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POLICY **BRIEFING**

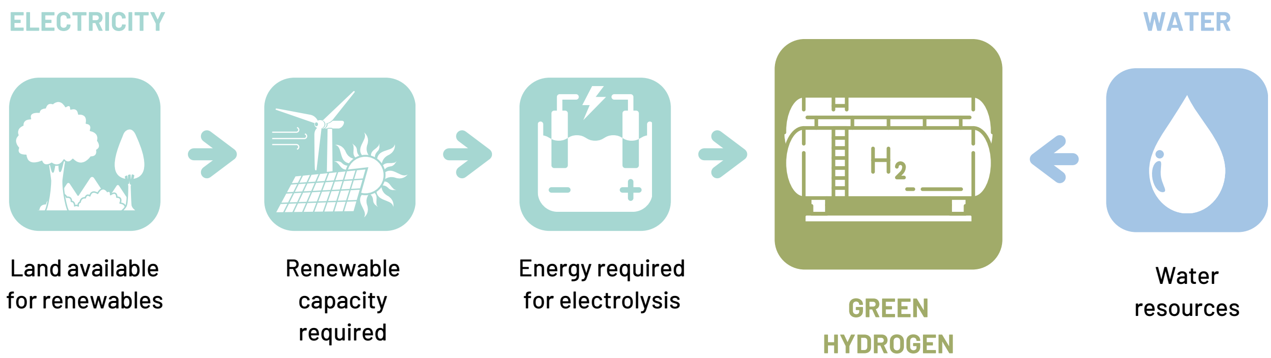
H_2 PROJECTS: DOES SIZE MATTER?

FUNDACIÓN RENOVABLES

Motivation, context and goal of the DOCUMENT

At **Fundación Renovables** through the various reports published on this subject, we have promoted and defended the production of green hydrogen in the areas where it is demanded and used, and prioritised the transport of electricity for its generation over the transport and storage of hydrogen in the form of gas. By avoiding large-scale development of long-distance renewable hydrogen transport, as well as the construction of new infrastructure (often subsidised with public money), it will be possible to attract new pioneering industry through more competitive prices and to accelerate the decarbonisation of existing industry in the region. As such, macro-project models for exporting hydrogen to other countries, both by land and by sea, have disadvantages and territorial impacts in the areas where they are located, affecting the local socio-economy as the supply is oversized in relation to local demand.

In Spain, estimates have been made by both the public and private sectors. The document "H2 Projects: Does Size Matter?" makes a comparative analysis of the MITERD and Enagás plans and of two models of hydrogen projects currently in the pipeline. This provides an initial approximation of which type of projects are most suitable and have the least impact in terms of meeting the various national targets. An analysis is made of photovoltaic and wind power in terms of electricity generation and their impact on natural resources (soil and water), according to the following scheme:



PUBLIC SECTOR GOALS

In Spain, in October 2020, the government approved the Hydrogen Roadmap, which aimed to install 4 GW of electrolysers by 2030. This represents 10% of the target set by the EU in July 2020 in the European Hydrogen Strategy (40 GW), with which it is hoped to produce up to 10 Mt of renewable hydrogen by 2030.

This target was increased in Europe with the publication of REPower EU which aims for the production of 10 Mt of renewable hydrogen and the import of an additional 10 Mt. It was also increased at the national level, rising to 12 GW in the updated version of the National Integrated Energy and Climate Plan (Plan Nacional Integrado de Energía y Clima; PNIEC) 2023-2030, despite the fact that there has been no evolution in the demand and technological and industrial maturity have not advanced.

The European Commission (EC), set up a tender through the European Hydrogen Bank, a financing instrument designed to unlock private investment in hydrogen value chains, in order to increase and ensure the profitability and financial support for new projects. At the end of April 2024, it granted €720 million to seven renewable hydrogen projects. The funding came from EU emissions allowances. The tender attracted a total of 132 bids.

PRIVATE SECTOR GOALS

At the end of January 2024, Enagás, as the technical manager of the Spanish gas system, presented the results of a Call For Interest for renewable hydrogen projects, launched during the last quarter of 2023. It was aimed at all stakeholders and companies involved in the gas sector, with a total of 206 companies participating with 650 projects.

It should be emphasised that this is not binding at a regulatory level or in any national, regional or local energy plan. The purpose of the measure was to ascertain and estimate the future real production capacity for green hydrogen, by conducting an initial assessment of the potential market for renewable hydrogen in Spain. In this way, they could define an adapted proposal for Spanish hydrogen infrastructures. Three scenarios of varying magnitude were proposed: Baseline, Call for Interest and Maximum Potential. Installed capacity, H_2 production and aggregate demand poles were defined.

