H2MA

D.1.6.1

Guidelines on how to update and develop H2 mobility strategies

Activity 1.6

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Short description

H2MA brings together 11 partners from all 5 Interreg Alpine Space EU countries (SI, IT, DE, FR, AT), to coordinate and accelerate the transnational roll-out of green hydrogen (H2) infrastructure for transport and mobility in the Alpine region. Through the joint development of cooperation mechanisms, strategies, tools, and resources, H2MA will increase the capacities of territorial public authorities and stakeholders to overcome existing barriers and collaboratively plan and pilot test transalpine zero-emission H2 routes.

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Author/s	Antonio Ballarin Denti, Domenico Vito, Mita Lapi, Stefania Fontana
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EXECUTIVE SUMMARY

This Methodology is the first deliverable of H2MA Activity A1.6 'Integrating H2MA knowledge and resources into partnership territories' H2 and mobility strategies.

It aims to guide partners in integrating key takeaways from H2MA WP1 deliverables results in their H2 and mobility strategies in their respective territories. These key takeaways are to be found in the following deliverables:

- Final report on green H2 mobility infrastructure gaps in Alpine space (D1.1.2)
- Input paper (D1.2.1) and Lessons learnt reports (D1.2.2 & D1.2.3) on planning specifications and requirements for setting up green H2 mobility routes (e.g., urban, and long distance H2 infrastructure)
- Scenarios forecasting the maturity of green H2 production and distribution in the Alpine space (D1.4.2)
- H2MA tool for transnational green H2 mobility planning in the Alpine space (D1.5.3)

To that end, the document provides:

1. An overview of the H2MA project and Activity A1.6.
2. Thematic background on the territorial state-of-play of hydrogen strategic planning at a) EU and b) Alpine space level with a focus on hydrogen mobility and key project findings so far.
3. Identification of potential areas for improvement within the territorial hydrogen strategies and mobility plans.
4. Operational guidelines and to help them update and develop hydrogen strategies and relevant action plans, including definitions, step-by-step process, and model examples.
5. Indicative recommendations to help H2MA partners draft their policy documents.

CONTENT

1. INTRODUCTION

The European Union (EU) committed to achieving carbon neutrality by 2050, has pushed for significant changes in the energy sector. This shift entails reducing reliance on fossil fuels and promoting renewable energy sources. In this context, the transition to a hydrogen-based economy emerges as a promising avenue in mitigating the impacts of climate change, offering a clean energy source that can substantially reduce CO2 emissions and enhance energy security by reducing fossil fuel dependence.

Hydrogen's significance lies in its potential to provide clean and sustainable energy across various sectors, with a special focus on transportation. Mobility is one of the applications of green hydrogen with the highest potential, particularly in hard to electrify areas (e.g., heavy-duty trucks, buses, planes, and ships). Green hydrogen offers a zero-emission alternative to traditional fossil fuels, significantly cutting greenhouse gas emissions and curbing air pollution. This is particularly crucial, given that the transportation sector is a major contributor to global carbon emissions, with lorries, buses, and coaches alone accounting for over a quarter of GHG emissions from road transport in the EU and more than 6% of total EU GHG emissions[1]. While there have been improvements in fuel consumption efficiency, emissions have continued to rise largely due to increased road freight traffic[2].

Several Alpine countries have embraced hydrogen-powered transportation and associated infrastructure, fostering innovation and research in hydrogen mobility. The abundance of renewable energy sources in the area, especially hydroelectric power, offers a unique opportunity for scalable green hydrogen production and distribution. However, substantial infrastructure gaps and disparities persist. The production and distribution infrastructure has not yet reached a critical mass, leading to elevated costs. Furthermore, the Alps region demonstrates an uneven deployment of hydrogen mobility, with some areas rapidly embracing this technology while others lagging behind.

As a result, realising the full potential of hydrogen mobility requires strategic planning and coordinated efforts, particularly in regions like the Alps, where unique geographical and logistical challenges exist. The fact that the Alpine area serves as a critical transit corridor in Europe highlights the need to address infrastructure disparities and establish a comprehensive green hydrogen mobility network through territorial cooperation.

[1]https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en
[2]https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/reducing-co2-emissions-heavy-duty-vehicles_en

1.1 Project overview

H2MA aims to enhance the capacities of territorial public authorities and stakeholders to collaboratively plan and pilot-test transalpine zero-emission H2 routes. This is achieved through the development of cooperation mechanisms, strategies, tools, and policy resources. To this end, H2MA brings together 11 partners from all 5 Interreg Alpine Space EU countries (Slovenia, Italy, Germany, France, and Austria) with the goal of coordinating and accelerating the transnational expansion of green H2 infrastructure for transportation and mobility in the Alpine region. In particular, H2MA aims to facilitate the development of economies of scale by jointly planning policies and testing solutions for the optimisation of H2 mobility routes, thereby strengthening the commercial viability of green H2 mobility.

H2MA's integrated planning and implementation solutions for H2 mobility will facilitate the coordinated deployment of transnational infrastructure for both freight and passenger transport in tandem with urban mobility planning (buses), with a short-term focus on heavy-duty trucks and railways, and a long-term vision that includes maritime and aviation transportation. Through these efforts H2MA will contribute to the transformation of the Alpine region into a sustainable transportation hub, advancing the transition to low-carbon mobility by reducing GHG emissions, mitigating climate change, and decreasing air and noise pollution.

In particular, H2MA will enhance partners and target groups' capacities to:

a. Streamline and coordinate territorial H2 roll-out plans for both commercial/transnational and urban heavy-duty transportation, to promote an integrated approach to supply and distribution planning and build a critical mass for further business development.
b. Design measures to connect H2 production for mobility with renewables, to facilitate the planning of transalpine zero-emission routes for HDVs.
c. Propose areas of harmonisation between H2 Alpine strategies on green mobility, to improve existing policy frameworks.

1.2 Activity A1.6 overview

Activity A1.6 within the H2MA Interreg Alpine Space project FLA aims to provide partners with a clear methodology for integrating WP1 results into their H2 mobility strategies within their respective territories. In particular, these results include crucial insights into infrastructure and policy gaps in the Alpine region (D.1.1.2 by KSSENA), planning specifications and requirements for establishing green H2 mobility routes, both in urban and long-distance H2 infrastructure (D1.2.1 & D.1.2.2 by EMS and D1.2.3 by ITALCAM), forecasts concerning the maturity scenarios of green H2 production and distribution within the Alpine space (D.1.4.1 by ITALCAM and D1.4.2 by KSSENA) and the development of the H2MA tool for transnational green H2 mobility planning in the Alpine area (D.1.3.2 by PVF and D1.5.3 by RL).

This report's analysis outlines specific strategies and an action plan for incorporating the key insights and recommendations from the previous WP1 deliverables into policy planning and implementation for H2 mobility in the Alpine region. Consequently, project partners (KSSENA, BSC, CMT, RL, EMS, PVF, KPO, and 4ER), with support from their respective national counterparts, will propose necessary updates to existing reports, with the ultimate objective of developing novel H2 strategies. Finally, RL will compile the implemented changes from H2 strategies and plans, drawing input from all project partners, and consolidate them into comprehensive policy documents that will outline the anticipated impact of integrating H2MA resources.

2. THEMATIC BACKGROUND

2.1 Territorial state-of-play within H2MA partnership

Green hydrogen has emerged as a critical component of Europe's clean energy transition and sustainability, offering potential to decarbonise various sectors such as transportation, industry, and heating. The Alpine Space area demonstrates a substantial commitment to the expansion of hydrogen mobility infrastructure, with a particular emphasis on the production and utilisation of green hydrogen to decarbonise heavy-duty transportation. This cooperative approach aligns with the broader framework of the European Union's Strategy for the Alpine Region (EUSALP), designed to facilitate the resolution of these challenges and the removal of barriers. The primary objective of this collaboration is to strengthen joint efforts to achieve hydrogen mobility related goals, ultimately working towards a sustainable and green hydrogen-powered future in the Alpine region.

However, it is essential to acknowledge that this collaborative effort presents distinctive challenges specific to each region, particularly in relation to the supply and demand dynamics of green hydrogen in the transportation sector. These complexities are exacerbated by disparities in national and regional green hydrogen requirements, emphasising the need for a strategic roadmap for large-scale green hydrogen mobility deployment among countries and regions within the Alpine Space.

Most countries in the EUSALP have developed their own national strategies and policy frameworks, each outlining specific objectives for green hydrogen infrastructure in the coming years. These strategies often highlight distinct goals especially concerning the use and production of green hydrogen for mobility purposes. Nevertheless, there seems to be a shared focus on the transport sector in the current hydrogen policy debate among Alpine countries.

The H2MA project places a strong emphasis on establishing a transnational collaboration mechanism that enables Alpine public authorities and relevant target groups to work together in planning the rollout of hydrogen infrastructure for heavy-duty transportation. The relevant national and regional strategies along with EU's specific initiatives on green hydrogen mobility deployment and production can significantly contribute to this end, by laying the foundation for the establishment of transalpine governance and action plans for developing green hydrogen mobility supply and distribution value chains in the Alpine area. This section begins with an exploration of the EU hydrogen policy landscape and then discusses the national and regional hydrogen strategies within the Alpine Space Area.

2.1.1 Hydrogen strategic planning at EU

At the European Union level, hydrogen plays a central role in the pursuit of the European Green Deal's objective to achieve climate neutrality by 2050. The EU's Hydrogen Strategy, released in July 2020, offers a comprehensive framework for advancing hydrogen as an essential element in the transition to a sustainable energy system. The EU Hydrogen Strategy follows a roadmap, divided into three distinct phases, each with specific objectives.

- In the short-term phase (Phase 1, 2020-2024), the primary focus lies on decarbonising current hydrogen production methods used extensively in sectors such as the chemical industry and promote the use of green hydrogen for new applications. In this phase, the goal is to establish **a minimum of 6 gigawatts (GW) of renewable hydrogen electrolysers within the EU and the production of up to 1 million tonnes of renewable hydrogen by 2024**, with an annual production capacity of up to one million tonnes of green hydrogen.
- In the medium term (Phase 2, 2025-2030), hydrogen is projected to become an intrinsic part of an integrated energy system. **The total capacity of electrolysers is envisaged to reach 40 GW in 2030, enabling an annual production of up to 10 million tonnes of hydrogen**. Furthermore, the strategy foresees the establishment of an additional 40 GW of electrolyser capacity in the eastern and southern neighbouring countries of Europe, with a particular emphasis on strategic partners like Ukraine to facilitate cross-border hydrogen trade. Hydrogen will gradually expand in new sectors, including energy-intensive industries like steel production and diverse transportation applications. During this phase, hydrogen production will remain closely tied to end-users and renewable energy sources within local ecosystems.
- In the long term (Phase 3, post-2030 towards 2050), green hydrogen’s adoption is projected to expand across all technically feasible applications where it demonstrates cost advantages over alternative green technologies. At that time, **renewable hydrogen technologies should mature and be deployed at large scale to reach all hard-to-decarbonise sectors** where other alternatives might not be feasible or have higher costs.

