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Foster Hydrogen Technologies into Mediterranean Ports Areas: The Transnational Project H2MOVE

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Abstract. Decarbonisation is the solution to reduce the carbon footprint and combat climate change by promoting responsible practices such as the use of green hydrogen technologies. In particular, the maritime transport sector represents one of the most significant and challenging sectors to decarbonize from an environmental perspective, particularly in terms of its reliance on non-renewable fuels. In particular, the production of green hydrogen, synthesised by electrolysis using renewable energy sources, results in zero carbon emissions, making it a crucial vector for the decarbonisation of strategic sectors. In this perspective, the EU Interreg Marittimo IT-FR-Maritime H2MOVE project aims to transform Mediterranean ports into sustainable maritime hubs by analysing the technological, economic and regulatory issues of integrating hydrogen technologies in ports. The H2MOVE project mainly promotes some key activities to transform ports into sustainable hubs: (I) create a strategic cooperation committee in the cooperation area to support the green transition; (II) involve universities and centres of excellence in green energy to provide scientific support regarding H2 technologies and assess the technological feasibility; (III) analyse the regulatory plans of the involved nations; (IV) encourage the production of a master plan that reviews and summarises all strategies (EU, national and regional) and finally (VI) identify and categorise the hydrogen ecosystem along the supply chain between the involved region and analyse the green hydrogen demand. The Interreg Marittimo IT-FR H2MOVE project aims to create a new cross-border vision between Italy and France that can be developed on a large scale, and the main activities are structured into three work packages. WP1 analyses the governance, the legal framework and the regional, national and European action plans; WP2 defines a master plan up to 2050 for the development of the hydrogen supply chain; finally, WP3 foresees pilot actions and technical and scientific feasibility studies. The coalition and the work of the partners will ensure that a solid and comprehensive public database on the Hydrogen Valleys will be established. The Hydrogen Valleys platform currently being developed includes a large number of valleys that are expected to receive investment over the next few years.



1. Introduction

Ports are a fervent centre of trade activities, both tourist and commercial. Their impact is particularly felt by the population in coastal areas, who very often live in close contact with the port drawing both advantages and disadvantages from it [1]. Climate neutrality in ports is a particularly heartfelt topic [2,3] among the numerous actions that can be carried out to mitigate the disadvantages to live in harbour areas. To face this challenge, governance tools, action plans as well as feasibility studies must be developed, with the aim of identifying the key actions to reduce the port's carbon footprint. Such an objective needs a profound effort by all the involved stakeholders among the transboundary maritime dimension.

The sustainable approach in ports goes through the use of different energy vectors, such as Liquefied Natural Gas LNG [4]. Recently, studies have been conducted to assess the port sustainability using LNG as an alternative fuel to diesel oil, since it is well known the use of LNG represents an effective solution to decrease pollution emissions [5]. The evident environmental benefits coming from the LNG were further studied by Iannaccone et al. [6]: through a multi-criteria analysis that considers environment, economics and safety domains, the authors highlighted that LNG technologies offer better sustainability than marine gas oil. Particularly, LNG or other energy sources have a robust state of the art and could be considered robust technologies in port applications.

On the other hand, to address climate change, many countries started to propose a net-zero greenhouse gas emissions politics up to 2050, mainly focusing on the use of hydrogen H_2 and on the implementation of H_2 in ports [7,8]. In addition, the European Commission recently adopts a measure entitled "A hydrogen strategy for a climate-neutral Europe", proposing to exploit hydrogen as a key energy vector for the transition to climate neutrality in various sectors such as transport, industry, power generation and heating [9].

Concurrently, even other countries are exploring the possibility of integrating ports in the hydrogen chain. Chen et al. in [10] investigated the opportunities for Australia and Japan, starting from the citizens' perspective point of view. Qualitative interviews were conducted, highlighting that significant opportunities exist for both countries. Further investigations about opportunities, infrastructures and facilities were conducted. Surveys have evidenced that at the present time, citizens do not have enough information to understand the challenges, the risks and the opportunities of the integration of H_2 in ports. On the other hand, studies also evidenced that the stakeholders are accumulating expertise and knowledge, while researchers will be able to provide general recommendations for planning and implementing H_2 ports.

