. Introduction

Nowadays, mankind is facing two of the most difficult challenges in its life:

- global warming and associated climate

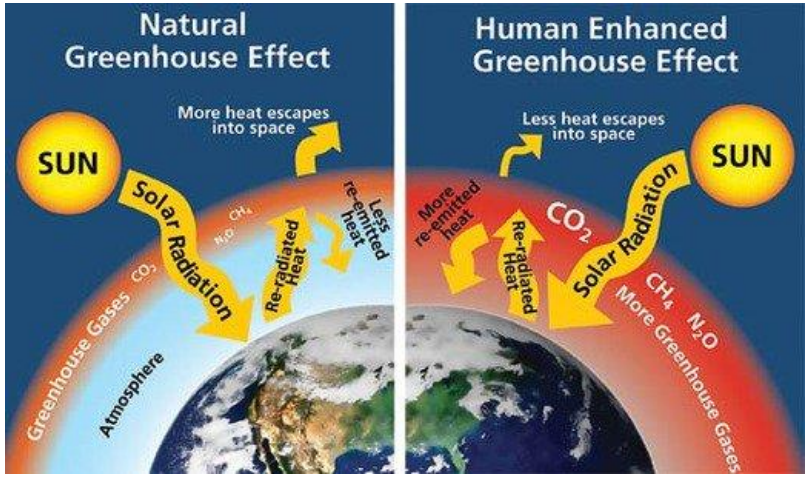
- local pollution of urban areas.

Energy production 21st Century

- Majority from fossil fuel derivatives (carbon based): Currently, more than 80% of global primary energy use is fossil based. Over the last decade, 85% of the increase in global use of energy was fossil based.
- CO_2 production

Greenhouse gasses

- **Effect:** Trap IR-radiation (heat)
- **Emission CO_2:** Natural & human activity



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1. Introduction

Greenhouse gases. Reduce emissions to environment.

- Increasing Energy efficiency;
- Carbon Capture, Utilizations and Storage
- Low carbon processes
- Net-negative global emission
- Search for renewable energy carrier: Hydrogen,……
- …..

European Green Deal: Set of policy initiatives by the European Commission with the overarching aim of making Europe climate neutral in 2050.

- Reducing greenhouse emissions by at least 55% by 2030 (compared to 1990 levels).
- Greater energy efficiency: 36-39% energy efficiency for final and primary energy consumption.
- Maximise the deployment of renewables and the use of electricity to fully decarbonize Europe's energy supply
- Increase renewable energy to at least 40% of the EU's energy mix by 2030.
- Promote the uptake of renewables fuels, such us hydrogen in industry and transport.

Renewable energy is playing an important role in addressing some of the key challenges facing today's global society, such as the cost of energy, energy security and climate change.

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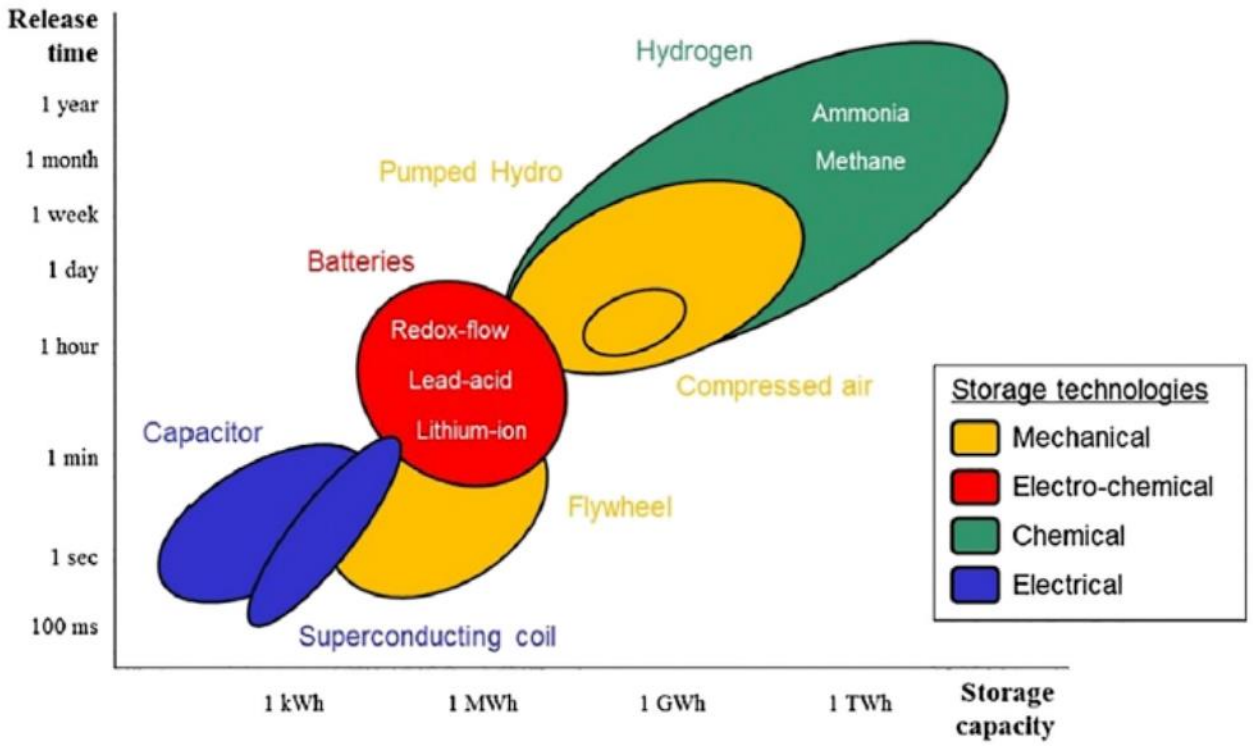
1. Introduction