While the primary emphasis is placed on green hydrogen, the EU Hydrogen Strategy considers and acknowledges the role of alternative low-carbon hydrogen sources, such as natural gas (blue hydrogen) and biomass, during the transition phase in the short to medium term. To illustrate their view of the relative importance, the report outlines a projected cumulative investment ranging from €3 billion to €18 billion for low-carbon fossil-derived hydrogen, in contrast to €180 billion to €470 billion for renewable hydrogen.

At the core of the EU Hydrogen Strategy lies the imperative to establish additional hydrogen production capabilities, specifically through the construction of electrolysers. Considering that current electrolyser production capacity in Europe is under 1 GW per year, it would require a very rapid scale up in electrolyser capacity and/or strong reliance on imported electrolysers to reach the ambitious goal of reaching 40 GW by 2030[3].

Achieving these objectives requires a substantial commitment of funds, and the EU aims to secure approximately €470 billion in combined public and private investments by 2050. To secure the necessary funding for this massive and rapid scale-up, the EU is actively pursuing financial support through public-private partnerships and programs, such as InvestEU and European Clean Hydrogen Alliance. In addition, various EU financial instruments come into play to support these endeavors. Notably, the EU Emissions Trading System (ETS) Innovation Fund is earmarked to amass approximately €10 billion, to bolster low-carbon technologies during the period from 2020 to 2030.

The EU Hydrogen Strategy further highlights the continued need for support schemes to improve the cost-effectiveness of renewable hydrogen at the envisaged scale. To this end, the strategy envisions an amendment to the EU Emission Trading System (ETS) in its upcoming revision. This entails incentivising the production of renewable and low-carbon hydrogen, all while considering the risk of carbon leakage. In addition to the European Clean Hydrogen Alliance, Carbon Contracts for Differences (CCfDs) emerge as an additional valuable support mechanism in the strategy. CCfD involves a public compensation scheme to investors, covering the difference between the carbon strike price[4] and the actual strike price in the ETS.

2.1.1.1 The impact of European Hydrogen Strategy to the energy and transport sectors

In the long term, the EU Hydrogen Strategy is poised to have a substantial impact on several industries, including energy and transport. These sectors hold considerable significance in the context of planning green hydrogen infrastructure and transportation routes within the Alpine area. The following sections outline the opportunities and challenges facing these sectors in relation to the hydrogen strategic planning at the European level.

Energy

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[3] OEIS, *EU Hydrogen Strategy: a case for urgent action towards implementation*, 2020, pg. 3, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/07/EU-Hydrogen-Strategy.pdf.

[4] This is the fixed, pre-agreed price that generators receive for the low carbon electricity they produce for the duration of the contract.

The envisioned scaling up in green hydrogen capacity must align with a corresponding expansion of renewable energy deployment, primarily through large-scale wind and solar plants. The strategy identifies a requirement of €220 billion to €340 billion to scale up and directly connect 80 GW to 120 GW of solar and wind energy production capacity to electrolysers, ensuring a stable supply of electricity.

The EU Hydrogen Strategy also emphasises the importance of energy infrastructure, with plans to repurpose existing natural gas pipelines alongside dedicated hydrogen infrastructure. Germany and the Netherlands, for example, are anticipated to integrate up to 90% of their hydrogen networks from repurposed gas infrastructure. Regulation for this emerging European hydrogen grid remains a challenge, requiring significant investments and regulatory adjustments.

Transport

The decarbonisation of the transport sector in the EU comprises a vital step to meet the standards of the Paris agreement. To this end hydrogen holds promise in significantly reducing carbon emissions within the transport sector. In 2019 the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) published the Hydrogen Roadmap Europe: A sustainable pathway for the European Energy Transition, which proposed a roadmap for the large-scale deployment and use of hydrogen power and fuel cells in Europe. The roadmap proposed the following milestones:

- Passenger vehicles: **a fleet of 3.7 million fuel cell passenger vehicles are projected to be on the road by 2030**
- Commercial Vehicles: **500,000 fuel cell Light Commercial Vehicles and 45,000 fuel cell trucks and buses are projected to be on the road by 2030**.
- Hydrogen mobility infrastructure: **about 3,700 refueling station are expected to be installed by 2030**. Moreover, according to the European Automobile Manufacturers Association (ACEA) at least 300 HRS should be available in 2025 and 1,000 HRS in 2030 that would specifically address the growing refuelling needs of hydrogen-powered heavy-duty vehicles (e.g. FCETs).

The EU Hydrogen Strategy recognises hydrogen's role in transport applications where electrification is challenging, such as city buses and commercial fleets (i.e., vehicles used for transporting goods and groups of people). Hydrogen fuel cells are also encouraged for heavy-duty road vehicles, and hydrogen fuel-cell trains are seen as an alternative for train routes that are difficult or not cost-effective to electrify, noting that certain fuel-cell hydrogen train applications are already cost-competitive with diesel today.

In relation to maritime, the EU Hydrogen Strategy sees hydrogen as an alternative low emission fuel for inland waterways and short-sea shipping and, in the long term, longer distance and deep-sea shipping if fuel cell power is scaled up and renewable hydrogen is used to produce synthetic fuels (methanol/ammonia) with a higher density.

The strategy also briefly addresses aviation, highlighting the production of liquid synthetic kerosene or other synthetic fuels and hydrogen powered fuel cells or hydrogen-based jet engines as potential long-term solutions for decarbonising these sectors. However, these innovations require substantial research, innovation, and aircraft design adaptations.

To facilitate a substantial reduction in the carbon footprint of the transport sector and to enhance the production, use, and distribution of green hydrogen, the EU has set forward a proposal concerning the creation of a new Regulation for the deployment of alternative fuels infrastructure [Alternative Fuel Infrastructure Regulation (AFIR)] with the aim to revise and amend the 2014 Directive on the Alternative Fuels Infrastructure (AFID) and transform it into a regulation. This new regulation which is yet to be approved will form a crucial component of the interconnected policy initiatives within the 'Fit for 55' package[5] aiming at the creation of a comprehensive and efficient network of recharging and refueling stations of alternative fuels across the EU. To this end the AFIR proposal provides a more defined and coherent set of rules and targets concerning the deployment of green hydrogen mobility and the associated infrastructure:

- For hydrogen refuelling the target is to establish **publicly accessible HRS at regular intervals every 200 km along the TEN-T core network, with a minimum cumulative capacity of 1 t/day and equipped with at least a 700-bar dispenser by 2030**.
- At least **one publicly accessible hydrogen refuelling station must be deployed in each urban** node.
- **Liquid hydrogen shall be made available at publicly accessible refuelling stations with a maximum distance of 450 km in-between them by the end of 2030.**
- **Measures to promote HRS deployment through national policy frameworks should be submitted to the Commission by 2024.** Member States shall include a clear linear trajectory towards meeting the 2030 targets, along with a clear indicative target for 2027 that delivers sufficient coverage of the TEN-T core network with a view to meeting developing market demands.

In the context of green hydrogen consumption within the transportation sector, the forthcoming revision of the Renewable Energy Directive II (RED II) foresees that 5.5% of the

[5] The overarching goal of the 'Fit for 55' package is to enable the EU to decrease its net greenhouse gas emissions by a minimum of 55% by 2030, relative to 1990 levels, and to attain climate neutrality by 2050.

total renewable fuels utilised in transport by 2030 will be sourced from advanced biofuels (mainly derived from non-food-based feedstocks) and renewable fuels of non-biological origin (mainly renewable hydrogen and hydrogen-based synthetic fuels), with a minimum allocation requirement of 1% for the latter.

2.1.2 Hydrogen National Strategies in the Alpine space area

Germany

Germany has been a front-runner in the development of a green hydrogen economy. The country has already demonstrated its willingness to take a leading role in the production of green hydrogen and is actively addressing regulatory considerations essential for building up a hydrogen market. In particular, the **German Federal Network Agency** has focused on the establishment of a comprehensive regulatory framework for hydrogen grids, with green hydrogen receiving special regulatory attention. This endeavor culminated in the introduction of a new Renewable Energies Sources Act (EEG) in 2021 (amended in 2023), which for the first time features specific provisions to support the production and industrial usage of green hydrogen.

In June 2020, the country **Federal Government** unveiled its National Hydrogen Strategy (NHS), notably predating the European Union's hydrogen strategy. Germany's overarching ambition is to attain carbon neutrality, with hydrogen assuming a pivotal role in this endeavor. The strategy underscores the importance of green hydrogen, which is the only variant endorsed as sustainable by the German Government in the long-term. In particular, green hydrogen deployment is seen as a potential game changer for mitigating greenhouse gas emissions linked to transportation. Nevertheless, it also acknowledges the role of blue and turquoise hydrogen as transitional solutions in the European hydrogen market.

The strategy is organized into a two-phase plan. The initial "ramp-up" phase, extending until 2023, establishes the groundwork for a well-functioning domestic hydrogen market. The second phase will strengthen this market development and provide a basis for European and international cooperation[6].

The 2020 National Hydrogen Strategy outlines some ambitious goals for hydrogen infrastructure and green hydrogen production:

- **Hydrogen Production Scale-up:** Germany plans to build up to **5 GW of electrolyser capacity by 2030 to meet a projected hydrogen demand of 90 to 110 TWh**. For the period up **to 2035, a further 5 GW will be added if possible, by**

[6] OEIS, *EU Hydrogen Strategy: a case for urgent action towards implementation*, 2020, pg. 3, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/07/EU-Hydrogen-Strategy.pdf.

2040 at the latest. This corresponds to an annual production of up to 14 TWh (or 10 million tons) of green hydrogen and a required renewable electricity quantity of up to 20 TWh.

- **Support Schemes:** Industrial users are encouraged to invest in green hydrogen technologies through Carbon Contracts for Difference (CfD) programs. In doing so, the German Government guarantees to support the differential costs between actual abatement costs or a project-related, contractually defined CO2 price per avoided quantity of greenhouse gas emissions and the ETS prices. This will significantly reduce the risk of changing CO2 prices for investors.

- **Hydrogen Transport:** Expanding hydrogen transport and distribution capacity is crucial for facilitating the use of green hydrogen in each of the identified application areas (energy and energy storage, industrial use and fuel alternative). The strategy proposes the expansion of already existing hydrogen infrastructure while further considering the rededication of existing natural gas infrastructure that is no longer needed for natural gas transport.

