HYDROGEN MASTER PLAN IN ARAGON

[2021 - 2025]

FOUNDATION FOR THE DEVELOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

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Upper Image on front cover: FHa´s facilities at Walqa Technology Park.
Lower Image on front cover: Presentation GetHyGA Initiative- July 2021.

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FOREWORD

Over the last few years, different countries and international bodies have clearly expressed- in an array of summits and signed treaties- their will to move forward towards the attainment of environmental sustainability, decarbonisation of the economy and fight against climate change. The intended climate neutrality that Europe places at its core on the horizon 2050 demands a collective effort that in addition to aiming for a reduction in emissions, has renewables, smart storage, energy efficiency and flexible grids at its centre. This scenario highlights the role that already thriving hydrogen technologies must play at its forefront. Europe has been working on this for quite some time, aware of its usefulness both for green energy supply and storage of surplus from renewables as well as for the decarbonisation of sectors with difficulties for their electrification such as heavy industry or transport.

The European Strategy for Hydrogen published by the EU Commission in 2020 with the European Alliance for Clean Hydrogen as one of its main axis for action, embody this spirit. They seek to translate Europe´s leadership in hydrogen - more specifically in electrolysers, hydrogen refuelling stations and fuel cells- to the industrial sector in order to achieve its implementation in close partnership with the main European associations linked to research, development and innovation.

Spain has also issued its "Hydrogen Road Map: a Commitment to Renewable Hydrogen", promoted by the Ministry for the Ecological Transition and the Demographic Challenge. It is a strategy geared towards encouraging the deployment of this sustainable energy carrier, key for Spain to attain its climate neutrality, with a safe and 100% renewable electric network.

Thus, the promotion of hydrogen technologies conducted by the Autonomous Community of Aragon and its successive governments, finds its current relevance. They have played a leadership role in Spain and Europe, with a pioneering strategic vision in industrial and energy policy and landmarks such as the setup of the Foundation for the Development of the New Hydrogen Technologies in Aragon in 2003. It is precisely this private entity, geared towards cross-sectoral cooperation along the whole value chain in the energy and industrial fields that promotes the current Hydrogen Master Plan in Aragon 2021-2025, the fourth Master Plan in the Autonomous Region. This plan and its predecessors are the result of an indispensable process of analysis, reflection and participation of stakeholders to ensure the overall fulfilment of goals set over the years, and that go beyond a theoretical approach. For instance, under the umbrella of the former HMPA 2016-2020, Aragonese companies and bodies took part in 77 research and promotion projects related to hydrogen technologies and fuel cells, bringing in 35.2 million euros to the Region, and winning funding of 25.9 million euros in different competitive public calls – mainly European and national – in which they participated.

The overall aim of the Hydrogen Master Plan in Aragon 2021-2025 is to act as a tool that may allow the continual identification -through 7 clearly defined lines of action in the fields technology development and its introduction into the market - of opportunities for the development of hydrogen technologies in Aragon enabling the implementation of specific actions that involve companies, institutional and academic bodies as well as research centres geared towards growth creation in the region and help meet decarbonisation targets in the economy. A plethora of Aragonese companies have already drawn benefits from this approach and participate and even lead projects in this field worldwide.

The road covered so far has been fraught with obstacles. Should we look back, we would realise the huge commitment to hydrogen that has been made, when few in Europe and even fewer in Spain at that time followed this path. Looking into the future, there is no scarcity of exciting challenges or initiatives such as GetHyGA - the action plan promoted by the Department of Industry, Competitiveness and Business Development of the Government of Aragon, through the Foundation for the Development of the New Hydrogen Technologies in Aragon geared towards the creation of an industrial ecosystem (hydrogen valley) in the region. With over 2.3 billion

euros it encompasses hydrogen generation and consumption projects with hydrogen as an energy source, as well as its transport, storage and integration in industrial processes. This global initiative aiming to include a large number of hydrogen related projects from the energy, economic, developmental and re-industrialisation perspectives, is an outstanding example of the premise underlying each of our actions and this Hydrogen Master Plan itself: helping attain a society that is more prosperous, sustainable and inclusive, by taking advantage of the huge potential that hydrogen provides to that aim.

His Excellency Mr. Arturo Aliaga López

Vice-president of the Regional Government of Aragon. Councillor for Industry, Competitiveness and Business Development.

President of the Foundation for the Development of the New Hydrogen Technologies in Aragon.

01

INTRODUCTION

01. INTRODUCTION

Since 2003 the region of Aragon, with hydrogen as a key solution to the decarbonisation of energy, transport and industrial sectors as well as a factor to boost the regional economy and industry, has been at the forefront of the development of hydrogen technologies. That year saw the landmark set-up of the Foundation for the Development of the New Hydrogen Technologies in Aragon (FHa) of Aragon.

The Regional Government of Aragon promoted the set-up of the FHa alongside a range of companies and bodies that established its board of trustees. Hydrogen was regarded as a new path of technological and industrial development for the creation of knowledge and quality employment in the region. In 2007, the FHa´s Board of Trustees decided to develop a Regional Master plan. This plan, based on the interests, opportunities and capabilities of all the regional organisations involved is to be used as a tool where priority lines of action found in the entire hydrogen chain of value were set.

FHa´s building at Walqa Technology Park.

This document, the Hydrogen Master Plan in Aragon 2021-2025, hereinafter HMPA 2021 - 2025), is the fourth edition of the regional planning document. The previous master plans set different milestones and objectives for each period. They were subsequently assessed to review the degree of achievement of said objectives, with the aim of positioning Aragon as a pioneer region at the forefront of the development of hydrogen technologies.

These previous master plans became reference documents for other regions when both at national or international level hydrogen-specific strategies were virtually non-existent.

The current HMPA 2021 - 2025 is to be released at a moment in which hydrogen use has received strong support at the European level, and particularly in Spain. Hydrogen is regarded as a key element for the new industrial energy and environmental policies. Such backing is substantiated by the unprecedented allocation of funds. Against this backdrop, new hydrogen strategies are being developed at European, national and even regional levels.

Being aware of these circumstances and in alignment with national and European planning schemes, Aragon continues to develop its Hydrogen Master Plan 2021-2025. In it, the new framework for action at different tiers is included, while being aware of its role as a tool for regional development. Therefore, within this framework, the plan incorporates, in particular, the interests of and opportunities for, the region of Aragon. An increase in cooperation with other territories and the involvement of a larger number of national and international companies and bodies with interests in the region is also present.

The Master Plan, as was the case in previous editions, has been developed with the collaboration of a broad range of actors and stakeholders, and on this occasion -as shown in Annex I- the participation of companies and bodies present in former versions was surpassed, with huge impact at both national and international levels.

Likewise, the HMPA 2021-2025 keeps the structure of previous plans, preserving the continuity of the work done by the region of Aragon since the foundation of the FHa and the companies and bodies involved.

First of all, an overview of the current European Framework for Action is provided in chapter 2, through the collection of documents of reference, goals and most relevant actions being developed at the moment. The actions incorporated in this Plan must be in line with the current European Framework for Action.

Chapter 3 deals with the keys for competitiveness and positioning of the region of Aragon in terms of hydrogen energies. Insights into achievements in the development of the previous plan are found, alongside the main figures involved and major projects developed. This chapter also includes a rough overview of the main challenges and interests for the 2021-2025 period.

Chapter 4 points out the general and specific objectives of the new HMPA 2021-2025 while chapter 5 sets out the course of action and specific actions to take bearing in mind the potential and opportunities for the region during the 2021-2025 period. The actions presented have been prioritised, and indicators and targets for monitoring and final assessment have been set.

As on previous occasions, a monitoring system for the Plan (chapter 6) is set up. It includes follow-up indicators on results, governance and management, which will allow to continuously monitor the evolution of technologies in the region as well as FHa's activities while enabling the comparison of the main indicators with previous periods.

Finally, we find a chapter devoted to conclusions drawn in the light of the information gathered over the lifetime of the Plan and estimates on the near future in terms of support for hydrogen at different levels.

02

HYDROGEN TODAY. FRAMEWORK FOR ACTION

02.
FRAMEWORK FOR ACTION

The energy transition to achieve climate-neutral societies is not a wild idea of the far future, but a reality we are already fully immersed in. Aware of the main threat posed by climate change and environmental degradation, Europe and the rest of the world are developing plans, legislation and regulations to stem it, with hydrogen as one of the key elements conducing to decarbonisation.

2.1. EUROPEAN FRAMEWORK

The EU, in its new mandate 2019 – 2024, has put forward a political agenda where a set of priorities for the said period to address the major challenges faced by EU members at both political and societal levels, have been laid out. The European Commission´s priorities are:

- A European Green Deal.
- A Europe ready for the digital age.
- An economy at the service of the people.
- A stronger Europe in the world arena .
- The promotion of our European way of life.
- A new drive to Europe´s democracy.

The European Union´s investment strategy hinges on three pillars: The Green Pact, the Digital Transition, and Reindustrialization, known as "vectors of transformation".

Of these, the European **Green Deal**, stands out. Presented in December 2019 as one amongst the first actions outlined in the agenda geared towards the transformation of the EU into a modern, resource-efficient and competitive economy, it is based on the reduction of emissions and job creation, and with the overall goal of achieving a climate-neutral Europe by 2050.

THE GREEN DEAL ADVOCATES ACTION THROUGHOUT ALL ECONOMIC SECTORS

- Investment in environmentally-friendly technologies.
- Support for innovation in the industrial sector.
- Deployment of private and public transport systems that are cleaner, cheaper and less harmful to health.
- Decarbonisation of the energy sector.
- Ensuring higher energy efficiency in buildings.
- Cooperation with international partners to enhance world environmental standards.

The Green Deal includes hydrogen as one of the key elements to attain carbon neutrality by 2050. Energy decarbonisation will be achieved by replacing the use of fossil fuels with renewable energy sources (RES). Given the intermittent nature of RES, storage becomes essential for this transition. In this sense, hydrogen has been identified as the most promising option.

On the other hand, at the time this plan is being developed, Europe is experiencing –as a result of the Covid-19 pandemic- the gravest economic crisis in its history. The Recovery Plan for Europe was launched in mid-2020 in response to this crisis. The purpose of this plan is not limited to overcoming the crisis but aims at laying the foundations for a more modern and sustainable EU.

The Recovery Plan mobilises the largest financial stimulus package ever in EU history. It boasts a total of €1.8 trillion to rebuild a greener, more digitalised and resilient Europe.

In December 2020, an agreement was reached with more than 50 % of the budget allocated to the modernisation of Europe, in line with the following points:

- The strengthening of R&D through the Horizon Europe programme.
- Support for a just digital and climate transition through the Just Transition Fund and the Digital Europe programme.
- Preparedness, recovery and resilience through the Recovery and Resilience Fund, rescEU, and a new health programme, EU4Health.

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In addition, this agreement includes the modernisation of cross-cutting policies such as the cohesion policy, CAP, biodiversity protection and gender equality among others. One of the main instruments in the Recovery Plan for Europe, is the Next Generation instrument.

NEXT GENERATION is a new instrument, with a limited lifespan, whose aim is to boost EU´s budget by mobilising €750 billion, financed through the issuance of EU debt, which alongside the €1 074.3 billion of the Multiannual Financial Framework 2021-2027, will make it possible to deal with an unprecedented volume of investments in the coming years.

NEXT GENERATION funds are mainly found distributed in two instruments:

a.) The **Recovery and Resilience Mechanism (RRM)** is the core of the Recovery Fund. Endowed with €672.5 billion, -with €360 billion in the form of loans and €312.5 billion as non-refundable transfers. Its purpose is to support investment and reforms in Member States so that a sustainable, resilient and just recovery can be attained while promoting EU´s Green and digital priorities.

b.) **REACT EU**, endowed with €47.5 billion. REACT EU funds operate in the same way as structural funds. However, they have greater flexibility and swiftness in their implementation. REACT EU aims to promote the green, digital and resilient recovery of the EU economy.

Furthermore, within this global framework, 2020 has been crucial for **the decisive drive toward the development of hydrogen technologies.** Hydrogen is aligned with overall EU objectives, and as is the case for every policy geared toward energy transition, it is regarded as a tool for economic recovery and job creation, receiving the ensuing strengthened support.

At a European level, the main specific actions for hydrogen within an overall framework for action are shown below.

Image 1: Organisation and main EU level actions revolving around Hydrogen

Political coordination

European Clean Hydrogen Alliance (ECH2A)

Legal Framework

European Hydrogen Strategy

Instruments and Programmes

Next Generation EU; IPCEIs; EU Green Deal; ETS Innovation Fund; Horizon Europe; Clean Hydrogen Partnership; etc.

Source: Own Production.

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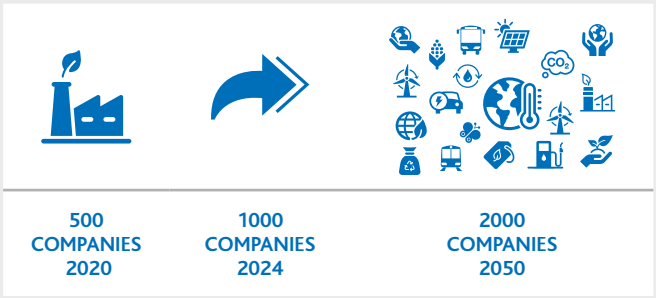
• **EUROPEAN CLEAN HYDROGEN ALLIANCE (ECH2A).** This Alliance for clean hydrogen was officially set up at its kick start meeting on July 8th 2020. It brings together industry, national and local public authorities, civil society and other stakeholders. In 2020 the Alliance brought together about 500 actors, whereas in 2021 it has managed to involve virtually twice as many actors, exceeding its projections while remaining open to further participation. FHa is member of ECH2A and an active participant of all roundtables.

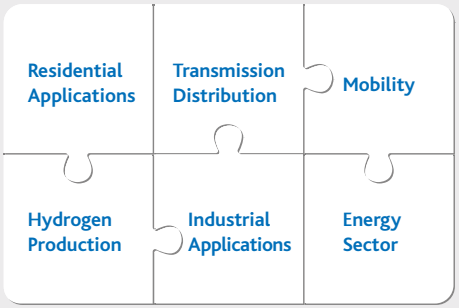
• Its objective is to provide support across the hydrogen chain value. It encompasses low- carbon content renewable hydrogen, from generation - through transport and distribution- to mobility, industrial and energy applications, as well as applications in the home.

Image 2: Participants to the Alliance and Action Pillars

Projection of Participants to the Alliance



Action Pillars



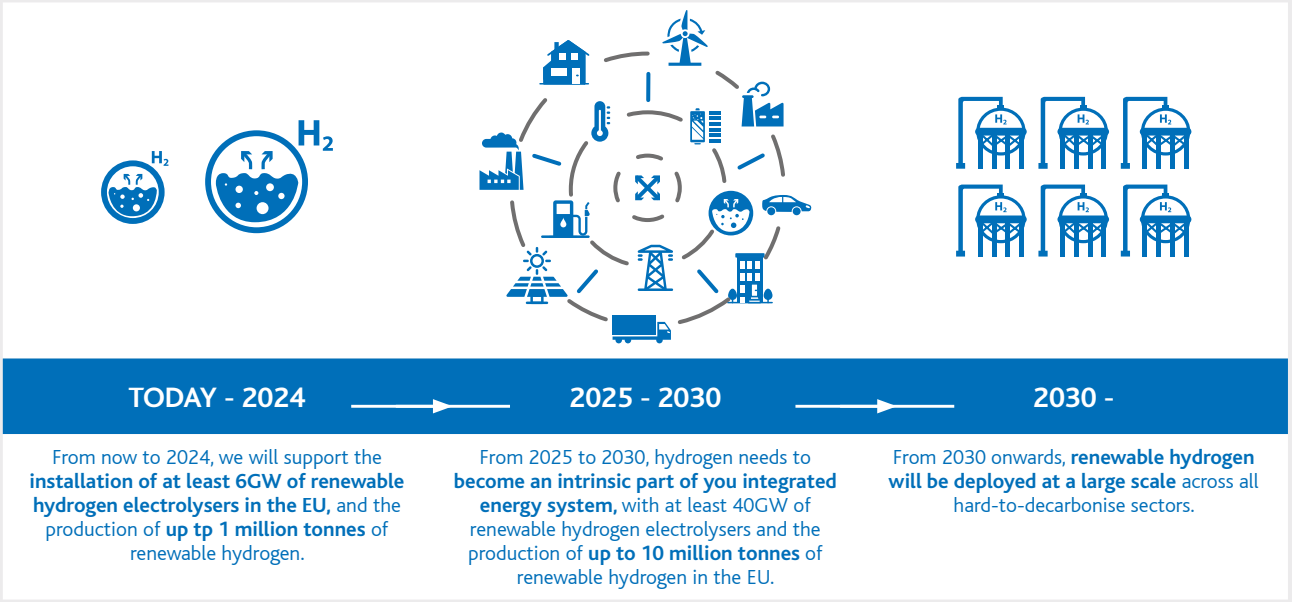
Source: European Clean Hydrogen Alliance https://ec.europa.eu/commission

• **EUROPEAN HYDROGEN STRATEGY.** The European Hydrogen Strategy, approved by resolution of the European Parliament on May 19th, 2021 is a key tool for attaining climate neutrality and Green Deal´s goals by 2025. It supports EU industry´s leadership in its transition to climate neutrality while helping create these new markets.

• This Strategy emphasises the inclusion of hydrogen for a range of uses: electricity decarbonisation, widespread use in transport (including heavy haulage, maritime and aviation freight) as well industrial and domestic use.

• Priority goes to developing renewable hydrogen – by resorting to generation through wind and solar power- in order to attain climate neutrality. By 2050, renewable hydrogen should be progressively deployed on a large scale, with mature technologies and a reduction in costs. However, given the fact that markets are competition-driven, in order to attain these goals other forms of low-carbon hydrogen generation may be needed so as to support the concurrent and future use of renewable hydrogen. Thus, the phasing-in of hydrogen will be based on three major developmental stages: 2024, 2030 and 2050.

Image 3: The path towards a European Hydrogen Eco-system



Source: European Hydrogen Strategy.

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The Strategy, on its first phase (2020-2024), sets the strategic goal of installing at least 6GW of renewable hydrogen electrolysers in the EU and the generation of up to 1 million tonnes of renewable hydrogen. To that aim, the construction of electrolysers must be increased - Including those of large scale- 100MW.