Energy storage technologies



L.Ye et al. Reaction: "Green" Ammonia Production. Catalysis Vol. 3, Issue 5, p712-714, 2017
DOI: https://doi.org/10.1016/j.chempr.2017.10.016

Challenges

- Sustainable energy production can only work well when the specific different energy storage challenges are solved: provide the required capacity for grid-scale energy storage.
- Overcoming the inherent intermittency of renewable resources and increasing their share of generation capacity (i.e. integration of renewable energy in the grid).
- Other technologies have to be developed that can respond to these needs, and their readiness for market deployment has to be shown.
- New or improved materials for these technologies must be developed in combination with new design/architecture (i.e. improvement of electrolysers…)
- Economic competitiveness and environmental aspects have to be considered (i.e. recycling)

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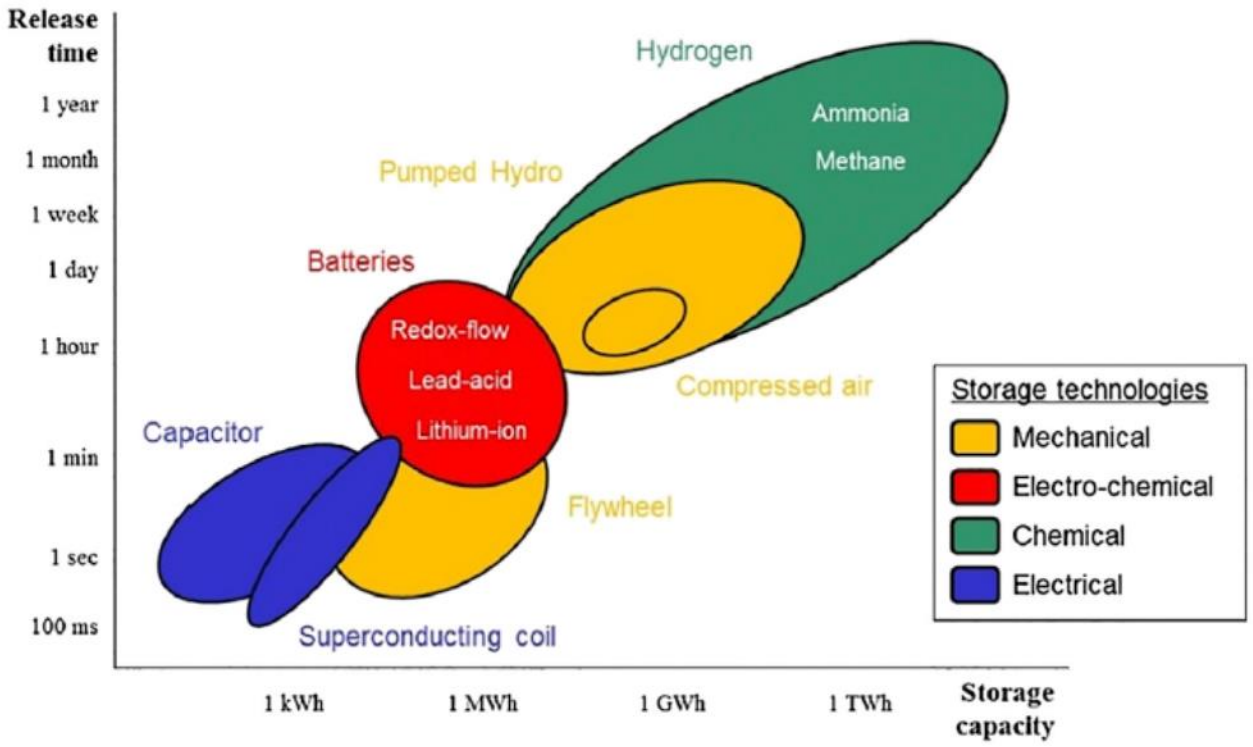
1. Introduction