- **Public Funding:** Germany commits to providing €7 billion in public funding to support hydrogen technology market development.

In July 2023, an updated version of the National Hydrogen Strategy was unveiled. While affirming the continued validity of the original strategy, this update seeks to accelerate the market ramp-up by introducing “specific, toughened measures in order to make a contribution to Germany’s transformation to a climate-neutral economy by 2045”. The update responds to the evolving global landscape, emphasising the significance of supply security, particularly in light of the energy crisis and the Ukraine conflict. It also aims to send an “important industry policy signal” to the world, bolstering Germany's position as a business and industry hub and contributing to job creation and global competitiveness.

The 2023 strategy update redefines several targets for the period until 2030, including:

- **Doubling domestic electrolyser capacity for green hydrogen production to 10 GW by 2030**.

- Establishing **a "hydrogen start-up grid" with 1,800 km of new and refurbished infrastructure by 2027-2028** (also connection with neighbouring countries through the European Hydrogen Backbone initiative).

- Expanding hydrogen applications in industry, heavy-duty commercial vehicles, air and shipping transport, H2-ready gas power plants.

- Positioning Germany as a "lead supplier for hydrogen technologies" by 2030.

- Creating the right framework conditions at European and international level (e.g. efficient permit procedures, joint standards and certification systems).

To reach the 2030 Targets the updated strategy outlines measures in four distinct areas of action for the short (by 2023), medium (by 2024/2025), and long term (until 2030):

a) **Ensure Sufficient Hydrogen Supply by 2030:** The anticipated total hydrogen demand of 95-130 TWh by 2030, will necessitate significant imports, particularly through shipping, and exploring options like green methane, synthetic methanol, and LOHC (Liquid Organic Hydrogen Carrier) for the medium to long term.

b) **Establish Robust Hydrogen Infrastructure:** The 2023 strategy envisages core hydrogen grid proposals and regular gas grid planning expansion on a national level, with a focus on the pushing for clear framework conditions for grid development at EU level (European Hydrogen Backbone), on commencing negotiations and strengthening collaborations with partner countries on cross-border joint production and distribution clusters and on developing infrastructure for imports from third countries.

c) **Establish Hydrogen Applications:** Measures will include support for industry through "climate contracts," IPCEI projects, and other programs, along with strategies for hydrogen transformation in transport, electricity, and heating sectors.

d) **Create Effective Framework Conditions:** Addresses planning and permit procedures, sustainability standards, and certification, research, innovation, and skills development.

Although not explicitly addressed by the National Hydrogen Strategy but mentioned in an official document of the Federal Ministry of Transport and Digital Infrastructure (BMVI) there are targets to increase the number of refuelling stations for FCEVs **to 400 in 2025 and 1,000 in 2030**. There are also projections for reaching **8.000 FCEVs by 2030, 1.200 buses by 2030 and 200.000 FCETs (N3/>12t) by 2030** [7].

The National Hydrogen Strategy and its implementation will have a substantial impact on some core areas and markets, such as the energy, transport and infrastructure sectors. Meeting the strategy's goals requires substantial expansion of renewable energy facilities, particularly offshore wind and onshore wind projects. Green hydrogen production is expected to complement renewable energy and contribute to energy storage solutions. With regard to infrastructure, Germany recognizes the need for partnerships with other countries to access production facilities outside its borders. Regulatory questions regarding the transport of green hydrogen within Germany are being addressed. Lastly, as regards the applications of green hydrogen in transportation, the introduction of fuel cells

[7] See H2MA Deliverable D.1.1.2 “Final report on green H2 mobility infrastructure gaps in Alpine space”.

can complement battery-electric mobility in public transport systems (buses and trains) in the short term and potentially for the German shipping sector in the medium term. The national strategy also makes plans to develop and integrate fuel cell technology in regional aviation (hybrid system).

Governance

In order to successfully implement and develop the National Hydrogen Strategy, it is vital to ensure continuous monitoring of progress and to identify potential needs for adjustment. A flexible and output-oriented governance structure has been created to facilitate this goal. This structure ensures the involvement of the relevant stakeholder groups and facilitates efficient cooperation. The following provides a detailed overview of the various stakeholder interactions.

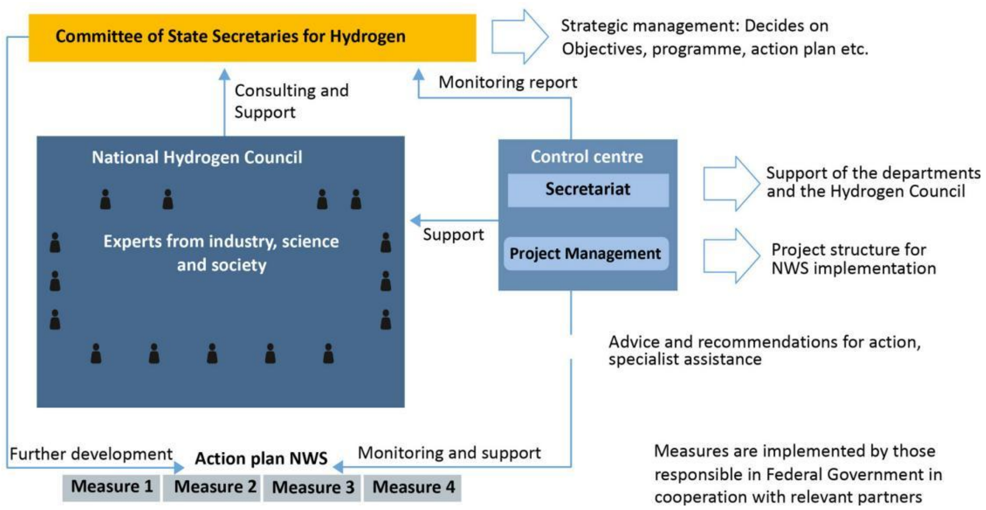

Figure 1. Governance of the National Hydrogen Strategy Germany
Source: /www.bmwk.de/

France

France's strategic approach to hydrogen deployment and its particular emphasis on green hydrogen mobility demonstrates its commitment to sustainable development and transitioning to a low-carbon economy. This commitment is supported by a well-developed legal framework and ambitious targets, positioning France as a key player in the global hydrogen landscape. This framework was initiated with the introduction of the Multiannual Energy Program (PPE) in 2018, which has played a pivotal role in shaping the country's hydrogen strategy. Furthermore, the 2019 Mobility Orientation Act laid the groundwork for hydrogen refueling stations catering to private vehicles, buses, and ships.

On 8 September 2020, **the Minister for the Economy, Finance and Recovery,Bruno Le Maire, and the Minister for the Ecological Transition**, Barbara Pompili, announced a **major Government initiative to develop the hydrogen industry in France.**
France unveiled its National Strategy for the Development of Decarbonised Hydrogen, aiming to create favorable conditions for France to be at the forefront of the development of a veritable carbon-free hydrogen market. This comprehensive strategy encompasses a wide range of measures to facilitate the widespread adoption of hydrogen technologies across key sectors, aligning with the broader climate change mitigation goals and the pursuit of carbon neutrality.

France's hydrogen strategy revolves around three primary objectives:

1. **Increasing Carbon-free Hydrogen Usage in Industry:** The country aims to drive industrial decarbonisation by installing sufficient electrolyser capacity to achieve **6.5 GW by 2030, with expected production capacity of 10 TWh in 2023 and 20 TWh in 2030**. Pursuant to the government's Multi-Annual Energy Programme (PPE), the overarching target is to reach a rate of 10% carbon-free hydrogen for industrial usage by 2023. In the long-term, the core objective is to have 20-40% of total hydrogen and industrial hydrogen consumption sourced from low-carbon and renewable hydrogen by 2030.

2. **Advancing Carbon-Free Hydrogen in Heavy Mobility:** France seeks to promote carbon-free hydrogen use in heavy mobility applications. According to the Hydrogen Distribution Plan for the Energy Transition that was presented in 2018, there should be **5,000 light trucks, 200 buses and heavy-duty vehicles equipped with hydrogen fuel cells** and **100 HRS in 2023**. The goal is to scale up to **20,000-50,000 light trucks, 800-2,000 buses and heavy-duty vehicles equipped with hydrogen fuel cells** and **400-1000 HRS by 2028**.

3. **Supporting Research and Development (R&D) and Skills Development:** The strategy prioritizes fostering innovation and expertise in the hydrogen sector.

In 2021, France established the "Ordonnance n° 2021-167 du 17 février 2021 relative à l'hydrogène" (Ordinance on Hydrogen) complements other national initiatives, including the National Strategy for the Development of Decarbonized Hydrogen. This comprehensive ordinance addresses crucial aspects such as:

- **Hydrogen taxonomy** by categorizing it into renewable, low-carbon and fossil fuel-based on production methods and greenhouse gases emissions.

- **Government support schemes** for low- and zero-carbon production, setting out the framework.

- **Guarantees of origin and certification regimes** for green or low-carbon hydrogen.

- **Regulatory requirements for hydrogen deployment and its transportation** via the gas grid with a long-term view of building a hydrogen market and contributing to the security of supply.

To support the decarbonisation of industry, France is committing significant public support, with an investment plan of €7 billion until 2030. Substantial financial support, totaling €50 million annually, has been allocated to the hydrogen sector as part of the Multiannual Energy Program for 2019-2023 and 2024-2028.

Governance

A national hydrogen committee with representatives from all industrial stakeholders, chaired by the Minister for the Economy, Finance and Recovery, will be tasked with tracking the rollout of the investment programme and monitoring the objectives set by the national strategy.

Hydrogen-specific laws and regulations are expected to be introduced in France over the coming weeks and months.

In accordance with the legislative authorization granted to the Government by the Energy and Climate Act of 8 November 2019, one or more orders are likely to be enacted in the coming weeks, establishing the framework applicable to hydrogen production, transportation, storage and traceability, as well as the related support mechanism.[8]

Italy

Italy recognises the importance of hydrogen deployment in achieving its binding target of reducing national greenhouse gas emissions by 55% by 2040 while also increasing energy production from renewables. The plan promotes the utilization of power-to-gas (P2G)[9] technologies, focusing particularly on the use of electricity produced by renewable energy sources in order to curtail the carbon footprint of the hydrogen production.