During this phase, consumption at larger refineries, steel works and chemical facilities is to be promoted. As for mobility, the aim is for buses to be powered by means of hydrogen fuel cells and, at a later stage, for heavy haulage to adopt the same, with the requisite infrastructure for the transport of hydrogen. This way, despite the initial stage of the hydrogen supply being met by means of on-site or nearby generation, - planning for medium and long range infrastructure must be initiated.

In the second phase (2025-2030), hydrogen must become key within a fully integrated energy system, with the strategic target of at least 40 GW coming from renewable hydrogen electrolysers by 2030 and the generation of up to 10 million tonnes of renewable hydrogen in the EU by 2029.

In the third phase, from 2030 onwards and with 2050 in sight, renewable hydrogen technologies must reach maturity and be deployed on a large scale in order to reach every single sector struggling with decarbonisation -where other alternatives might be unviable or entail higher costs.

Accrued investments within the European Hydrogen Strategy could range between €180 billion and €470 billion from present day until 2050.

In addition to the European Hydrogen Strategy, in late 2019 and 2020 various strategic documents analysing a diversity of fields related to hydrogen technologies and developed by a range of bodies were published. All of them are aligned to attaining the eventual deployment of hydrogen technologies. Some of the documents analysed are listed below:

- **2050 Hydrogen Roadmap Europe.** Published by the FCH JU. This study, produced with input from 17 leading European industrial actors, sets out the path to large-scale deployment of hydrogen and fuel-cells up to 2050, and quantifies the associated economic impacts.

- **The Future of Hydrogen.** Published by the IEA (International Energy Agency). By request of the government of Japan under the presidency of the G20, the IEA drafted this report to analyse the current situation of hydrogen and provide guidance on its future development while including practical and viable recommendations to governments and industry alike.

- **Path to hydrogen competitiveness.** A cost perspective 2020. Published by Hydrogen Council. The report provides a database on the path towards competitiveness of costs incurred by 40 Hydrogen technologies used in 35 applications. This backdrop provides public officials and politicians with firm grounds for a rationale of financial and non-financial support to unlock hydrogen´s economic value all the while helping develop appropriate political frameworks. For decision-makers in industry, it brings forth a comprehensive picture of cost dynamics and interactions across the value chain, allowing more informed decisions thanks to a wider picture.

- **Green Hydrogen for a European Green Deal.** A 2x40 GW Initiative. Published by Hydrogen Europe. This report points out that the European Union, in close collaboration with its neighbouring countries, must take advantage of its unique assets and build a world leading industry through green hydrogen generation plants, with a range of GW, to unlock the renewable potential of hydrogen.

- **Strategic Research and Innovation Agenda (Clean Hydrogen for Europe). Published by Hydrogen Europe.** The strategy aims at accelerating the development and deployment of clean hydrogen European strategies leading to a sustainable, decarbonized economy, and a fully integrated energy system.

- **Manifesto for the development of a European "Hydrogen Technologies and Systems".** Signed by 22 EU member states. It aims at developing a European value chain of hydrogen systems and technologies through an important European common interest project (IPCEI initiative on hydrogen).

- **POST COVID-19 AND THE HYDROGEN SECTOR.** The Hydrogen Europe industry association has published a post COVID-19 hydrogen sector analysis putting forward the need and rationale for rapid action as a result of the impact of the COVID-19 pandemic.

- **Hydrogen Act - Towards the creation of the European hydrogen Economy.** Published by Hydrogen Europe. This document does not limit itself to being a mere compilation of legislation but aims to provide a vision of a general framework for the harmonization and integration of separate hydrogen related actions and legislation, focusing on market and infrastructure aspects.

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• **INSTRUMENTS AND PROGRAMMES.** In order to implement the activities set forth in the Alliance and the Strategy, it will be necessary to rely on existing and new financial instruments and programmes to acquire the requisite investments and attain the goals set.

Although one could presume that the 2020 COVID-19 pandemic might have had a negative impact on commitments to hydrogen, the contrary seems to have been the case. Thus, the European Green Pact has taken up a stronger stance with hydrogen as a key element for Europe´s economic recovery. This support comes from a set of traditional instruments financed by the new Multi-annual Financial Framework 2021-2027 budget, and the Next Generation EU recovery plan. Support includes that of the **Environment and Climate Action Programme (LIFE) 2021-2027,** territorial cooperation programmes included in **Interreg Europe** and other mechanisms such as the **European Regional Development Fund, the Cohesion Fund, the Just Transition Fund, and the Emissions Trading Scheme (ETS) Innovation Fund.**

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Particularly noteworthy is **Horizon Europe – which includes the new Fuel Cells and Hydrogen Joint Undertaking, "Clean Hydrogen for Europe"**- a **public-private** initiative that specifically promotes research, technology development

LIFE SustainHuts Project at Montfalcó mountain refuge.

and demonstration of hydrogen and fuel cell technologies in Europe; and which plays a key role in the implementation of a hydrogen economy across Europe. The EU Commission has shown its commitment to this initiative, with the Commission´s contribution estimated to increase five-fold for the period 2021-2027, when compared to 2014-2020.

The **InvestEU** programme for 2021-2027 is another recently approved initiative that is part of the Next Generation EU recovery package. It has been conceived as a resilience mechanism to respond to the lack of strategic products and services that has become evident during the COVID-19 crisis among member countries. This fund will boost the EU business fabric by promoting investments and **public-private** collaboration.

In addition, the budget for the **«Connecting Europe» Mechanism** has recently been agreed upon. It supports investment in European digital, transport and energy infrastructures. This allocation of funds is intended to contribute to reaching the ambitious targets of the European Green Pact- a 90% reduction in carbon emissions by 2050 - through safe and sustainable transport systems, including vehicles and infrastructure for alternative fuels.

Among the new instruments, the **Recovery and Resilience Mechanism (RRM)** within NEXT Generation, is expected to start making, throughout 2021, specific public calls aligned with the **seven European Flagship Initiatives** put forward by the EU Commission in the Annual Sustainable Growth Strategy 2021. These European Flagship initiatives include: support for electrification, **integration of renewable energies and renewable hydrogen;** energy rehabilitation of buildings; deployment of charging infrastructure for electric vehicles; increased 5G coverage in a number of regions; modernisation and digitisation of Public Administration bodies; improvement in energy efficiency of computer processors and growth of Big Data and advanced cloud services, as well as an improvement in professional qualifications – particularly digital skills and vocational training.

In order to qualify for RRM funds, member countries must draft National Recovery and Resilience Plans which set out investment and reform programmes for the 2021-2023 period. Spain has adopted, specifically, the support to hydrogen technologies as one of its pillars. To this end, over the last quarter of 2020 and the first quarter of 2021, Expressions of Interest (EOI) have been called and will be used by the Spanish Ministry of Ecological Transition and the Spanish Ministry of Industry to develop these plans. The EOI for renewable hydrogen was called in late 2020 and has received large response from the Spanish business sector, with over 500 proposals.

IPCEIS (Important Project of Common European Interest) are also noteworthy. These are large projects for the development in Europe of value chain technologies considered strategic for the EU. After the success of the call for IPCEIS for the development of batteries and microelectronics, the IPCEIs in Hydrogen technologies are being launched.

The priorities and scope of the Hydrogen IPCEIs are:

- Sustainable low-carbon hydrogen generation, equipment manufacturing, solutions for hydrogen storage, transmission and distribution, and industrial applications;

- R&D&I activities, first industrial deployment and large scale deployment as well as large implementation of facilities, factories and related grids.

On a preliminary basis, throughout 2020, Member States called for **expressions of interest** for hydrogen IPCEIs- Spain did so in June 2020. The calls for expressions of interests are the preliminary step at Member State level to collaborate with other Member States and companies in the specific preparation of IPCEIs for hydrogen.

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The official calendar for the planned actions regarding this instrument proposes the organisation of match-making workshops, followed by a project drafting and development period over 2021 with the assessment of projects at the end of said year, leading to their eventual implementation in 2022.

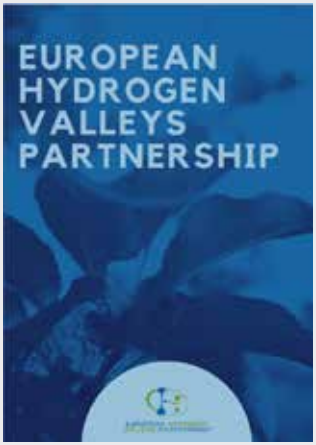
• **S3 Hydrogen Valleys Partnership.** The European Commission through its Directorate General for Growth (DG GROW) launched the initiative of a series of Thematic Platforms in relation to the Smart Specialisation Strategy (S3).

S3 Platforms provide advice to EU countries and regions for the design and implementation of their Smart Specialisation Strategy by:

- Providing guidance material and examples of good practices.
- Informing of strategy building and policy-making.
- Facilitating peer-review and mutual learning.
- Facilitating access to relevant data so that policy-makers can make better informed decisions.

On hydrogen, the S3 Hydrogen Valleys Partnership is an initiative promoted by the European regions of Aragon; Auvergne Rhône Alpes; Normandie; and Northern Netherlands, with the aim of strengthening visibility and influencing capacity of European regions as key users of hydrogen technologies. This platform aims to promote the emergence and implementation of hydrogen projects integrated in the entire value chain, as well as policy-makers´ awareness with a view to facilitating clean energy transition. The platform currently comprises 48 European regions, including regions in Norway and Scotland - with active participation - making it the largest of all thematic platforms in terms of participation.

Image 4: European Hydrogen Valleys Partnership Smart Specialisation Platform – S3 EHV



Source https://s3platform.jrc.ec.europa.eu/hydrogen-valleys.

Hydrogen Refuelling Station at Walqa Technology Park

Other platforms with relevant information about the development of hydrogen technologies are:

• **Mission Innovation Hydrogen Valley Platform.** This platform is a key driving element for other European initiatives aimed at promoting hydrogen technologies. It currently comprises 32 Hydrogen Valleys from 18 countries –including non-EU countries. A virtual platform https://www.h2v.eu/[12] has been built to support global collaboration and allow access to all information on large-scale hydrogen flagship projects (Hydrogen Valleys - H2Vs).

This Platform has been developed within the framework of Mission Innovation´s "Clean and Renewable Hydrogen" Innovation Challenge. The Innovation Challenge is co-led by Australia, Germany and the European Commission, with more than ten participating member countries from around the world. Mission Innovation (MI) is a global initiative of 24 countries and the EU Commission (on behalf of the EU) working to revitalise and accelerate global innovation in clean energy and to make it widely affordable.

[1] https://s3platform.jrc.ec.europa.eu/hydrogen-valleys.
[2] This platform has been developed in collaboration with INYCOM - a large Aragonese technology company.

It should also be pointed out that the increasing progress in hydrogen technologies has led countries across the world to develop their own national strategies, integrating them both into domestic legislation and planning as well as into concrete plans for the development of hydrogen technologies. Some of the major strategies at international level are:

- *Hydrogen Society Strategy of Japan,* Released in 2017. Japan updated its strategic roadmap in order to implement its basic hydrogen strategy. It includes new targets for hydrogen deployment and fuel cell costs.

- Australia´s *National Hydrogen Strategy,* released in November 2019 by the Council of Australian Governments (COAG) Energy Council.

- *"Die Nationale Wasserstoffstrategie",* Germany´s National Hydrogen Strategy, June 10, 2020, released by the Federal Cabinet in June 2020.

- *"National Strategy for the Development of Renewable and Low Carbon Hydrogen in France"*. Released in September 2020 by the French Government.

- USA´s *Hydrogen Program Plan* developed by the U.S. Department of Energy with the participation of the Offices of Energy Efficiency and Renewable Energy, Fossil Energy, Nuclear Energy, Electricity, Science and the Advanced Research Projects Agency.

- Chile´s *Green Hydrogen Strategy*. Released by the Chilean Ministry of Energy in November 2020.

- The Scottish Government´s Hydrogen Policy Statement: Released in December 2020 by the Scottish Government.

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2.2 NATIONAL FRAMEWORK

For some years now, support for hydrogen in Spain has been included in several plans and strategies, albeit indirectly.

On the one hand, on May 13, 2021, the Spanish Parliament finally approved Spain´s first **Climate Change and Energy Transition Law.** It sets a target for a reduction of 23% in greenhouse gas emissions by 2030 compared to 1990 levels. Its goal is to achieve climate neutrality by 2050 - an objective in line with those defined by the EU.

As for hydrogen, Article 12 - On Promotion and Objectives for Renewable Gases-, states that the Government will promote, through the approval of specific plans, the rollout of renewable gases, including biogas, bio-methane, hydrogen and other fuels which in their generation and manufacturing process have resorted exclusively to using feedstock and energy of renewable origin or allow the reuse of organic waste or by-products of plant or animal origin.

Promotion plans in the section above may foresee, among others, the following provisions, to be approved by the Government:

- Annual targets for the penetration of renewable gases in the sale or consumption of natural gas, stating the types of product to meet the obligations set and the parties bound to compliance.
- A certification system that allows the monitoring and inspection of compliance with obligations, as well as flexibility mechanisms that favour maximum efficiency in attaining these objectives.
- Regulations that favour the direct industrial use of gases or their use for mobility solutions, as well as the injection of these renewable gases into the natural gas grid.

On a regulatory level, one of the most relevant documents is the **National Integrated Energy and Climate Plan (PNIEC 2021 - 2030).** The PNIEC, published by Resolution of March 25, 2021 jointly by the General Directorate of Energy Policy and Mines and the Spanish Office for Climate Change, specifies the targets for the reduction in greenhouse gas emissions; renewable energy penetration, and energy efficiency.

The provisions contemplated in the PNIEC 2021 - 2030 will make it possible to reach the following targets by 2030:

- A reduction of 23% in greenhouse gas (GHG) emissions compared to 1990.
- Share of 42% of renewables in the final use of energy.
- An improvement of 39.5% in energy efficiency.
- Electric power generation from 74% renewable energy.

The Plan includes "**chemical storage in the form of hydrogen,** either through electrolysis and consumption by means of fuel cells, or by its injection into the grid", among the actions aimed at combating climate change and favouring energy transition. All this will will help to reach flexibility and optimisation of energy systems.

Priority objectives of R&D&I in energy and climate in Spain fall within the framework of areas focused on the development of clean energy sources (on-shore and off-shore wind, solar photovoltaic and solar thermoelectric, bioenergy, tidal, bio-mass, geo-thermal) and energy efficiency as well as **energy vectors such as hydrogen** and more specifically the **generation of hydrogen from 100% renewable** sources and its use as stationary storage for large quantities over long periods of time.

Hydrogen is present in the following measures included in the Plan:

- Measure 1.2. Demand management, storage and flexibility.
- Measure 1.8. Promotion of renewable gases.
- Measure 2.4. Promotion of electric vehicles (with electric vehicles meaning both battery and hydrogen fuel cell vehicles)
- Measure 4.7. Integration into the gas market.

Dissemination of innovation projects at national level.

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Hydrogen is also found in the following action mechanisms:

- Promoting the coupling of sectors, the alignment with other energy uses, such as electric vehicle recharging, heat or cold generation for industrial or air-conditioning uses, hydrogen generation, etc., enabling the introduction of power management capabilities while responding to other energy uses.
- Facilitating, through the approval of specific plans, the penetration of renewable gas, including bio-methane, 100% renewable hydrogen and other fuels , which exclusively involves renewable feedstock and energy, including R&D&I actions for biogas and hydrogen, as well as for less mature technologies such as power to gas.
- Designing an ***ad hoc*** communication strategy focused on providing information on electric vehicles, price and location of recharging points, availability and performance of vehicles, and others.

As early as 2020, there was a firm commitment to hydrogen by the Spanish Government itself, and in particular by the Spanish Ministry for the Ecological Transition and the Demographic Challenge (MITERD) and the Spanish Ministry of Industry, Trade and Tourism (MINCOTUR).

In Spain, as in the rest of Europe and the world, the health crisis brought about by COVID-19 has highlighted the need to accelerate the ecological transition as a central element in the recovery phase. As seen in the previous section, very ambitious initiatives have been launched in this respect in Europe with EU Member Countries being required to establish **Recovery, Transformation and Resilience Plans**. In October 2020 Spain developed the document **Spain Can** (España Puede), which must be completed and specify concrete measures for the distribution of the NEXT GENERATION funds.

The document entitled España Puede is fully aligned with the seven European flagship initiatives, including the integration of renewable energies and renewable hydrogen. It highlights ten structural reform lever policies for sustained growth. The third of them is the **Just and Inclusive Energy Transition,** with measure 9 within it clearly establishing the development of *the Renewable Hydrogen Roadmap and its sectoral integration as sign of Spain´s commitment to renewable hydrogen aimed at decarbonising the economy, - reducing energy costs for industry, the service sector and households-, and promoting competitiveness. Its innovative development along the entire value chain is included, as well as the generation of knowledge and own technological capabilities, the promotion of pilot and commercial projects and the support to hydrogen demanding sectors, for the decarbonisation of the current consumption of fossil hydrogen while taking advantage of its potential as an energy vector for sectoral integration and support to the electric power system.*

The **Renewable Hydrogen Roadmap** was published by MITERD in October 2020. It was defined with the participation and contribution of a range of economic actors, administrations and citizens.

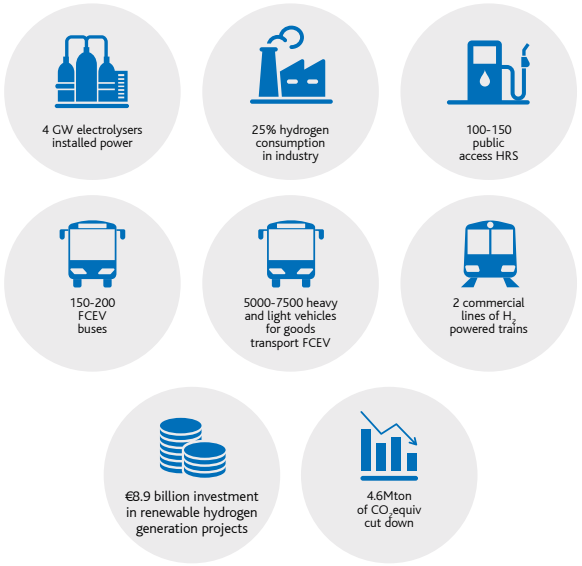
The document also includes information on the proposal of numerous innovative projects for the different stages of the renewable hydrogen value chain.