Energy storage technologies



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- Batteries may not be the best solution to face all energy storage needs, due to cost, safety and environmental issues.
- Pumped hydro and methods such as compressed gas energy storage suffer from geological constraints to their deployment.
- Non battery-based storage technology, such as Power-to-X technologies (Power-to-Gas, -Chemicals, -Liquids) that allows transforming renewable electricity into synthetic gases (hydrogen, methane or other gases) and chemicals/liquids, can be suitable solutions for different energy storage needs.
- The only sufficiently flexible mechanism allowing large quantities of energy to be stored over long time periods at any location is chemical energy storage: via hydrogen or carbon-neutral derivatives.
- H_2 has gained considerable attention as an ideal and clean energy carrier:
  - H_2 combustion produced only water as by-product
  - High efficiencies for energy conversion are achieved when it is employed as feedstock for power production.

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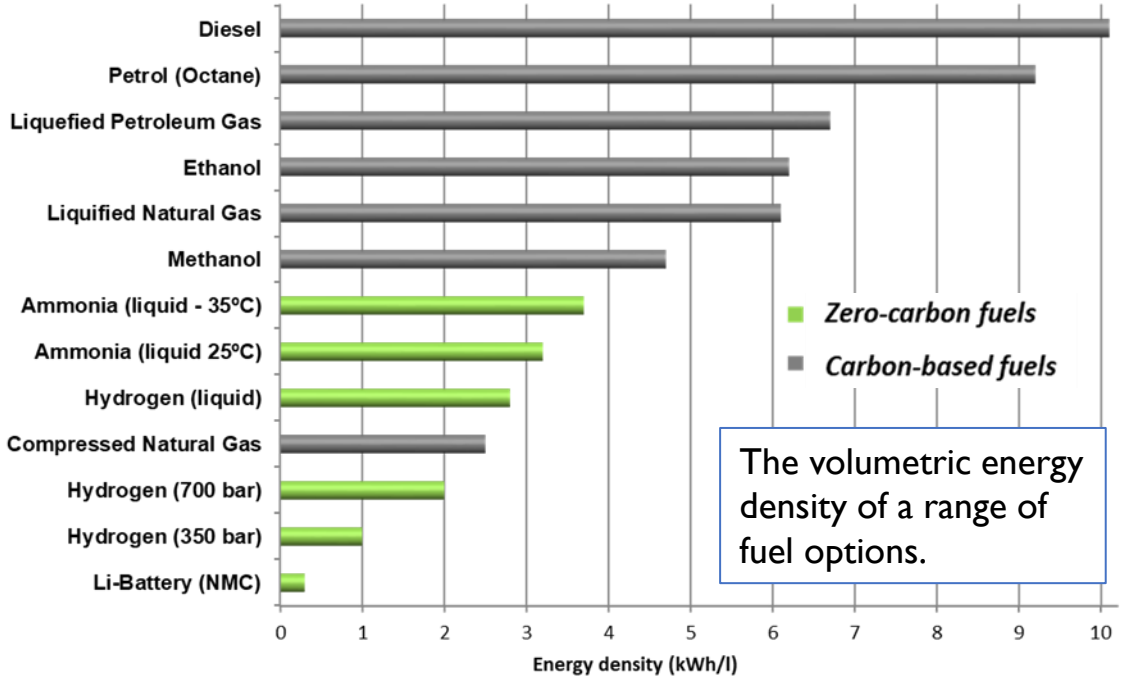
2. Objectives

- 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, ammonia storage, ammonia dehydrogenation and direct energy use of ammonia.
- ARENHA main goal is to develop, integrate and demonstrate key material solutions enabling the flexible, secure and profitable storage and utilization of energy under form of green ammonia.
- 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.