Italy's favorable geographical position and well-developed gas transport network, connecting the southern region to North Africa and Middle East, provide a strategic advantage for the development of green hydrogen production and distribution. Despite its potential, the roll out of green hydrogen infrastructure in Italy faces considerable challenges due to regulatory concerns, such as the absence of specific legislation for green hydrogen production through electrolysis and the lack of incentives for P2G plants. The

[8] https://www.cliffordchance.com/content/dam/cliffordchance/briefings/2020/10/focus-on-hydrogen-eur-7-2-Billion-strategy-for-hydrogen-energy-in-france.pdf

[9] Power-to-Gas (P2G) represents the method of converting excess renewable energy into hydrogen gas using electrolysis technology. This hydrogen can then be injected into the natural gas distribution network. This integration allows for the displacement of natural gas, resulting in a reduction in greenhouse gas emissions and a decrease in dependence on high-carbon energy sources.

current regulatory framework for hydrogen production mainly addresses fossil fuel-based production, leading to lengthy administrative procedures. Moreover, specific regulations for green hydrogen through electrolysis are lacking. Transport and distribution networks also need regulatory clarity, while technical specifications for hydrogen injection into gas grids need to be developed further.

Hydrogen consumption in Italy is currently limited to industrial processes, primarily utilizing grey hydrogen. Currently, only a small portion of hydrogen produced in Italy is low- or zero-carbon. However, the country anticipates increased production of green hydrogen aknowledghig its potential for various applications, including transport, heating, and industrial uses due to decreasing renewable energy and electrolysis costs.

Simplified authorisation processes for green hydrogen production, clear classification of hydrogen based on technologies, and incentive mechanisms for P2G plants are essential to unlock the full potential of hydrogen in Italy's energy transition. Pilot projects and research activities are also expected to play a crucial role in testing and optimising existing natural gas transmission and distribution networks.

Italy's commitment to the European Green Deal and its energy transition goals are reflected in its National Hydrogen Strategy Preliminary Guidelines. Italy is actively advancing its green hydrogen mobility strategies, aiming to transform its energy landscape and contribute to reduced greenhouse gas emissions. Key elements of Italy's hydrogen strategy include:

1. **Electrolysing Capacity:** Italy is committed to developing substantial electrolyser capacity, **targeting at least 5 GW by 2030 and 50 GW by 2050**. This capacity expansion aligns with the growing hydrogen penetration in final energy demand, which is expected to reach 2% of the national energy demand by 2030 and 20% of the demand by 2050 .

2. **Hydrogen Refueling Stations (HRS):** The country intends to build a comprehensive hydrogen refuelling station network to accommodate the expected increase in fuel cell electric vehicles (FCEVs), including buses and trucks. Partners have identified the following objectives and projections: (i) the installation **of 40 HRS by 2030**, (ii) the existence of **2,000 FCEVs by 2025, with an ambitious goal of reaching 30,000 by 2030** and (iii) the deployment of **4,000 FCEVs with a further ambition to reach 10,000-14,000 units**[10]**.**

3. **Railroad Conversion:** Italy plans to convert up to 50% of existing diesel railroads to hydrogen-powered systems, promoting eco-friendly transportation options.

[10] See H2MA Deliverable D.1.1.2 “Final report on green H2 mobility infrastructure gaps in Alpine space” and H2MA. Territorial Perspectives and Development Potentials: Italy, 2023. https://www.alpine-space.eu/project-news/territorial-perspectives-and-development-potentials-italy/

4. **Hydrogen Energy Mix:** Italy aims to achieve a 2% share of hydrogen in its overall energy mix, reducing greenhouse gas emissions and contributing to decarbonisation.

The government acknowledges the need for substantial investments, including €10 billion at the national and European levels between 2020-2030. This budget covers hydrogen production, distribution facilities, R&D, and infrastructure integration. Italy has also allocated nearly €60 billion of their National Recovery and Resilience Plan (NRRP) to energy transition efforts, including boosting renewable energy, such as green hydrogen. This commitment demonstrates Italy's determination to become a leader in the green hydrogen sector.

Governance

We report here the Regulatory bodies of the Italian framework at various levels for projects related to hydrogen

Regulatory Body	Role
Local Public Authorities and regulatory bodies (Regions, Municipalities, ARPA, Others) Local Fire Department	• Regulates the use of the land; • Assess the compatibility of the project with the Land Use Plan; • Assesses the safety of the plant and any relevant fire risks.
Ministry for Ecological Transition (formerly Ministry of the Environment and Protection of Land and Sea)	• Grants the Integrated Environmental Authorisation
Ministry of Economic Development	• Regulates import/export activities
Ministry of Economic Development ARERA (the Italian Regulatory Authority for Energy Networks and Environment)	• Regulates new pipelines and decommissioning • Regulates the gas network, including fees

Source: https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/italy

Austria

Austria recognises the pivotal role of hydrogen in increasing the national share of renewables in final energy consumption and complying with European legislation. Austria's primary focus is on increasing green hydrogen production levels and establishing an extensive refueling infrastructure, both publicly and privately owned, in order to achieve climate neutrality by 2040.

Despite the large-scale hydrogen initiatives that exist in the country and several legal acts that touch upon the processes of hydrogen production and distribution, the country lacks a hydrogen-specific legal framework. In 2019 the Austrian government launched a Hydrogen Initiative, with plans to amend the existing legal framework through the introduction of the Renewable Expansion Act. Nevertheless, the process has been delayed leading to ongoing reliance on existing gas legislation and, when necessary, EU law.

To bridge this gap Austria presented its National Hydrogen Strategy in 2022 focusing on ramping up hydrogen deployment. The key pillars of Austria's hydrogen strategy include:

1. **Increase of Electrolyser Capacity with a goal of reaching at least 1 GW by 2030.** This ambitious expansion aims to meet the expected rising demand for hydrogen.
2. **Replacing fossil fuel-based hydrogen with climate neutral hydrogen in energy intensive industries by 80 % until 2030**.
3. **Development of an integrated hydrogen infrastructure, by gradually converting the gas infrastructure into a targeted hydrogen infrastructure**.
4. **Development of hydrogen technology for economic and transport sectors, echoing Austria's ambition to lead in the global hydrogen arena**.

Governance

We report here the Regulatory bodies of the Austrian framework at various levels for projects related to hydrogen

Regulatory Body	Role
Municipality	The respective municipality makes the decisions on land use plans.
State (Bundesland)	The "Bundesland" is a one-stop-shop for the Environmental Impact Assessment
Gas Connect Austria as Transmission System Operator (“**TSO**”)	Gas Connect Austria is responsible for the safe operation of a high-pressure natural gas pipeline network. It is up to the transmission system operator to decide whether hydrogen can be injected into the gas grid.
AGGM Austrian Gas Grid Management AG	AGGM is the independent System operator of the Austrian gas network.
E-Control GmbH	E-Control monitors and supports the implementation of the liberalisation of the Austrian electricity and gas markets.

Source: https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/austria

Slovenia

At present, Slovenia lacks both a national hydrogen strategy.*
However, the country's vision for hydrogen is articulated through two key documents: the Integrated National Energy and Climate Plan of the Republic of Slovenia (NECP), which was released in 2020, and the Resolution on Long-Term Climate Strategy until 2050, issued in the summer of 2021.
One of the important national documents for alternative fuels in transport is ACTION PROGRAM FOR ALTERNATIVE FUELS IN TRAFFIC, 2019. In this document the hydrogen production capacity is not defined, nor the number of refueling station, however, the number of H2 vehicles are: by 2030, 2% of H2 vehicles first registered is planned.
Moreover the Transport Development Strategy of the Republic of Slovenia Until 2030, that states that by 2030 there should be 5.559 personal vehicles on H2, 455 lightweight commercial vehicles, 57 buses, 800HDV on H2.
According to the NECP, Slovenia views hydrogen as a potential contributor to its renewable energy goals (aiming for a 27% share of renewable energy by 2030) while also enhancing energy security and pursuing decarbonisation. Furthermore, in alignment with its Long-term Climate Strategy, Slovenia's indicative objective is to introduce 10% of renewable hydrogen (or synthetic methane) into transmission and distribution networks by 2030, primarily through pilot projects. By 2040, the nation aims to replace 25% of natural gas with hydrogen and/or synthetic methane, ultimately phasing out natural gas entirely by 2050. With regard to the transport sector, the country aims to inject green hydrogen into its existing gas network, with aspirations to meet approximately 7% of fuel demand with hydrogen by 2040. Additionally, Slovenia is exploring the adoption of hydrogen-powered vehicles as an alternative solution for challenging-to-electrify transportation sectors, such as road freight transport.
The Transport Development Strategy of the Republic of Slovenia Until 2030 defines regarding hydrogen different lines of intervention

- **Measures to promote the use of hydrogen and fuel cell vehicles (chap 4.2)** in this field in the country established the Development Center for Hydrogen Technologies. By 31 December 2025, the state is also obliged to provide an adequate number of publicly accessible charging points that will enable both local traffic and cross-border connections. By 2020, the implementation of a demonstration project is planned, which will have a comprehensive business model and will provide charging infrastructure and vehicle

- **Promotion of research work and innovation** (chap 4.2.1) : Slovenia will promote industry-related research work to maintain its place among manufacturers and suppliers for the automotive industry

- **Development of demonstration project:** Slovenia has a hydrogen filling station (chap 4.2.2). in accordance with the chosen technology, the construction of four, or eight hydrogen filling stations in the period after 2023 is foreseen. The construction of charging stations/infrastructure will have to be fully subsidized (mainly with grants from the EU - according to experience so far, only strong consortia of EU cities and the largest bus manufacturers have obtained such funds). By 2020, the preparation and implementation of a pilot project is planned, which will comprehensively regulate the procedures, from the provision of hydrogen and the appropriate charging infrastructure to the area of users (public transport, public services), in order to verify the entire business model of the use of fuel cell technology.

  Within the framework of the demonstration project, measures are foreseen to encourage the purchase of vehicles, eliminate administrative obstacles, prepare educational programs and promotional campaigns. Implementation is planned with the following measures:

  - ✓ V1 and V2: subsidizing the purchase of hydrogen fuel cell vehicles and crediting the purchase of vehicles,
  - ✓ V3 and V4: co-financing of the purchase and installation of the charging infrastructure and implementation of the pilot project

To achieve these targets, Slovenia plans to establish a market and a *market development strategy* for renewable hydrogen (supported by a guarantee of origin scheme) while also promoting infrastructure development and creating a suitable legislative framework for the use of the two gases (i.e., natural gas and hydrogen).

Governance

The first hydrogen refueling station in Slovenia was commissioned in 2013. It was co-financed by the EU and coordinated by the Center of Excellence for Low-Carbon Technologies (CONOT). The development of hydrogen in the country has been slow however the government has taken steps toward adopting green hydrogen. In 2017, the Slovenian government revealed its commitment to stimulate alternative fuels including hydrogen, and to stop the sales of new petrol and diesel cars by 2030.

The environmental fund of the Republic of Slovenia provides loans at low-interest rates to renewable energy projects through tendering.