The document sets out a vision for the 2030-2050 period with extremely ambitious targets for 2030 to try to ensure Spain´s industrial and technological positioning in the field of hydrogen.

The roadmap focuses on the production of renewable hydrogen (green hydrogen) with the generation of blue and grey hydrogen being contemplated as an intermediate step as well.

Targets for 2030 as shown in the image below:

Image 5: Country Targets for 2030



Source: Renewable Hydrogen Roadmap.

As an intermediate step to reach the 4GW target by 2030, it is estimated that by 2024 it may well be possible to have an installed capacity of 300 MW to 600 MW of electrolysers.

The roadmap includes the main challenges and opportunities for Spain and introduces 60 measures that support actions throughout the hydrogen value chain, including: regulatory instruments, sectorial (technical) instruments, cross-cutting instruments, and R&D&I support instruments.

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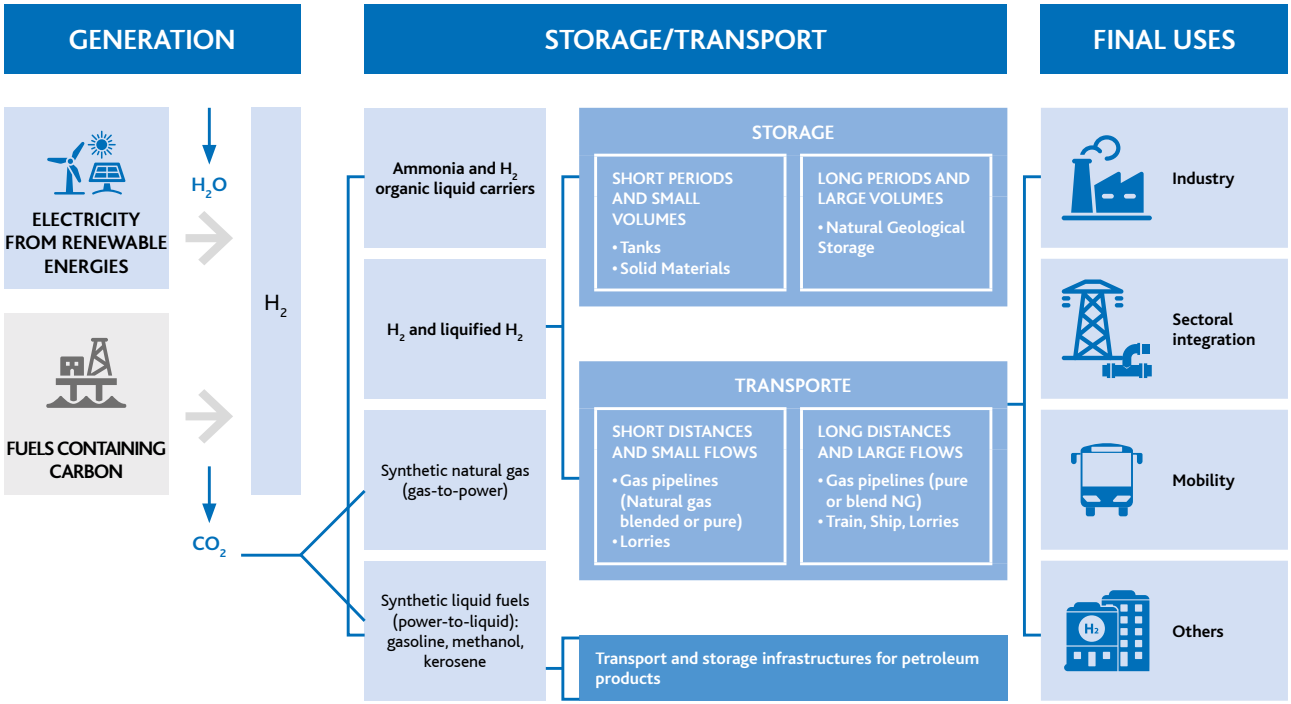
Image 6: Stages in the Hydrogen Value Chain



Source: Renewable Hydrogen Roadmap.

In addition to the Renewable Hydrogen Roadmap, the Council of Ministers, at the proposal of MITERD, also approved the **Energy Storage Strategy,** which will support the deployment of renewable energies and will be key to guaranteeing security, quality, sustainability and affordable prices in the energy supply.

In this strategy, hydrogen is very present as a key tool for the integration of the different energy sectors. It will strengthen security, availability and flexibility, as well as provide greater efficiency and profitability in the energy transition while contributing to the decarbonisation of the economy.

As for the aforementioned Expressions of Interest, in November 2020 MITERD issued a call for **Expression of Interest: Recovery Transformation and Resilience Plan. "Driving-force projects for collaboration for a just and inclusive energy transition",** so that each stakeholder could have access to a communication channel within the framework of the Recovery Plan in order to identify and pinpoint financially-sound renewable hydrogen projects in Spain, get to know their impact on the entire value chain and industrial development, from R&D&I to their ultimate use, as well as their impact on employment while ascertaining their transformative effect on the economy, decarbonisation and on social and territorial cohesion.

Aware of the fact that, in order to meet all the targets set, Spain´s businesses must become strongly involved and industrial development promoted, the Spanish Hydrogen Association (AeH2) has also developed the **Sectoral Agenda for the Hydrogen Industry**, commissioned by the Spanish Ministry of Industry, Trade and Tourism (MINCOTUR).

Likewise, the Institute for Diversification and Saving of Energy (IDAE) has also set out to conduct a **prospective study -Study on the Generation, Logistics and Demand for Renewable Hydrogen in Spain and the Prospective High Penetration of Renewable Energies 2020-2050,** to be carried out in 2021-2022 under the guidance of the Foundation for the Development of the New Hydrogen Technologies in Aragon.

It is evident that the period 2020-2021 has been crucial to the development of hydrogen specific strategies at a national level. Nevertheless, we should not ignore the fact that hydrogen is also present in other national plans of wider scope such as:

- **National Action Framework for Alternative Energies in Transport** (Transposition of Directive 2014/94/UE on the implementation of Infrastructure for fuels). With MINCOTUR at its origin, it is currently being assessed at European level.
- **Plan for the Stimulus of the Value Chain in the Automotive Industry -Towards a connected and sustainable mobility.** This plan has clear objectives for the automotive sector, including hydrogen. It specifically identifies the following challenges:
    - Positioning as a world platform in the production of zero CO_2 emission vehicles and manufacture of key fixtures such as batteries or renewable hydrogen for said vehicles.
    - Industrial innovation in Renewable Hydrogen: sustainable mobility. Through the instrument "Science and Innovation Missions: Smart and Sustainable Mobility".

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FRAMEWORK FOR ACTION

As a result of all these initiatives at national level, some major projects are already being implemented. Among them stand out four projects advanced by the Spanish Prime Minister himself in his speech at the opening of the Conference Renewable Hydrogen: an Opportunity for Spain - organised by the Spanish Ministry for the Ecological Transition and the Demographic Challenge. These four projects are:

- **Green Hydrogen Plant for Industrial Use in Puertollano.** This project is being carried out through an agreement between Iberdrola and Fertiberia. Iberdrola will be in charge of the generation of green hydrogen from a solar photovoltaic plant and a battery system. The hydrogen generated at this facility will be used in Fertiberia´s fertilizer and ammonia plant in Puertollano. The project envisages the development of 800 MW of green hydrogen, with an investment of €1.8 billion over the next seven years, with Fertiberia´s plant to become the largest green H2 plant in Europe.

- **The European project H2PORTS,** led by the Valencia port Foundation, with the participation of the Port Authority of Valencia (APV). The Hydrogen refuelling station (HRS), developed by CNH2 (Spanish National Centre on Hydrogen) will reach the Port of Valencia in 2021, becoming the first port in Europe with hydrogen-powered port vehicles.

- The world´s largest **zero net emissions synthetic fuels production plant using green hydrogen,** generated with renewable energy , promoted by Petronor – a subsidiary of Repsol- in Bilbao (Spain)

- Project on **Hydrogen Train project linking Zaragoza/Canfranc (Zaragoza/Huesca – Spain) with Pau (France)**. Promoted by the company Dhamma Energy -a company that is part of the FHa´s board of trustees. The company is planning to build a large scale plant to generate green hydrogen through water electrolysis supplied "by means of renewable origin electric power" for road and rail haulage.

Source: CAF S.A.

02.
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2.3 REGIONAL FRAMEWORK

Since the setup of the FHa, the Regional Government of Aragon has been committed to supporting hydrogen technologies. This support has been directly translated into the main regional plans and strategies.

Throughout 2020, as it was the case at other political levels, and as a response to the crisis caused by the COVID-19 pandemic, the Regional Government of Aragon convened in June 2020 all political parties represented in the Regional Parliament of Aragon as well as social actors, the Federation of Municipalities, Counties and Provinces of Aragon (FAMCP) and the **Aragonese Strategy for Social and Economic Recovery** was thus defined.

This strategy incorporates 273 recovery measures, with hydrogen present in several ones.

- Measure 43. Fostering alternative systems favouring sustainable mobility between municipalities with over 5000 inhabitants.
- Measure 176. Fostering renewable energy projects, planning of the electric power transport grid for the 2021-2026 period, as well as the promotion of technologies related to power storage, renewable gas (biogas, hydrogen), sustainable and efficient mobility.
- Measure 177. Development of the industrial fabric linked to these renewable projects and new technologies.

Likewise, as in previous editions, the **Energy Plan for Aragon (PLEAR 2013 - 2020)** includes specific backing for hydrogen applications in transport, as well as its own heading inside the R&D&I section, designating hydrogen as a priority line in this field. PLEAR 2021-2030 is currently under review, and, in line with previous plans, hydrogen technologies are to be supported.

In terms of climate change, in February 2019 the Regional Government of Aragon passed, in its Council of Government, the Aragonese Strategy on Climate Change Horizon 2030. This is the Aragonese reference framework for the development of public policy and the associated necessary measures, within Horizon 2030, for the mitigation of Greenhouse gases (GHG) and adaptation of the activities carried out in the region to climate change. Hydrogen and fuel cell technologies are found within, with the FHa being a member of the Climate Change Council of Aragon set up to draft the said Strategy.

33rd meeting of the FHa's Board of Trustees.

In the field of Research and Innovation, LAW17/2018, on Investigation and Innovation in Aragon, of December 4 was passed. It provides the legal framework of reference for the regulation, promotion and coordination of research, development, knowledge transfer and innovation within the Autonomous Region of Aragon, within the applicable State and EU legislation. FHa is one of the actors in the R&D&I system of Aragon.

By the same token, the new Aragonese Research and Innovation Strategy for Smart Specialisation **(RIS3 Aragon**) is being developed, alongside the III Regional Plan for Research, Development and Knowledge Transfer (III PAID) and the Aragonese Strategy for Research, Development and Innovation **(Aragonese R&D&I Strategy)**. All of them have previously included specific support for hydrogen, and it is expected that this will continue to be the case.

On the other hand, the proactivity of the Government of Aragon must be stressed, since as seen in the previous section, **Aragon leads the S3 European Hydrogen Valleys Partnership**, alongside three other European regions.

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KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

FHa´s facilities at Walqa Technology Park.

3.1 REGIONAL INVOLVEMENT AND EXPERIENCE IN PLANNING HYDROGEN TECHNOLOGIES

As previously pointed out, 2020 was particularly fruitful in the publication of initiatives, strategies, plans and programmes that regard hydrogen as one of the most promising solutions for energy transition.

Aragon is one of the pioneering regions in Spain and Europe for the promotion of hydrogen technologies. This places the region in an extremely favourable position to continue developing technology and projects in this field while keeping its competitive edge and wealth of experience.

Since 2003, with the setup of the Foundation for the Development of the New Hydrogen Technologies in Aragon – created with the support of 28 Aragonese companies and organisations-, work on hydrogen projects has continued uninterrupted, with an increasing interest from companies that have joined FHa´s Board of Trustees. Currently, this board is comprised of more than 80 trustees representing companies and organisations, as well as a nominative trustee and three other honorary members. The following image shows the composition of the FHa Board of Trustees as of the date of publication of this document.

Two years into FHa´s workings, the Regional Government of Aragon came to the conclusion that it was important to have a regional Master Plan to provide guidelines for action, analyse advancements made in the state of the art of hydrogen technologies, reflect on prospective opportunities and set priority lines of action in the region for different periods. Thus, in 2007 the first Hydrogen Master Plan in Aragon was published, with the 2011-2015 and 2016-2020 plans in its wake.

36th meeting of the FHa's Board of Trustees.

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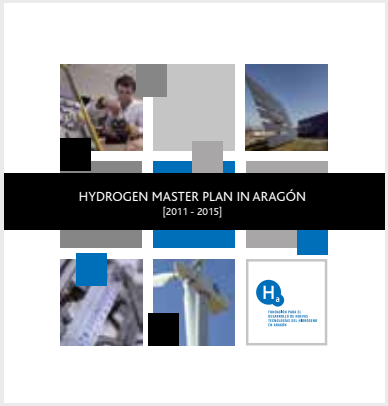
KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

Image 7: FHa´s Board of Trustees (2021)

Source: Own Production

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

Image 8: Former Master Plans



Each Master Plan has had a very distinctive structural continuity. The new Hydrogen Master Plan in Aragon 2021-2025 maintains that structure while adapting to the current situation the hydrogen sector is going through. Therefore the HMPA 2021-2025 provides continuity in the key task of defining the strategy to adopt in order to develop hydrogen technologies within the current scenario.

The HMPA 2021 – 2025 keeps its alignment to European and national strategies, seeking synergies with other regional roadmaps and complementary actions, keeping the Aragonese socioeconomic environment at its core at all times.

The drafting, development and execution of past HMPAs has led to the Region to gain relevant experience and knowledge, helping the region to reach the top ranking positions at national and international level. Thanks to this the region will not only be able to take advantage of the identified opportunities along the way but lead the way to approach opportunities in the sector.

3.2 ACHIEVEMENTS OVER THE LIFETIME OF THE HMPA 2016 - 2020

2016-2020 has shown lots of activity around hydrogen, as it was foreseen in the Intermediate Assessment of the Hydrogen Master Plan in Aragon conducted in 2018.

Among the major milestones and achievements we find the implementation of a high number of collaboration projects with Aragonese bodies, of public-private nature. Below, we can find a table displaying the projects implemented during the period - some of them still ongoing- as communicated by the involved participants:

FHa´s facilities at Walqa Technology Park.

15 ANIVERSARIO
FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

Table 1: Projects with Aragonese Participation during 2016-2020.

Project	Participants with links to Aragon	Funding Entity	Lines of Action included
4AirCRAFT	FHa, CSIC	EU Commission – H2020 - International cooperation with Japan for Research and Innovation on advanced biofuels and alternative renewable fuels	Hydrogen Applications
Adaptation of mining mobile equipment from diesel to hydrogen by means of fuel cells	FHa	CORFO CHILE	Hydrogen Applications
Management application for electric vehicles charge	Tafyesa, FHa	Regional Government of Aragon- Department of Industry, Competitiveness and Business Development – Aid program for Industry and SMEs in Aragon (PAIP)	Hydrogen Applications
	Tafyesa, FHa	Regional Government of Aragon- Department of Industry, Competitiveness and Business Development – Aid program for Industry and SMEs in Aragon (PAIP)	Hydrogen Applications
AUTO ERM	REDEXIS	Spanish Ministry of Science and Innovation - Centre for the Development of Industrial Technology (CDTI)– Research and Development Projects (PID)	Storage, Transport and Logistics
BIG HIT	FHa, Calvera Maquinaria e Instalaciones S.L.	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Generation, Transport and Applications
BIOGAS-RIS3	FHa, CSIC and Unizar Collaborators: ENAGÁS, MANN HUMMEL, ARAID, SAMCA and GRHUSA	Regional Government of Aragon – Department of Innovation, Research and Universities –Development of R&D&I on priority lines of RIS3 Aragon and multidisciplinary excellence.	Hydrogen Applications

Project	Participants with links to Aragon	Funding Entity	Lines of Action included
BIOSOC	FHa	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Applications
BloW-Up	CSIC	EU Commission - H2020 – EIT Raw materials	Hydrogen Generation
Characterisation SOFC.	CSIC	Spanish Ministry of Science and Innovation- National Plan call	Hydrogen Applications
COMPACT SAI 4.0	FHa, Vea Global, Satel	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Applications
ComputaMeH	FHa, REDEXIS	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Storage, Transport and Logistics
CORALIS	CIRCE Foundation	EU Commission – H2020	Producción de hidrógeno
Demo4Grid	FHa, INYCOM	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Generation
Powerpack development by means of PEM fuel cell (Proton-Exchange Membrane) for AGV	GREEN GROUPING	Own Resources	Hydrogen Applications
Technological development of applications to cater for market niches in the short term	FHa, EBOCA	Own Resources	Hydrogen Applications
Development of the Fuel Cells and Hydrogen Observatory	INYCOM	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) - OP - Contract 216	Training and Awareness-raising

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Project	Participants with links to Aragon	Funding Entity	Lines of Action included
Development of the Hydrogen Valley Platform	INYCOM	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) - OP - Contract 249	Training and Awareness-raising
DISIRE	CIRCE Foundation	EU Commission – H2020	Hydrogen generation
eGHOST	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Technology Transfer, Protection and Economic Impact
ELY4OFF	FHa, EPIC POWER, INYCOM	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Generation
ELYntegration	FHa, ARAID, INYCOM	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Generation, Technology Transfer, Protection and Economic Impact
ELYPLUS	FHa	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Generation
ENERAGRI 4.0	FHa, UZ, VEA	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Generation
Preliminary Study of viability for infrastructure deployment solution	SFICE	Own Resources	Hydrogen Applications
EVERYWH2ERE	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Applications
FLEDGED	CSIC	EU Commission - H2020 - Development of next generation biofuel technologies	Hydrogen Generation
FLEXNCONFU	CIRCE Foundation	EU Commission – H2020 Programme Low-cost, low-carbon energy supply	Hydrogen Generation
GRAFELEC	CSIC	Spanish Ministry of Science, Innovation and Universities- State-level Plan of Scientific and Technical Research and Innovation	Hydrogen Generation

