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Alpine Space

AMETHyST

Deliverable D.1.2.1

MAP OF GREEN HYDROGEN INITIATIVES IN THE ALPS

Activity A.1.2: Mapping of H2 initiatives in the Alpine region

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Short Description
This deliverable maps the state-of-the-art hydrogen solutions adopted in local Alpine territories, including production, use, transport, distribution and cross-cutting projects and initiatives developed in recent years.

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Executive summary

This report aims at mapping the state-of-the-art hydrogen solutions adopted in local Alpine territories, including hydrogen production, use, transport, distribution and cross-cutting projects and initiatives that have been developed in recent years.

Information about specific hydrogen projects was collected through questionnaires shared with local stakeholders that are involved in the hydrogen sector and through roundtable discussions organized within the pilot territories of the AMETHyST project. Additionally, hydrogen dedicated platforms available online were accessed and consulted for retrieving information on specific hydrogen implementation initiatives. All projects with a high Technology Readiness Level (TRL) application in the Alpine Space area, as well as cross-cutting activities that are specifically supporting the implementation of hydrogen solutions in a certain location, are reported on a map to identify and showcase clusters of hydrogen applications. For each project or initiative detailed information is provided, including a brief description and its position within the hydrogen value chain (production; use; storage, distribution, and transport; cross-cutting). Moreover, the hydrogen technology used and the TRL of its application is specified, along with details about the project's duration and its sources of financing.

In the Alpine Space area, there is a strong focus on hydrogen, particularly for mobility. Funding from various sources, including the public and private sectors, underscores its strategic importance. Regions like South Tyrol and southern Germany lead in innovation and play a key role in the European hydrogen landscape; while collaborative and transnational projects demonstrate the benefits of cross-border partnerships in developing hydrogen ecosystems, which can enhance both commercial and institutional ties. All macro-regions take a comprehensive approach to green hydrogen ecosystems, covering the entire value chain from production to distribution and end-use. However, new initiatives face the challenge of matching supply and demand.

In general, it is clear that the Alpine regions are witnessing an increasing momentum in the development of hydrogen ecosystems. While challenges persist, the concerted push for diversifying applications, supported by various funding mechanisms and regional partnerships, signifies a determined endeavor to integrate hydrogen as a pivotal component of the sustainable energy landscape in the Alpine Space regions.

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1 Introduction

In recent years there has been a significant surge of interest and investment in hydrogen technologies throughout Europe. Hydrogen is considered a versatile and clean energy carrier with the potential to play a pivotal role in addressing climate change, energy security, and decarbonizing various sectors of the economy. Alpine regions also face environmental vulnerabilities due to climate change and emissions associated with use of fossil fuels for transportation, ski resorts, tourism activities and infrastructures. Decarbonization efforts in Alpine regions aim to mitigate these challenges and promote their sustainable development, through implementation of renewable energy solutions and improvement of energy efficiency in buildings, transportation, and industrial processes. Hydrogen can support the creation of clean and green Alpine energy ecosystems, strengthening energy efficiency and sufficiency measures adopted. While decarbonization efforts in Alpine regions face peculiar challenges related to their unique characteristics, these areas are increasingly recognized as laboratories for sustainable development and innovative solutions.

Many stakeholders in the Alps are keen to develop sustainability projects involving the implementation of hydrogen, but there is often lack of information about hydrogen-based solutions that can address the needs of local territories, and limited exchanges at Alpine level for sharing knowledge and experiences in the field.

This report provides an overview of existing green and low carbon hydrogen solutions that have been implemented in Alpine regions. Its purpose is to highlight the best practices and specific applications across the entire hydrogen value chain, encompassing production, utilization, storage, distribution, and transportation. Cross-cutting projects have also been mapped, and, in particular, initiatives in the education and professionalization sectors. These can play an important role in sharing information and knowledge, and in supporting the development of local hydrogen ecosystems.

Regional and local public authorities, as well as key energy actors interested in the application of hydrogen solutions can benefit from this report and use it as a tool to enhance their understanding of the building up of a hydrogen economy within the Alpine regions.

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2 Mapping of hydrogen solutions in the Alps

2.1 Alpine Space area

The collection of information on projects and initiatives focused on the implementation of hydrogen solutions in the cooperation area of the Interreg Alpine Space program, that covers the Alps and their surrounding lowlands (**Figure 1**). The area spreads across the borders of seven countries that share geographical and environmental characteristics and challenges, and include the following regions:

- Austria: Wien, Niederösterreich, Oberösterreich, Burgenland, Steiermark, Kärnten, Salzburg, Tirol, Vorarlberg;
- France: Bourgogne-Franche-Comté, Auvergne-Rhône-Alpes, Provence-Alpes-Côte d'Azur, Grand Est;
- Germany: Oberbayern, Niederbayern, Oberpfalz, Oberfranken, Mittelfranken, Unterfranken, Schwaben; Stuttgart, Karlsruhe, Freiburg, Tübingen;
- Italy: Lombardia, Friuli Venezia Giulia, Veneto, Provincia Autonoma di Trento, Provincia Autonoma di Bolzano / Bozen, Valle d'Aosta / Vallée d'Aoste, Piemonte, Liguria;
- Liechtenstein;
- Slovenia: Zahodna-Slovenija, Vzhodna-Slovenija;
- Switzerland: Ostschweiz, Zürich, Zentral-Schweiz, NW-Schweiz, Espace Mittelland, Région Lémanique, Ticino.

***Figure 1**. Regions included in the Alpine Space area.*

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2.2 Projects and initiatives

Projects and initiatives were mainly collected through direct involvement or knowledge of AMETHyST project partners, and through questionnaires shared with stakeholders from the Alpine Space area who are engaged in activities related to hydrogen. For a detailed description of the survey, see Deliverable D.1.1.1 "Green Hydrogen in the Alps" of the AMETHyST project. Additionally, hydrogen dedicated platforms available online were accessed and consulted for retrieving information on specific hydrogen implementation initiatives (e.g., hydrogen valleys). Among these platforms, the following are reported:

- H2 Valley Map[1]. Joint initiative by the Clean Hydrogen Joint Undertaking and Mission Innovation, resulting in a platform including all information on large-scale hydrogen flagship projects aimed at promoting the emergence of integrated h2 projects along the value chain.
- H2.LIVE[2]. Information portal for hydrogen mobility in Europe, including information on locations and availability of hydrogen refueling stations throughout Europe.
- HyLand – Hydrogen Regions in Germany[3]. Map of concrete hydrogen projects and infrastructure developed and implemented (HyPerformer category) in Germany. These initiatives stem from state government funds launched in 2019 by the Federal Ministry of Digital and Transport for initiating, planning and implementing hydrogen-related projects.