The tender loan calls are for applications that subsidize the reconstruction and renovation of renewable energy plants. This loan applies to residents, local communities, and corporations. All renewable energy sources technologies are eligible for soft loans or loan guarantees. The technologies eligible for the loan are wind, solar, geothermal, biogas, hydropower, and biomass.[i]

2.2 Identification of potential areas for improvement within the territorial hydrogen strategies and mobility plans

In light of the European Union's more ambitious climate targets, the green hydrogen rollout has gained increasing importance within national initiatives to implement the energy transition. Almost all EU countries have formulated strategies or action plans where they acknowledge the long-term opportunities associated with green hydrogen production and utilisation. Yet, the national laid-out plans differ in ambition, breadth and level of specificity and concreteness. Based on the review of national and regional strategies and considering the key findings from prior deliverables, several areas for improvement within territorial hydrogen strategies and mobility plans have been identified, along with provisional recommendations.

1. ESTABLISHING CLEAR AND SPECIFIC TARGETS FOR GREEN HYDROGEN MOBILITY AT NATIONAL AND REGIONAL LEVELS

The hydrogen mobility planning of Alpine countries presents various differences which manifest particularly in the definition of objectives, the formulation of hydrogen mobility plans, and the emphasis on building green hydrogen infrastructure.

For instance, although all Alpine countries, have set explicit targets for the growth of green hydrogen production capacity in both the short- and long-term, not all have articulated concrete or explicit objectives regarding the share of hydrogen in fuel consumption or the anticipated number of hydrogen refuelling station (HRS) installations, fuel cell electric vehicles (FCEVs), and fuel cell electric trucks (FCETs). It's worth noting that these specific targets do not find explicit mention within the official documents of their respective national hydrogen strategies. Instead, they are derived from supplementary reports and statements, resulting in a somewhat fragmented representation and definition of their hydrogen mobility planning efforts.

In case of Slovenia, information on these objectives can be found inside the EU project NORTH ADRIATIC HYDROGEN VALLEY signed in March 2022 by representatives of the Slovenian Ministry of Infrastructure, Croatian Ministry of Economy and Sustainable Development and Friuli Venezia Giulia (FVG) Autonomous Region in Italy, contributing to the European Green Deal and European Hydrogen Strategy goals.

Here some references: NORTH ADRIATIC HYDROGEN VALLEY, PRESS RELEASE.

To ensure the successful implementation of the hydrogen economy, particularly in the transport sector, it is imperative not to limit planning solely to electrolysis capacities. Developing precise, quantifiable, and comparable infrastructure targets (e.g., the number of hydrogen refuelling stations and their allocation within the Trans-European Transport

Network, projected figures for fuel cell electric vehicles and fuel cell electric trucks) a will facilitate the tracking and monitoring progress against those objectives, aiding in identifying gaps and obstacles and further promoting cross-border cooperation and partnerships.

2. TRANSALPINE POLICY HARMONISATION THROUGH THE ADOPTION AND INTEGRATION OF EU TARGETS AND BENCHMARKS INTO NATIONAL STRATEGIES AND TRANSALPINE GREEN HYDROGEN MOBILITY

Current disparities in economic structures, coupled with variations in hydrogen utilisation and potential energy demands among countries significantly influence the formulation of national targets. As a consequence, diverse national priorities emerge concerning the deployment of green hydrogen and the establishment of nation-specific hydrogen value chains. Nations with more ambitious plans for expanding renewable energy and experiencing higher energy consumption growth tend to be more inclined to adopt hydrogen as an additional energy source.

A recent study commissioned by the Fuel Cells and Hydrogen Joint Undertaking, has formulated demand and production scenarios for green hydrogen across EU countries. The study has projected both low and high scenarios for electrolyser production capacities and the requisite input of renewable energies by the year 2030. For instance, due to its substantial demand potential, Germany is expected to possess the highest production capacities, with projected capacity averaging 8.35 GW, more than twice that of the second-largest producer, France, at 3.25 GW.

Enhanced cross-border policy collaboration can play a crucial role in bridging infrastructure gaps and establishing clear targets and benchmarks. This approach is instrumental in effectively implementing a unified hydrogen mobility infrastructure across the EU and the Alpine region. To this end the integration of EU directives into national legislation is essential for ensuring the effectiveness of regulatory measures supporting the rollout of hydrogen production. To achieve this, national plans should align their medium and long-term goals with the targets and benchmarks outlined in the EU hydrogen strategy, drawing upon EU-wide consultations. Investment support, as part of the European Green Deal, will be pivotal, with the European Commission taking a leading role in steering these investments.

In the context of the Alpine region, hydrogen mobility encounters unique geographical challenges and policy disparities that call for transalpine cooperation. Survey results from the H2MA project have revealed varying rates of progress in hydrogen development across the Alps. Continuous transalpine and transnational collaboration through knowledge sharing, expertise exchange, and cross-border strategic initiatives will enable territorial actors to overcome infrastructure barriers. This cooperative effort should primarily focus on harmonising policies, regulations, and standards across borders, fostering consistency, and creating a conducive environment for businesses.

3. TRANSALPINE COLLABORATION IN ESTABLISHING A SHARED MOBILITY PLAN FOR ALLOCATING HYDROGEN REFUELLING STATIONS IN THE TEN-T NETWORK IN LINE WITH EU TARGETS

Almost all countries are assigning green hydrogen a key role in their strategies for decarbonising transportation. In addition, most countries recognise the potentials of fuel cell-powered trucks in road freight transport. Fuel cell-driven cars and buses are also identified by most countries as a viable options for passenger traffic, despite frequent acknowledgment of the competition with battery-driven electric cars as a growth impediment. Less frequently mentioned is the application of hydrogen in other modes of transportation, such as aviation, shipping, and trains. Table 2 below presents the application fields explicitly highlighted by the Alpine countries as potentially suitable, as discerned from their national hydrogen strategies (where available) or other policy documents:

Table 2: *Hydrogen application areas mentioned in national policy plans of EUSALP countries.*

	Heating	Energy	Industry	Transport				
				General	Passenger	Truck	Aviation	Maritime
Austria		x	x	x		x	x	x
France		x	x	x	x	x		x
Germany	x	x	x	x	x	x	x	x
Italy			x	x	x	x		x

Slovenia		x		x				

Survey findings further highlight an uneven distribution of existing hydrogen stations within the Trans-European Transport Network (TEN-T). To address this issue, it is imperative to engage in a transalpine strategic infrastructure planning that would ensure more equitable allocation of new HRS along major transportation corridors in the Alps. This will facilitate widespread access to hydrogen FCEVs, with a special emphasis on heavy duty transportation. Moreover, a shared mobility plan for the establishment of HRS will take into account interoperability considerations related to HRS, further reinforcing the foundation for a robust and integrated hydrogen infrastructure network. The designing of territorial HRS networks across the Alpine region should be also aligned with the EU target of establishing HRS every 150 km along the TEN-T core network with a minimum cumulative capacity of 1 t/day and equipped with at least a 700-bar dispenser by 2030.

4. TRANSALPINE COORDINATION IN ESTABLISHING A SHARED PIPELINE DISTRIBUTION NETWORK

Emphasis should also be placed on developing an efficient shared network for hydrogen distribution, with a primary focus on repurposing existing natural gas pipelines. This approach will contribute to a reduction in transportation costs while mitigating the limitations associated with hydrogen storage options in regions with high demand. A transalpine pipeline network will also ensure a reliable supply to hydrogen refuelling stations and end-users while enabling scalability and further growth of hydrogen mobility, allowing Alpine regions to meet their ambitious targets.
On this vision we can mention the European Hydrogen Backbone (EHB), an initiative that consists of a group of thirty-three energy infrastructure operators, united through a shared vision of a climate-neutral Europe enabled by a thriving renewable and low-carbon hydrogen market.The EHB initiative aims to accelerate Europe's decarbonisation journey by defining the critical role of hydrogen infrastructure – based on existing and new pipelines – in enabling the development of a competitive, liquid, pan-European renewable and low-carbon hydrogen market.The initiative seeks to foster market competition, security of supply, security of demand, and cross-border collaboration between European countries and their neighbours[11].

[11] https://ehb.eu/

5. ESTABLISHING COMMON SAFETY STANDARDS AND REQUIREMENTS IN THE DESIGN AND OPERATION OF HRS

Common safety guidelines and regulations concerning safety standards for the design and operation of HRS must be clearly defined and commonly adopted. These guidelines should be comprehensive, taking into careful consideration the inherent risks and hazards associated with hydrogen deployment. It is important for all countries in the Alpine region to adopt commonly accepted risk management plans during the planning and deployment phases of HRS along with establishing a robust safety management system.

Such an approach not only fosters social and political acceptance among stakeholders but also promotes knowledge sharing, ensuring that safety and quality standards are consistently upheld across the Alpine infrastructure network. The commitment to uniform safety standards is vital for the establishment of an integrated and high-quality Alpine green hydrogen market.

2.3 Review and analysis of relevant case studies

To date, various national hydrogen strategies have been put into action, with most of them including provisions for future updates. These updates hinge on various inputs including studies (scientific data), technological advancements, international best practices, peer pressure, stakeholder consultations, pilots as well as scenarios and forecasts pertaining to the evolution of green hydrogen deployment. Moreover, scenarios forecasting the evolution of green hydrogen deployment can help decision makers to better understand the nature of current trends and their impact on driving. In particular, trends related to policy matters, economic conditions, technological advancements, and geopolitical considerations can act as catalysts for policy reformulation, leading to the setting of more ambitious targets or the amendment of existing ones. This section will present two case studies of hydrogen strategy reformulation:

- Germany's recent revision of its National Hydrogen Strategy in 2023 and
- France's updates of its hydrogen strategy in 2020 and 2023.

The brief exploration of these case studies offers valuable insights into how contemporary energy trends, combined with geopolitical considerations and forward-looking forecasts, can shape the strategic planning of green hydrogen rollout. Understanding how these factors intersect within the energy landscape and influence strategy formulation will help partners to evaluate various contingencies and tailor their own forecasts to update and align their strategies with potential outcomes associated with each forecasting scenario.

Case study 1: Germany's Hydrogen strategy update

Germany unveiled its comprehensive national hydrogen strategy in 2020. In 2023, the country updated its strategy, building upon the existing 2020 roadmap and introducing a set of more ambitious targets covering domestic production, imports, infrastructure, applications, and technology. A significant alteration in this updated strategy pertains to Germany's objectives for domestic green hydrogen production. To bolster production, Germany has elevated its domestic electrolyser target from its prior aim of achieving 5GW of domestic renewable hydrogen capacity by 2030 to an impressive 10GW. This shift signifies Germany's determination to foster homegrown green hydrogen and stimulate economic growth in the sector, with the ultimate goal of becoming the leading market for hydrogen technologies by 2030.

