HYPOP: supporting the implementation of the hydrogen economy through awareness raising and guidance

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The European Union has identified hydrogen as part of the decarbonisation path to be followed in achieving its net-zero carbon targets (European Commission, 2020). The implementation of the hydrogen economy also supports energy independence and the development of new jobs, skills and technologies. Many national and regional authorities have included hydrogen within their energy and climate plans; however, it appears that in many parts of Europe, the regulatory and procedural apparatus has not yet fully incorporated the specificities of hydrogen technologies.

Project **HYPOP (HYdrogen Public Opinion and accePtance)** found this while working on understanding the public acceptance of hydrogen, exploring also how institutional stakeholders see hydrogen alongside citizens' perceptions.

Mapping the regulatory landscape

Started in June 2023, the project first analysed the state of play in terms of policy, regulations and procedures related to the safety and permitting of hydrogen technologies and systems. The analysis spanned Italy, Spain, Belgium, France, Germany, Switzerland and the Netherlands, as well as the EU 13 (Bulgaria, Croatia, Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia), and mapped quite different situations in terms both of hydrogen strategies and implementation in the field of mobility (e.g. hydrogen refuelling stations) and residential sectors/stationary applications.

While most of the countries mentioned hydrogen as one decarbonisation solution included or under evaluation in their Integrated National Energy and Climate Plan, only half of the countries analysed had a fully developed hydrogen strategy. However, many bottom-up initiatives on hydrogen, driven by regional authorities, private investors or funded projects, could be found even in countries without a clear national hydrogen strategy. In other words, the hydrogen economy is already on the move, with adopters interfacing with public authorities to obtain permits and licences for their plants. The question is: are the procedures in place?

To answer this question, HYPOP analysed if each country's body of regulations and procedures for the permitting and safety of those categories of plants, which hydrogen installations could be assimilated to (e.g. refuelling stations, chemical plants or other gas-related facilities such as storage) included specifics for hydrogen, either as dedicated documents, including guidelines or clauses and processes within existing documents.

HYPOP found that, in general, there is no specific legal framework for the deployment of hydrogen projects and/or well-established procedures. However, among the countries analysed, France, Switzerland and the Netherlands, which started working on the implementation of the hydrogen economy among the first, also showed themselves to be frontrunners in terms of aligning their regulatory and procedural frameworks for both permitting and safety authorisation. For safety, in particular, HYPOP found evidence of hydrogen-specific regulations, codes, and standards/or guidelines for safety evaluation to support the decision-making process.

For many other countries, the adoption of measures developed for other gases or evidence of the assimilation of hydrogen into other gases, e.g. compressed natural gas, regarding safety requirements, was found.

Permitting and safety: gaps in best practices

Interestingly, two main categories of approaches were identified in the safety authorisation regulatory or guidance documents: prescriptive and performance-based.

The **prescriptive approach** to safety is mainly based on standard requirements defined in advance in the regulatory framework. Typical requirements of this prescriptive approach are fixed safety distances from a single component or from the perimeter of the plant to the surroundings. Safety distances can vary according to different factors (e.g. quantities of hydrogen, maximum operating pressures, flow rates of the dispensing systems, or the type of hydrogen technologies themselves). A few countries apply this approach, which has the advantage of providing a fixed reference for designers and adopters of hydrogen installations, thereby supporting both the selection of sites and the budgeting of safety measures. On the other hand, the philosophy behind the prescriptions is not so clear, with significant differences between countries that have adopted such an approach.

The **performance-based approach** is mainly related to the concept of risk assessment, which relates to the specific installation on a case-by-case basis. Both quantitative and/or qualitative tools, used for risk management across different stages of a facility/installation/plant lifecycle, have been developed. Based on the identified risks, avoidance or mitigation measures are proposed. These analyses and risk reduction measures are then presented and discussed with the authority. This is more of an engineering approach that allows the introduction of measures tailored to the specific site as well.

The frontrunner countries had mostly adopted a performance-based approach, alongside a prescriptive one.

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The first year of the project concluded the analysis with an acknowledgement that differences in regulatory responsibilities make it virtually impossible to define a single procedural line that could be applied throughout Europe; however, best practices could be identified and proposed as examples to be adapted to local circumstances. Those best practices cover not just the single procedures, but also organisational and communication approaches.

Engaging authorities: key to success

Direct engagement with authorities was found to be key to the successful implementation of hydrogen technologies in all the best practice cases analysed. This early interaction enabled onboarding and early discussion of planned measures to reduce the impact of the hydrogen installations on the surrounding area (planning), as well as the evaluation of risks and their avoidance or mitigation (safety). This interaction, currently initiated by the authorisation/permitting applicants, could be made more structured through the establishment of working groups involving authorities, users and adopters of hydrogen installations to support advancements in the procedural aspects of permitting and safety licensing. These groups might need to be instituted at the regional level, depending on the statutory duties of the different levels of authorities in terms of permitting and safety, or, in any case, have a strong connection with the regions. Indeed, HYPOP found that very often, within the same country, each regional authority had different approaches.