The mapping of projects and initiatives attempts to cover main hydrogen applications in the whole Alpine Space area, in order to identify local applications involving any step of the hydrogen value chain, from production to end-uses, and to trace those territories where local hydrogen ecosystems are being initiated and developed.

Four categories of hydrogen applications have been assigned to each identified project or initiative:

- Production. E.g., electrolysis, steam methane reforming.
- Use. E.g., light-duty and heavy-duty mobility.
- Storage, distribution, and transport. E.g., hydrogen refueling stations, trailers.
- Cross-cutting. E.g., educational activities.

Figure 2 reports the map of intercepted projects and initiatives that have introduced and integrated hydrogen-based applications in the Alpine Space area. The map is not comprehensive of all green hydrogen ecosystems developed in the Alps but includes all initiatives collected by AMETHyST project partners and connected stakeholders, and it attempts to showcase and share information on best practices in their territories. More detailed close-up views of the map are provided in the following figures (**Figure 3** to **Figure 6**) for significantly clustered areas. Each marker on the map is color-coded to correspond with a specific category (production; use; storage, distribution, and transport; cross-cutting). The labels accompanying these markers help to uniquely identify each individual project or initiative, all of which are further detailed in **Table 1**. In addition, projects may have multiple H2 applications spanning across different locations. To distinguish each pilot or demonstration site within these projects, a progressive series is employed, denoted, for instance, as 1.1, 1.2, 1.3, and so forth.

Entries 1 – 32 in **Table 1** refer to projects mapped in **Figure 2** and in the corresponding close-up maps. These projects are characterized by specific high-TRL[4] applications of hydrogen in the Alpine Space area. Cross-cutting activities that have no corresponding TRL but are specifically supporting the implementation of hydrogen solutions in a certain location, are also mapped.

[1] H2 Valley Map at https://h2v.eu/hydrogen-valleys. Accessed 16.10.2023.
[2] H2.Live platform at https://h2.live/en/. Accessed 16.10.2023.
[3] HyLand – Hydrogen Regions in Germany at https://www.hy.land/en/. Accessed 16.10.2023.
[4] Technology Readiness Level. This is a European common method for assessing the maturity of a product or service and its relation to the market.

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Entries 33 – 51 refer to projects and initiatives that do not have pilot sites in the Alpine Space area, so they are not reported on the map, but are carried out by stakeholders operating in the Alpine Space and/or are developing systems (located in the Alpine Space area) at low TRL that cannot be considered as applied H2 solutions yet. These projects offer insight into the level of engagement of Alpine territories and stakeholders in projects or initiatives related to hydrogen, hence their interest in integrating hydrogen solutions into existing energy systems.

It should be noted that some projects which are still in the beginning or development phase (e.g., 26 - NAHV) have not yet shared specific locations of pilot or demonstration sites, so only approximate locations are indicated in the map, but multiple and precise locations will most likely be available at a later stage of the project. Moreover, additional projects might be on-going and not shown in the analysis, because not intercepted during the survey.

2.3 Results

As mentioned, **Figure 2** shows the general geographic distribution of the collected projects and initiatives (P&Is) that have, have had, or plan to have, a concrete onsite hydrogen application. What immediately emerges from the map is that some regional clusters of P&Is can be distinguished. The four main clusters are located in:

- Auvergne-Rhône-Alpes region, France (**Figure 3**)
- Switzerland (**Figure 4**)
- Southern Germany (mostly Upper Bavaria) and Tyrol, Austria (**Figure 5**)
- Northern Italy (mostly Trentino-Alto Adige and Friuli Venezia Giulia) (**Figure 6**)

A closer look at **Figure 3** unveils how most P&Is in the French region of Auvergne-Rhône-Alpes mostly regard use, storage, and distribution of hydrogen within the mobility sector. This is mainly due to the Zero Emission Valley (ZEV) project with an additional contribution from the H2 en Haute-Tarentaise project. The ZEV project aims at creating a hydrogen mobility environment with refueling stations (storage and distribution) and commercial vehicle deployments (use) in the region's major cities by 2024. This ambitious project benefits from EU funding programs as well as national and regional funding. On the other hand, the H2 en Haute-Tarentaise project, started in 2023, aims at establishing a localized hydrogen ecosystem in Haute-Tarentaise (Savoie department) comprehensive of production, use, and storage and distribution/transport of hydrogen in a mountainous environment. The project aims to assess and deploy a demonstrator project involving local hydroelectric hydrogen production for local utilization for snow groomers, last-mile passenger transport to ski resorts, waste management, operating machinery, and construction. Lastly, this region will also feature one green hydrogen production center starting from 2025. Indeed, Lhyfe Le Cheylas project aims ad deploying a 5 MW electrolyzer in Le Chelyas (Isère department) to encourage decarbonization of hard-to-abate sectors in the region.

Looking at the P&Is in Switzerland (**Figure 4**), a similar conclusion to that drawn for the French region can be stated. P&Is in the region regard hydrogen mobility and are coordinated through a single privately funded project. The Hydrogen Mobility Switzerland Association is concentrating its effort in creating the necessary infrastructure for hydrogen mobility across Switzerland. This infrastructure development, started in 2018, not only regards the nodal points represented by refueling stations but also encompasses the deployment of fleets of long-haul fuel cell electric trucks. Moreover, the envisioned effect of establishing such a broad infrastructure is that of enabling the adoption of hydrogen passenger transport. Regarding the production stage, the hydrogen will be mostly produced through hydropower-fed electrolysis.