Ammonia as a potential H_2 carrier:

High volumetric energy density | Relatively low cost | Easy to liquefy | Easy to store and transport | Carbon free



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2. Objectives

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/h 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 (<80 bar) and temperature (<450 °C).
- To develop and integrate innovative materials into a decomposition reactor able to generate 10 Nm^3/h 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.

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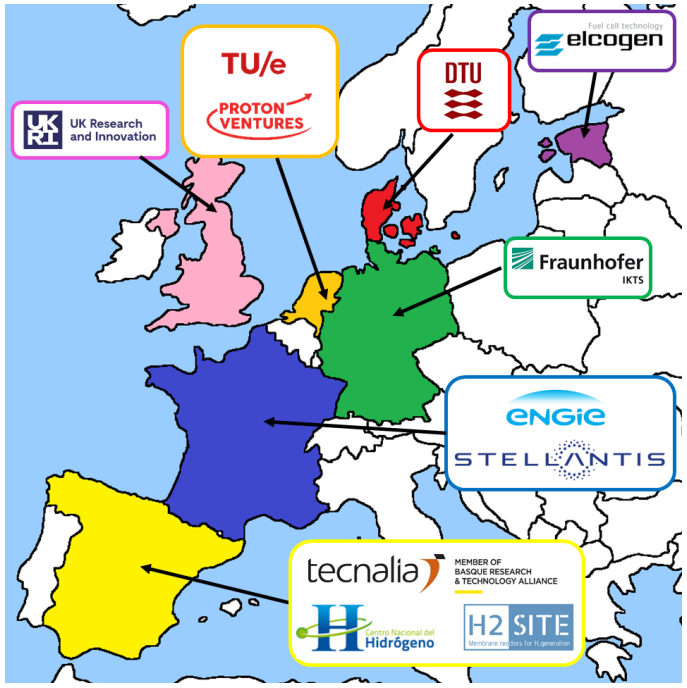
3. Partnership

- Multidisciplinary and complementary team.
- 11 partners in 7 countries.
- Industrial oriented (45%): 5 SME/IND + 6 RTO/HES
- 3 SMEs & 2 IND



Part No	Participant organisation name	Short name	Type of Organisation	Country
1	Fundación Tecnalia Research & Innovation	TECNALIA	RTO	Spain
2	Technische Universiteit Eindhoven	TUE	HES	Netherlands
3	Centro Nacional del Hidrógeno	CNH2	NPO	Spain
4	Danmarks Tekniske Universiteit	DTU	HES	Denmark
5	Fraunhofer Gesellschaft zur foerderung der angewandten forschung E.V.	FhG-IKTS	RTO	Germany
6	United Kingdom Research and Innovation	STFC	RTO	UK
7	Proton Ventures BV	PV	SME	Netherlands
8	Aktsiaselts Elcogen	ELCOGEN	SME	Estonia
9	Hydrogen Onsite, S.L	H2SITE	IND	Spain
10	Stellantis (PSA ID)	PSA ID	IND	France
11	Engie	ENGIE	IND	France