In this complex context, the European Commission has made significant efforts to promote and develop sustainable energy and climate policies in member states. In 2021, the European Commission has adopted the new EU Adaptation Strategy that aims to increase efforts to protect nature and people against the impact of climate change [11]. Furthermore, the European Commission supports the planning and implementation of national and transnational projects. This can be possible thanks to the Madrid Conventions, which had the main objective of promoting cooperation and verifying cross-border relations between the regional authorities in Europe [12].

Particularly, the Interreg Marittimo-IT FR-Maritime programme supports the transnational projects between Italy and France, and the cooperation area consists in Liguria Region, Sardinia Region and five provinces of Tuscany Region (Massa-Carrara, Lucca, Pisa, Livorno, Grosseto) from the Italian side and Corsica and French departments of Alpes-Maritimes and Var in France. Among this cooperation area, numerous are ports and industries and the potential growth of the territory is high; nevertheless, the cooperation area is also exposed to risks related to climate change that

must be taken into account. In order to strengthen the cross-border cooperation between Italy and France, the European Regional Development Fund co-funds projects aiming to make the cooperation space competitive and sustainable in terms of innovations, sustainable growth, cross-border cohesion and social development.

Among these considerations, the Interreg Maritime programme 2021–2027 aims to support activities delves in specific macro-themes that are grouped into five categories, in accordance with the European Regulation UE 2021_1058, 2021_1059 and 2021_1060 [13].

- Innovation, competitiveness and sustainable growth (Programme Priority 1).
- Environment, land and climate (Programme Priority 2).
- Mobility, connectivity and accessibility (Programme Priority 3).
- Employment and training (Programme Priority 4).
- Cross-border Cooperation and Cohesion (Programme Priority 5).

In such a scenario, Interreg Marittimo-IT FR-Maritime H2MOVE emerges as a strategic project, part of Priority 3, that aims to support the development of an attractive cross-border territory that shares the challenges of decarbonising maritime and port activities, where carbon emissions play a crucial role. The project partnership will collaborate in the definition of the macro-strategy for the development of hydrogen in ports and adjacent areas.

2. H2MOVE Action Plan

The Interreg Marittimo-IT FR-Maritime H2MOVE project is a strategic project of 42 months being part of Priority 3 (start date 01/03/2024, conclusion date 31/08/2027).

The general action plan is structured into three macro-parts. The first part is the short-term phase (0-6 months) that aims to define the strategic committee and create a call for external experts to participate in the strategic committee. The second part is the medium-term plan (6-18 months); it focuses on the evaluation of the working packages and deliverables and on the engagement of external experts in the next 36 months of the project. The third part is the long-term part (after 18 months) aiming to promote strategic partnerships with key actors, including local authorities, businesses, associations and academic institutions, to consolidate project actions. **Figure 1** shows the H2MOVE project partnership and the work packages (WP).

2.1 WP1 – Governance and preliminary analysis

The WP1 resulted in four deliverables, as listed in **Figure 1** (start 01/03/2024, conclusion 31/08/2025). The project activities started with the deliverable D1.1.1 ‘Composition of the Strategic Cooperation Committee’: the deliverable delves into the creation of the strategic committee, which is composed of Project Partners and external stakeholders. External experts, in particular, are crucial to project development; in this perspective, each partner is asked to identify one or more external stakeholders/ invited partners with expertise in the hydrogen sector that can be strategic into the Cooperation Committee.

The subsequent project activity, outlined below, concerns the ‘Segmentation and mapping of the hydrogen ecosystem within the geographical scope of H2MOVE’ (WP1.2, D1.2.1 product). The objective was to identify and map hydrogen-related projects in the Maritime cooperation and surrounding areas, in order to support the development of cross-border strategic plans and define a roadmap for hydrogen development in ports. The actual database of hydrogen-related projects in the cooperation area and near the cooperation area is shown in **Figure 2**.



Figure 1. The 15 Partners of H2MOVE project and WP of H2MOVE project.