The macro region of southern Germany and Tyrol (Austria), depicted in **Figure 5**, presents a more heterogenous landscape of P&Is, differently from the French and Swiss cases. These P&Is differ from one

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another not only in terms of addressed hydrogen sector (production, use, and storage and distribution/transport) but also in terms of the origin of the funding schemes. Funding origin is not only divided between private and public, but the latter can be further differentiated into EU, national, and regional funds. This macro-region also hosts some of the earliest projects to have started among the ones listed in **Table 1**. For example, the transnational (IT, DE) Clean Hydrogen in European Cities (CHIC, funded through the EU FCHJU program) project brought to the implementation of hydrogen bus fleets in Bolzano (IT) and Aargau (DE) already between 2010 and 2016. This aspect highlights the long-standing experience and affinity to innovation of this particular part of the Alpine Space area. In general, many of the projects of the region regard hydrogen use in mobility and in particular, the common element to most projects that involve hydrogen mobility, aim at deploying (or have deployed) bus fleets for local public transport. Complementarily, projects also address green hydrogen procurement, envisioning electrolyzer instalments coupled with renewables. Lastly, connecting supply and demand, projects also address the transport and distribution through tube trailers and hydrogen refueling stations. In Germany, two projects, H2Rivers and HyBayern, encompass all sectors in single coordinated efforts and are labelled as Hydrogen Valleys. In a similar way, Austria is home to a large initiative, HyWest, which encompasses various projects with acting on different final uses of hydrogen and ultimately involve all aspects of the hydrogen sector. This might suggest how Austria benefits from a local hydrogen strategy that enables coordination of multiple aspects of hydrogen ecosystems.

The Northern Italy regions in **Figure 6** display a good level of coordination in terms of hydrogen projects, with its hydrogen valleys, though still under development: H2iseO, HYMANTOVALLEY, and the North Adriatic Hydrogen Valley. The latter is particularly an example of best practice in terms of coordination as its realization required the coordination of multiple, transnational, players across Italy, Slovenia, and Croatia. A remark on the pioneering attitude towards hydrogen can be observed for South Tyrol. The South Tyrolean Hydrogen Valley was started with EU pilot projects CHIC and HyFIVE in the field of electric fuel cell buses and cars. Now, South Tyrol is currently in a second phase with the regional roll-out being realized thanks to the projects MEHRLIN, JIVE and LIFEalps, which are supported by the South Tyrolean Provincial Government and the EU. Another aspect that emerged from the assessment of P&Is in the region is the implementation of pilot projects that feature manufacturer proprietary technology. Some of these pilot projects are relevant to the further development of hydrogen ecosystems in the Alpine Space region. Lastly, there are also purely cross-cutting initiatives that aim at supporting the adoption of hydrogen as an energy vector in terms of policy and technical advisory or education and professionalization.

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***Figure 2**. Map of projects and initiatives that have a specific application of hydrogen solutions in the Alpine Space area.*

Figure 3. *Map of projects and initiatives that have a specific application of hydrogen solutions in the Alpine Space area. Focus on Auvergne-Rhône-Alpes region (France).*

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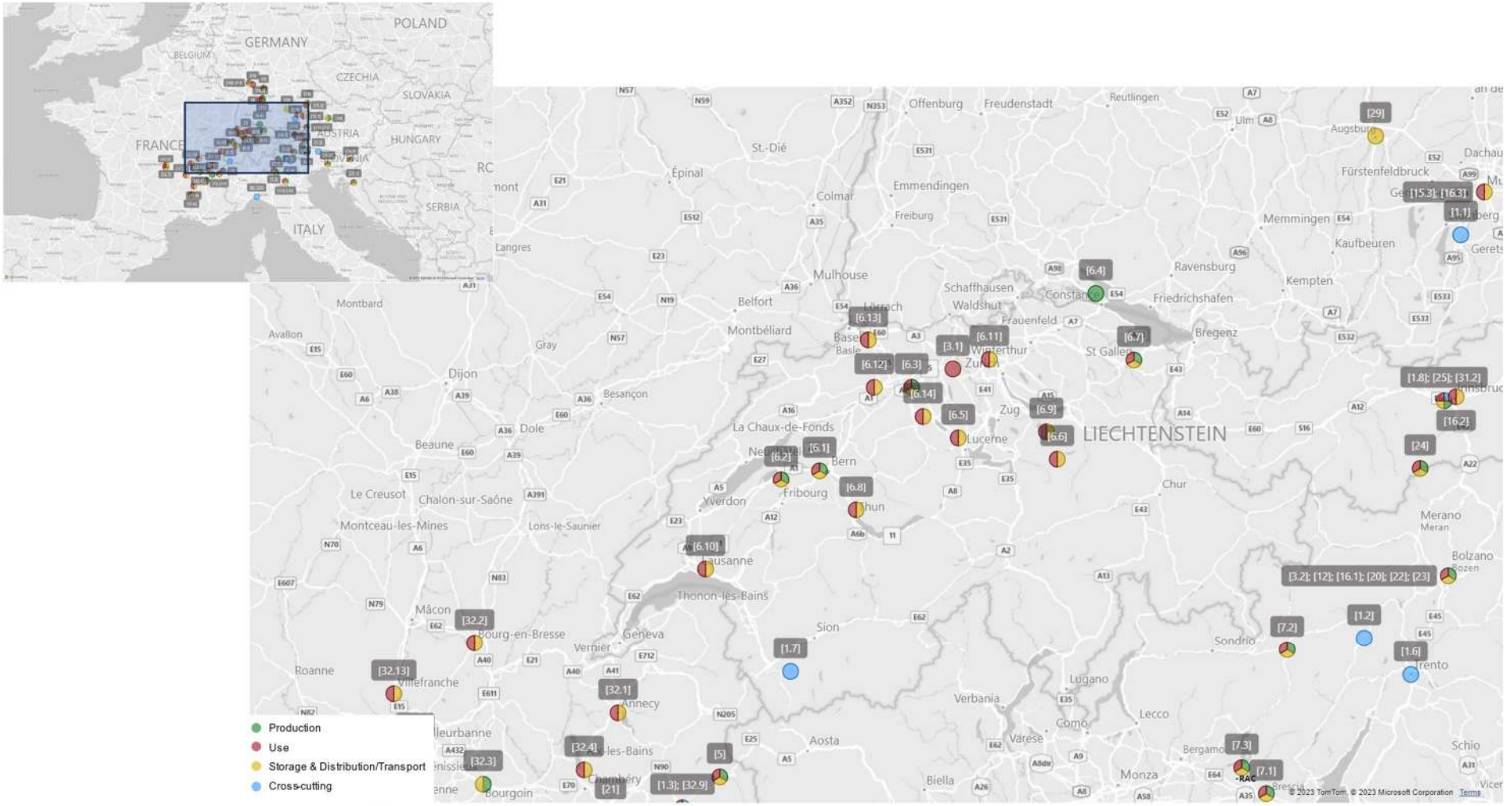