The goal was to understand the implications of increasing renewable energy facilities and the potential impact on natural resources (water and soil) that would result from achieving the different objectives set out by MITERD and Enagás.

	MITERD		ENAGÁS		
	Hydrogen Roadmap	PNIEC 2024	Baseline	*Call for interest*	Maximum potential
Installed capacity in 2030 (GW)	4	12	13,4	23,3	74,3
Hydrogen produced (Mt/year)	0,125	0,74 *	1,6	2,5	7,9

Table 1. *Green hydrogen production targets.*
**Neither domestic production nor consumption is specified; the data is from Enagás.*
Source: *Hydrogen Roadmap and PNIEC 2024 (MITERD), Enagás.*

To better understand the impact at the local level and its repercussions in terms of energy and resources, **two hydrogen generation projects, currently in the pipeline, with different sizes, consumption and production characteristics** will be analysed. We have focused on Aragon, one of the regions with the largest number of renewable and hydrogen generation projects.

CASE STUDIES

The first is the **H_2 Pillar project, from the company Aragonesa del Hidrógeno Verde S.L.** This company is 50% owned by Compañía Energética Aragonesa de Renovables S.L. and Enagás Renovable S.A. It is located in the municipalities of El Burgo de Ebro and Fuentes de Ebro. The project consists of two phases:

1. **Stage 1,** scheduled to be operational in February 2026. According to the specifications, an initial production of 2,212 t/year of renewable hydrogen is estimated thanks to a 15 MW electrolyser, with a 10 MW wind farm and a 5 MW photovoltaic farm. Subsequently, a production of 4,400 t/year will be achieved with a 30 MW electrolyser and 40 MW from three wind farms and two photovoltaic farms totalling 13.6 MW. It involves an investment of €122.7 million.

2. **Stage 2,** built 5 years after the approval of the Aragon General Interest Project (PIGA; Proyecto de Interés General de Aragón). Production will double to 8,800 t/year thanks to 60 MW of electrolysers and 103 MW of renewables. This involves a further investment of €57 million.

The project has obtained the PERTE qualification linked to the Next Generation European Funds, receiving financial aid of €14.31 million, which requires the stages to be completed within the established deadlines.

Among the uses for the hydrogen produced, at 25 t/year (potentially reaching 100 t/year) is the incorporation of at least three hydrogen-powered buses during the first phase, which may increase depending on the results and the costs of the technology. There will also be a hydrogen filling station for refuelling heavy vehicles (buses), which it is hoped will be open to the public in the future, and additional hydrogen filling stations for the same purpose. In addition, there will be an industrial supply of 3,200 tonnes/year for the production of hydrogen peroxide and 2,500 tonnes/year for furnaces for melting raw materials. The rest of the production will be used for blending[2] into the network through a 6 km pipeline.

The second project is Catalina, an initiative led by a consortium comprising the Copenhagen Infrastructure Partners (CIP), Enagás Renovable, S.A. and Fertiberia. It is located between Andorra, the province of Teruel and 10 other municipalities. The total capital investment amounts to €2.35 billion and the project will be operational by December 2027. It is currently undergoing an Environmental Impact Assessment procedure. It consists of two main elements:

1. A renewable hydrogen generation plant, with an installed capacity of 500 MW, scalable in successive phases up to 2 GW. The plant will produce up to a maximum of 84,000 tonnes/year of green hydrogen, which is intended to be increased to 336,000 tonnes/year from 2030, with a capacity of 2,000 MW, and a corresponding additional investment on top of the initial €714 million.

2. An installed capacity for renewable electricity generation (self-consumption without surplus) of seven wind farms of 897 MW and six solar photovoltaic farms of 729 MW.

[2]Hydrogen blending with natural gas in small percentages with a dilution of the hydrogen's energy value.

Analysis of the production impacts of HYDROGEN

ANALYSIS OF NATIONAL PROPOSALS

	MITERD		ENAGÁS		
	Hydrogen Roadmap	PNIEC 2024	Baseline	*Call for interest*	Maximum potential
Installed capacity 2030 (GW)	**4**	**12**	**13,4**	**23,3**	**74,3**
Hydrogen produced (kt/year)	**125**	**740**	**1.600**	**2.500**	**7.900**
Electricity demanded (GWh)	5.050 - 7.038*	29.896 - 41.662*	64.640 - 90.080*	101.000 - 140.750*	319.160 - 444.770*
Renewable power to be installed (GW)	2 - 3*	12 - 17*	26 - 36*	40 - 56*	127 - 177*
Area occupied by renewables (ha)	6.300 - 8.700*	37.100 - 51.700*	80.200 - 111.800*	125.400 - 174.700*	396.200 - 552.200*
Water consumption (hm3)	1 - 3*	8 - 17*	17 - 36*	27 - 56*	85 - 176*