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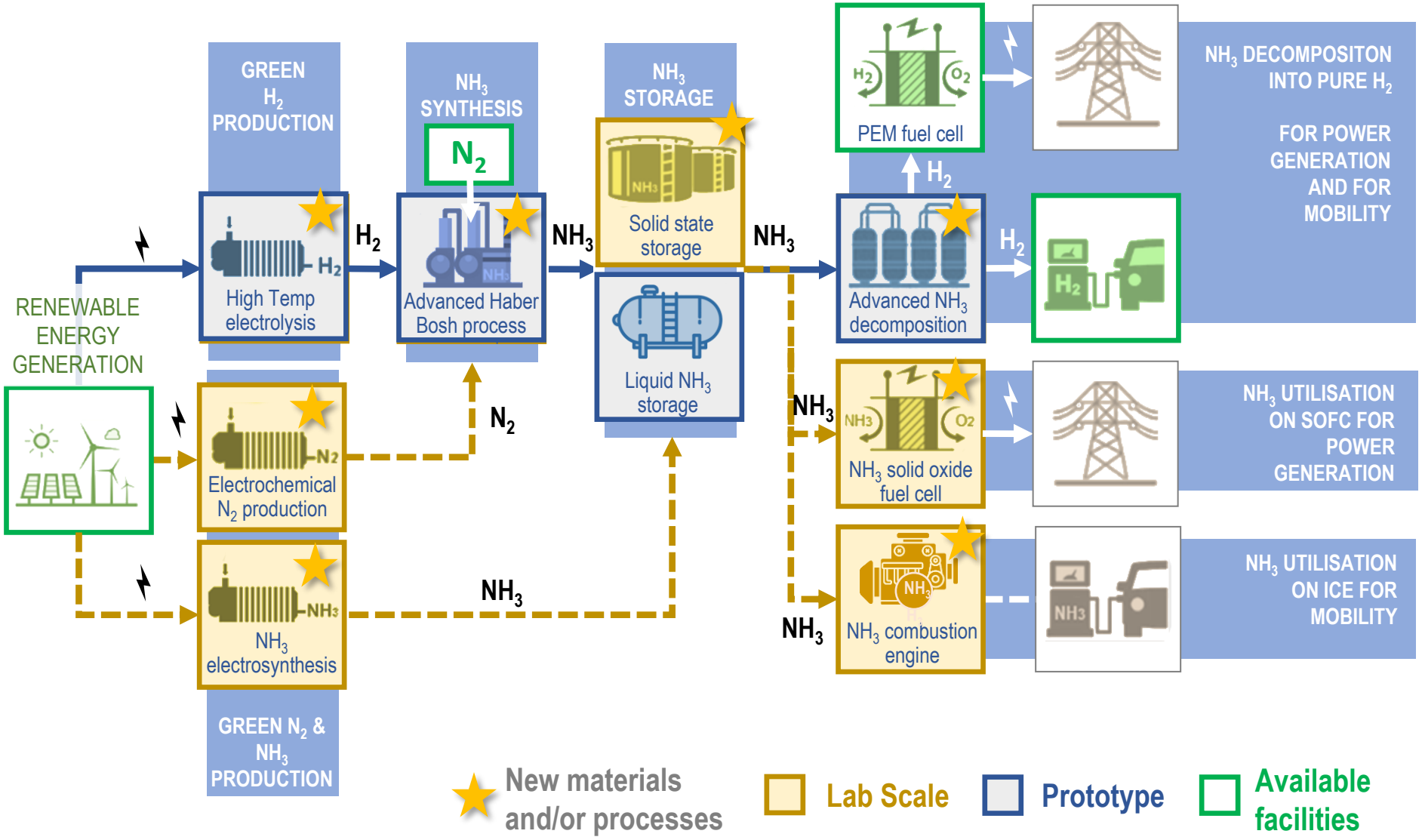
4. Approach / Solutions & innovations

Power-to-ammonia-to-usage value chain in ARENHA



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4. Approach / Solutions & innovations

ARENHA's ground-breaking technologies are currently positioned between TRL2 and 3, and based on performance and commercial potential, they will be brought to TRL4-5. Next Table shows the positioning of the project at the beginning and end of ARENHA. Green represents, the ones developed in the frame of the project. Red represents the technologies available that will be used to benchmark the results.

Technology	Lab scale (TRL 2-4)	Prototype (TRL 3-5)
Hydrogen Production		
SOEC stack (ELCOGEN)		X
SOEC CFY stack (FhG-IKTS)		X
- Stack module with CFY stack		X
- Stack module with ELCOGEN stack		X
Battolyser (PV)	X	
Alkaline Electrolyser (CNH2)		X
Ammonia Synthesis (Proton Ventures)		
- Electrosynthesis (DTU)	X	
- H-B + Absorber (PV/DTU)		X

Technology	Lab scale (TRL 2-4)	Prototype (TRL 3-5)
Ammonia Storage (CNH2/DTU)		
- Liquid (CNH2)		X
- Solid state storage (DTU)	X	
Ammonia Decomposition (TUE/TECNALIA)		
- Membranes (TECNALIA)		X
- Membrane Reactor (TUE)		X
Ammonia usage (PSA ID)		
- Engine (PSA ID)	X	
- SOFC (IKTS)	X	
Hydrogen usage (CNH2)		
- H_2 refueling station (CNH2)		X
- Fuel Cell (CNH2)		X