Figure 4. *Map of projects and initiatives that have a specific application of hydrogen solutions in the Alpine Space area. Focus on Switzerland.*

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***Figure 5**. Map of projects and initiatives that have a specific application of hydrogen solutions in the Alpine Space area. Focus on southern Germany and Austria.*

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Figure 6. *Map of projects and initiatives that have a specific application of hydrogen solutions in the Alpine Space area. Focus on northern Italy.*

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***Table 1**. Detailed information on mapped hydrogen projects and initiatives in the Alpine Space area. 1 – 32: high-TRL applications and cross-cutting activities specifically supporting the implementation of H2 solutions in a certain Alpine location; 33 – 51: projects that do not have pilot sites in the Alpine Space area but are carried out by stakeholders operating in the Alpine Space and/or are developing systems (located in the Alpine Space area) at low TRL that cannot be considered as applied H2 solutions yet. TRL ranges definitions: 1-2 (Basic technology research); 3-5 (Technology development); 6-8 (System/subsystem development); 9 (System proven in operational environment). There might be projects or initiatives not captured by the survey due to various reasons such as non-participation in the questionnaire; as such, the list should not be considered exhaustive.*

Code	Project or initiative	Category	Hydrogen technology	TRL	Description	Location of implemented H2 solution	Years	Financing
[1]	**AMETHyST**	Cross-cutting	Policy and technical guidance for H2 solutions implementation; awareness-raising	n.a.	Increase local authorities awareness and knowledge of hydrogen; development of guidelines and financial evaluation toolkit for Alpine H2 ecosystems; pilot territories for a preliminary study on possible H2 application in touristic areas for residential, mobility, energy supply purposes.	- Icking, DE [1.1] - Madonna di Campiglio, IT [1.2] - Assemblée de Pays Tarantaise Vanoise and Arlysere, FR [1.3] - Ravascletto, IT [1.4] - St. Lorentzen, IT [1.5] - Trento, IT [1.6] - Val de Bagnes, CH [1.7] - Völs, AT [1.8]	2022 - 2025	Interregional funding program (Interreg Alpine Space)
[2]	**Bio Hotel - Arieshof**	Production; Use; Storage & Distribution/Transport	Electrolyzer; metal-hydride H2 storage; fuel cell for power generation	9	Self-sufficient organic farm powered by renewable energy sources, provided with storage solution based on metal-hydride technology by GKN Hydrogen. Electricity produced by photovoltaics can be stored in the form of electrolytic hydrogen when excess energy is available.	St. Lorenzen, IT	2021 - 2022	Private funding
[3]	**CHIC - Hydrogen Valley South Tyrol**	Use	Fuel-cell buses vehicles and infrastructure	6 - 8 --> 9	The Clean Hydrogen in European Cities (CHIC) project aimed at full commercialization of hydrogen-powered fuel cell (H2FC) buses. Testing of 26 H2FC buses in medium-sized fleets in normal city bus operation and enlarging of hydrogen infrastructure in 5 European regions, accelerating the development of clean public transport systems. Life cycle assessment of the use of H2FC buses in public transport, considering environmental, economic and social aspects.	- Aargau, DE [3.1] - Bolzano, IT [3.2] - other outside Alpine Space	2010 - 2016	EU funding program (FCH JU)
[4]	**Green Hydrogen Esslingen - Neue Weststadt Klimaquartier**	Production; Use; Storage & Distribution/Transport	H2 urban district; electrolyzer; use of H2 in CHP plant with natural gas; HRS; H2 pipeline; tube trailers	6 - 8	In Esslingen am Neckar the site of the old freight depot is being turned into a research district: “Neue Weststadt” will be built here on an area of 100,000 m^2 offering 450 apartments, office and commercial space, as well as a new building for the Esslingen University of Applied Sciences. The district integrates	Esslingen am Neckar, DE	since 2021	State government funding (Federal Ministry for Economic Affairs and Energy, BMWi and Federal Ministry of Education and Research, BMBF -

					the use of H2 with the aim of reducing CO2 emissions. H2 is produced from PV and superregional electricity generation via electrolysis, stored and used to substitute fossil fuels, according to demand, in mobility and industry or fed into the gas grid. A small part of H2 is directly utilized in the energy center. If electricity and heat are needed in the buildings in times when there is not enough PV electricity, H2 can be quickly and easily converted back into electricity using the bivalent combined heat and power plant (H2 and natural gas) (P2G2P). Waste heat from the electrolysis process is also used to supply heat to the neighborhood. In order to supply H2 for use outside the district, a feed-in station to the natural gas network as well as an H2 filling station are built. H2 transport via H2 pipeline from the energy center to the gas grid feed-in station and H2 filling station. Most of the hydrogen (100-400 kg/d) is to be loaded into trailers with tube bundle storage via the filling station and transported by trucks to customers in the industrial or public transport sector. H2-Filling Station used to refuel private or public vehicles.			Germany, Solar Construction/Energy-Efficient Towns initiative)
[5]	**H2 en Haute-Tarentaise**	Production; Use; Storage & Distribution/Transport	Hydrogen valley; use of H2 for snow groomers, passenger transport within ski resorts, waste transportation, special construction equipment, and industry	6 - 8 --> 9	GEG (Gaz Electricité de Grenoble) is developing a hydrogen ecosystem project in Haute-Tarentaise, Savoie, in collaboration with the local energy firm, Régie électrique de Tignes. The project aims to establish a hydrogen ecosystem (comprehensive of production, distribution, and end uses), using local renewable electricity, primarily hydroelectricity, for diverse applications like snow groomers, passenger transport within ski resorts, waste transportation, special construction equipment, and industrial use. The project will start with a demonstrator phase before the realization of the infrastructures on the scale of the Haute Tarentaise territory.	Bourg Saint Maurice, FR	since 2023	EU funding programs; state government, regional and local funding; private funding