Project	Participants with links to Aragon	Funding Entity	Lines of Action included
GREEN HYSLAND	ENAGÁS, REDEXIS, CARBUROS METÁLICOS, Calvera Maquinaria e Instalaciones S.L, FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Applications
H2GLOBAL	FHa	EU Commission - Executive Agency for SMEs (EASME) – Competitiveness of Small and Medium-Sized Enterprises (COSME)	Technology Transfer, Protection and Economic Impact
H2PiyR	FHa, Calvera Maquinaria e Instalaciones S.L., Zoilo Ríos, Huesca´s City Council	EU Commission – Programme for Cross-Border Cooperation Spain, France, Andorra (POCTEFA)	Storage, Transport and Logistics
H2SOLAISLADA	FHa	Regional Government of Aragon – Department of Economy, Industry and Employment, - Aid for energy savings and diversification, rational use of energy and utilization of renewable local resources	Hydrogen Generation
HEAVENN	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Applications
HIBRIPEM	CSIC	Spanish Ministry of Science, Innovation and Universities- State-level Plan of Scientific and Technical Research and Innovation	Hydrogen Generation
On-site fuel cell integrated Hydrogen Refuelling Station to supply hydrogen at 350 bar	Calvera Maquinaria e Instalaciones S.L.	Commissioning Contract for client: Angloamerican Chile (mining company)	Storage, Transport and Logistics
HIGGS – Hydrogen in Gas Grids	FHa, ARAID, REDEXIS	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Storage, Transport and Logistics
Hydrogen	FHa	EU Commission - The European Association of National Metrology Institutes European Metrology (EURAMET) - Programme for Innovation and Research (EMPIR)	Technology Transfer, Protection and Economic Impact
HyLaw	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Technology Transfer, Protection and Economic Impact

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

Project	Participants with links to Aragon	Funding Entity	Lines of Action included
HyResponder	Zaragoza´s City Council, Firefighter School, FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Applications and Technology Transfer, Protection and Economic Impact
HySTORIES	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Storage, Transport and Logistics
HYTECHCYCLING	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Applications
Hy-Tunnel CS	FHa, IDOM	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Applications and Technology Transfer, Protection and Economic Impact
INSTUNH2-I	FHa, IDOM, Calvera Maquinaria e Instalaciones S.L.	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Applications and Technology Transfer, Protection and Economic Impact
INSTUNH2-II	FHa, IDOM, Gotor.	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Applications and Technology Transfer, Protection and Economic Impact
INTELISAI	FHa, Calvera Maquinaria e Instalaciones S.L., INYCOM	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Applications
MefHysto	FHa	EU Commission - The European Association of National Metrology Institutes European Metrology (EURAMET) - Programme for Innovation and Research (EMPIR)	Applications and Technology Transfer, Protection and Economic Impact
MERCURIA	Unizar	Spanish Ministry of Science and Innovation- National Plan Call	Hydrogen Applications
MetroHyVe	FHa	EU Commission - The European Association of National Metrology Institutes European Metrology (EURAMET) - Programme for Innovation and Research (EMPIR)	Technology Transfer, Protection and Economic Impact
MIRARA	GREEN GROUPING	Regional Government of Aragon- Department of Industry, Competitiveness and Business Development – Aid program for Industry and SMEs in Aragon (PAIP)	Hydrogen Applications

Project	Participants with links to Aragon	Funding Entity	Lines of Action included
NEWGASMET	FHa, ENAGÁS	EU Commission - The European Association of National Metrology Institutes European Metrology (EURAMET) - Programme for Innovation and Research (EMPIR)	Hydrogen Applications
New electrodes for SOFC.	CSIC	Domingo Martínez Foundation.	Hydrogen Applications
PROMET-H2	FHa	EU Commission - H2020 - Industrial Sustainability	Hydrogen Generation
QualyGridS	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Generation
RECOBIOHY	Unizar	Spanish Ministry of Science and Innovation- National Plan Call	Hydrogen Applications
RE4INDUSTRY	CIRCE Foundation	EU Commission – H2020	Hydrogen Applications
RIEG 4.0	FHa, Vea Global, Satel, Tafyesa	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Applications
SH2E	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Technology Transfer, Protection and Economic Impact
Pumping System in 350 bar and 700 bar Hydrogen Refuellig Station.	Calvera Maquinaria e Instalaciones S.L.	Own Resources	Storage, transport and Logistics
Hydrogen Refuelling Station storage systems. High pressure.	Calvera Maquinaria e Instalaciones S.L.	Own Resources	Storage, Transport and Logistics
Smart HyAware	IAF, FHa, IDOM	EU Commission- Interreg Europe	Applications and Technology Transfer, Protection and Economic Impact
SMARTBIOGRES	FHa, ARAID, CSIC, Tafyesa	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	H2 Applications

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

Project	Participants with links to Aragon	Funding Entity	Lines of Action included
SOFT-CDC 4.0	FHa, Satel, Tafyesa, Vea Global	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Applications
Space POWERPACK	Green Grouping	Regional Government of Aragon, Department of Industry, Competitiveness and Business Development-Aid programme for Industry and SMEs in Aragon (PAIP)	Hydrogen Applications
SPOTLIGHT	FHa	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Hydrogen Generation
SUN2HY	ENAGÁS, FHa	Commissioning contract for client	Hydrogen Generation
Surf n' Turf	Calvera Maquinaria e Instalaciones S.L.	EU Commission – H2020 - Fuel Cells and Hydrogen Joint Undertaking (FCH-JU)	Storage, Transport and Logistics
SUSTAINHUTS	FHa, FAM	EU Commission - LIFE+	Hydrogen Generation, Storage,
TEMAut Self-guided multifunctional electric Tractor	FHa	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Applications
Vertegas	FHa, ARAID, Unizar, Tafyesa	Spanish Ministry of Industry, Trade and Tourism- General Secretariat for SMEs-Innovative Business Groups (AEI)	Hydrogen Generation
VUELTAH	FHa	Spanish Ministry of Science and Innovation-Spanish Foundation for Science and Technology (FECYT)	Training and Awareness-raising
ZEROENERGYMOD	FHa, ARPA, CUDZ, B+HAUS	EU Commission – LIFE + Programme for the Environment and Climate Action	Hydrogen Generation, Storage, Hydrogen Applications

Source: Own Production from information supplied by members of the Board of Trustees and participating companies.

In addition to the projects shown above, other actions must be mentioned, particularly cross-cutting actions carried out by other bodies such us the Official Professional Associations of Engineers COGITIAR, COIIAR, the project Mobility City by Ibercaja, or the multiple training and awareness-raising activities with the presence or focused on hydrogen done by San Valero Foundation and SEAS, which have done multiple training and awareness-raising activities with the presence of hydrogen, or hydrogen at their centre.

The execution of the Hydrogen Master Plan in Aragon 2016-2020 has been regarded as a success. After its intermediate assessment in 2018, the third HMPA ends with a higher number of projects carried out when compared to those present in the previous plan, with work done on the specified actions, as well as increased involvement of Aragonese businesses which has led to a better positioning in the sector. Other indicators prove this milestone, such as the level of investment in Aragon for the said period, estimated at a minimum of €35 million, with a support well above €26 million.

The most outstanding global figures for the execution of the previous plan are as follows:

Presentation of ZeroEnergyMod project.

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

Image 9: Global figures of results for the Hydrogen Master Plan in Aragon (2016 - 2020)

76 entities and 1 natural person are part of FHa´s Board of Trustees

77 projects executed or in progress

≈ €35 296 000
Global investment in Aragon

≈ €25 941 000
Global returns from open public calls

Source: Own Production from information supplied by members of the Board of Trustees and participating companies.

3.3 COMMUNICATION, COOPERATION AND PROJECTION OUTSIDE REGIONAL BORDERS

In addition to the development of technology, FHa´s objectives include knowledge dissemination about hydrogen throughout society and business. To that aim, it conducts and participates in a wide range of events, webinars, fairs, conferences and other training and awareness-raising activities.

For 2016-2020, the following landmarks must be highlighted:

• WORLD HYDROGEN ENERGY CONFERENCE (WHEC 2016)

The World Hydrogen Energy Conference 2016 (WHEC 2016) held its 21st edition in the Conference Palace Expo Zaragoza. It was organised by the Spanish Hydrogen Association AeH2 in collaboration with the Foundation for the Development of the New Technologies of Hydrogen in Aragon (FHa) and the Regional Government of Aragon under the auspices of the International Association for Hydrogen Energy (IAHE). About 800 people from 50 different countries participated over a week of presentations and debates to exchange information and facilitate contact between stakeholders.

World Energy Hydrogen Conference 2016.

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

• HYDROGEN FUEL CELLS AND ELECTRO-MOBILITY IN EUROPEAN REGIONS (HYER)´S GENERAL ASSEMBLY

On the occasion of WHEC 2016, the annual General Assembly of Hydrogen Fuel Cells and Electro-mobility in the European Regions (HyER), - of which the Community of Aragon was a founding member and holder of one of the Vice-Presidencies – was organised in Huesca (Spain).

• IBERO-AMERICAN CONFERENCE ON HYDROGEN AND FUEL CELLS (IBERCONAPPICE 2017)

The Ibero-American Conference on Hydrogen and Fuel Cells was held in Huesca in October 2017. Organised by the Spanish Fuel Cell Association (APPICE) in collaboration with the Government of Aragon through the Foundation for the Development of New Hydrogen Technologies in Aragon. It is a forum to showcase the developments in fuel cells from across the Ibero-American Community. It was attended by scientists, companies and suppliers of the sector to discuss fuel cells´ basic and technological aspects, and their final applications.

• FHA´S XV ANNIVERSARY AWARDS

The FHa has issued, as one of the activities in its XV anniversary, the first call for the FHa´s awards for Doctoral theses, Master´s degree theses and Bachelor´s degree final year Projects.

The aim of this initiative – a decision made by FHa´s Board of Trustees- is to stimulate both top level research and to promote the research and knowledge into hydrogen technologies as an energy carrier, renewable energies and decarbonisation in the transport and energy sectors. The awards have been sponsored by diverse companies that are members of the foundation (Redexis, Air Liquide and IDOM) and have found a large resonance and acceptance at regional and national level.

In addition, both the foundation and some of its members have participated in other initiatives such as Researchers´ Night, International Day of Women and Science, as well as several fairs and conferences specific to hydrogen or renewable energies.

FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN

1ª CONVOCATORIA PREMIOS FUNDACIÓN HIDRÓGENO ARAGÓN PARA TESIS DOCTORALES, TRABAJOS DE FIN DE MÁSTER Y TRABAJOS DE FIN DE GRADO

The foundation is also expanding its field of action through a **number of alliances** with other organisations to allow the transfer of knowledge and experience, as well as support its trustees in broadening its scope of action. Some of the major alliances signed for the period include:

• MEMBERSHIP TO THE EUROPEAN CLEAN HYDROGEN ALLIANCE (CH2A).

- Joining the 2018 European "Hydrogen Initiative" promoted by the Ministry of Sustainability and Tourism of the Republic of Austria, which aims to develop and implement hydrogen technologies in Europe, signed on September 17, 2018 in the framework of the High Level Conference 'Charge for Change: Innovative Technologies for Energy Intensive Industries', held in the Austrian city of Linz.

- Participation in the framework of the High-Level Conference 'Future Energy Systems: Sustainable and Smart Gas Infrastructure Supported by Hydrogen and Other Renewable Gases' held in the city of Bucharest, (Romania).

- Joining the "Bucharest Initiative", promoted by the Ministerial meeting On Central And South-Eastern Europe Energy Connectivity (CESEC).

- Memorandum of Understanding between the Chilean Hydrogen Association and the Foundation for the Development of the New Hydrogen Technologies in Aragon with a view to strengthening links and developing activities that help both organisations to meet their objectives and those of their members in an efficient and timely manner.

- Memorandum of Understanding between the Scottish Hydrogen and Fuel Cell Association and the Foundation for the Development of the New Hydrogen Technologies in Aragon with a view to strengthening links and developing activities that help both organisations to meet their objectives and those of their members in an efficient and timely manner.

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

- Memorandum of Understanding between the Foundation for the Development of the New Hydrogen Technologies in Aragon and the Public Interest Grouping CHEMPARC to promote the industrial development and expansion of hydrogen technologies.
- General Cooperation Protocol between the consortium for the Design, Manufacture, Equipment Supply of and Operations in the National Centre for Hydrogen and Fuel Cell Technology Experimentation and the Foundation for the Development of the New Hydrogen Technologies in Aragon.
- Cooperation Agreement between the foundation "Aragonese Agency for Research and Development" (ARAID) and the Foundation for the Development of the New Hydrogen Technologies in Aragon).
- Joining agreement to the Ordesa and Monte Perdido National Park Centenary.
- Membership of Aragon Energy Cluster (CLENAR) - being the FHa one of its founding members..
- Membership to the Aragonese Council on Climate of Aragon for the drafting of the Aragonese Law on Climate Change and Energy Transition.
- Cooperation Agreement with the Aragonese Society of Agricultural and Environmental Management (SARGA), to carry out activities that help promote and disseminate a public awareness of the "Ordesa and Monte Perdido National Park Centenary."
- Joining the non-profit association "Excellent Huesca Business Forum", with its Managing Director authorised to carry out the necessary tasks for the implementation of this agreement and act as FHa´s representative inside said Association".
- Cooperation Agreement with the Foundation for the Preservation of the Gypaetus Barbatus ('bearded vulture) to promote sustainable mobility in the municipality of Ainsa (Huesca), helping combat climate change and improve the quality of air.
- Cooperation Agreement with SEO BIRDLIFE to promote sustainable mobility helping combat climate change and improve the quality of air.

Finally, we highlight the **main awards** received by the FHa over the 2016-2020 period:

- Empresa Huesca 2017 award, under the category 'Innovation'. This award was promoted by the Regional Government of Aragon, CEOS-CEPYME Huesca and the Chamber of Commerce, Industry and Services of the province of Huesca.
- European Award for Business Management and Innovation 2018, awarded by the European Association of Economics and Competitiveness (AEDEEC).
- FCH JU Awards 2019, on its special category, to the BIG HIT Project (Building Innovative Green Hydrogen Systems in an Isolated Territory: a pilot for Europe) coordinated by FHa and awarded by the Fuel Cells and Hydrogen Joint Undertaking.
- The National Energy Globe Award Spain, for Project ELY4OFF developed by FHa
- EveryWh2ere: Best OutReach Award by the FUEL CELLS AND HYDROGEN JOINT UNDERTAKING during the European Hydrogen Week, held from 23 to 27 November 2020.

Mr Arturo Aliaga -Vice-president and Councillor for Industry, Competitiveness and Business Development of the Regional Government of Aragon- being handed, as President of FHa, the diploma certifying the National Energy Globe Award Spain granted.

03. KEYS FOR COMPETITIVENESS AND POSITIONING OF ARAGON

3.4 CHALLENGES AND INTERESTS OF THE ARAGONESE COMPANIES DURING 2021-2025

In order to draft the new Hydrogen Master Plan, as can be seen in the diversity of collaborative actions carried out, Aragonese bodies and companies have provided a frank and constructive picture of their main interests and challenges faced. These have been used as the foundation for drawing the lines of action and establishing specific actions found in the Hydrogen Master Plan.

The main challenges the region faces in terms of hydrogen technologies during the next period are:

- Maintaining its national and international leadership position, taking full advantage of the experience gained for more than 15 years, increasing that leadership at all levels as the reference region for hydrogen, grabbing any opportunity hydrogen technologies may offer for reindustrialisation, technological development and job creation.

- Increasing not only turnover from hydrogen but disseminating its use leading to higher growth and wealth creation in the region.

To that aim, the following resolutions must be pursued:

- Promotion of hydrogen generation, backing renewable hydrogen generation en masse so that it becomes competitive and meets demand growth.

- Capability-building of the Aragonese industry along the entire hydrogen value chain, opening up new markets that allow the diversification of activities and increase competitiveness.

- Setup of a supporting regulatory framework as well as developing specific legislation focused on harmonisation and standardisation of products, processes and equipment – the goal being to help facilitate access to markets and ensure security and safety in hydrogen related facilities.

- Boosting the creation of new markets for hydrogen. The competitiveness of the sector will be achieved through a supply and demand balance.

- Support aligned joint actions from all Spanish and European regions under the umbrella of the EU National Hydrogen Strategies.

Among the areas of interest expressed by companies and bodies part to the drafting of the HMPA in their response to the Survey on Opportunities and Interests the following stand out:

- 40% of participating entities expressed their interest in the development of cross-cutting actions in which training and awareness-raising are present, as well as actions involving the development of a regulatory framework and promotion of the entire value chain.

- 12% of respondents showed interest in Hydrogen Generation, especially renewable hydrogen generation through electrolysis.

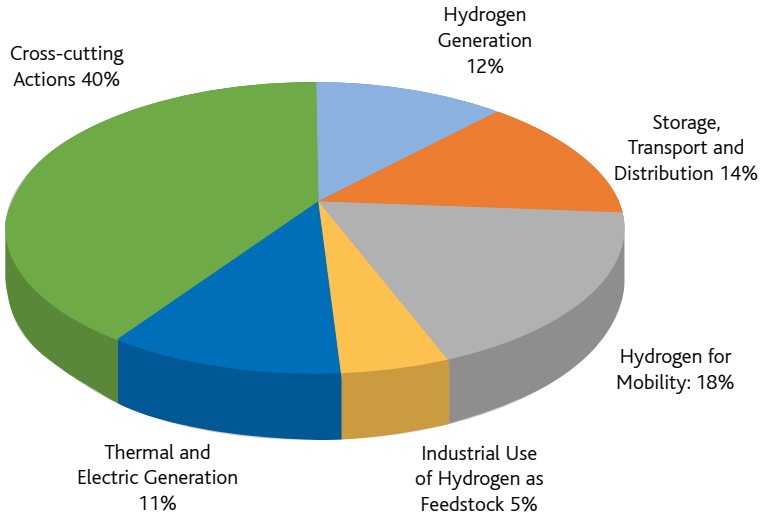
- 14% showed interest in Storage, Transport and Logistics, with main advancements already made by Aragonese companies in Pressurised transport of Hydrogen as well as R&D in other storage and transport systems.