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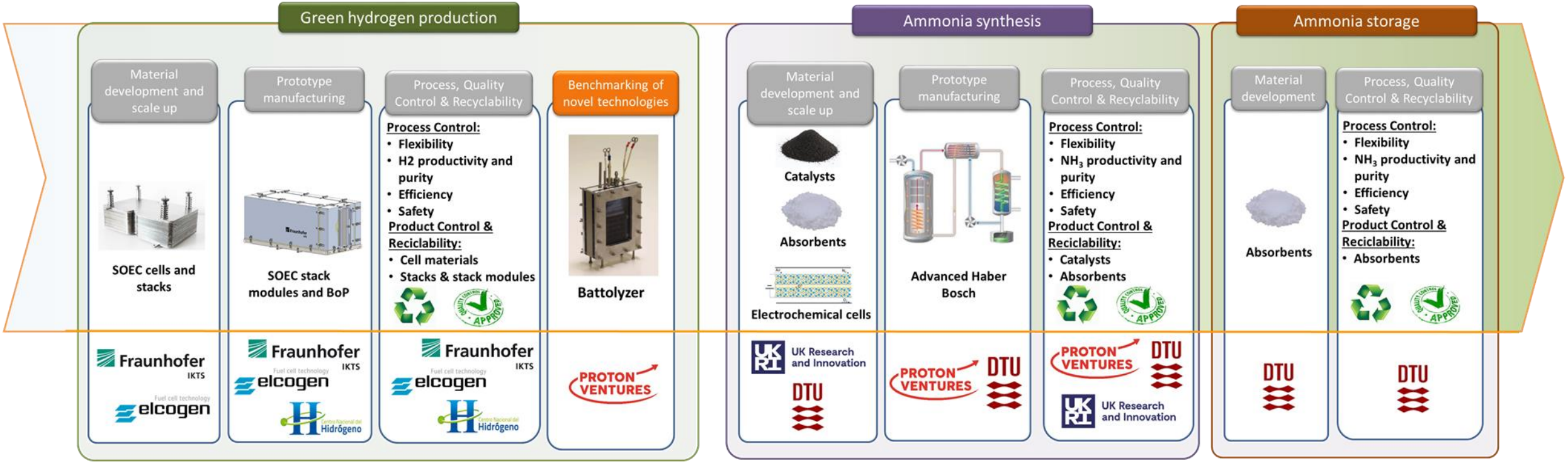
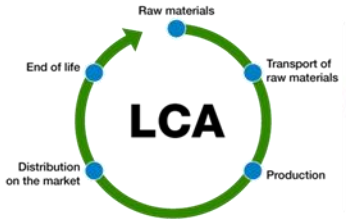
4. Approach / Solutions & innovations