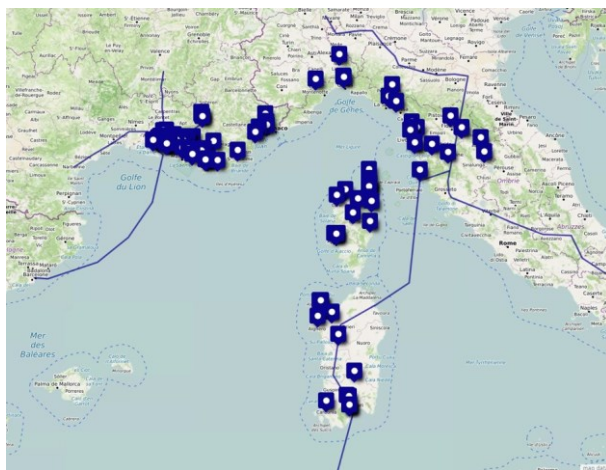


Figure 2. UMAP Cartography. Overview of H2MOVE mapping, (WP1.2, D1.2.1).

Mainly, in Europe, the main form of collaboration in terms of hydrogen studies level is called 'Hydrogen Valley'. Hydrogen Valley refers to a cluster of projects regarding H₂, from production to storage and use. This study highlights that at the present day the Hydrogen Valleys diffusion is limited because of various causes, such as lack in funding and in a complete political legislation, social awareness, lack in specialized personnel and the presence of 'hard-to-abate' industries that operate continuously, as large-scale industries that require mature technologies to operate [14]. In this perspective, in the WP1 project, Partners will study the Hydrogen Valleys for the entire duration of the project and, at the end, the obtained information will be used for future initiatives and collaborations between the project partners and external experts.

Subsequently, the deliverable 'Report on the legal framework in the two countries and obstacles to be overcome' (product D1.3.1), analyzed all the existing legal frameworks in France and Italy, even in terms of environmental impact, highlighting the main guidelines proposed by the National Italian Strategy for hydrogen [15] and the decrees law recently introduced [16].

Further deliverables regarded the 'Report on existing strategies and gaps to be filled' (D1.4.1), and 'Consolidated report on the state of the art of cross-border H₂ sector development' (D1.4.2). The first one analysed the European strategy for H₂ implementation in terms of energy transition and the integration into the existing systems, as well as infrastructure development. Even the hydrogen infrastructure implementation in other European countries was examined; the second one aims to provide a consolidated report about the state of the art of the cross-border hydrogen supply chain.

2.2 WP2 – Border Masterplan

This working package is currently in progress (start date 01/09/2024, conclusion date 28/02/2027). In particular, the WP2 focuses on the definition of a cross-border masterplan for the development of the H₂ sector in the cooperation area. Such masterplan must highlight the guidelines and objectives up to 2030 and up to 2050.

The first deliverable in WP2 (D2.1.1) 'Guidelines for the strategy and action plans' proposes a methodological approach to convert the masterplan into concrete action plans. Particularly, actions must align with the definition of regional/national objectives, based on regional needs. After the identification of needs, the main actions must be defined in terms of resource supply and chronological organization of the activities. The conversion from a Masterplan to concrete actions requires rigorous planning and monitoring stages. Then, each action must be assigned to a coordinator and subsequently implemented, while for each action, performance indicators must be selected, to assess the quality of the obtained results. Such kind of organisation requires a deep knowledge of the involved regions and their needs, considering that needs may rapidly change because of industrial investment decisions or lack/changes in political legislations.

The deliverable D2.2.1 'Cross-border masterplan for the development of the cross-border H₂ sector' is based on previous deliverables and aims to define the strategic directions for the development of the H₂ sector in the specific cross-border area up to 2050.

Nevertheless, the Masterplan must be declinated in different regional action plans, due to the territorial differences within the cooperation area. In particular, production, storage and use of hydrogen must be evaluated in three key-markets: industrial, mobility and residential.

Such activities fall into the writing of five deliverables belonging to the activity 2.3, namely the action plans for each region involved in the Interreg Marittimo IT-FR cooperation area:

- Action Plan in departments of Alpes-Maritimes and Var;
- Action Plan in the Tuscany region;

- Action Plan in the Liguria region;
- Action Plan in Corse;
- Action Plan in the Sardinia region.

The study regarding the industrial application will cover the use of hydrogen as an energy source for various industrial applications, in both port and harbour areas. The study regarding the mobility application will focus on the development (or implementation) of hydrogen-based mobility solutions in the cross-border maritime and land sectors and, finally, the study regarding the residential application wants to encourage the use of hydrogen-based technologies in households, private and public companies living in peri-port areas.