In the case of Germany the influence of geopolitical factors and current energy trends played a significant role in the government's decision to realign its national strategic objectives. Specifically, in its introduction, the updated strategy highlights the necessity to reassess the supply goal outlined in the 2020 strategy, driven not only by climate protection imperatives but also from a security policy perspective. This shift is notably underscored against the backdrop of the war in Ukraine and its global ramifications on energy markets, as evidenced by the recent gas energy crisis.

From the standpoint of Germany's energy security, the recent international and geopolitical developments indicate the vulnerabilities associated with excessive reliance on energy imports from specific countries, notably its dependence on Russian gas. Consequently, strategic planning regarding the deployment of green hydrogen must factor in the imperative of enhancing energy autonomy through increased domestic production and supply.

Apart from the geopolitical factors and energy security concerns, the revision of Germany's hydrogen strategy was also underpinned by meticulous forecasting and substantiated by relevant research and comprehensive action plans. Given Germany's well-developed hydrogen infrastructure and the surging demand for hydrogen, the projected scenarios indicated that the nation was well-positioned to attain its 2020 targets with ease. Moreover, maturity scenarios forecasting an increase in FCEVs and FCETs and an overall expansion of green hydrogen production in the country, revealed the need to set new infrastructure targets. The updated objectives encompass the construction or refurbishment of 1,800 km of pipelines by 2030, alongside significant investments in storage and import infrastructure. Despite the challenges ahead, especially in meeting these new objectives within the specified timeframe, Germany's revised hydrogen strategy showcases its commitment to its broader mission of achieving net-zero emissions by 2045.

Case study 2: France's Hydrogen updates

France took an early lead in the field of hydrogen with the launch of its hydrogen plan back in 2018, setting specific objectives for hydrogen development. In 2020, the country undertook a comprehensive update of its strategy, with a renewed emphasis on the advancement of decarbonised hydrogen. In particular, the 2020 hydrogen strategy aimed at achieving 6.5 GW of electrolysis capacity by 2030, a pledge which, at the time of its announcement, was the largest initial pledge from a member state.

This revision was informed by implementation forecasts as well as from input and data gathered from consultations with experts and key stakeholders representing various sectors, including research, industry, and institutions. These consultations contributed to the identification of the obstacles that need to be overcome to establish a fully-fledged hydrogen value chain. The identified challenges encompassed technical, regulatory, and financial barriers, as well as obstacles regarding research and development (R&D) and the transition to industrial-scale production. Additionally, the data revealed a marked advancement in both technological and economic maturity within the hydrogen landscape, thereby permitting the adoption of more ambitious targets.

Much like Germany, France's decisions surrounding the amendment of its overall hydrogen strategy have also been influenced by concerns related to energy sovereignty. Specifically, the 2020 hydrogen strategy focused solely on domestic hydrogen production, opting not to commit to imports of hydrogen – a route explored by other northwest European member states such as Belgium, the Netherlands and Germany.

In response to the Russia-Ukraine conflict and the remarkable progress made within the hydrogen sector since 2020, the French government has announced another update to its hydrogen strategy in 2023. This potential update could entail an increase in the expected hydrogen production capacity, with the goal of reducing the nation's dependence on energy imports. Moreover, the planned 2023 update places a pronounced emphasis on 'decarbonised' or emissions-free hydrogen production, which is due to aid the decarbonisation of emissions-heavy industries (e.g., steelmaking, cement, fertilizers, long-distance transport, aviation). The use of such terms instead of using green or renewable hydrogen is likely associated to the substantial nuclear capacity in France that could produce hydrogen with zero emissions. Given France's commitment to achieving net-zero emissions by 2050, the proposed 2023 update of the hydrogen strategy underscores the nation's dedication to sustainability and aligns with its overarching environmental goals.

3. GUIDELINES FOR INTEGRATING H2MA RESULTS INTO POLICY DOCUMENTS

3.1 Methodological approach of strategic planning

3.1.1 What is strategic planning?

Strategic planning is a systematic and structured process that governments use to define long-term goals and objectives around a specific thematic area and to develop a clear roadmap on how to achieve them. It involves assessing the state-of-play, analysing relevant factors to acquire a better understanding of future developments, and creating a plan that outlines the actions that are required. Strategic planning typically covers a multi-year horizon and serves as a guiding framework for decision-making and resource allocation.

In the case of green hydrogen infrastructure, strategic planning helps to establish a clear sense of direction and purpose. It ensures that all stakeholders coming from politics, business or civil society are aligned and work towards common goals. This alignment fosters better communication, collaboration, and coordination among all interested parties. Moreover, it assists them in making informed decisions about resource allocation, including financial, human, and other resources. In a rapidly changing geopolitical environment, sound strategic planning for hydrogen allows governments to respond to external energy disruptions and anticipate market opportunities. Finally, since strategic planning typically assigns responsibilities and timelines for various initiatives, it allows responsible authorities to track and monitor KPIs and milestones, assess regular performance, and make adjustments to the initial plan if necessary.

3.1.2 The development of strategies and action plans

Strategic planning for hydrogen encompasses two main document types: strategies and action plans. While most strategies are formulated at the national level, some are also to be found at the regional level, as is the case with Bavaria and Piemonte regions, among others. **Strategies** serve as the conceptual framework or roadmap for achieving a goal, while defining the ‘what’ and ‘why’ of achieving this goal. **Action plans** on the other hand, focus more on the practical steps to be undertaken to achieve the overarching objectives. They aim to translate a strategy’s key objectives into concrete actions. An action plan has three major elements: a) specific tasks: what will be done and by whom, b) time horizon: when will it be done, and c) resource allocation: what specific funds are available for specific activities.

Developing a **national strategy**, such as one for hydrogen, is a complex and comprehensive process that involves several key steps and considerations. While the exact methodology may vary depending on the specific national context, the development of a national strategy typically follows the following steps:

1. INITIATION AND PLANNING

The process usually begins with the government identifying the need for a strategy. In the case of hydrogen, this need is driven by environmental goals, economic objectives related to energy autonomy, and current technological advancements. During strategic planning, governments tend to engage with a wide range of stakeholders, including industry experts, scientists, environmental groups, businesses, and the general public, to gather input and build consensus on the strategy's priorities.

2. RESEARCH AND ANALYSIS

Another important step in the planning process is the collection of data on the current state of the hydrogen sector, including production methods, the existence of infrastructure, and market trends. The analysis of the collected data aims to assess the maturity and potential of hydrogen technologies, including green hydrogen production, storage, and distribution. According to the results of the analysis and the development of maturity scenarios forecasting hydrogen deployment, each strategy sets specific quantified targets and goals.

3. GOAL SETTING

This step lies in the core of strategy development. The establishment of clear objectives, that are specific, measurable, achievable, relevant, and time-bound (SMART), is key for a successful strategy. Yet, in many cases, strategies fail to include specific and quantifiable targets, which can undermine the strategy’s implementation and overall efficiency. On the contrary, strategies that establish quantified objectives across a predefined timeline, have the most chance of being successfully implemented.

4. DEVELOPMENT OF A POLICY FRAMEWORK

Beyond the overarching strategic vision of the strategy, it is essential to establish a policy framework, including regulations, administrative bodies and financial incentives, which will streamline the implementation of the strategy. For this purpose, the development of an **action plan**, which provides specific policy measures and actions across various sectors within the hydrogen value chain (e.g., a hydrogen mobility plan) can significantly contribute to the attainment of the strategy’s objectives. Action plans typically include legislative changes and funding mechanisms (public and private sector investments, grants, subsidies), emphasize timelines, define responsible parties and assign tasks (as for example the setting of safety standards and specifications), and establish performance metrics, which are especially valuable for tracking and monitoring progress toward predefined targets.

5. MONITORING AND EVALUATION

Strategies and/or action plans typically include a framework for monitoring progress and evaluating the strategy's effectiveness. This allows regular reporting on KPIs attainment and milestones and making adjustments to strategic planning or the relevant action plan as needed.

6. COMMUNICATION AND PUBLIC ENGAGEMENT

Effective communication is often an inherent component of strategies. It outlines how the strategy will be communicated to the public and stakeholders (including educational materials, campaigns, or public meetings and events to raise awareness) and how feedback will be collected and incorporated. Involving stakeholders in both the strategy's development and implementation through diverse communication channels can help identify potential barriers, public concerns and allows for adjustments and mitigations where required.

3.1.3 How to update a strategy or an action plan?

Updating a strategy or an action plan is a proactive approach to ensure that it remains relevant, effective, and aligned with changing circumstances in a dynamic environment. In most cases, the need for an update arises due to external factors, such as geopolitical issues, shifting market dynamics, changing environmental conditions and public concerns. The war in Ukraine for example, that changed the geopolitical landscape and created the need for more energy security, has played a crucial role in accelerating strategic planning for the development of renewable energy sources (RES) and hydrogen technologies. Conversely, a significant drop in oil prices might have slowed down the overall decarbonization process, calling for less ambitious targets and goals and more subsidies for RES development.

As is the development of a strategy or action, the process of updating them is a complex procedure that involves several key steps and requires input from various sources to allow policy makers to make informed decisions.

The **first step** to initiate an update is **to gather input** from various sources, namely:

- **Scientific research and expert feedback**. This includes new studies, including technological advancements, related to the subject matter as well as input from experts in the field, whether from academia or industry. For instance, new findings on hydrogen risks can inform the strategy's technical aspects with stricter safety specifications or enrich an action plan with a more detailed risk assessment protocol.
- **Market analysis, including maturity scenarios and forecasts**. These provide a better understanding of supply chains, demand and supply and allow the responsible authorities to make more precise market projections. This analysis can also incorporate insights, factors and trends beyond the market itself integrating, environmental concerns and the existence of other strategies promoting sustainability (such as electric mobility).

- **International best practices**. The process of adopting successful practices from other regions or countries is sometimes referred to as "policy transfer." By studying innovative solutions and effective policies implemented elsewhere stakeholders and policy makers can identify mistakes and ineffective approaches, thus saving time and resources. Yet, it is crucial to make a careful assessment of the suitability of the foreign policies in the local context, since what works well in one place may not be directly applicable in another and adaptations or modifications might be required.
- **Projects' outcomes.** These can cover a wide range of inputs from projects and initiatives, such as pilot studies and public/private stakeholder collaborations. Projects' outcomes may include know-hows, innovative solutions, planning tools, algorithms, proofs of feasibility, new business models, policy recommendations, guidelines, prototypes, demonstrators, databases and datasets, trained researchers, new infrastructures, networks, and so many more. H2MA Interreg Alpine Space project outcomes lie in this category.

The **second step** in updating a strategy is to **adapt input gathered to local context**. While technological advancements, market analysis and international best practices offer valuable lessons, it's crucial to consider the local context when applying these insights. Project outcomes on the other hand are usually already tailored to local contexts since they tend to address geographic-specific issues. This increases their suitability for directly informing current strategies and action plans.