- Hydrogen uses for mobility are of interest for 18% of respondents. The following stand out: last-mile captive transport; rail haulage currently under development and, for the first time, uses in the aviation sector, with the participation of entities such as PLATA and the Aragonian Aerospace Cluster.

- Interest in hydrogen as feedstock is currently low. Only 5% of respondents selected that option. New niche sectors such as food or other emerging sectors must be explored given the fact that Aragon is not home to large consumers such as refineries or steel works.

Lastly thermal and electric generation drew the attention of 11% of respondents, with PtP and PtG usage, industrial usage (to promote) and usage in building, -particularly with niche sectors such as tourism and culture- standing out.

Image 10: Fields of interest for Aragonese bodies and companies



Source: Responses to the Survey on Opportunities and Interests in Aragon, conducted during the collaborative drafting of the HMPA 2021 - 2025

04

OBJECTIVES OF THE HMPA [2021 - 2025]

04. OBJECTIVES OF THE HMPA

GENERAL OBJECTIVE

- Having at our disposal a tool that allows us to identify opportunities for the development of hydrogen technologies in Aragon; to initiate concrete actions and take the necessary steps to involve companies, institutional and academic bodies as well as research centres in their implementation, with the final objective of attaining the goals of regional growth, wealth creation and decarbonisation of the economy.

SPECIFIC OBJECTIVES

- Strengthening the plan´s focus as a **document of reference** in Aragon for the development of hydrogen technologies, while moving forward following the line of previous efforts that were included in former Master Plans in the region.
- Identifying **strategic lines of action** for the region as well as setting up actions for the deployment of said lines during 2021-2025 period, analysing the regional potential for hydrogen, emerging markets as well as analysing specific opportunities adapted to the actual social and economic situation and circumstances of the region.
- Increasing the involvement of Aragon´s business sector into the entire hydrogen value chain, enabling the emergence of new markets for the diversification of actions and increased competitiveness while helping attain the decarbonisation targets in the economy, as set by the EU.
- **Align actions** in the region with national and European goals, as set in the documents and strategies setting lines of action and a number of targets for different time frames such as 2030 and 2050 already published.
- Become a key tool for the **attraction of investment** and the development of unique and cross-cutting projects in Aragon.
- Showcase support and cross-cutting actions such as market deployment actions, training, awareness-raising and technology transfer that help successfully deploy the rest of lines of action: generation, storage, transport, distribution and hydrogen applications.

HMPA 2021-25 drafting stages.

05

LINES OF ACTION AND UNDERTAKINGS

05. LINES OF ACTION AND UNDERTAKINGS

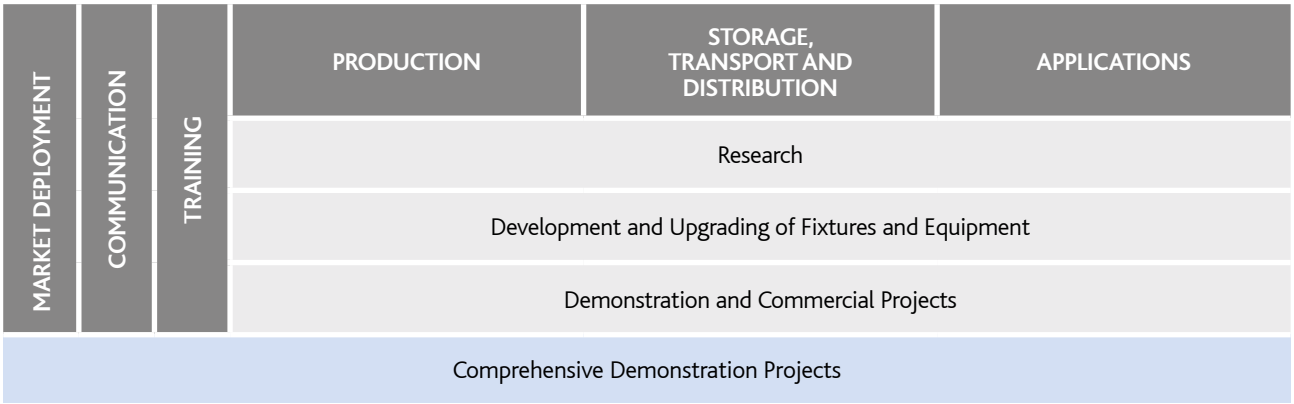
The Hydrogen Master Plan in Aragon 2021 - 2025 is structured following a set of technical lines of action that include the hydrogen value chain in its entirety: generation, storage, transport and distribution, and hydrogen applications, in all stages involved - from research, development and improvement of components and equipment to demonstration and commercial projects.

It also sets three cross-cutting lines of action with regards to support and promotion actions of the hydrogen value chain, market deployment, communication and training.

Of major relevance -and in line with other European trends of support to the deployment of flagship projects (also known as Hydrogen Valleys) through initiatives explained in chapter 2-, the plan also includes a cross-cutting line to promote and support comprehensive demonstration projects. These projects are presented as major regional projects (even inter-regional) that encompass situations of impact along the entire value chain, and also includes cross-cutting activities with social impact such as job creation and improvement in the quality of jobs, as well as raising social awareness of hydrogen technologies as a key solution for the decarbonisation of the economy.

The structure of the HMPA 2021 - 2025 is as follows:

Image 11: Lines of action proposed in the Hydrogen Master Plan in Aragon 2021 - 2025



Source: Own Production.

FHa´s facilities at Walqa Technology Park.

For each line of action, the main opportunities found while the plan was being drawn are provided. They have been taken as the starting point to set both strategic and specific actions in Aragon for the development of hydrogen technologies in the region.

Previous experiences -analysed and included in former Master Plans and revisions of said plans- have helped profile the development lines that are regarded as of major importance and with highest projection capability within the region and where the FHa and Aragonese companies are already well positioned. Thus, development opportunities that were present in previous plans are included, and new actions in light of new national and European directives, programmes and strategies specific to hydrogen are either resumed or added.

The following sections provide us with an analysis of the specific lines of action, and an overall reflection on the opportunities detected in the region. These elements come from the collaboration to define the Master plan and the subsequent strategic and specific actions as defined by participants.

In agreement with these strategic lines, **GetHyGa initiative** will be deployed over the 2021-2025 period. This initiative is an action plan stemming from the idea that hydrogen must not only be generated but also be transported, stored and integrated into industrial processes, as well as integrated into consumption and energy production. This entails the creation of the so-called "hydrogen valleys", that is, industrial ecosystems where hydrogen is generated and consumed- which may become a great opportunity for development in Aragon.

05. LINES OF ACTION AND UNDERTAKINGS

The actions present in GetHyGA that are to be developed in and by the Region of Aragon in terms of hydrogen technologies, are not exclusively geared towards the usage and implementation of said technologies -with the aim of decarbonising or providing power to those sectors that need to cut down or eliminate their carbon footprint in their activities or processes. GetHyGA also includes essential actions for development, growth and wealth creation in the region utilising hydrogen related opportunities. In other words, hydrogen is not only considered as an energy carrier, but as a vector that drives industrial and economic growth and development, that is, a vector that ensures a future for the region.

The initiative encompasses different proposals to be implemented in or from Aragon, by strengthening them, providing them with cohesion and coherence to keep in line with the development strategies for the region while at the same time providing public and private tools to raise the funds needed for their implementation.

GetHyGA entails the deployment of a 'Beacon Project' such is the case of Hydrogen Valleys with specific investment projects for hydrogen generation, storage, transport as well as decarbonisation applications for industry, mobility, haulage and freight sectors; not forgetting the primary (farming and fishing) sector and with projects in cultural and tourism sectors alike. It also provides for unique demonstration infrastructure, reindustrialisation and industrial conversion as well as actions for the promotion of R&D&I, training, qualifications/ capability-building and talent attraction, with employability and knowledge generation structures. Lastly, it provides the framing for formulation of regional policies.

FHa´s facilities at Walqa Technology Park.

This project and initiative has the aim of establishing relations with neighbouring territories and regions in the South of France, so as to supplement and consolidate territorial actions around the region of Aragon, creating and strengthening applicable synergies.

Therefore the GetHyGA initiative is an action plan that is consistent with the strategy formulated in HMPA 2021 – 2025, and with other initiatives arisen in the last year as a result of the EU hydrogen strategies for a climate neutrality and Power system integration. It is also consistent with the Renewable Hydrogen Roadmap approved by the Council of Ministers, with the call for expressions of interest by the Ministry for the Ecological Transition and the Demographic Challenge, and the Ministry of Industry, Trade and Tourism. In addition this initiative must be contextualised within EU Recovery Fund Next Generation and/ or other funding instruments supported by public-private cooperation, and is open to incorporate prospective initiatives should they be regarded as strategic for Aragon. Thus, by its very nature, the project is open to modification in accordance with new initiatives that could be carried out in totality or partially.

05. LINES OF ACTION AND UNDERTAKINGS

5.1 LINE OF ACTION 1: HYDROGEN GENERATION

The main opportunities for hydrogen identified in the Aragon are:

- The **huge potential in Aragon for renewables,** particularly wind and solar power, which allows the region to generate green hydrogen from them. There is an untapped potential of renewable resources in the existing power generation plants, as well as great capacity for the installation of new ones. According to data provided by Red Electrica de España (REE), by late 2020 the wind and photovoltaic power capacity installed in Aragon was 5190 MW, alongside over 430 wind and photovoltaic generation projects submitted, entailing a power generation capacity that doubles the installed capacity, and consolidates Aragon as a powerhouse for renewable energies in Spain.

- **Green hydrogen generation** opens up the way to actions that may promote a local industry for the development and improvement of hydrogen generation components and equipment as well as integration for different uses (electrolysers, compressors, power electronics, and so on).

- **Transition to green hydrogen,** -the ultimate long-term goal- is a path that necessitates promotion and stabilisation of demand. Current hydrogen prices are still too high. In order to make them more competitive, demand stabilisation through economies of scale must be achieved. All along this path, , as is the case for European level strategies, the generation of hydrogen by means of processes other than hydrolysis cannot be ruled out in order to help create sustained demand for hydrogen by providing demand-sided stimuli. Thus, support for grey and blue hydrogen may be necessary to facilitate the transition to green hydrogen. To that aim the plan contemplates actions for hydrogen generation through bio-methane reforming processes, anaerobic digestion, biogas and others.

- **Adaptation to the different options and magnitudes of hydrogen generation and consumption**. Hydrogen generation can neither be detached from its consumption, - with very different magnitudes required- nor from hydrogen store and distribution solutions. From this stance, centralised generation projects as well as on-site generation for lower consumption, specific market niches –building, tourism, mobility, off-grid and others- are considered.

- **Possible support of research,** especially for the development of a variety of electrolysers or other means of hydrogen generation such as photo-electrochemical generation of hydrogen.

- Last but not least, it is necessary to explore the implementation of a **Guarantee of Origin System** for Hydrogen, -a cross-cutting goal considered in line 4- for which concrete action proposals will be included in the applicable section.

FHa´s facilities at Walqa Technology Park.

The first major European technological and power generation project for the deployment of hydrogen economy from local generation of renewable energies

Lessons learnt and knowledge gained from BIG HIT on the benefits of using hydrogen with renewable energy sources in the Orkney Islands (Scotland) will support replicability and further larger deployments of renewables alongside hydrogen technologies and fuel cells in other isolated territories, with direct application in the HEAVENN project (Holland) and GREEN HYSLAND Projects (Majorca- Spain).

In light of these opportunities, the table below shows major and specific actions for hydrogen generation in the Plan. The assessments of the established priority as well as indicators applicable to each line of action are included, as well as a proposed target for 2025.

05. LINES OF ACTION AND UNDERTAKINGS

ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Green Hydrogen Generation by Electrolysis	Study of the potential of renewable energies in Aragon that could be used for green hydrogen generation.	HIGH	Studies conducted related to the purpose of the action.	3
	R&D&I into anion-exchange membrane electrolysers (AEM).	HIGH	Number of R&D projects carried out.	2
	R&D&I into hydrogen generation electrolysers with lower costs and higher efficiency.	MEDIUM	Number of R&D projects developed.	1
	Production of electrolyser components and other equipment included in the green hydrogen value chain.	HIGH	Number of companies developing components.	5
			Number of projects carried out.	2
	Hydrogen generation by electrolysis with electricity from the grid using the Guarantee of Origin System.	LOW	Number of projects developed and Aragonese companies involved.	2

FHa´s facilities at Walqa Technology Park.

ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Hydrogen Generation by means of Other Technologies	R&D into hydrogen generation by means of photo-electrochemical technologies.	MEDIUM	Number of projects developed.	1
	Hydrogen generation from different types of waste. Improvement of associated technologies -especially gasification technologies.	MEDIUM	Study of resource potential (waste catalogue).	1
			Number of projects developed.	1
	Hydrogen generation by bio-methane reforming.	MEDIUM	Number of projects developed.	1

FHa´s facilities at Walqa Technology Park.

05. LINES OF ACTION AND UNDERTAKINGS

5.2 LINE OF ACTION 2: HYDROGEN STORAGE, TRANSPORT AND DISTRIBUTION

In Aragon, as a result of a number of factors, hydrogen storage, transport and distribution has been one of the most developed lines of action in recent years. Particularly noteworthy factors are the number of projects developed in this field, as well as the involvement of Aragonese companies with products developed and currently present on the market; not to mention the region´s positioning itself for years for the deployment of a larger hydrogen logistics infrastructure. This positioning was initiated with the development and implementation of the first hydrogen corridor in Spain: the Hydrogen Refuelling Station at Expo Zaragoza 2008 in Zaragoza and the Hydrogen Refuelling Station at FHa´s headquarters in Huesca.

Hydrogen storage, transport and distribution technologies are closely linked to both generation and end-consumption, with the aim of adapting available technologies to successfully provide competitive storage and transport according to the needs of each project. Thus, different solutions are contemplated. Among them stands out the construction of infrastructure for massive storage and transport by pipeline through connections with non-EU countries so as to meet Europe´s foreseeable demand in 2050. These goals allow envisaging different scenarios with room for a diversity of solutions for storage, transport and logistics adapted to the evolution of demand.

Source: Calvera Maquinaria and Instalaciones S.L.

Portable habitation modules for military camps, designed and manufactured in Aragon, by means of strategic management of energy flows

Life Zero Energy Mod

Zero Energy Habitable Mobile Modules in Europe

The solution will comprise two independent and coupled modules- one of them inhabitable- built under the PassivHaus standard, with highly reduced power consumption when compared to current modules, and a second one for generating the power consumed in the first module. It will have renewable generation (wind and photovoltaic) and daily (batteries) and stationary (hydrogen) storage.

05.
LINES OF ACTION AND UNDERTAKINGS

In this regard, the major opportunities detected in the region to date - endorsed throughout the participation and discussions during the drafting of the Masterplan- are:

- Knowledge and experience in pressurised **storage and distribution.** Regional companies such as Calvera Maquinaria e Instalaciones, LAPESA and Carbotainer are examples of companies with products on the market and carry out their work with their own proprietary technology at national and international level. Pressurised storage and distribution is a solution for certain scales of consumption and it is considered that there is still wide room for product development and improvement. Particularly noteworthy are compression technologies (for pressure increases up to 1000 bar at competitive prices), new materials for tanks and scale demonstration projects, among others.

FHa's R&D team at Walqa Technology Park.

- Storage by means of **liquid carriers (Carriers)** such as ammonia (NH3) and organic liquids (LOHC). The use of carriers is contemplated for the transport of large quantities of hydrogen, as well as in specific uses in areas such as maritime transport, ports and intermodal centres. In Aragon, the opportunities detected in the field are still at research stage, as is the case for the assessment of prospective applications.

- **Grid distribution,** contemplating both distribution through existing natural gas networks and development of dedicated hydrogen pipelines. In Aragon there are projects in this field already under development: companies such as ENAGAS and REDEXIS are involved in this specific type of projects in the region. In addition, important factors such as existing infrastructure and the geographical location of the region must be taken into account, as these will facilitate connections to major consumption centres.

- **Underground storage.** This takes place in salt caverns and other type of hermetically sealed locations. It is not challenge-free. Yet, it remains under consideration as a line to be developed in Aragon, analysing different locations and solutions.

- **Expanding refuelling infrastructure by means of hydrogen refuelling stations (HRS)** for distribution to end-consumers in road mobility. This technology is quite mature at present. Therefore, opportunities are centred on developing a HRS network linked to a large Aragonese project and connected to major and minor Trans-European Transport Networks (TENT-T) –in the case of Aragon, aligned with the Logistics Platform PLAZA.

The HIGGS project will develop the first pilot hydrogen facility into the natural gas grid in Aragon

HIGGS
Hydrogen in Gas Grids

To facilitate hydrogen generation from renewables in large quantities, the existing gas infrastructure will need modifying to allow hydrogen transport from main generation points to consumption points. The main goal of the HIGGS project is to address the potential of hydrogen injection into the high-pressure natural gas transmission grid as a way to achieve the decarbonisation of the gas system and its uses.

In view of these opportunities, the table below shows major and specific actions in this area. It also includes an assessment of their priority, indicators applicable to each line and a proposed target to be attained before 2025.

05. LINES OF ACTION AND UNDERTAKINGS

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Pressurised Gas	With regard to comprehensive projects: optimisation economy at scale. Complementarity industrial renewable hydrogen pipelines close to consumption locations and high-pressure virtual gas pipeline for use in vehicles	HIGH	Projects carried out	3
	Building a base Hydrogen HUB (with centralised and green generation) for road distribution to consumption locations	HIGH	Number of Hubs created	3
	R&D&I in cost reduction compression/ improvement of process efficiency	MEDIUM	Number of R&D projects implemented	2
	Test bench for analysis of materials and components of high-pressure gas transport network.	MEDIUM	Number of projects carried out	1
	Inter-modal transport tanks customised to customer or market.	MEDIUM	Number of products/projects implemented	3

Hydrogen Storage at Bachimaña´s hut.

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Liquid Hydrogen	R&D in system optimisation of storage and liquid hydrogen handling.	MEDIUM	Number of products/projects implemented	1
	Demonstration Project at the Airport of Teruel of Liquid hydrogen supply for prospective aircraft.	MEDIUM	Number of products/projects implemented	1

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Carriers (NH_3, LOHC, etc.)	Analysis of possibility of renewable NH_3 supply from large scale generation.	MEDIUM	Number of products/projects implemented	1

HIGGS project's facilities at Walqa Technology Park.