[6]	**H2 Förderverein Schweiz**	Production; Use; Storage & Distribution/Transport	HRS; long-haul fuel-cell trucks	9	The H2 Mobility Switzerland Association is setting itself the goal of establishing a nationwide network of green hydrogen filling stations across Switzerland as well as fleets of long-haul fuel cell electric trucks. The intention is to promote clean, CO2-free, motorized passenger transport in Switzerland and implement fuel cell technology for road transport on a commercial basis. Within this system there currently are 47 nineteen-ton trucks in operation.	- Ittigen, CH [6.1]* - Bern Bethlehem, CH [6.1]* - Müntschemier, CH [6.2]* - Schiffenen, CH [6.2]* - Niedergösgen, CH [6.3]* - Zofingen, CH [6.3]* - Reichenau, CH [6.4] - Rothenburg, CH [6.5] - Bürglen, CH [6.6] - St. Gallen, CH [6.7] - Uetendorf, CH [6.8] - Chur, CH [6.9]* - Hunzenschwil, CH [6.9]* - Crissier, CH [6.10]* - Puidoux, CH [6.10]* - Dietikon, CH [6.11]* - Rümlang, CH [6.11]* - Egerkingen, CH [6.12] - Frenkendorf, CH [6.13]* - Pratteln, CH [6.13]* - Geuensee, CH [6.14]* - Schötz, CH [6.14]* * Very close sites have been assigned the same marker and the same code	since 2018	Private funding
[7]	**H2iseO**	Production; Use; Storage & Distribution/Transport	Hydrogen valley; fuel-cell trains and buses; H2 production plants	9	The "H2iseO Hydrogen Valley" project is an initiative by FNM, FERROVIENORD, and Trenord, aimed at fostering sustainable mobility and decarbonizing public transport in Val Camonica (Lombardy, Italy), along the non-electrified Brescia-Iseo-Edolo railway line. Implementation of the first 6 H2-powered electric trains, built by Alstom and delivered by 2024. By the first half 2025, an H2 production plant will also be built at the Iseo station. 8 more electric trains and two H2 production plants (in Brescia and Edolo) by 2026. Hydrogen produced by the plants will be used for other public transport vehicles (40 buses).	- Brescia, IT [7.1] - Edolo, IT [7.2] - Iseo, IT [7.3]	2020 - 2026	State government funding; private funding
[8]	**H2MOVE**	Cross-cutting	n.a.	n.a.	Cartography of the ecosystem, benchmarking; experimentations; cross-border Strategy Committee for the creation of a cross-border hydrogen network in the various fields of	- Liguria, IT - other outside Alpine Space	2023 - 2027	Interregional funding program (Interreg Italia-Francia Marittimo 2021-2027)

					application starting from the use in ports and in road and rail mobility			
[9]	**H2orizon**	Production; Use; Storage & Distribution/Transport	PEM electrolyzer; use of H2 in CHP plant with natural gas; use of H2 for rocket engines research; mobile storage system	6 - 8	In the Harthäuser Wald wind farm, electricity is generated from wind power. Part of this electricity is routed via a direct connection to the DLR (German Aerospace Center) site in Lampoldshausen and used for producing green H2 via electrolysis. The hydrogen is compressed to 350 bar and stored, then filled in a mobile storage system and transported to be used in mobility applications (private FC cars, local public transport). Part of the H2 is purchased by DLR and used in research applications for rocket engines. H2 is also used, mixed with natural gas, in two CHP plants.	Lampoldshausen, Germany	since 2018	State government funding (Baden-Württemberg Ministry for the Environment, Climate and Energy Sector - Germany)
[10]	**H2Rhein-Neckar**	Use	Fuel-cell buses	9	The H2Rhein-Neckar project aims to strengthen climate-friendly public transport by using hydrogen as an energy source. To this end, the urban diesel buses previously used in Mannheim and Heidelberg will be replaced by emission-free fuel cell range extender articulated buses. The change affects the entire urban articulated bus fleet and will be scientifically evaluated through accompanying research.	- Heidelberg, DE [10.1] - Mannheim, DE [10.2]	2020 - 2024	State government funding (Baden-Württemberg Ministry for the Environment, Climate and Energy Sector - Germany)
[11]	**H2Rivers**	Production; Use; Storage & Distribution/Transport	Hydrogen valley; fuel-cell passenger cars, buses, trucks, refuse collection vehicles, road maintenance vehicles; H2 infrastructure; H2 production plants (electrolysis); H2 transport (trailers)	9	The aim of the project is to establish a regional H2 economy in the Rhine-Neckar model region. H2Rivers is providing for the demand for hydrogen with the purchase of 90 passenger cars, 62 buses, 10 industrial trucks, 3 refuse collection vehicles and 2 road maintenance vehicles powered by fuel cells. At the same time, the necessary infrastructure is being built. This includes the construction of an H2 hub in Mannheim, where 400 t of hydrogen per year can be prepared and filled into trailers via a high-performance filling plant at 300 bar or 700 bar. In addition, up to 240 t of hydrogen per year will be produced in Waiblingen in a 2 MW electrolysis plant fed with PV electricity from the local solar park. The green hydrogen will then be used by industrial	- Mannheim, DE [11.1] - Waiblingen, DE [11.2]	2020 - 2023	State government funding (Federal Ministry of Transport and Digital Infrastructure - Germany, National Innovation Program for Hydrogen and Fuel Cell Technology - NIP2)