The final activity belonging to the WP2 regards the creation of a manifesto for the implementation of the action plan in the cooperation area and the regional perspective. The manifesto is a letter of intent aiming to confirm the objective of implementing the action plan in the territory. Deeply, such manifesto will illustrate the idea, the commitments, the common vision and the objectives of all the stakeholders involved. The manifesto will be included in Deliverable D.2.4.1. WP2 output is the Masterplan O2.1, namely a strategic roadmap providing a global framework for decision-making and investment planning in the whole cooperation area.

2.3 WP3 – Implementation

The WP3 main pilot action delves in the implementation of the action plan recommendations into ports, for making them green ports (start date 01/09/2025, conclusion date 31/08/2027).

The first activity, 3.1, is a pilot action designed to stimulate hydrogen demand. Particularly, Partners will develop a cross-border H₂ ecosystem mapping platform. The deliverable D3.1.1 will contain details about the H₂ ecosystem mapping platform, highlighting the actors involved in H₂ chain, types of projects, actors interested in the hydrogen green transition and State bodies involved.

Then, in the second activity of the WP3, Partners will develop a decision-support system DDS aiming to guide strategic choice for spatial planning about the hydrogen use in the cooperation area; platform details will be reported in deliverable D3.2.1. Such DDS platform aims to understand the potential impact of the investments on the cross-border regions.

After the spatial planning, technical-economic feasibility studies must also be considered. In the activity 3.3 of WP3 economic studies will be performed, and each contribution will be inserted into the final deliverable D3.3.1.

- Technical-economical feasibility study on the use of H₂ as fuel in ports (equipments and/or vehicles).
- Technical-economic feasibility study on the use of H₂ as fuel for ferries.
- Technical-economic feasibility study on the use of H₂ as a carrier in integrated port energy systems (heating, cooling, electricity).
- Technical-economic feasibility study on the use of H₂ for performing the handling of goods in ports and the connection between port areas and goods-distribution centers.
- Technical-economical feasibility study and the cost-benefit analysis about the green electricity types and the purchase costs.

This WP has two outputs. The first output O3.1 regards the realization of the DDS, the development of the cross-border H₂ ecosystem mapping platform and the development of a main platform that permits the networking between the H₂ actors in the cooperation area.

The second output, O3.2, delves into the technical-economic studies coupled with the decision-support system and the ecosystem mapping platform.

3. Project investment

Two prototypes, property of University of Pisa, will be installed in one Port managed by the ADSP MTS (Livorno, Piombino or Carrara). The prototypes will be temporarily installed into the port, to allow the study of their performance.

- A data acquisition prototype for recording various parameters during the crane's operation into ports.
- Small-scale prototype of a hybrid system for cranes or port vehicles.

The second project investment is the digital platform. The platform will be based on a geographical database, in which it will be possible to identify each hydrogen-related initiative, both geographically and in terms of the information needed to determine its activities, objectives and owners. Such platform will consist of four components. The first component gives information about all the active projects. The second component provides the location and name of the industrial actors interested in the hydrogen supply chain. The third component will cover the active industrial actors along with their project details/markets, and finally, the last component will cover the activities in the hydrogen supply chain, divided by application sector, managed by public bodies.

4. Final remarks and conclusions

H2MOVE project is a strategic project that aims to study the H₂ supply chain in the European framework, particularly in the cross-border regions included in the Interreg Marittimo IT-FR cooperation area [17]. Through the realization of the Masterplan and the adhesion manifesto, the aim is to stimulate interest and to foster the connection between realities operating in the green-hydrogen sector and realities that want to approach the topic. The partners, supported by the presence of external stakeholders, will carry out state-of-the-art studies and technical-economic assessments to foster the development of the hydrogen supply chain into the cooperation area. Furthermore, these studies will allow the realization of an always updated database that will collect all the ongoing projects and entities involved in green-hydrogen chain (private or public).

The realization of a decision support system – DDS, in support of a spatial modelling tool, will enable a more accurate assessment of the geographical areas involved or that can be involved in the Hydrogen Valleys. All the performed studies will lead to the development of two prototypes that will operate for a short period of time into a port, giving crucial information about (I) the use of the hybrid system for cranes or for port vehicles and (II) the working parameters and performances of such system. At the present time the project is ongoing, aiming partners to focus on the present challenges; additionally, technical-economic studies in WP3 could be managed to focus on the newest strategies or H₂ scenario, to espouse as much as possible the continuous evolution of the energy transition scenario in the cooperation area.

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