05. LINES OF ACTION AND UNDERTAKINGS

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Transport and distribution Gas pipeline / Hydrogen pipeline	Definition of a backbone hydrogen pipeline network (Ebro Axis + connection with saline storage areas + main industrial estates+ renewable generation areas).	HIGH	Number of projects developed for grid deployment	3
	Real projects of hydrogen injection to the gas grid at demonstration scale (real cases with progressive blending until pure hydrogen transport is achieved).	HIGH	Number of projects implemented	2
	Projects focused on supply chain, which optimise complementarity between mobile storage systems, hydrogen pipelines and gas grid.	MEDIUM	Number of projects implemented	1

Source: Circe Foundation.

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Underground Storage	Mapping of locations for underground storage linked to renewables and techno-economic analysis.	HIGH	Mapping carried out	YES
	Analysis Study on safety measures applicable to underground storage facilities/locations.	MEDIUM	Conduction of Studies	2

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Hydrogen Refuelling Stations	Project on the Corridor Hydrogen Refuelling Stations with captive fleets in the logistics sector located in main locations: PLAZA, PSA, Huesca, Teruel...	HIGH	Number of working Hydrogen Refuelling Stations	3
	Public-private Plan on Hydrogen refuelling stations´ deployment and connection to other regions.	HIGH/ MEDIUM	Number of Hydrogen Refuelling Stations	4

05. LINES OF ACTION AND UNDERTAKINGS

5.3 CROSS-CUTTING LINE OF ACTION 3: HYDROGEN APPLICATIONS

The main hydrogen related opportunities analysed in Aragon refer to the following fields:

- Development of applications in the mobility sector. Land mobility is particularly looked into. Nevertheless, great expectations for applications in the aeronautical sector have arisen. With regard to land mobility, the commitment to the strength of the logistics sector in Aragon has been deemed of interest, fostering –as shown in the previous section- hydrogen applications in heavy transport and other logistics elements (forklift trucks, vans, delivery fleets, and so on). As for the aeronautical sector, it is worth noticing the particular interest of PLATA (Airport Platform of Teruel) and other companies party to the Aragonian Aerospace Cluster (AERA). Projects are likewise being implemented in the railway sector- arousing great interest, as seen in the proposal of pilot projects in various axes: Huesca-Canfranc, and Teruel-Valencia as well as the central axis Algeciras-Zaragoza.

The H2PiyR has allowed Aragon to have the first hydrogen-powered car registered in Spain

Hydrogen Refuelling Station at Pamiers.

The arrival of the Hyundai Nexo to the FHa takes place as part of the European project H2PiyR. Its aim is to develop a cross-border corridor of Hydrogen Refuelling Stations connecting Spain, France and Andorra with central and northern Europe – where the deployment of infrastructure for this type of zero emission sustainable mobility is more advanced.

Source: Calvera Maquinaria and Instalaciones S.L.

- Applications in the **farming sector.** Throughout the development of the plan, a growing interest of the Aragonese agricultural sector in the implementation of hydrogen technologies has been detected. Given the important weight of the sector in the region (roughly 5.7% of the GDP), the plan includes a specific section dedicated to identified opportunities related to both stationary and mobile machinery in farming vehicles, energy applications in isolated warehouses, sheds or other premises, etc.

- Hydrogen use for **electricity and thermal generation,** at industrial level and buildings (housing, tourism and cultural uses in the tertiary sector). This opportunity has been detected on demonstration at scale (particularly in industrial uses) as well on demand promotion is needed. In this field, it is essential to promote the industrial production-with a focus on the development of components and capital goods- of fuel cells, burners, turbines, etc. Aragon´s metal-mechanic industry could address initiatives in this sector.

- Hydrogen use as **feedstock.** This line is of great interest at European level. Therefore, transferring projects under this line of action to Aragon is a possibility, identifying use cases for renewable ammonia production.

In view of these opportunities, the table below shows major and specific actions in this area. It also includes an assessment of their priority, indicators applicable to each line of action and a proposed target to be attained before 2025.

05. LINES OF ACTION AND UNDERTAKINGS

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Promotion of hydrogen mobility	Study of costs associated to hydrogen mobility (adaptation of national and international studies to prospective changes required by the industrial and geo-strategic situation of Aragon)	HIGH	Implementation (yes/no)	YES
	Demonstration mobility projects in local captive fleets (cabs, buses, last-mile vans, public cleaning and others, as well as in heavy transport).	HIGH	Number of projects implemented	2
	Development of hydrogen railway mobility. Development of components, integration and implementation of demonstration project	HIGH	Number of projects implemented	1
	Promotion of hydrogen in the aeronautical sector. Development of special equipment (cryogenic hydrogen tanks, integration in fuselage, etc.) Demonstration Project at PLATA	HIGH	Number of projects implemented	2
	Hydrogen promotion in the farming sector: adaptation of hydrogen to special farming machinery, power supply to electric power transmission implements, hydrogen uses for new agricultural robots	LOW	Number of projects implemented/products	1

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Hydrogen use for electricity and thermal generation	Development of Auxiliary Power Units (APU) with different fuel cell technologies for home-use, use in trade and tourism, or seasonal applications	HIGH	Number of products/projects developed	3
	Industrial-scale demonstration of hydrogen combustion in gas-turbine.	MEDIM	Number of projects/products	1
	Development of adaptation of boilers/ burners for use with H2/Natural Gas blends.	MEDIUM	Number of projects/products	1

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Use of hydrogen as feedstock	Definition of case uses for large comprehensive project (clean hydrogen generation-consumption)	LOW	Search for potential consumers and definition of case of use	1
	Use of renewable hydrogen for renewable ammonia production	HIGH	Number of projects implemented	1
	Production of alternative renewable fuels by means of hydrogen	LOW	Number of projects implemented	3

05. LINES OF ACTION AND UNDERTAKINGS

5.4 CROSS-CUTTING LINE OF ACTION 1: MARKET DEPLOYMENT

Within the four cross-cutting lines of action presented, market deployment includes specific actions to help facilitate it. This especially refers to issues regarding the development of a legal and regulatory framework as well as the promotion of hydrogen´s value chain and technology transfer to different sectors.

The project HyTunnel-CS provides insightful research into safety in hydrogen powered vehicles in tunnels and confined spaces

The main aim is to ensure that hydrogen powered vehicles circulating on underground traffic networks pose equal or lower risks than vehicles powered by traditional fossil fuels.

Presentation of HyLaw Project at Centre of Local Technology Dynamization CDTL's Headquarters.

The strategic actions laid out for this line of action are:

- **Development of a legal and regulatory framework.** The principal actions in terms of adaptation to the regulatory framework must be concurrent at national and European levels. Work is being done in this field –as can be seen in previous sections. In particular, the draft roadmap on hydrogen at national level ("Renewable Hydrogen Roadmap") includes a specific line of action exclusively dedicated to regulatory instruments. In Aragon this means, within this field of action, streamlining and swiftly adapting said regulations, either through participation in committees and projects at national and international level, or through the adaptation of administrative or bureaucratic procedures by the competent authorities (Regional Government of Aragon, local authorities). These actions may act as incentives so that big companies may consider the region for the deployment of driving-force projects. Committees and working groups where FHa as well as several Aragonese companies are present during this period are listed below.

05. LINES OF ACTION AND UNDERTAKINGS

COMMITEES AND WORKING GROUPS WITH FHA´S PARTICIPATION

- Comité UNE "CTN 181 - TECNOLOGÍAS DEL HIDRÓGENO": Technical Committee for the standardisation of aspects related to systems and devices for generation, storage, transport, distribution, measuring and use of hydrogen. Comité UNE "CTN 216 - EFICIENCIA ENERGÉTICA, CAMBIO CLIMÁTICO Y ENERGÍAS RENOVABLES" Technical Committee for the standardisation of organisational aspects and definition of tools for the promotion of electricity generation through renewables, as well as the promotion of tools for Greenhouse Gas emission allowance and tools for the promotion of a cost-effective and more efficient end-use of energy. FHa participates in the specific working group "GT 9 -Garantías de origen de la energía" , which acts a participation and influence avenue of Spanish companies in the international working group "CEN/CENELEC/JTC 14 /WG 5 'Guarantees of Origin related to energy'"Comité UNE "CTN 60 / SC 5 / GT 1 "Otras instalaciones y equipamiento / Instalaciones y equipamiento para GNL, con excepción de las plantas satélites y las instalaciones para GNV" Technical Committee for the Standardisation of aspects related to liquefied natural gas. FHa participates in the specific working group on liquid hydrogen "CEN/TC 282 Ad-Hoc Group Liquefied Hydrogen".

Work meeting on FHa´s premises in Walqa Technology Park.

Source: Zoilo Ríos S.A.

- "CEN-CENELEC Social Forum Energy Management (SFEM) WG Hydrogen". This sectoral forum was set as a collaboration platform between CEN and CENELEC, with the aim to establish a long-term collaboration framework with major bodies and strengthen cooperation in regulatory, standardisation work as well as R&D&I. Since it was set up in 2015, the FHa participates in the ***ad hoc*** group for hydrogen, whose scope of action encompasses hydrogen generation by means of electrolysis; as well as transport, distribution and use of hydrogen in its pure form or as the dominant blend in natural gas. All this in addition to cross-cutting actions such as safety and staff training.

- Hydrogen Europe (HE) is the European association of hydrogen and fuel cells representing over 220 companies in the sector, as well as 26 national associations. Hydrogen Europe collaborates with the EU Commission in the Fuel Cells Hydrogen Joint Undertaking (FCH JU) innovation programme to promote hydrogen as an energy carrier in a zero emissions society. Among its different activities, it coordinates and organises different working groups focused on areas of interest for the hydrogen sector with the collaboration and participation of specialised companies and entities. FHa participates in the "Gas Grid WG - GGWG", focused on hydrogen use in gas infrastructures; "Maritime WG - MAWG" focused on hydrogen technologies applied to maritime transport; "Energy WG" , where the Hydrogen Act Paper has been drafted; "Policy WG" where emphasis goes to the need for research as support of technology development for widespread use in society at large; and it also participates in the "Group on Skills" where the challenges in skills and training throughout the hydrogen value chain are discussed alongside the best way to address them in the short, medium and long term in response to the EU Commission´s initiative European Pact for Skills.

- Smart Specialisation Platform Hydrogen valleys: S3EHV. There are four regions acting as coordinators: Aragon, Auvergne Rhône-Alpes, Normandie, and Northern Netherlands. It currently involves over 52 European regions within 12 working groups. FHa is co-coordinator for WG Generation, Storage and Transport.

- Collaboration with the sub-working group with Autonomous regions on hydrogen technologies. Its aim is to analyse existing regulations applicable to both hydrogen generation facilities and supply facilities, including storage and transport, while identifying the adequacy of current regulations or whether regulatory changes are needed to ensure that investments can be made with the requisite industrial safety and legal certainty.

05. LINES OF ACTION AND UNDERTAKINGS

- There is currently a wide range of technologies and generation processes from different raw materials to obtain hydrogen at large scale, which, in turn, generates a wide range of greenhouse emissions´ levels. Hydrogen generated through processes and materials entailing sufficiently low carbon emissions will play a fundamental role in the decarbonisation of society. To that aim, a system that verifies and quantifies such emissions is needed. FHa has identified this situation as an opportunity for low- carbon, green hydrogen producers, as it may be a boost to their business due to an increasing demand for this high value-added product. The development of these systems and generation schemes involves working on different activities in which the Foundation will actively participate. It will start by **monitoring every initiative for the development of Guarantee of Origin schemes for green** and low-carbon **hydrogen** in Europe, as enacted by Directive (EU) 2018/2001 of the European Parliament and of the European Council of 11 December 2018. It will continue with an analysis of the status of the update of the European Standard "EN16325:2013+A1:2015 Guarantees of Origin of Energy. Guarantees of Origin of Electricity" working in committee "CTN216/GT9. Guarantees of Origin of Energy", a group set up by UNE.

BH2C presentation.

- **Promotion of hydrogen's value chain and technology transfer.** Actions planned consist in stimulating collaboration between different productive sectors and public-private collaboration to facilitate the deployment of hydrogen technologies. In addition, other actions that contribute to facilitating technology transfer and spur the sectors where hydrogen technologies must be introduced- as is the case of the automotive industry. In this regard, the Automotive Cluster of Aragon (CAAR) is planning to conduct a study on the different transformations of fixtures and parts needed, between conventional and electric cars. This idea would also be transferable or applicable to hydrogen-powered cars.

- In addition, other clusters such as ALIA, TECNARA, CLENAR and bodies such as ZLC and Mobility City are also involved, alongside companies and the FHa in the promotion of H2 value chain and its uses.

The attached table lists actions prioritised for development included in the HMPA 2021-2025, with indicators for measuring results and their 2025 target.

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Development of a legal and regulatory framework	Adoption of a clear legal and regulatory framework to give certainty and stability to those companies with investment capabilities for the development of technologies and demonstration projects	HIGH	Participation of Aragonese Agencies in committees and legal and regulatory definition projects	YES
	Defining specific funding instruments for the promotion of investment, in a way that is fully aligned with national strategy and in connection with European Funds	HIGH	Regional programmes including specific support to hydrogen	2
	Development and implementation of the Guarantee of Origin System	MEDIUM	Participation in bodies for the implementation of the Guarantees of Origin system	YES

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Promotion of value chain and technology transfer	Comprehensive Demonstration projects for the entire hydrogen value chain	HIGH	Number of projects	1
	Collaboration actions between clusters and sectoral entities, with R&D&I bodies (FHa, universities, ITA, etc.) to promote diversification of companies all along the entire hydrogen value chain. Transfer of knowledge and technology.	HIGH	Number of actions to promote collaboration	5
	Implementation of scalable, collaboration structures for development and demonstration of components, open to the participation of companies	MEDIUM	Number of collaboration installations	2

05. LINES OF ACTION AND UNDERTAKINGS

5.5 CROSS-CUTTING LINE OF ACTION 2: COMMUNICATION AND AWARENESS-RAISING

Communication and awareness-raising has been and continues to be a key aspect throughout the successive Master Plans and numerous activities at all levels in this regard have been carried out by the FHa since it was setup.

Communication and awareness-raising campaigns promoted by the FHa have encompassed a wide range of objectives at all levels, from those aimed at schools through specific visits of students from regional schools to FHa facilities; providing companies with support in their communication efforts to society; through participation in the principal hydrogen related events held over the years (Fairs, Conferences, etc.) to the organisation of specific actions.

In section 3.3 we can see activities carried out during the lifespan of the HMPA 2016-2020. While the organisation in Zaragoza of the World Hydrogen Energy Conference (WHEC 2016) is the action that stands out, numerous other activities, such as participation in conferences, fairs seminars and webinars carried out by the FHa itself as well as many other bodies and companies part of its board of trustees were carried out.

In addition to all this, FHa´s website has a specific section for communication. The FHa is also present on social networks such as Twitter, Linkedin, and others.

Although the development of hydrogen technologies and their firm support for the decarbonisation of the economy is an indisputable fact, there is still a certain lack of knowledge in society in this regard as well as a certain reluctance to incorporate new technologies. For this reason, for the EU and every State and organisation involved, as shown in their plans and strategies, communication and awareness-raising is a central and cross-cutting aspect in order to attain the goals included in these plans.

Dissemination actions on FHa's premises at Walqa Technology Park.

Along this line, upon reflection for the HMPA 2021-2025 lifespan, communication has become a line of action on its own, and a series of actions have been defined for society in general as well as the economy, -particularly the industrial sector.

The attached table lists actions prioritised for development included in the HMPA 2021-2025, with indicators for measuring results and their 2025 target.

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Awareness-raising in society	Inform and help companies by means of knowledge dissemination actions by sector.	HIGH	Number of knowledge dissemination actions by sector carried out	25
	Organisation of the hydrogen week in Aragon to work alongside the educational sector. Creation of an experimental space, which could coincide with the World Hydrogen Day.	MEDIUM	Organisation of the hydrogen week in Aragon	YES
	Search for synergies, while taking advantage of efforts made by other scientific dissemination initiatives with an extensive track-record (Researchers´ night, Women and Science Week, etc.)	MEDIUM	Number of collaborations with other thematic events	5
	Awareness-raising and training through demonstration events. Bring citizens and technology advancements closer together, demonstrating daily life applications.	MEDIUM	Number of public demonstration events	10
	Publications and presence on educational and informative events, in general press, TV and radio programmes and Social Media.	HIGH	Presence (n. of times)	200

05. LINES OF ACTION AND UNDERTAKINGS

5.6 CROSS-CUTTING LINE OF ACTION: TRAINING

Advancement and integration of hydrogen technologies in the market will call for specific professional skills, capabilities and competences at different levels, such as design, installation, operation and maintenance of systems. Training offered to cater for this need should be based on an interdisciplinary syllabus that does away with existing barriers and finds nexus points between both scientific and technological branch subjects.

One of the main challenges is to have adequate and suitable training and qualifications for professionals in the sectors involved, mainly industry and energy sectors – all along the value chain.

The development of new hydrogen technologies will impact the STEM system (Science, Technology, Engineering and Mathematics), as it requires an integrated approach of each scientific branch subject through an innovate approach to learning where in-depth knowledge of and hands-on practice with hydrogen related technologies and their integration into the entire value chain should be present.

The FHa, from its outset, has regarded training as a fundamental pillar of its actions. Thus, it has collaborated with the University of Zaragoza, other entities such as San Valero Foundation through SEAS Open Learning, and other bodies, by providing tuition on hydrogen specific subjects at Master´s degree level and specific courses.

Currently formal technical training related to hydrogen technologies mainly includes university training programmes and Master´s degrees on renewable energies,

with no formal technical training exclusively focused on hydrogen. At other levels on-site and on-line tuition is provided, but mostly of a non-specific character. Training plans and syllabi will need updating in order to cater for the new needs of professionals in this field at all levels: university (undergraduate, graduate and postgraduate) as well as vocational training.

Additionally, another action carried out by the FHa -in the contexts of its XV anniversary- to promote research and academic aspects was the setup of the annual FHa´s Awards, for the best PHD, the best Master´s degree project and the best degree level project at a national level.

During the design of the HMPA a strong commitment has gone to the strengthening of professional qualifications and competences, and work has been done within the National system of professional qualifications on the definition of Certificates of Professional Standard´s Adequacy and specific Vocational Training Certificates.