The **third step** is to **develop specific policy recommendations** that can enhance and improve an existing strategy or action plan. These recommendations are intended to emphasize recurring patterns, emerging trends, and aspects in which the current strategy may require enhancement or improvement.

Finally, the **fourth step** consist in addressing public authorities or other institutions responsible for the preparation of strategies and action plans and **advocate** for their adoption and the refinement or update of the existing strategy or action plan. This step involves the development of a clear and persuasive communication strategy and the engagement with relevant political authorities and decision makers on the one hand, and with relevant stakeholders on the other. The latter can include industry actors, advocacy groups, community organisations and can help gain support for the proposed policy changes.

3.2 Developing strategic pathways for hydrogen development based on the H2MA WP1 outputs

The H2MA Interreg Alpine Space project has the objective of coordinating and accelerating the cross-border roll-out of green hydrogen infrastructure for transportation and mobility across the Alpine region. As a result, the project has a hands-on approach and leverages proven methodological tools (e.g., surveys, study visits) and solutions (e.g., planning tools, collaboration mechanisms) that have already demonstrated success in other projects and programs. The results of the corresponding activities will be actively disseminated within the partnership territories to ensure their widespread adoption, ultimately ensuring substantial impact and facilitating the desired update of national, regional, and transalpine policies.

H2MA Work Package 1 (WP1), covering the first 2 periods of the project focuses on setting the ground for the joint strategic planning for green hydrogen mobility. It involves the development and utilisation of tools, resources and H2 maturity scenarios to jointly coordinate the expansion of hydrogen infrastructure and the design of commercial and urban mobility routes. The last activity of WP1, Activity A1.6, aims to capitalise on the outcomes of previous WP1 activities (A1.1-A1.5) and ultimately lead to updates in territorial hydrogen strategies and action plans. Partners are expected to use these Guidelines to integrate WP1 results into policy papers that will inform specific updates to existing policy documents (e.g., national, and regional strategies, mobility plans) or will help develop new hydrogen strategies based on H2MA findings.

For the update of strategies, a three-step process is envisioned:

Step 1: Identifying key takeaways from WP1 outputs

Step 2: Identifying discrepancies between these findings and national/regional strategies

Step 3: Formulating policy recommendations for knowledge and insights integration in key strategic areas

The following sections provide detailed information on these steps.

3.2.1 Step 1: Identification of H2MA WP1 key takeaways

In this step, partners who will be tasked with writing policy recommendations for the update of their national or regional strategies should identify and analyse key findings and the conclusions derived from the WP1 deliverables. These findings correspond to the outputs of four distinct activities: A1.1, A1.2, A1.4, and A1.5 (which received input from A1.3). The key outcomes are outlined here.

3.2.1.1 Activity A1.1. Green mobility infrastructure gaps in Alpine space Policy

Within Activity A1.1, partners mapped their respective territories to identify a) existent and planned hydrogen mobility infrastructure, b) hydrogen mobility targets set in European, national, and regional frameworks and c) discrepancies between the two. The final report

(D1.1.2) analysed the survey results and elaborated on key findings that emerged throughout the analysis.

Some of these **key findings** are presented below:

1. While most countries have declared their political commitment to promote green hydrogen mobility, most strategies don't have concrete quantifiable targets.
2. Existing hydrogen refueling stations (HRS) are not evenly distributed across the TEN-T Network. Strategic infrastructure planning to ensure improved distribution of new HRS along major transportation corridors and urban centers in the Alps is urgently required.
3. Hydrogen development in the Alps is progressing at different speeds, hindering the trans-Alpine roll-out. To respond to the unique geographical challenges of the Alps, a transalpine cooperation mechanism is needed.
4. Policies, regulations, and standards (e.g., safety standards) are not harmonised among Alpine countries.
5. There aren't enough hydrogen vehicles in the freight and urban transport. Most heavy-duty trucks still operate on fossil fuels and only some buses got electrified.
6. Hydrogen distribution is being done through transportation with hydrogen tracks or liquid hydrogen tankers. This type of transportation is costly and suitable only for small quantities and will not be sustainable in a scale-up.

Based on the above-mentioned findings the following **recommendations** have been developed.

A) Setting quantitative targets for hydrogen mobility at national and regional level.
B) Improving strategic infrastructure planning to ensure optimal distribution of HRS on the TEN-T network.
C) Fostering transalpine collaboration partnerships.
D) Developing harmonised policies and standards.
E) Promoting coordinated fleet conversions to achieve economies of scale.
F) Prioritising the development of a pipeline network.

3.2.1.2 Activity A1.2 – Planning specifications and requirements for setting up green H2 mobility routes

Activity 1.2 concerned two study visits in HRS in Strasbourg, Région de Grand Est (organized by EMS and PVF) and in Augsburg, Bavaria (organized by ITALCAM) with the aim to provide hands-on knowledge on planning requirements needed for integrating green H2 in a) urban transportation, focusing on buses and b) commercial long-distance transportation, focusing on trucks and trains. Two study visit reports summarize the main results and lessons learnt from the study visits, focusing on key planning specifications and technical, economic and safety requirements that were identified during each study visit.

During the two site visits to HRS in Germany and France, partners and stakeholders had the opportunity to observe significant variations in architectural design and refuelling purposes. The first HRS has been designed to serve primarily commercial long-distance vehicles, while the second focused on enabling interoperability for electric vehicles, FCEVs, FCETs, and urban buses. These differences in design and safety specifications stem from the absence of standardized regulations, technical specifications, and safety standards for hydrogen. Partners also observed that the level of safety requirements was largely determined by the station operator. For example, the R-Hynoca station in Strasbourg conducted its own risk assessments and studies, resulting in a custom design with enhanced safety specifications. Additionally, it included a risk management platform within the station's design, which served to train maintenance personnel and first responders in effectively addressing hydrogen-related risks.

Partners responsible for crafting policy briefs to update strategies should extract insights from the reports of the two study visits and consider ways to incorporate this knowledge into national strategies and action plans. The objective is to foster greater coordination and harmonization in the development of safety standards across the Alpine region.

3.2.1.3 Activity A1.4 – Maturity scenarios on green H2 production and distribution

As part of Activity A1.4, partners engaged in a collaborative effort to formulate maturity scenarios for the supply of green hydrogen in the Alpine region. Initially, they identified and ranked influential factors, barriers and trends expected to shape the adoption of hydrogen and renewables within their respective territories. Subsequently, they synthesized the collected data to create forecasting scenarios, encompassing a range of projections, including baseline, pessimistic, and optimistic scenarios. These scenarios stand as valuable resources that partners can use to propose recommendations for the enhancement of their national and regional strategies. More specifically, they can inform decisions regarding the location and scale of hydrogen production and supply infrastructure, optimizing HRS allocation on the TEN-T network to meet future demand. Maturity scenarios can also help public authorities prioritise investments, launch incentives and supportive frameworks for diverse target groups to encourage the adoption of hydrogen technologies.

3.2.1.4 Activity A1.5 – H2MA planning tool to cooperatively design transnational green H2 mobility supply and distribution networks across the Alpine space

The objective of Activity A1.5 is to create a planning support tool using Geographical Information Systems (GIS) as a foundation. In general, GIS's key advantage lies in its ability to model complex systems and simulate various scenarios. For instance, it can estimate the potential output of renewable energy sources like solar or wind farms, guiding the sizing and placement of hydrogen production facilities. GIS also models hydrogen transport and storage, identifying potential bottlenecks and optimizing infrastructure design.

This A1.5 tool is expected to play a critical role in spatial planning and the optimisation of the hydrogen mobility network design. The tool will be highly helpful in identifying suitable locations for hydrogen production and storage facilities, as well as refueling stations for land vehicles like trucks and trains. In addition, the tool will be able to analyse factors such as population density, land-use patterns, renewable energy accessibility, and transportation infrastructure to further optimise (in terms of efficiency, coverage, and cost-effectiveness) network design.

Overall, the A1.5 planning tool is expected to provide insights for the update of current strategies and mobility plans in the following areas:

1. **Site selection**: It can be employed for the identification and selection of suitable locations for hydrogen production and storage facilities, as well as HRS for heavy-duty vehicles. GIS data can be used to analyse factors such as proximity to renewable energy sources, transportation infrastructure, population density, and land-use patterns.
2. **Network design**: GIS can be used to design the hydrogen distribution network, including the routing of hydrogen pipelines and the placement of hydrogen storage tanks. It will help analyse factors such as distance, terrain, and land-use patterns to minimize the costs and environmental impacts of the network.

3.2.2 Step 2: Identifying shortcomings of national/regional strategies

The second step requires good knowledge of the existing strategies and action plans coupled with an understanding of the regional and local authorities' receptiveness and willingness to develop new ones. Drawing on the key findings and results of the above outcomes, partners should firstly identify the strategies that could benefit from an update and secondly identify any shortcomings (both in terms of content and formulation) to make targeted policy update recommendations rather than general, one-size-fits-all suggestions that will not correspond to territorial needs. Below, the current and future strategic development pathways that could benefit from an update per country are presented.

Slovenia

Slovenia has been working on its **National Hydrogen Strategy** since 2022. However, the strategy has not yet been officially published. This strategy is expected to set a goal of meeting 7% of fuel consumption, particularly in the transportation sector, with green hydrogen by 2040. KSSENA is actively involved in the strategy's drafting working group as a technical partner. In this role, it will be well positioned to employ H2MA outcomes and planning approach to suggest:

a) Optimal infrastructure expansion for transalpine routes.
b) Pathways for the development of hydrogen ecosystems in regions that heavily rely on coal.

Additionally, the **Action Plan on Alternative Fuels Infrastructure** from 2019, issued by the Slovenian Ministry of Infrastructure under Directive 2014/94/EU (transposed in 2017), mandates the rollout of hydrogen infrastructure. KSSENA is in direct collaboration with the Ministry's working group responsible for monitoring and yearly revisions of the plan's measures. In this capacity, KSSENA could focus on improvements related to:

a) Increased deployment targets for green hydrogen infrastructure.
b) Cooperative initiatives in coordination with other Alpine countries.
c) Green hydrogen quotas within the transportation sector.

Austria

Austria's Hydrogen Strategy, unveiled in 2022, currently places a lower priority on hydrogen transport applications. As a research partner 4ER will suggest to re-evaluate this approach. Drawing upon the H2MA WP1 results, 4ER will get in contact with the Ministry of Environment (BMK) and suggest to define at least targets for the green hydrogen infrastructure within the mobility sector. Drawing upon the H2MA WP1 results, 4ER can advocate for the reprioritization of green hydrogen within the mobility sector.