					customers and in the transport sector, including in garbage trucks, forklifts, and buses.			
[12]	**H2-South Tyrol**	Production	Electrolyzer	9	H2-South Tyrol Hydrogen Centre for storing renewable energy in the form of hydrogen and distributing it as a fuel to emission-free vehicles. Established in close cooperation with the Brennerautobahn AG operating the A22 motorway and financed by the European Regional Development Fund.	Bolzano, IT	since 2014	EU funding program (Fondo Europeo per lo Sviluppo Regionale, FESR); private funding
[13]	**Hy2B Wasserstoff Elektrolyseur - HyBayern**	Production; Storage & Distribution/Transport	Electrolyzer	6 - 8 --> 9	First green hydrogen source in South Bavaria with a production capacity of up to 700 tons per year. The facility includes a 5 MW electrolysis (manufactured by NEL) with trailer filling in Pfeffenhausen, Lower Bavaria. The hydrogen will be supplied to customers via trailers of 1250 kg capacity at 450 bar and used for fuel cell buses in the Munich area and for heavy-duty transport. The green electricity for green hydrogen production will mainly be generated in the region around the electrolysis plant. A 10 MW photovoltaic ground-mounted system will be connected directly to the electrolyzer and linked to the grid through it. Linked to HyBayern hydrogen valley.	Pfeffenhausen, DE	2020 - 2024	Regional funding; private funding
[14]	**Hy2Green**	Production; Use; Storage & Distribution/Transport	Electrolyzer; metal-hydride H2 storage; fuel cell for power generation	6 - 8	The Hy2Green – Kanppenhaus „Casa dei minatori“ research project aims to assess the performance of an energy self-sufficient house in a climatically demanding location, striving to produce the energy it needs and storing it for the consumption required throughout the year. The semi-detached residential house produces electricity through its own hydropower turbine (surplus production in summer) and covers its heating needs with a pellet heating system. The project system consists of producing hydrogen by electrolysis from the energy extracted from the turbine. The H2 produced is stored through metal-hydride storage technology and converted back into electricity via a fuel	Prettau, IT	2016 - 2018	Private funding

					cell when energy is needed. There is also a battery energy storage system.			
[15]	**HyBayern**	Use; Storage & Distribution/Transport	Hydrogen valley; fuel-cell vehicles	9	The districts of Landshut, Ebersberg and Munich, together with transport companies, energy suppliers, industry, trade, and commerce, intend to implement a closed cycle of green H2 production, distribution and use in emission-free hydrogen vehicle fleets. The project aims to establish a decentralized green H2 economy in Munich's rural areas, focusing on producing cost competitive green H2 for vehicle fleets using renewable energy sources like solar and hydropower, and potentially, wind power. This hydrogen will be generated via a large-scale electrolyzer and distributed to various new and existing filling stations and potential hydrogen technology centers, utilizing interchangeable trailers for transport. Two sub-projects focusing on decentralized hydrogen generation and on-site refueling from PV electricity are in progress, aiming to power up to 35 new hydrogen buses and various vehicles. Linked to Hy2B Wasserstoff Elektrolyseur.	- Ebersberg, DE [15.1] - Landshut, DE [15.2] - Munich, DE [15.3]	since 2019	State government funding (Federal Ministry of Transport and Digital Infrastructure - Germany, HyLand - Hydrogen Regions in Germany)
[16]	**HyFIVE - HyWest**	Use; Storage & Distribution/Transport	Fuel-cell vehicles; HRS	9	HyFIVE (Hydrogen For Innovative Vehicles) is aimed at deploying 185 fuel cell electric vehicles (FCEVs) from leading automotive companies like BMW, Daimler, Honda, Hyundai, and Toyota. The project aims to develop refueling stations in three clusters, integrating 6 new stations with 12 existing ones. The project examines the practicality and environmental viability of FCEVs, explores best practices for supporting FCEVs including maintenance and training, analyses solutions for technical issues related to hydrogen refueling stations (HRS), investigates challenges related to producing renewable hydrogen through electrolyzers, and analyzes the operational aspects of operating a multi-owner network of	- Bolzano, IT [16.1] - Innsbruck, AT [16.2] - Munich, DE [16.3] - Stuttgart, DE [16.4] - other outside Alpine Space	2014 - 2018	EU funding program (FCH JU)

					filling stations. It also aims to understand the purchasing behaviors of early adopters and gather evidence on the probable trajectory of FCEVs commercialization in Europe, especially focusing on high costs and limited infrastructure.			
[17]	**HYMANTOVALLEY**	Production; Use; Storage & Distribution/Transport	Hydrogen valley; H2 production; use of H2 for ships, trains, buses, and buildings	6 - 8 --> 9	Hymantovalley aims at demonstrating the de-carbonization of air-polluted area by building a replicable green H2 ecosystem with H2 production, storage, transportation and utilization for heat, power and mobility. Including the development and use of hydrogen-fed and zero-emissions ships, trains, buses and buildings.	Mantova, IT	2023 - 2026	EU funding program (I3)
[18]	**HYPER**	Storage & Distribution/Transport	H2 transport (500 bar trailers)	6 - 8 --> 9	The Hydrogen High-Pressure Efficient Renewing (HyPER) project will design, construct, test and validate 500 bar tube trailers, and assess the safety of these high-pressure systems. Technical-economic analysis will also be carried out.	Mantova, IT	2023 - 2025	State government funding (National Recovery and Resilience Plan - NRRP - Italy)
[19]	**HyTrain - HyWest**	Production; Use; Storage & Distribution/Transport	H2 production; H2 storage; HRS; fuel-cell trains	9	The project "HyTrain" aims to develop the world's first hydrogen-powered narrow-gauge train with the corresponding infrastructure (production from local renewable energy sources, storage and refueling of green H2) for the mobility sector (trains). HyTrain is part of the R&D flagship project HyWest together with MPREIS Demo4Grid and Power2X projects, serving as a model for the development of a largely autonomous regional green hydrogen economy. The main focus is the investigation of cross-sectoral production, storage and application of green hydrogen.	Zillertal, AT	2020 - 2024	State government funding (FFG - Austria, Austrian Climate and Energy Fund - Vorzeigeregion Energie program)
[20]	**JIVE**	Use	Fuel-cell buses; HRS	9	JIVE (Joint Initiative for hydrogen Vehicles across Europe) paves the way to the commercialization of fuel cell buses through the deployment of 142 units across 8 locations. They will operate in large fleets of 10-30 buses, reducing the overhead costs per bus, as well as allowing more efficient supply chains and maintenance operations compared to	- Bolzano, IT - other outside Alpine Space	2017 - 2024	EU funding program (HORIZON 2020); regional and local funding