The regulatory development of these formal education qualifications is the responsibility of the Spanish Ministry of Education and Vocational Training, and organisations such as the Spanish National Agency for Qualifications (INCUAL). In the first case, the Ministry of Education and Vocational Training is working on a draft paper on maintenance of electric and hybrid vehicles, with a section on hydrogen (650 teaching hours- job placement included) for students at medium-grade vocational training courses on vehicle electro-mechanics. On the other hand, INCUAL has set up an alert network to respond to new professional profiles detected that may be in need in the future.

05. LINES OF ACTION AND UNDERTAKINGS

In addition to these two entities, the Regional Government of Aragon, in collaboration with the FHa and training bodies, is studying the possibility of facilitating access to these actions to other national bodies, through pilot training schemes, helping launch new qualifications or at least by updating the competences and fitting qualifications present in other vocational training for vehicles – for instance, Vocational training++ on electric and hybrid vehicles.

As well as formal training, there is also interest in implementing specific non-formal training that is demanded by companies. This training can be provided within the framework of ongoing training within the company by different bodies, and it is finding approval by professionals in the sector -organisations such as AENOR, for instance.

The attached table lists actions prioritised for development included in the HMPA 2021-2025, with indicators for measuring results and their 2025 target.

World Conference on Sustainable Rural Tourism Ainsa Boltaña.

STRATEGIC ACTIONS	ACTIONS	PRIORITY	INDICATOR	TARGET 2025
Training	Support actions for the introduction of hydrogen into vocational training: certificates of professional standard´s adequacy, specific qualification certificates, etc.	HIGH	Actions in Aragon in support of the inclusion of hydrogen into vocational training domain	2
	Specific short duration online training, (20 to 50h)	HIGH	Number of training actions implemented	5
	Implementation of hydrogen studies at University level in Aragon	HIGH	Number of training actions implemented	1
	Promotion and recognition of merits of undergraduate, graduate and postgraduate students at national and international level	HIGH	Number of calls made	1/year
	Module-based content generation focused on different business domains and different training levels on the hydrogen value chain	HIGH	Number of courses implemented	50
	Training for assessors: drafting of basic handbooks to provide public administration´s technical assessors with information on hydrogen technologies	MEDIUM	Number of handbooks	1

05. LINES OF ACTION AND UNDERTAKINGS

5.7 COLLABORATIVE LINE OF ACTION: COMPREHENSIVE DEMONSTRATION PROJECTS

Hydrogen technologies have already attained a fairly mature state throughout the entire value chain. Although there is still room for development and continuous improvement in different technologies and components is still required, it is also important to start to demonstrate the validity of hydrogen as an energy carrier at a commercial scale. Comprehensive projects enable us to visualize and demonstrate at scale how these technologies work towards speeding up the decarbonisation of the economy.

As shown in chapter 2, hydrogen is one of the seven European Flagship initiatives recently presented by the EU Commission in the Annual Sustainable Growth Strategy 2021. This comes alongside large investment forecast, and more specifically, large demonstration projects.

In Spain, the National Recovery and Resilience Plan is currently being drawn up. It is a key instrument that will lay out the investment and reform programme for 2021-2023 through the Next Generation instrument. To this end, different Ministries are calling for Expressions of Interest (EOI), to ascertain the degree of maturity of the initiatives. The call for Expressions of Interest on Renewable Hydrogen was published in late 2020 with the aim of putting together initiatives of driving-force projects for a just and inclusive energy transition by means of renewable hydrogen.

Within this context, **the new HMPA 2021 – 2025 heavily leans on the development of comprehensive demonstration projects** in the region; and to attain this goal the Regional Government, the FHa and a large number of companies are involved. While awaiting specific calls for EOI, several proposals have already been submitted under the GetHyGA initiative. This will allow the identification of synergies and complementarities to define comprehensive demonstration projects.

GetHyGA Initiative presentation.

06

MONITORING AND FOLLOW-UP

06. MONITORING AND FOLLOW-UP

The monitoring and follow-up system for the Hydrogen Master Plan in Aragon 2021-2025 is similar to the monitoring system applicable to the previous Master Plan. The new structure has been adjusted and the number of indicators included has been simplified, as has been the case for the assessment process – which, notwithstanding the inclusion of a sole final assessment, is no obstacle for the FHa monitoring of the Plan´s annual evolution.

The structure of the system of indicators is maintained. Thus, we find:

A.) Monitoring and Follow-up Indicators

B.) Result Indicators

C.) Governance/Management Indicators.

A.) MONITORING AND FOLLOW-UP INDICATORS

Monitoring and Follow-up indicators are used to analyse effectiveness of implemented actions included in the HMPA. They allow assessing the level of dissemination of hydrogen technologies and actions associated. Monitoring and follow-up indicators are laid out in two types.

a.1. 1. Global monitoring indicators

They analyse overarching magnitudes of hydrogen related actions carried out in the Region of Aragon. An annual control is set so that the evolution of compliance with the HMPA can be monitored. The proposal regarding these global monitoring indicators is as follows.

Indicators	Periodicity	Responsible Entity/Source
Number of hydrogen related projects in Aragon that received funding	Annual	FHa Regional Government of Aragon/ National Ministries/ EU Commission
Number of Doctoral Theses on Hydrogen	Anual	FHa University of Zaragoza
Number of companies involved in Hydrogen technologies	Annual	FHa / Sector stakeholders

a.2. 2. Specific monitoring and follow-up indicators for the lines of action which are laid out in the HMPA.

Specific indicators for each activity have been included, as well as target attainment at the end of the period (2025).

FHa´s facilities at Walqa Technology Park.

06. MONITORING AND FOLLOW-UP

B.) RESULT INDICATORS

Result indicators measure the implementation effects of HMPA in monetary terms and returns obtained. All indicators present in the previous period are maintained for this block as well as their annual monitoring, and their assessment at the end of the period.

Indicators	Periodicity	Responsible Entity /Source
Global investment in Hydrogen technologies in Aragon	Annual	FHa Regional Government of Aragon/ National Ministries/EU Commission
Global returns obtained through public calls (regional, National, European) in specific hydrogen and fuel cell projects	Annual	FHa Regional Government of Aragon/ National Ministries/EU Commission
Global returns obtained by private companies through public calls (regional, National, European) in specific hydrogen and fuel cell projects.	Annual	FHa Regional Government of Aragon/ National Ministries/EU Commission

C.) MANAGEMENT INDICATORS

Management indicators measure the overall performance of FHa´s coordination activities with regard to its trustees, as well as the overall level of implementation of lines of action in the plan (in this case, without assessing the effectiveness of their application, which will be analysed in previous indicators. Indicators proposed in the plan are as follows:

Indicators	Periodicity	Responsible Entity/Source
Number of proposals submitted by the FHa within International programmes	Annual	FHa
Number of collaboration agreements with other associations,/entities for the development of joints projects	Annual	FHa
Actions being implemented- as compared with the total- per action line	Annual	FHa
Actions completed -as compared with the total-per action line	Annual	FHa

To ensure the effectiveness of the proposed monitoring system, the proposed indicators will be quantified on the first implementation phase of the HMPA, with a view to facilitating the subsequent periodical measurement of results achieved.

A final assessment of the implementation and fulfilment of actions to be carried out and their effectiveness, -to be conducted in 2025- is proposed.

Meeting of SustainHuts team.

07

CONCLUSIONS

07. CONCLUSIONS

During the HMPA 2021-2025 drafting, a number of actions presented in this document have being carried out. The following general conclusions can be drawn:

Firstly, the hydrogen sector is getting a **particularly important boost** as it has been recognised as a sustainable solution to decarbonise energy and industrial sectors. At European level, 2020 has been particularly fruitful in the setting up of main action lines of action, by setting a number of timelines and goals to be met by the EU in general, with the different Member States and Regions developing strategies aligned to EU guidelines.

As to the development of **the HMPA 2021-2025** itself, the main conclusions are:

- In the development of the HMPA 2021-2025 there has been **higher participation** than in previous editions. The largest part of the process has taken place in the context of a health emergency, with virtual actions taking place in order to make up for this constraint. This fact has not had negative repercussions in itself but seems to have favoured the participation to its development of other companies and bodies at national and international level.
- During the first round of **panel discussions** 306 people from a diversity of companies and entities with an interest in hydrogen took part. In the second round, 122 experts participated to define much more specific actions to be carried out in the region of Aragon. As for the online survey questionnaires submitted, 57 responses were received in the first round to gather results on the previous plan and 55 responses in the second round to highlight opportunities and capacities in the region.

HIGGS project Launch meeting.

As for the new **HMPA 2021-2025**, its structure includes the present situation for hydrogen and highlights that:

- The main objective of the plan is **wealth creation and economic development in the region** in order to help meet economy decarbonisation targets. For that, some of the main aims are: to involve Aragon´s business fabric in the development of hydrogen technologies; to align its actions with targets set at national and European levels; to become a key tool for attracting investment; to continue the promotion of R&D&I and cross-cutting and support actions.
- The HMPA 2021 - 2025 maintains its **three technical lines of action** for hydrogen generation, storage, transport and distribution, and hydrogen applications. It also develops **three cross-cutting lines** encompassing market expansion, communication and training and particularly the implementation of comprehensive demonstration projects as a collaborative line of action.
- For each of these lines of action, **specific actions are** proposed. They are clearly result-driven, and priorities, indicators and specific targets for 2025 have been set for them.
- The Plan has been provided with a **monitoring and follow-up system** to evaluate the targets achieved by 2025, divided into indicators for follow-up, results and governance/management.
- In general terms, this new Plan reflects the maturity reached by certain technologies in their development stages (generation, pressurised storage, uses in mobility and so on), alongside the support they receive. This is making it possible to address large-scale projects aimed at overcoming the barriers these technologies encounter in their deployment.

Therefore, and as a conclusion, in regard to the **positioning of Hydrogen technologies in Aragon** and their promising future expected for their development in the region, we can highlight that:

- Aragon has come a long way, with the publication of its regional master plans since 2007. They have positioned the region at the vanguard in the development of hydrogen projects over the last 15 years. This has been achieved especially by the FHa and a number of companies that have positioned themselves as leaders in their field of action.
- Over the period 2016 – 2020, more than 70 projects have been developed, with an overall investment of at least €35 million, of which a minimum of €25.9 million have been obtained from public calls for proposals.

07. CONCLUSIONS

- It is important to **keep the track record achieved over the last years** and go on to make the most of the opportunities that may arise to reinforce this trend even further. The promotion of actions along the entire hydrogen value chain such as increasing Green hydrogen generation, paving the way for new markets, gaining improved competitiveness and returns, as well as improving technology reliability must continue to be pursued. By grabbing these emerging opportunities, it will be possible to advance towards scales that are high enough and will allow meeting the targets set for each timeframe. Nevertheless, a large part of these actions may require, as a precondition, that the immediate improvement of legal and regulatory framework for hydrogen be established.

- The **great potential for renewables present in Aragon** stands out, alongside a firm commitment to large-scale green hydrogen generation. Knowledge and experience gained in hydrogen storage and distribution in previous years have positioned some Aragonese companies as benchmarks in this sector. Furthermore, new fields of action to incentivise large scale hydrogen production in different sectors and scale are emerging. All this, alongside the support of the Regional Government and capacities offered by research and development centres and business promotion centres in the region alike- but also organisations such as FHa at the forefront, the University of Zaragoza, the Technology Institute of Aragon (ITA), energy, automotive and aeronautics clusters-, place the region in a favourable position to meet the targets set while standing out as a reference region in hydrogen technologies.

In short, this new Plan is published at a time when the launch of new opportunities for Hydrogen -both in technology and funding- are arising, in a region such Aragon with extensive experience in the field to ensure its positioning in this area in the coming years.

ANNEX I

SDGs: SUSTAINABLE DEVELOPMENT GOALS

ANNEX I

1. OBJECTIVE AND SCOPE

Sustainable Development Goals – SDGs- is an initiative promoted by the United Nations to continue implementing the development agenda determined in the Millennium Development Goals (MDGs), set forth in 2000. The MDGs were aimed at reducing extreme poverty and child mortality rates, fighting disease epidemics such as HIV/AIDS, and fostering a global partnership for development. Eight MDGs and targets for 2015 were set for each of them.

Sustainable vending solution at EBOCA's installations.

After this period, The UN revised the development goals to include new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice. In September 2015, with the participation of 193 UN Member States, at a high-level Plenary Session of the General Assembly, world leaders approved the Agenda entitled **"Transforming our World: The 2030 Agenda for Sustainable Development"**, which came into effect on January 1st, 2016. It included the recommendation of 17 Sustainable Development Goals, setting 169 targets, to set out in 2015 and reach completion in 2030.

The Sustainable Development Goals (SDGs) define global sustainable development priorities in an environment that is facing enormous economic, social and environmental challenges. SDGs aspirations for 2030 seek to mobilise global efforts around a set of common goals and targets. SDGs are a call for collaboration between governments, business and civil society aimed at ending poverty and creating a life of dignity and opportunity for all on a planet where resources are not unlimited.

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This final proposal translates into 17 goals, encompassing very diverse domains, to name:

- **Goal 1:** End poverty in all its forms everywhere.
- **Goal 2:** End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- **Goal 3:** Ensure healthy lives and promote well-being for all at all ages.
- **Goal 4:** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- **Goal 5:** Achieve gender equality and empower all women and girls.
- **Goal 6:** Ensure availability and sustainable management of water and sanitation for all.
- **Goal 7:** Ensure access to affordable, reliable, sustainable and modern energy for all.
- **Goal 8:** Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
- **Goal 9:** Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- **Goal 10:** Reduce inequality within and among countries.
- **Goal 11:** Make cities and human settlements inclusive, safe, resilient and sustainable.
- **Goal 12:** Ensure sustainable consumption and production patterns.
- **Goal 13:** Take urgent action to combat climate change and its impacts.
- **Goal 14:** Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- **Goal 15:** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- **Goal 16:** Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
- **Goal 17:** Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Sustainable Development Goals - SDGs

Since the adoption of the SDGs, with the 169 targets they include, many public and private organisations have committed themselves to acting by considering the impact of their activities on these goals and targets, and by planning and implementing actions to help improve their contribution to these goals.

While the SDGs are primarily aimed at governments, they are designed to bring together a wide range of organisations, and shape priorities and aspirations for achieving sustainable development around a common framework. More importantly, SDGs recognise the critical role that businesses and agencies can and should play in attaining these goals.

It is obvious that not every agency or, above all, companies have an impact on each of the goals and targets set. Therefore, proposals in methodology have been developed in order to help define the alignment of activities with the SDGs, and to set specific targets for each organisation.

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To help companies in this endeavour, the UN have defined a guide, ***SDG Compass***[3], geared, in principle, to large multinational companies. However, Small and Medium-Sized enterprises, as well as other organisations are encouraged to use it as a source of inspiration and adapt it as needed. Likewise, it is designed to be used at entity level, but can be applied at product, site, division or regional levels as fitting.

The methodology to apply takes into account the development of five phases as proposed by *SDG Compass,* namely:

1. Understanding the SDGs
2. Defining priorities
3. Setting goals
4. Integrating
5. Reporting and communicating

[3] https://sdgcompass.org/

FHa, as a non-profit organisation, whose objective is the development of new energy technologies based on hydrogen to help decarbonise and improve the environment, is set to conduct an analysis of the impact of its activities on the SDGs, using the methodology proposed on the *Guide for Business Action on the SDGs. UN. SDG Compass,* alongside complementary documents. This document shows the results of the analysis and how the impact of FHa´s activities on the SDGs will be measured.

The steps to follow are:

1. **Selection of the SDGs** on which FHa´s activities have an impact, and the **targets for each SDG**
2. **Review of indicators** for each goal, as proposed by SDG Compass based mainly on the Global Indicator Framework and the GRI standards (Sustainability Reporting Guidelines).
3. Adapting these **indicators** or proposing more relevant indicators to meet the goals and targets selected.
4. Setting up a baseline for those indicators and a 2025 target for them, with a view to aligning them to the execution of the HMPA 2021 - 2025

This exercise of alignment with SDGs is the first one done by the FHa. Therefore a number of suitable goals, targets and indicators for monitoring of activities aligned with SDGs will be selected. All this aims to reduce excessive complexity and facilitate measuring and monitoring so that the FHa may continue working on the SDGs in subsequent periods.

ANNEX I

2. SELECTION OF GOALS AND TARGETS IMPACTED BY ACTIVITY OF FHA

The first step taken has been a process that involved pondering and understanding the SDGs. Thus, a selection of the goals most impacted by FHa´s activities- for which there is room for improvement and that allow determining values to be attained for each selected goal- was thus made.

Out of the seventeen proposed goals, eight have been selected. They are shown below:

Sustainable Development Goals- SDGs on which FHa's activity has an impact.

For each goal, the following targets have been selected:

Goal 4: Quality Education

- Target 4.4. Increasing skills to facilitate access to employment

Goal 5: Gender Equality

- Target 5.5. Ensuring full participation of women and equal opportunities

Goal 7: Affordable and Clean Energy

- Target 7.2. Increasing substantially the share of renewable energy

Goal 8: Decent Work and Economic Growth

- Target 8.2. Increasing productivity through diversification, technology and innovation
- Target 8.3. Promotion of growth of Small and Medium-Sized enterprises
- Target 8.4. Improvement of consumption and production, in a sustainable manner

Goal 9: Industry, Innovation, and Infrastructure

- Target 9.5. Enhancement of scientific research, upgrading of technological capabilities
- Target 9.A. Facilitating sustainable and resilient infrastructure development

Goal 11: Sustainable Cities and Communities

- Target 11.6. Reduction of environmental impact of cities

Goal 12: Ensure sustainable consumption and production patterns

- Target 12.8. Ensure education on sustainable development
- Target 12.A. Strengthen scientific and technological capabilities for sustainability

Goal 13: Climate Action

- Target 13.2. Integration of climate change measures into national policies, strategies and planning

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3. DEFINITION OF INDICATORS BY GOAL AND TARGET

To determine indicators there has been a review of the indicators proposed by SDG Compass for each goal, both present in their website tool (https://sdgcompass.org/) and the document "Global indicator framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development", contained in the Resolution adopted by the General Assembly on Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development A/RES/71/313.