Table 2. *Summary of hydrogen production projections in Spain.*
**Theoretical calculations carried out by Fundación Renovables. These do not appear in official documents.*
Source: *Enagás and MITERD.*

After the analysis, it can be seen that the electricity required for the government's plans and Enagás' private projects differ greatly. The Enagás baseline scenario doubles the tonnes of hydrogen that the PNIEC projects will be produced while maintaining a very similar power output. This indicates that the private company expects the electrolysers to operate for many more hours than the government calculates, a trend that is included in all Enagás scenarios. Therefore, the electricity needs will be much greater for the scenarios proposed by Enagás and, as the hydrogen has to be of renewable origin, this will impact both the installed renewable power and the region.

In particular, **the demand for electricity** could represent between 40% and 70% of the electricity currently consumed in Spain in the private sector scenarios. This figure is particularly striking when compared to the maximum in the case of the PNIEC, which is 7%; this may not seem like much in comparison, but it still represents a significant commitment to this technology.

The same happens with **renewable power**; in the case of Enagás, this would represent 40% of the current capacity (84.6 GW) in the baseline scenario but exceed it in the 'maximum potential' scenario. For the government scenario, this would mean reaching approximately 12-14% of what there is currently. This is equivalent to approximately 11% of the photovoltaic and wind power projected by the PNIEC for 2030.

This new renewable power **would impact the region** because it would mean occupying up to 1% of the national land area in the case of maximum potential, the equivalent of occupying all of La Rioja with renewables. This is 10 times more than the government's scenario.

In terms of **water consumption**, the government proposes the equivalent of one day's water use for urban water supply in Spain. Enagás doubles this in its baseline scenario; in the Call for Interest this would represent the entire annual consumption of Navarre; and for the maximum potential it would be equivalent to the entire annual consumption of the Basque Country.

ANALYSIS OF THE CASE STUDIES

	H_2 Pillar		Catalina	
	Phase 1	Phase 2	Phase 1	Phase 2
Installed capacity of electrolysers (GW)	**0,03**	**0,06**	**0,5**	**2**
Hydrogen produced (kt/year)	**4,4**	**8,4**	**84**	**330**
Renewable power to be installed (GW)	**0,05**	**0,01**	**1,63**	**No new renewable capacity defined**
Electricity demanded (MWh)	178-248*	356 - 495*	3.393 - 4.729*	13.574 - 18.916*
Operating hours	3.335 - 4.647*	3.441 - 4.796*	2.086 - 2.906*	8.342 - 11.626**
Area occupied by renewables (ha)	1.946,62*	1.991,25*	10.000	Indefinite
Water consumption (hm3)	0,07 - 0,14*	0,14 - 0,28*	1.33 - 2.71*	5.328.960 - 10.834.960*

Table 3: *Summary of hydrogen projects in Aragon.*
Theoretical calculations carried out by Fundación Renovables.* ***These do not appear on the technical specification.*
*****These operating hours exceed those possible for renewable technologies, including those available in a year: 8,760.***
Source: *Catalina, H_2 Pillar.*

The two real projects that have been analysed are in the same Autonomous Community, but there are significant differences in size. When both projects are completed, Catalina is expected to produce 40 times more hydrogen than H_2 Pillar. The electrolyser capacity is some 33 times greater in Catalina.

According to the calculations made, **the electricity demanded** in the second phase of H_2 Pillar represents 4% of what is currently generated in Zaragoza, while the Catalina project would involve doubling Teruel's wind and photovoltaic generation.

On the other hand, with regard to the **renewable energy operating hours, it is clear that these have been scaled down from what is actually required,** since in the Zaragoza project it would be necessary to almost double the projected hours (2,580), but in the case of Teruel these even exceed the number of hours available over the year. The projected hours are 2,049, which is even below the requirements for phase 1.

As for **land area,** in the case of H_2 Pillar it is specified that there is hybridisation between the plants, unlike Catalina where no reference is made to this detail. In the first case, 2,000 ha would be occupied and in the second, without hybridisation, this would be five times greater, although we should remember that even with this occupied surface area, we would still be a long way from achieving the necessary renewable hours; it would therefore be necessary to make an energy purchase agreement or install more renewables with storage systems.

In terms of **water consumption,** the H_2 Pillar project would use 1% of the water supply of Aragón, while Catalina would consume between 8% and 10%.