Another winning element was having, within the authority, a single point of contact for the adopter. In this case, the authority would direct the applicant to the different documentation required to obtain all permits and licences to operate, including those related to safety.

On the basis of these and other characteristics of the best practices, HYPOP developed a set of guidance documents aimed at supporting both parties (applicants and authorities) in the steps required to deal with the most common installations in the mobility and residential sectors, as explained later.

HYPOP framework: supporting decision makers

But how do decision makers understand if the hydrogen installation is also socially sustainable, and how do they communicate this to the citizens? HYPOP developed a framework to provide valuable support for practitioners, decision makers and other stakeholders when making informed and socially oriented decisions concerning hydrogen-related systems. The framework uses the Social Life Cycle Assessment methodology, which integrates social and socio-economic criteria into life cycle assessment. Covering the entire life cycle of a specific system and its supply chain, this methodology informs stakeholders about its potential impacts, checking if it enhances the overall social development of those connected to its supply chain. Reference to the Sustainable Development Goals is made for the selection of the indicators used to assess these impacts (Table 1). Two frameworks were developed, one for decision makers and the other for reporting to citizens. The **HYPOP S-LCA framework for decision makers** emphasises crucial features such as social hotspot analysis and multicriteria decision-making. The **HYPOP S-LCA framework for reporting** (particularly to citizens) identifies social hotspots (i.e. areas of potential social risk or impact) that are relevant to citizens, integrating visualisation techniques to provide individuals with a better grasp of the social factors involved.

Table 1: Social indicators and associated factors used in the HYPOP Social Life Cycle Assessment (S-LCA) framework, aligned with the Sustainable Development Goals.

Sustainable Development Goals	Stakeholder categories	Social indicators	Definition	Factors
Decent work and economic growth; no poverty	Workers	Fair salary	Wage offered to a particular service corresponding to its respective value	Minimum wage required by law; local prevailing industrial wage; living wage
Gender equality		Gender wage gap	Differences between median earning of men and women relative to median earning of men	Median earning by gender
Decent work and economic growth		Forced labour	Work or service that people are compelled to perform without their consent, under the menace of a negative consequence and often without receiving fair wages	Relationship between person performing and exacting the work; human trafficking; debt bondage; exploitation of children
		Child labour	Children aged 7–14 involved in economic activity for at least one hour in the reference week	Children involved
	Society	Contribution to economic development	Extent to which a sector contributes to the economic development of a country	Sector contribution to GDP; public education expenditure; literacy rate
Good health and well-being		Health expenditure	Indicator assessing health systems of the countries	Health status of society; public health expenditure; public health coverage, etc.

Case study: fuel cell bus deployment

The frameworks were tested on a specific case involving the introduction of a fuel cell bus in Spain, concerning both renewable hydrogen production at a hydrogen refuelling station and how that hydrogen is used to power the bus transport service.