For each goal and target, the most appropriate official indicators for the purposes proposed by the FHa are going to be specified, indicating in each case whether they are maintained as they have been collected, whether they are adapted to the reality of FHa´s actions or whether ***ad hoc*** indicators are determined for this purpose.

GOAL 4: QUALITY EDUCATION

Target 4.4. Increasing skills to facilitate access to employment

Reference and official indicators	FHa´s indicators	Baseline (value 2020)	Target 2025
Average training hours per year, per employee, by gender and by employee category	Average training hours per year per employee	20 hours 1% of the working days	50 hours 3% of the working days
GRI G4 Sustainability Reporting Guidelines	*Adapted from GRI*		

The base line encompasses internal training plus attendance to free webinars on key topics that broaden employee´s knowledge to carry out their duties.

The 2025 target doubles the current value as it is intended to include training in Occupational Health and Safety, specific equipment and language skills enhancement in foreign languages.

GOAL 5: GENDER EQUALITY

Target 5.5. Ensuring full participation of women and equal opportunities

Reference and official indicators	FHa´s indicators	Baseline (value 2020)	Target 2025
Proportion of women in management positions	Proportion of women in management positions	35%	50%
Global Indicator Framework	*The indicator from the Global Indicator Framework is maintained*		

FHa´s management positions are considered to be those filled by the Managing Director of the Foundation as well as the Heads of the departments and areas of the Foundation. There are currently 5 women occupying one of these positions (35%). The FHa aims to reach parity in management positions by 2025.

GOAL 7: AFFORDABLE AND CLEAN ENERGY

Target 7.2. Increasing substantially the share of renewable energy

Reference and official indicators	FHa´s indicators	Baseline (value 2019)	Target 2025
Renewable energy share in total final energy consumption	Renewable energy share in total final energy consumption	11%	80%
Global Indicator Framework	*The indicator from the Global Indicator Framework is maintained*		

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Target 7.2. Increasing substantially the share of renewable energy			
Reference and official indicators	**FHa´s indicators**	**Baseline (value 2019)**	**Target 2025**
It has not been possible to select an indicator that can adequately monitor FHa activities	Production of renewables fed into the electric grid per year *Own indicator*	800 MWh	800 MWh
Energy consumption within the organisation *GRI G4 Sustainability Reporting Guidelines*	Thermal energy consumption within the organisation *Adapted from GRI*	35 MWh	31,5 MWh

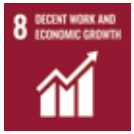
The FHa generates renewable energy by means of solar panels and wind turbines at its facilities. Part of this energy goes to own use in general activities in the office building. The rest is fed into the electric grid, as it is a financially sound way to get revenue for the Foundation and continue its actions and activity.

As for own consumption – currently 11%- the aim is to increase it to 80% in 2025, thanks to the introduction of a 60 kW PV farm. This will entail a great leap forward towards FHa´s daily activity sustainability.

The annual production fed into the electric grid is expected to be kept at the same level, as it mainly comes from wind energy. Thus, on the one hand, figures vary depending on annual wind availability and, on the other hand, on correct wind turbine maintenance, as has been the case to date.

Thermal consumption is to be reduced through planned improvements into the building, such as replacing boilers or upgrading external walls and partitions, a 10% gain in efficiency is expected with these measures.

Baseline data corresponds to 2019, since data for 2020 is not deemed to be relevant due to the long periods of forced telecommuting, with the ensuing drop in consumption.



GOAL 8: DECENT WORK AND ECONOMIC GROWTH

Target 8.2. Increasing productivity through diversification, technology and innovation.

Reference and official indicators	FHa´s indicators	Baseline (value 2019)	Target 2025
Number, type and impact of physical and technological legacies *GRI G4 Sustainability Reporting Guidelines*	Number of publications *Adapted from GRI*	4	20

The target number of publications is the accumulated number, with an annual average of 4-5 for the period. Thus, the 2025 target is an accumulated number, taking into account the aforementioned annual average.

Target 8.3. Promotion of growth of Small and Medium-Sized enterprises

Reference and official indicators	FHa´s indicators	Baseline (value 2020)	Target 2025
It has not been possible to select an indicator that can adequately monitor FHa activities	Number of Small and Medium-Sized enterprises from the region collaborating with FHa *Own indicator*	35	45

SMEs that collaborate with the FHa include some of the companies present in the Board of Trustees, other external companies as well as local SMEs companies supplying services necessary for the maintenance of the building: cleaning, maintenance, catering among others. The target for 2025 is to increase collaboration by 20% to reach 45 companies. It is an achievable target since there is an increasingly growing interest in hydrogen technologies, with extensive industrial impact and therefore, larger involvement of enterprises.

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Target 8.4. Improvement of consumption and production, in a sustainable manner			
Reference and official indicators	**FHa´s indicators**	**Baseline (value 2019)**	**Target 2025**
Material footprint, material footprint per capita, and material footprint per GDP *Global Indicator Framework*	Carbon footprint associated with transport *Adapted from the Global IndicatorFramework*	15 361 kg CO_2	10 752 kg CO_2

An indicator for carbon footprint associated with commuting to the FHa facilities, has been selected. Since calculations for 2019 had already been made (for 2020, with forced telecommuting distorting the data, those calculations are not appropriate), the 2019 figure has been selected. That figure is to be cut down by 30%, -with a CO2 reduction of 5000 kg- by adopting the continuation of part-time telecommuting measures, as well as fostering an internal campaign to share vehicle use or replace older polluting vehicles with those less polluting.

GOAL 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE

Target 9.5. Enhancement of scientific research, upgrading of technological capabilities			
Reference and official indicators	**FHa´s indicators**	**Baseline (value 2020)**	**Target 2025**
Research and development expenditure as a proportion of GDP *Global Indicator Framework*	Research and Development Expenditure *Adapted from the Global Indicator Framework*	35 M €	70 M €
Researchers (in full-time equivalent) per million inhabitants *Global Indicator Framework*	Number of researchers (in full-time equivalent) *Adapted from the Global Indicator Framework*	12	15

With regard to R&D expenditure, the baseline adopted (€35million) arises from the calculations made for the HMPA 2021-2025. To assess the target to reach by 2025, that figure is to be twice as high as the baseline (€70 million). This is an ambitious but reachable target, given the extensive support hydrogen technologies are to get from the new European and national Funding Schemes.

The second indicator refers to full-time equivalent research staff at the FHa. The target is to hire 3 more full-time equivalent staff by 2025, most likely through specific direct contract, with more time allocated to R&D.

Target 9.A. Facilitating sustainable and resilient infrastructure development

Reference and official indicators	FHa´s indicators	Baseline (value 2020)	Target 2025
Extent of development of significant infrastructure investments and services supported *GRI G4 Electric Utilities Sector*	Number of research and development projects aimed at supplying reliable electricity and encouraging sustainable development	3	5

The indicator for the R&D projects aimed at supplying reliable electricity and encouraging sustainable development (currently 3 projects) is increased to 5; this is consistent with the estimates made in the HMPA 2021-2025.

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GOAL 11: SUSTAINABLE CITIES AND COMMUNITIES

Target 11.6. Reduction of environmental impact of cities

Reference and official indicators	FHa´s indicators	Baseline (2020)	Target 2025
Extent of development of significant infrastructure investments and services supported *GRI G4 Electric Utilities Sector*	Number of projects developed on sustainable mobility in cities *Adapted fromGRI*	2	4

The selected indicator refers to Sustainable Hydrogen based mobility. At present, two projects are under way. The target set for 2025 involves doubling that number to four, remaining consistent with the HMPA 2021-2025.

GOAL 12: ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS

Target 12.8. Ensure education on sustainable development

Reference and official indicators	FHa´s indicators	Baseline (2020)	Target 2025
No *GRI G4*, indicator has been selected as only reference is made to information by means of product labelling	Training and external communication actions on sustainable development *Own indicator*	10	60

The baseline indicator selected refers to 2020, a year with few on-site training actions, events or visits to FHa´s premises but a higher number of webinars or online courses. The 2025 target, in consistency with the HMPA 2021-2025 is 60 actions, - including webinars, external courses, Master´s level courses, visits and events.

Target 12.A. Strengthen scientific and technological capabilities for sustainability			
Reference and official indicators	**FHa´s indicators**	**Baseline (2020)**	**Target 2025**
No *GRI G4* base indicator has been selected as only reference is made to supporting actions in developing countries	Public distinctions for external actions geared to sustainability *Own indicator*	1	1/year

Historically, the FHa has been and continues to be recognised in its actions as a body that promotes external sustainability actions, with an average of one distinction per year. Its aim is to continue this path, remaining consistent with HMPA 2021-2021.

GOAL 13: CLIMATE ACTION

Target 13.2 Integration of climate change measures into national policies, strategies and planning			
Reference and official indicators	**FHa´s indicators**	**Baseline (2020)**	**Target 2025**
Engage in initiatives that promote resilient practices and/or upgrade value chain procedures in order to address climate change *UN Global Compact- Oxfam Poverty Footprint*	Engaging in initiatives that promote resilient practices and/or upgrade value chain procedures to address climate change *The selected oficial indicator is maintained*	10	15

The value of the current indicator includes participation in actions such as: the national hydrogen roadmap; the national hydrogen sectoral agenda; participation in committees- CEN CENELEC, S3HV, Gas Grid WG, Maritim WG, Energy WG, Policy WG, Group on Skills; as well as participation in 3 Spanish standardisation technical committees. The 2025 target shows an increase of 50% of its value, so as to include participation in eco-design, sustainability, Life Cycle Analysis, women and science, women and sustainability, and other standardisation committees.

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4. SCORECARD

The following table shows the selected indicators in the scorecard to check the alignment of FHa´s actions with SDGs for 2021-2025.

SDG	TARGET	INDICATOR	TARGET 2025
Goal 4: Quality Education	Target 4.4. Increasing skills to facilitate access to employment	Average number of training hours per employee per year	50 hours
Goal 5: Gender Equality	Target 5.5. Ensuring full participation of women and equal opportunities	Proportion of women in management positions	50%
Goal 7: Affordable and Clean Energy	Target 7.2. Increasing substantially the share of renewable energy	Renewable energy share in total final energy consumption	80%
		Production of renewables fed into the electric grid per year	800 MWh
		Thermal energy consumption within the organisation	31.5 MWh
Goal 8: Decent Work and Economic Growth	Target 8.2. Increasing productivity through diversification, technology and innovation	Number of publications	20
	Target 8.3. Promotion of growth of Small and Medium-Sized enterprises	Number of Small and Medium-Sized enterprises from the region collaborating with FHa	45
	Target 8.4. Improvement of consumption and production in a sustainable manner	Carbon footprint associated to transport	10 752 kg CO_2

SDG	TARGET	INDICATOR	TARGET 2025
Goal 9: Industry, Innovation and Infrastructure	Target 9.5. Enhancement of scientific research and technological capabilities.	Research and Development Expenditure	€70 M
		Number of researchers (in full-time equivalent)	15
	Target 9.A. Facilitating sustainable and resilient infrastructure development.	Number of research and development projects aimed at supplying reliable electricity and promoting sustainable development	5
Goal 11: Sustainable Cities and Communities	Target 11.6 Reduction of environmental impact of cities.	Number of projects developed on sustainable mobility in cities	4
Goal 12: Ensure Sustainable Consumption and Production Patterns	Target 12.8 Ensure education on sustainable development.	Training and external communication actions on sustainable development	60
	Target 12.A Strengthen scientific and technological capabilities for sustainable patterns of consumption and production.	Public distinctions for external actions geared to sustainability.	1/year
Goal 13: Climate Action	Target 13.2 Integration of climate change measures into national policies, strategies and planning.	Engaging in initiatives that promote resilient practices and/or upgrade value chain procedures to address climate change.	15

ANNEX II

METHODOLOGY USED

ANNEX II

The drafting of the Hydrogen Master Plan in Aragon 2021-2025 has involved **huge participation in the process,** with more than 300 people participating throughout the different drafting stages.

The professionals involved represent the companies and bodies they work for. Noteworthy is the participation of entities belonging to the FHa Board of Trustees, but just as remarkable is the participation of many other Aragonese, national and international companies invited to the process, with an interest in gaining knowledge of activities carried out in Aragon. Amongst the participating bodies, we find local, regional, national and EU representatives. All of them have contributed their vision, complementing and aligning the actions set forth with policies at the highest levels.

The process for the execution of the HMPA has also required internal work for the drafting of the whole documentation necessary while the participation process was under way. This participation process was unavoidably conducted online due to the COVID-19 crisis, as was the case for results revision, drawing of conclusions etc. This work was carried out by FHa´s technical staff together with IDOM Consulting, Engineering & Architecture´s technical assistance.

To conduct the online-process a range of computer tools has been used. All this has facilitated attendance of people from different national and European locations.

The process has maintained the format of working group split into the five areas present in previous plans, namely:

- Hydrogen generation
- Hydrogen storage, transport and distribution
- Hydrogen applications
- Technology transfer, safety and economy impact
- Training and awareness-raising

The main activities implemented throughout the process are: :

- Information gathering by means of a questionnaire on specific activities carried out during the previous period and companies´ and bodies´ interests for the future, at national level
- First round of panel discussions at national level, in July 2020, in order to present general results regarding the previous period, to highlight the favourable action framework for hydrogen currently available and to debate on the major trends in and positioning of Aragon.
- Launch of an on-line survey to gather specific opportunities and capabilities for hydrogen in Aragon.
- Second round of panel discussions, in October, with smaller attendance, focused on Aragon, with the added objective of making debate more dynamic and manage to define lines of action and specific actions and activities for the new Master Plan.

The image below provides a visual representation of the participation process alongside the goal, process and result for each action.

1- QUESTIONNAIRE	1st ROUND OF WORKING GROUPS	ONLINE SURVEY	2nd ROUND OF WORKING GROUPS
GOAL • Collection of specific actions carried out by your company/body within the framework of the previous HMPA. • Stating interests and specific goals of the company/body for the 2021-2025 period.	**GOAL** • Presentation of first conclusions regarding the implementation of the HMPA 2016-2020. • Current action framework. Context at International, national and Aragonese levels. • Analysis of main trends. • Debate and positioning in the chain value.	**GOAL** • Analysis of opportunities and capabilities for H2 in Aragon based on participating companies and bodies' areas of knowledge and interest.	**GOAL** • Revision of main opportunities and capabilities for H2 in Aragon in the field of H2 generation. • Identification of lines of action and activities. • Prioritising.
PROCESS AND RESULTS • Sending out 280 questionnaires. - 78 members of the FHa Board of Trustees. - 57 Aragonese companies. - 145 bodies and national and European companies. • 57 responses received.	**PROCESS AND RESULTS** • 5 online working groups' discussions conducted, open to all groups of attendees. - Working group 1: 65 attendees. - Working group 2: 63 attendees. - Working group 3: 93 attendees. - Working group 4: 42 attendees. - Working group 5: 43 attendees.	**PROCESS AND RESULTS** • Sending out the online survey to attendees to the first round of working group discussions. • 55 specific responses received.	**PROCESS AND RESULTS** • 5 on-line working groups, reduced to Aragonese companies and organizations with presence in Aragon that have responded to the on-line survey. - Working group 1: 26 attendees. - Working group 2: 27 attendees. - Working group 3: 34 attendees. - Working group 4: 17 attendees. - Working group 5: 18 attendees.

Participative process for the definition of the Hydrogen Master Plan.

ANNEX III

BIBLIOGRAPHY AND ABBREVIATIONS

09. BIBLIOGRAPHY AND ABBREVIATIONS

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09. BIBLIOGRAPHY AND ABBREVIATIONS

AEI	Innovation Business Grouping.
AENOR	Spanish Association for Standardisation and Certification.
APU	Auxiliary Power Unit.
CENELEC	Comité Européen de Normalisation Electrotechnique.
CHP	Combined Heat and Power.
CO_2	Carbon Dioxide.
CSIC	Spanish National Research Council.
DGA	Regional Council of Aragon.
ECH2A	European Clean Hydrogen Alliance.
EERR	Renewable Energies.
EIT	European Institute of Innovation and Technology.
EMPIR	European Metrology Programme for Innovation and Research.
ETS	Emissions Trading Scheme.
FAM	Mountaineering Federation of Aragon.
FCEV	Fuel Cell Electric Vehicle.
FCH JU	Fuel cells and Hydrogen Joint Undertaking.
FCH 2 JU	Fuel cells and Hydrogen Joint Undertaking 2.
FECYT	Spanish Foundation for Science and Technology.
FHa	Foundation for the Development of the New Hydrogen Technologies in Aragon.
FP	Professional education.
GROSS DOMESTIC PRODUCT	Gross domestic product.
GW	Gigavatio.
H_2	Hydrogen.
HRS	Hydrogen refuelling station.
HMPA	Hydrogen Master Plan in Aragon
IDEA	Institute for Diversification and Saving of Energy
IEA	International Energy Agency.

INCUAL	National Institute of Qualifications.
IPCEIs	Important Projects of Common European Interest.
ITA	Instituto Tecnológico de Aragón.
kg	Kilogram.
kW	Kilovatio.
LOHC	Liquid Organic Hydrogen Carriers.
MDI	Expressiones of interest.
MINCOTUR	Ministry of industry, trade and tourism.
MITERD	Ministry for Ecological Transition and Demographic Challenge.
MW	Megawatt.
MWh	Megavatio-hour.
NH_3	Ammonia.
PAIP	Aid Programme for Industry and SMEs in Aragon.
PDHA 2021 - 2025	Hydrogen Master Plan of Aragon 2021 - 2025.
PEM	Proton Exchange Membrane.
POCTEFA	Cross-Border Cooperation Programme INTERREG V-A Spain, France and Andorra.
RES	Renewable energy sources
RIS3	Research and Innovation Strategy for Smart Specialisation.
RRM	Recovery and Resilience Mechanism
R&D	Research and Development.
R&D&I	Research and Developement and Innovation.
SHFCA	Scottish Hydrogen and Fuel Cell Association.
SMEs	Small and Medium-Size Enterprises.
SOFC	Solid Oxide Fuel Cell.
TEN-T	Trans-European Transport Networks.
TRL	Technology Readiness Level.
UNIZAR	Zaragoza University.

ANNEX IV

ACKNOWLEDGEMENTS

08. ACKNOWLEDGEMENTS

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