But to ensure alignment with both national and regional hydrogen strategies and transportation infrastructure plans, policy and governmental the observers, Land Carinthia, and AustriaTech, have expressed a keen interest in the forthcoming policy recommendations for Austria that will be generated through H2MA Activity A1.6. This proactive engagement underscores their dedication to maintaining congruence with not only national but also regional hydrogen strategies and transportation infrastructure plans.

France

The **Strasbourg Climate Plan 2030**, established in 2020, articulates a set of measures designed to foster the growth of an infrastructure network supporting hydrogen mobility and associated technological innovations. These efforts align with the plan's overarching priorities: 'Improve air quality for all' and 'Promote sustainable mobility' outlined under Priority 1.2. As the plan's owner and executor, EMS can directly leverage the H2MA WP1 outcomes to enhance its knowledge and capabilities in coordinating the regional rollout of hydrogen infrastructure, with a specific focus on the development of infrastructure for heavy-duty vehicles, urban buses and the already planned port-based HRS.

Moreover, PVF, a key contributor to the **Bourgogne-Franche-Comté H2 Roadmap** in 2019 and a participant in its ongoing monitoring as the Region's thematic expert, is well-placed to leverage the insights and planning methodologies of H2MA. In this role, PVF could:

a) Offer recommendations for streamlining regional investment planning from a transalpine perspective.
b) Propose revisions to specific sections of the Roadmap, particularly Section 4 ('Mobility uses'), focusing on hydrogen infrastructure configurations for trains and HDVs.

Additionally, PVF played a pivotal role in crafting the **Grand Est H2 2020-2030 Strategy** in 2020 and continues to participate in its monitoring as the Region's thematic expert. Drawing upon the pilot results and resources generated by H2MA, PVF can guide the Strategy's implementation in two key areas:

a) Expanding the scope of green hydrogen mobility applications and facilitating coordinated infrastructure expansion for HDVs, trains, and ships.
b) Ensuring the growth of relevant business ecosystems by identifying and promoting public-private collaborations.

Furthermore, in collaboration with regions, municipalities, and stakeholders in the green hydrogen mobility sector along the River Rhine, including those both within and beyond the Alpine space, Strasbourg, KPO, and PVF are planning to initiate an **Interregional Hydrogen Strategy** in 2023/2024. This strategy aims to coordinate hydrogen port infrastructure developments. H2MA outcomes can serve as the precursor to this envisioned pan-Rhine hydrogen strategy, which seeks to harmonize distinct territorial hydrogen strategies while emphasizing their integration with renewable energy sources, marine transport, and road transportation.

Germany

In 2020, Baden-Württemberg adopted a **Hydrogen Roadmap** that placed significant emphasis on establishing a refueling network and integrating hydrogen-powered Heavy-Duty Vehicles (HDVs) into public and commercial transportation systems. H2MA partner KPO can leverage WP1 resources and the A1.5 planning tool to, inter alia:

a) Facilitate the coordinated expansion of hydrogen infrastructure, mapping regional hydrogen demand in the mobility sector along with the Baden-Württemberg Ministry of the Environment.
b) Accelerate the development of the local business ecosystem in the hydrogen sector.

Italy

CMT is currently in the process of formulating an **Urban Logistics Plan**, set to be finalized in 2023. This plan underscores hydrogen as a pivotal decarbonization solution for both mobility and industry. As the primary author and executor of this plan, CMT will be well positioned to utilise H2MA WP1 studies, forecasts and planning methodology, to:

a) Enhance the precision of planning requirements for hydrogen mobility refueling infrastructure.
b) Advocate for the seamless integration of hydrogen production and distribution ecosystems with renewable energy production with emphasis on safety requirements and specifications.

Moreover, the **Piedmont H2 Valley Protocol**, established as a collaborative framework with the Italian government to facilitate hydrogen rollout in the region, is geared towards expediting infrastructure development within the mobility sector and fostering research and development initiatives. Leveraging its active participation in H2MA, CMT, a key contributor to realizing the Protocol's objectives, will provide support by enhancing the local planning for forthcoming HRS infrastructure, streamlining WP1 resources and tools.

In addition, the Lombardy Region is currently on a trajectory to craft a comprehensive **Regional Hydrogen Strategy** in 2024, with a specific focus on the mobility sector within the Alpine area. The results of the H2MA activities can be seamlessly integrated into this forthcoming strategy in the following ways:

a) Maturity scenarios can help establish targets for the general infrastructure rollout.
b) The planning tool can help optimise HRS distribution.

3.2.3 Step 3: Formulating policy recommendations for knowledge and insights integration in key strategic areas

As already evident, significant disparities among Alpine countries and regions arise from differences in their national hydrogen strategies, reflecting varying attitudes toward hydrogen's role in the energy transition. This underscores the necessity for targeted recommendations tailored to the specific needs and development pace of each territory. After having identified a) WP1 key findings and b) shortcomings in hydrogen strategies and areas for improvement, partners who will be tasked with drafting policy recommendations for the refinement of territorial strategies will have to:

1. Use clear and concise language, to ensure that policy recommendations are communicated in a straightforward manner, avoiding jargon or overly technical language that may hinder understanding.
2. Consider local context and the specific conditions, challenges, and opportunities within each Alpine country or region, as highlighted by the WP1 key findings; then tailor recommendations to address these unique circumstances.

3. Recognise that different territories may have varying development paces (e.g., Germany vs Slovenia) and capacities; consequently recommendations should be adapted to the readiness and capacity of each region.
4. Pay careful attention to the shortcomings and weaknesses identified in the existing hydrogen strategies as these areas require focused improvement efforts.
5. Ensure that the recommendations align with the broader energy and environmental goals of each territory, as well as with national and regional hydrogen strategies.
6. Encourage cooperation and collaboration between Alpine counties and regions to facilitate economies of scale in hydrogen development.
7. Involve all relevant stakeholders, including government and regional authorities, industry representatives and organisations with thematic interest, to gather diverse perspectives and feedback and stay up to date with evolving circumstances and technologies in the hydrogen sector.

3.3 Indicative policy recommendations

This subsection offers preliminary policy recommendations, drawing from the key findings of H2MA's WP1, to assist partners in their efforts to revise and enhance their regional hydrogen strategies.

1. FOSTERING A PERMANENT TRANSALPINE COOPERATION MECHANISM FOR HYDROGEN MOBILITY

Alpine commercial routes surpass national borders, and the deployment of hydrogen mobility solutions for freight and passenger transport requires coordinated transnational planning to avoid infrastructure redundancies and unnecessary spending. Collaborative public/private partnerships involving national, and sub-national policymakers, international agencies, economic and science stakeholders, supranational and local non-governmental organisations, and local communities, offer the potential to accelerate the roll out of green hydrogen mobility at the national and regional levels. Partners could coordinate their efforts to develop a **Transalpine Hydrogen Mobility Plan**, with the aim to streamline infrastructure planning and thus better execute EUSALP strategy, specifically addressing thematic policy area 2: "Mobility and Connectivity".

2. DEVELOPING HARMONISED POLICIES AND STANDARDS

Achieving policy and regulatory alignment is key for the development of an integrated green hydrogen mobility ecosystem in the Alpine space. The harmonisation of policies, regulations, and standards (e.g., technical, safety) across borders will be highly beneficial to businesses, notably in the logistics sector. To effectively steer the policy harmonisation of green hydrogen mobility within Alpine area, a dedicated transalpine policy task force consisting of representatives from Alpine countries, regional authorities, industry stakeholders, and domain experts can be created for crafting and advancing common policy proposals and measures.

The focal points of harmonised policy efforts should encompass the following areas:

- Safety Protocols and Standards: Develop and implement common operational safety standards for hydrogen infrastructure and transportation. Given the paramount importance of safety, harmonised standards will enhance social acceptance while ensuring the secure deployment of hydrogen technologies and the delivery of high-quality services.
- Interoperability Framework: Forge a harmonised regulatory framework that addresses interoperability standards, ensuring that hydrogen infrastructure across borders can accommodate various types of vehicles (e.g., cars, trucks, trains, vessels). This approach will facilitate seamless cross-border mobility and encourage the growth of hydrogen transportation.
- Tax Incentives and Financial Support: Explore the possibility of common tax incentives and financial support mechanisms to promote green hydrogen production and utilisation. Such measures will create a level playing field for businesses, fostering increased investment in the sector.

3. SETTING QUANTITATIVE TARGETS FOR HYDROGEN MOBILITY AT NATIONAL AND REGIONAL LEVEL

The establishment and adoption of specific quantitative targets for hydrogen mobility at both national and regional levels within the Alpine region would significantly enhance the formulation, implementation, and evaluation of hydrogen strategies. Setting concrete targets and indicators related to the development of green hydrogen mobility will provide a scientifically sound framework for implementing an evidence-based policy approach. This not only strengthens the identification of gaps, and obstacles in green hydrogen mobility development, but it also fosters policy communication and knowledge exchange among partners. Partners can also draw comparisons with other regions, helping them identify potential deficiencies or limitations in their own regional strategy goals and complement them with insights from their peers. Additionally, the introduction of measurable indicators and policy benchmarks supports the monitoring of ongoing pilot initiatives and the assessment of the applicability of their outcomes. This, in turn, streamlines the process of updating and revising national and regional hydrogen strategies.

Examples of precise hydrogen mobility targets that can be set for regions within the Alpine area may include:

- The number of HRS planned for establishment in each region for the medium (by 2030) and long term (by 2050).
- The projected number of FCEVs and FCETs on the road in each region in the medium (by 2030) and long term (by 2050).
- The quantity of green hydrogen production units in each region in the medium (by 2030) and long term (by 2050).

4. IMPROVING STRATEGIC INFRASTRUCTURE PLANNING TO ENSURE OPTIMAL DISTRIBUTION OF HRS ON THE TEN-T NETWORK AND THUS ENCOURAGE FLEET CONVERSIONS AND PIPELINE NETWORK DEVELOPMENT

Strategic infrastructure planning within the Alpine region must incorporate measures to ensure the even and improved distribution of new HRS throughout the Trans-European Transport Network (TEN-T). Planning should align with the European Union's objective of establishing publicly accessible HRS at regular 150 km intervals along the TEN-T core network, thereby promoting widespread access to hydrogen for both FCEVs and FCETs. To achieve this goal effectively, the use of the A1.5 planning tool can be highly beneficial to the responsible authorities, assisting them in the design of the territorial HRS networks. A good and efficient distribution of HRS could then enable a coordinated conversion of fleets for both heavy duty trucks and urban buses, facilitating a scale-up in green hydrogen demand. Consequently, the development of a hydrogen pipeline network, through repurposing of existing natural gas pipelines could prove to be a strategic move, enabling scalability and ensuring a consistent supply to end-users.

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[i] https://www.globaldata.com/store/report/slovenia-renewable-energy-government-regulation-policy-analysis/