There are different ranges because the type of electrolyser used in each of the projects is not specified, so a high value represents 100% proton exchange membrane (PEM) electrolysers while a low value would be 100% solid oxide electrolysers (SOEC).

CONCLUSIONS

This report only includes the challenges facing hydrogen in the planning and production phase, with the aim of identifying the current difficulties that projects may face and the reasons why the supply targets are overestimated. However, in this case we have not covered all the challenges involved once produced, as **there is no mention of storage and transport, leaks, and the consumption of a gas as light and unfamiliar on an industrial scale as hydrogen.** This is further detailed in the report Dismantling hydrogen: H_2MED. Cover story for a false energy transition.

Once approximate results have been obtained, some conclusions can be drawn that may help to address the debate on Spain's real potential, the installation capacity, and the effect that production would have at the local level:

- The PNIEC, understood as an update of the Hydrogen Roadmap data, is more consistent in terms of meeting the targets, as the results obtained are coherent with the electricity demand and the capacity of renewables by 2030. However, the annual rate of electrolyser installation up to 2030 would need to be 1,800 MW to reach the figure of 11 GW; this would require an increase in and acceleration of the roll out of renewable capacity. There is some doubt that we will have reached that figure by 2030, especially since green hydrogen cannot currently compete with grey hydrogen, except through high production subsidies, as in the case of European tenders for specific projects.

- Enagás Call for interest. The results obtained from the different analyses show that the planned electrolysis capacity in each of the scenarios is unfeasible, as well as dystopian, for a number of reasons. Even in the baseline scenario, meeting the high electricity demand required by electrolysers would mean that a large part of the land surface would have to be occupied locally to install the renewables needed for generation. It is therefore clear that **the oversizing of Enagás' green hydrogen production, despite the lack of transparency, is a clear sign that the proposed new core hydrogen network will, in the future, be an unprofitable stranded asset, barely covering the necessary transport capacity given the very unlikely possibility that the objectives are achieved.**

- This Call for Interest by Enagás calls into question its role as system manager, not only in terms of gas, but for hydrogen in general. Its direct participation, through its subsidiary Enagás Renovable, as an investor in more than 30 hydrogen and biogas generation projects, as evidenced on its own website, conflicts with the required impartiality, as the company may be an obstacle to the entry of other technologies or market stakeholders. A conflict of interest has arisen that diminishes the credibility of any strategy or energy outlook based on renewable gases.

The differences between small-scale and large-scale projects have become clear, especially when comparing the local and regional impact on the resources extracted and used. Furthermore, it should be kept in mind that the Catalina project plans to cover Fertiberia's hydrogen demand and export to other countries, with significant risks to water resources and the soil, especially given that a large-scale roll out of electrolysers and renewables is planned in Aragon. Clearly, Catalina's export model implies increased risks and pressures on local resources in the area.

As we have always advocated and emphasised, the reality is that there is already an energy vector with a significant installed production, distribution and transport infrastructure: **electricity**. It is therefore time to consider questions such as whether it makes sense to wait for hydrogen to become a mature technology or to continue to electrify consumption, since electricity is more competitive, in economic terms, with its fossil competitors than green hydrogen. In addition, it does not seem very logical to make a large investment to install a transport infrastructure for the production of renewable electricity and then make a further investment in producing hydrogen and transporting it by pipeline. The former is already a mature vector in the market, safe, easy to transport and more efficient.

Hydrogen production in large hubs would require an oversizing of the electricity system due to the significant energy losses associated with its transport and storage. It would also affect the social acceptance of renewable energies in the region, as the capacity to supply them would need to be expanded.

Although it would involve a technical and economic effort, all the fossil hydrogen produced in Spain could be replaced by green hydrogen. But, why would we do this? As we mentioned previously, **grey hydrogen is mainly used in refineries to synthesise derived fuels and fertilisers, promoting the kind of intensive agriculture that depletes resources and stresses the soil. In this way, we would continue to perpetuate the energy model that has existed since the Industrial Revolution and that has led us to the current situation.**

If our ultimate goal is decarbonisation to avoid the greenhouse gases (GHG) that cause climate change, the only option is to take a stand in favour of the energy transition, in other words, to bring about change. **This change begins with renewables and continues with electrification, leaving hydrogen for those cases for which consumption cannot be electrified.**