					previous deployments. JIVE will also test new hydrogen refueling stations with the required capacity to serve fleets in excess of 20 buses.			
[21]	**Lhyfe Le Cheylas**	Production	Electrolyzer	9	Construction of a 5 MW or (2 t/day) green hydrogen production plant in Le Cheylas (Isère, France), which will begin operation from the first semester of 2025. It will encourage the decarbonization of hard-to-abate sectors in the Auvergne-Rhône-Alpes region, in particular for mobility and industry applications.	Le Cheylas, FR	2023 - 2025	n.a.
[22]	**LIFEalps - Hydrogen Valley South Tyrol**	Use; Storage & Distribution/Transport	Fuel-cell vehicles (taxis, shuttle buses, good transport vehicles); HRS	9	The "Zero Emission Services for a Decarbonized Alpine Economy" project is based on the South Tyrol 2050 Climate Plan for reduction of CO2-emissions and aims at transforming South Tyrol into an Alpine model region for zero emission mobility. Partners develop the infrastructure for e-mobility, to bring pilot fleets on the streets and to create zero emission services (e.g., taxi, shuttle service, transport of goods).	Bolzano, IT	2019 - 2027	EU funding program (LIFE program)
[23]	**MEHRLIN - Hydrogen Valley South Tyrol**	Storage & Distribution/Transport	HRS	9	The MEHRLIN project will deploy seven hydrogen refueling stations serving bus fleets in cities across Europe, in the UK, the Netherlands, Italy and Germany.	- Bolzano, IT - other outside Alpine Space	2016 - 2023	EU funding programs (CEF program; LIFE program)
[24]	**Müllerhütte - Rifugio Cima Libera**	Production; Use; Storage & Distribution/Transport	Electrolyzer; metal-hydride H2 storage; fuel cell for power generation	6 - 8	The Müllerhütte is an off-grid cabin situated above 3,000 m and can only be reached on foot or by helicopter. In the past, the necessary energy was provided by a generator run on diesel transported by helicopter. The Müllerhütte wants to generate its own CO2-free energy, store it and use it during summer days, when it is open, to achieve 100% self-sufficiency and replace the diesel generator. GKN Hydrogen planned the modular construction of a metal-hydride hydrogen storage system. This system allows Müllerhütte to store the electricity in the form of electrolytic hydrogen produced by photovoltaics safely and compactly.	Racines, IT	2022 - 2024	Local funding; private funding

[25]	**MPREIS Demo4Grid - HyWest**	Production; Use; Storage & Distribution/Transport	Alkaline electrolyzer; H2 storage; HRS; fuel-cell delivery trucks	9	The project aims to utilize an alkaline elctrolyzer powered by hydropower to firstly provide grid balancing services under real operating conditions. H2 is stored on site and fuels MPREIS fuel-cell delivery trucks through a refueling station. MPREIS Demo4Grid is part of the R&D flagship project HyWest together with HyTrain and Power2X projects, serving as a model for the development of a largely autonomous regional green hydrogen economy. The main focus is the investigation of cross-sectoral production, storage and application of green hydrogen.	Völs, AT	2017 - 2023	EU funding program (HORIZON 2020)
[26]	**NAHV**	Production; Use; Storage & Distribution/Transport	Hydrogen valley; H2 production; use of H2 for energy, transport, and hard-to-abate sectors	6 --> 8	The North Adriatic Hydrogen Valley (NAHV) project primary goal is to establish a H2-based economic, industrial and social ecosystem across Friuli Venezia Giulia (Italy), Slovenia and Croatia, promoting growth and job creation while advancing green and digital transitions and setting the conditions for wider EU replicability. The project emphasizes cross-border hydrogen production, distribution, and consumption, targeting an exchange of over 20% of the annual H2 output forecast of over 5,000 tons. 18 test applications clustered in 3 main pillars - energy, transport, and hard-to-abate sectors. Four fuel-cell applications in the energy and transport sectors will also be demonstrated.	- Croatia [26.1] (outside Alpine Space) - Friuli Venezia Giulia, IT [26.2] - Slovenia [26.3]	2023 - 2029	EU funding program (HORIZON Europe)
[27]	**Power2X - HyWest**	Production; Use; Storage & Distribution/Transport	PEM electrolyzer; H2 use for fuel-cell vehicles (cars, trucks, commercial vehicles, buses)	9	The project envisages the construction of a sector coupling system with hydrogen center southwest of Kufstein, near the TIWAG Langkampfen run-of-river power plant in Tyrol. Sector coupling connects electricity, heat and gas networks as well as the mobility sector and thus creates an important prerequisite for a sustainable, future-proof and economically oriented energy system. Power2X is part of the R&D flagship project HyWest together with HyTrain	Kufstein, AT	2019 - 2025+	State government funding (FFG - Austria, Austrian Climate and Energy Fund - Vorzeigeregion Energie program)

					and MPREIS Demo4Grid projects, serving as a model for the development of a largely autonomous regional green hydrogen economy. The main focus is the investigation of cross-sectoral production, storage and application of green hydrogen.			
[28]	**Protocol for development and implementation of H2 in Liguria region**	Cross-cutting	Policy and technical guidance for H2 solutions implementation	n.a.	This initiative aims to foster collaboration in developing and implementing a strategy to expand the use of H2 as an energy vector in the Ligurian region (Italy). This effort aims to support an integrated energy system that encourages decarbonization across various sectors, including industry, electricity production, construction, transportation, and logistics. H2 will serve as alternative fuel for mobility and logistics, especially in public transport and the maritime-port sectors.	Liguria, IT	since 2022	n.a.
[29]	**Public HRS Augsburg**	Storage & Distribution/Transport	HRS	9	Tyczka Hydrogen GmbH will construct and operate a public filling station for green H2 in the Freight Village (Güterverkehrszentrum, GVZ) Augsburg. Starting from the beginning of 2024, this innovative filling station will offer hydrogen at pressure levels of 350 and 700 bar. The station will be able to serve commercial vehicles, buses, and passenger cars.	Augsburg, DE	2022 - 2024	State government funding (Ministry of Economic Affairs, Regional Development and Technology - Germany)
[30]	**USS2030**	Production; Storage & Distribution/Transport	Underground storage	6 - 8	With the Underground Sun Storage 2030 (USS2030) project renewable solar energy is converted into green H2 via electrolysis and stored in former underground natural gas reservoirs as part of a field trial. The project is also investigating hydrogen as a substitute for fossil natural gas; direct use in energy-intensive industry; processing and utilization of hydrogen with high purity.	Gampern, AT	2023 - 2025	State government funding (Ministry of Climate Protection, BMK - Austria, Climate and Energy Fund - Vorzeigeregion Energie program) State government funding (FFG - Austria, Austrian Climate and Energy Fund - Vorzeigeregion Energie program)