To be developed in ARENHA

To be tested in ARENHA for benchmarking

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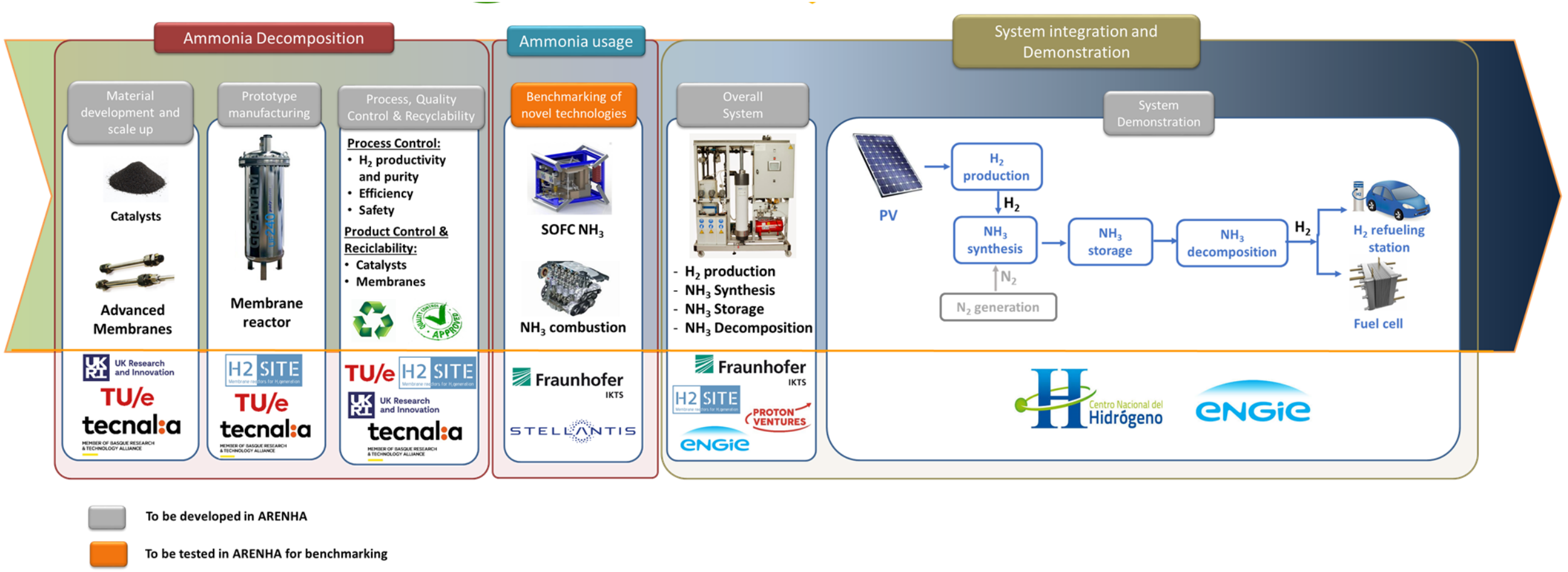
4. Approach / Solutions & innovations



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5. Impact

Decrease energy import dependency.

Promote the integration of offshore renewables for energy dependency.

Integration of renewable in power systems with large scale energy storage.

Strategic European leadership in energy storage.

Ammonia to diversify energy supply from third countries

Alternative energy import through renewable electricity storage and long distance transportation.

-  > $2.5 trillion per year
-  > 5000 future jobs
- Reduction of NOx-emission = Increase quality of life
- Avoid 20 million barrels of oil per day

- Reduce annual CO_2 emissions by around 6 Gt

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6. Dissemination and Communication

Website: https://arenha.eu/

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3	7	1	3	>10

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First Workshop ARENHA project, ENGIE Lab CRIGEN, 07-04-2022

Thank you for your attention

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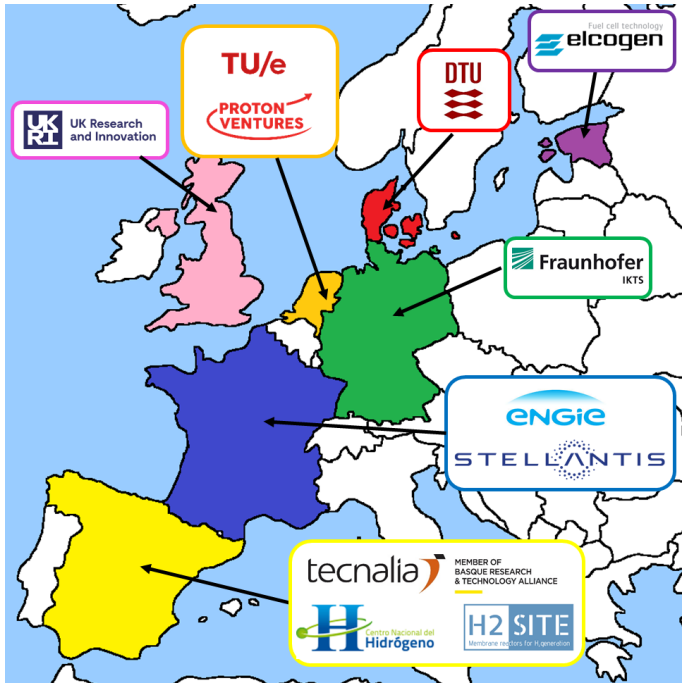
1. Project fiche

- Title: Advanced materials and Reactors for Energy storage tHrough Ammonia
- Acronym: ARENHA
- Funding scheme: Research and Innovation action
- Topic: LC-NMBP-29-2019: Materials for non-battery-based energy storage (RIA)
- Start/end dates: April 1st, 2020 – March 31st, 2024
- Budget/EU contribution: 5,684,325 Euros



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