EUROPEAN H_2 PROJECTIONS

SPAIN · PORTUGAL · FRANCE

1. INSTALLED CAPACITY 2030

- Spain: 12 GW
- Portugal: 5,5 GW
- France: 6,5 GW

2. HYDROGEN PRODUCED

- Spain: 0,74 Mt/year
- Portugal: 0,44 - 0,61 Mt/year*
- France: 0,68 Mt/year

3. WATER USE

- Spain: 8 - 17 hm3*
- Portugal: 5 - 14 hm3*
- France: 7 - 15 hm3

4. ELECTRICITY DEMANDED

- Spain: 29,9 - 41,7 TWh*
- Portugal: 24,7 TWh*
- France: 27,4 - 38,2 TWh

5. RENEWABLE POWER TO INSTALL

- Spain: 12 - 17 GW*
- Portugal: 12,6 GW*
- France: 14 - 20 GW

6. AREA OCCUPIED BY RENEWABLES

- Spain: 37.100 - 51.700 ha*
- Portugal: 37.400 ha*
- France: 800 - 1.100 ha

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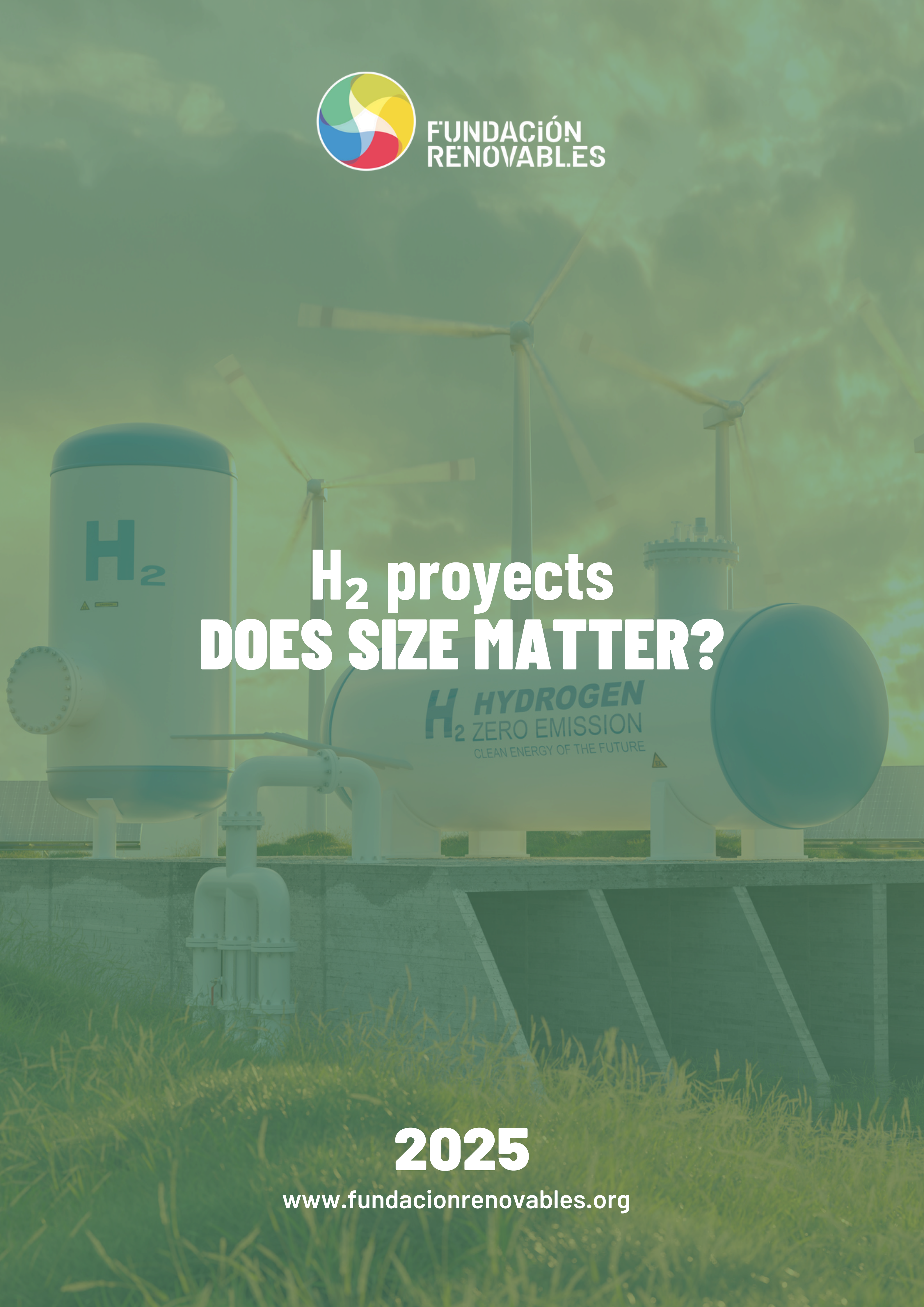

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