https://www.youtube.com/watch?v=Er6mzXOzslo

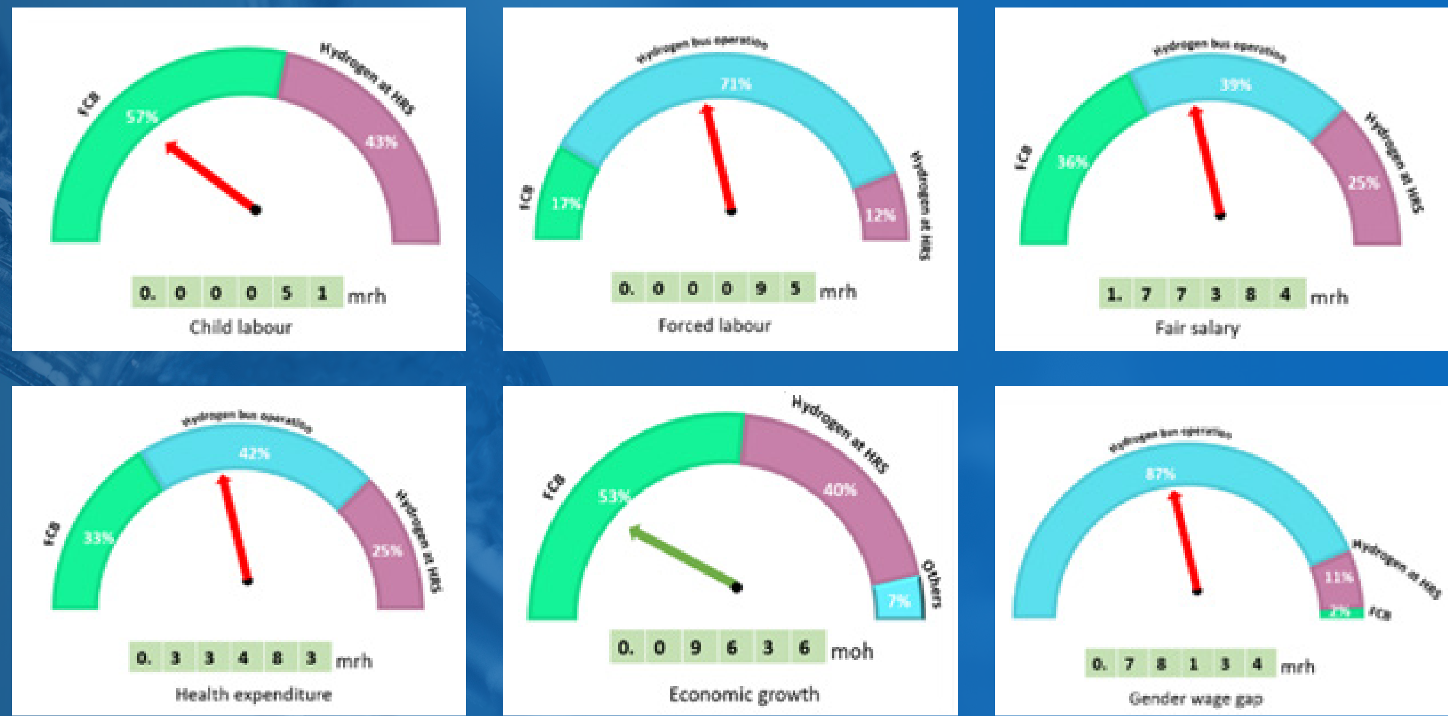

Figure 1: Dashboard of Social Life Cycle Assessment (S-LCA) results for the introduction of a fuel cell bus (FCB) in Spain, including renewable hydrogen production at a hydrogen refuelling station (HRS) and its use in bus operations (values per 15 passenger-kilometres). Indicators shown: child labour, forced labour, fair salary, health expenditure, economic growth and gender wage gap. NB: FCB = Fuel Cell Bus; HRS = hydrogen refuelling station; mrh = medium risk hours; moh = medium opportunity hours.

The results of the assessment are presented in **Figure 1** with a dashboard showing where the selected impacts derive from within the whole value chain.

S-LCA is a powerful tool that, at a broader level, initiates narratives and discussions related to hydrogen within society through a lens of fair transition. The S-LCA results illustrate the potential to bridge the gap between public perception and policy or corporate strategy towards a socially responsible hydrogen economy. However, the methodology for evaluating hydrogen systems still requires further development in consultation with stakeholders.

Beyond the project: HYPOP's legacy

HYPOP project concluded in September 2025, but it has left an important suite of guidance documents on safety, permitting and certification, translated into multiple languages (French, Spanish, Polish, Bulgarian, Italian), complemented by an analysis of the EU situation produced in 2024. These guidelines are mainly addressed to the institutional stakeholders (permitting authorities, fire authorities), adopters of hydrogen technologies and developers of innovative hydrogen technologies.

The S-LCA framework and the full study on the fuel cell bus and the hydrogen refuelling station are also available. Finally, the websites also host guidance for citizen engagement, to support the communication of hydrogen projects to the public, and a gallery of awareness-raising videos on hydrogen and hydrogen projects, as well as infographics and other materials to support public engagement on hydrogen and clear communication on the subject.

Work on education, training, and awareness raising needs to continue to build trust in hydrogen technologies, with the HYPOP legacy contributing to support this effort.

References

European Commission (2020) *A hydrogen strategy for a climate-neutral Europe: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions* (COM(2020) 301 final), 8 July. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301

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PROJECT SUMMARY

The term 'hydrogen economy' was first used in 1970, and hydrogen has been a focus of the International Energy Agency for decades. Hydrogen is a carbon-free energy carrier which can be produced from renewable sources and converted into emission-free electricity via fuel cells. As costs drop and storage and safety improve, revisiting public opinion will be important to acceptance and adoption. The EU-funded HYPOP project aims to raise public awareness and trust in hydrogen technologies and their benefits. It has prepared guidelines and best practices to help people get involved in the implementation of H_2 technologies. Its web platform, based on the outcomes of public engagement activities, provides informative videos and other materials.

PROJECT PARTNERS

The project involves eight partners in six different countries: together with Environment Park in the role of coordinator, the Consortium is composed of three clusters dedicated to hydrogen (Cluster Tweed, Regional Pomeranian Chamber of Commerce with the Cluster of Hydrogen Technologies, BH2C), three research centres (IMDEA Energy, CNH2 – Spanish National Hydrogen Center, IMI – Institute of Methods Innovation) and the European research agency APRE (Agency for the Promotion of European Research).

PROJECT LEAD

Environment Park is involved throughout the project as the **coordinator**. Thanks to their experience in the field of hydrogen and fuel cells, they are also involved in the analysis of the requirements necessary for the installation of FCH technologies. **Aspects related to safety, authorisation and certification** will, in fact, be mapped in the different EU countries, analysing the needs and barriers for stakeholders. In HYPOP, Envipark also collaborates in the development of guidelines and good practices as final project outputs and contributes to the creation of videos and infographics to improve HYPOP's communication activities and raise awareness about hydrogen among citizens.

PROJECT CONTACTS

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