[31]	**ZEM-Zero Emission Mobility - H2Alpin**	Use	Fuel-cell buses and trucks; business model development	3-5 --> 6-8	The H2Alpin project aims to address technical, economic, and organizational issues of H2 implementation through a large-scale interdisciplinary demonstration project. It will test H2-powered buses and trucks in Alpine conditions (extreme temperature, snow, windy mountain roads, transit passes), collecting real-world data on driving behavior, maintenance, energy consumption, etc. Economic challenges include high vehicle procurement costs. The H2Alpin project aims at overcoming this by prompting the development of business models for procurement platforms through which vehicle pools can be procured, maintained, and made available to third parties via a leasing model. Hydrogen demand and production simulations will help design appealing pricing strategies for hydrogen	- Kufstein, AT [31.1] - Völs, AT [31.2] - Zillertal, AT [31.3]	0 - 0	State government funding (FFG - Austria, Austrian Climate and Energy Fund - Zero Emission Mobility program)
[32]	**ZEV - Zero Emission Valley**	Use; Storage & Distribution/Transport; Production	Hydrogen valley; fuel cell commercial vehicles; HRS	9	Zero Emission Valley (ZEV) is the largest hydrogen mobility project in France, accelerating the deployment of fuel-cell vehicles and hydrogen stations throughout the region while helping to create a profitable model that can be replicated on a European scale. The ZEV project aims to deploy 20 hydrogen distribution stations and 1,200 hydrogen-powered commercial vehicles in the region's major cities. The synchronized deployment of vehicles and refueling infrastructure will be carried out by Hympulsion.	- Annecy, FR [32.1] - Bourg-en-Bresse, FR [32.2] - Bourgoin-Jallieu, FR [32.3] - Chambéry, FR [32.4] - Clermont-Ferrand, FR [32.5] - Grenoble, FR [32.6] - Lyon, FR [32.7] - Montelimar, FR [32.8] - Moûtiers, FR [32.9] - Riom, FR [32.10] - Saint-Etienne, FR [32.11] - Valence, FR [32.12] - Villefranche-sur-Saone, FR [32.13]	2017 - 2024	EU funding programs; state government and regional funding
[33]	**KICstartH2**	Cross-cutting	Education and professionalization	n.a.	The project aims to create an e-learning platform on H2 technologies and economy to enable Higher Education Institutions (HEIs) to play an active role in the development of new ecosystems based on renewable energy and H2 as an energy carrier and storage. The objective is also the growth of an entrepreneurial and innovative capacity of the HEIs, promoting new start-ups and	n.a.	2022 - 2024	EU funding program (EIT's HEI Initiative)

					collaborations with local industrial realities.			
[34]	**AMON**	Use	Ammonia solid oxide fuel-cell for power generation	3-5	AMON will develop a novel system for the utilization and conversion of ammonia into electric power at high efficiency using a solid oxide fuel cell system. The project will deal with the design of the basic components of the system including the fuel-cell, an ammonia burner, ammonia resistant heat exchangers, the engineering of the whole Balance of Plant, and validation of the compliance with ammonia use for all the specific parts and components. Optionally, depending on system needs, an ammonia cracker and anode gas recirculation will be developed.	Protype in real context. Still undefined location.	2023 - 2025	EU funding program
[35]	**CH2P**	Production	Solid oxide fuel-cell for power generation; H2 production	3-5 --> 6-8	CH2P uses carbon-lean natural gas or bio-methane to produce hydrogen and power, using Solid Oxide Fuel Cell (SOFC) technology. Like combined heat and power systems, the fuel cell heat generates hydrogen. This results in efficient (up to 90%) H2 and electricity production with minimal environmental impact. CH2P systems promise high H2 purity, low CO levels, and a target hydrogen cost below 4.5 €/kg. The tech is modular for gradual infrastructure rollout. Two CH2P systems will be developed, 20 kg/day for validation and 100 kg/day for field tests. Post-project, industrial partners plan to commercialize the CH2P technology.	Test bed at HyGEAR in Arnhem (NL)	2017 - 2022	EU funding program
[36]	**Devise**	Storage & Distribution/Transport	H2 storage	3-5	DEVISE (Different Energy Vector Integration for Storage of Energy) will develop a storage system that enables efficient and rational end use of all forms of energy by having a heterogeneous storage facility for diverse forms of energy and to facilitate conversion from one form to another for optimal catering of diverse loads. The developed energy bank will be demonstrated for typical demand-supply scenarios in India that will also lead to developing a decision	Prototypes at Centre for Sustainable Energy - Fondazione Bruno Kessler in Trento (IT) / India	2020 - 2023	EU funding program

					support system for planning in EU and India.			
[37]	e^4	Cross-cutting	Education and professionalization	n.a.	e^4 - tools in higher Education for an Embodied & creative Energy Education, aims at both supporting and reforming teacher education at academic level, by fostering creative and innovative teaching methods to facilitate the transfer of energy-related scientific knowledge	n.a.	2022 - 2025	EU funding program (Erasmus+ KA220-HED)
[38]	**EDEN**	Storage & Distribution/Transport	Metal-hydride H2 storage	1-2 --> 3-5	EDEN (High energy density Mg-Based metal hydrides storage system) strives to advance expertise in energy storage, with a focus on H2 due to its environmental benefits and high energy density. Past EU projects have identified solid state H2 storage, particularly Magnesium-based systems, as promising due to their capacity and performance. Yet, their adoption is hindered by high working temperatures and substantial heat of reaction. EDEN aims to address these challenges by integrating market solutions, past project findings, and innovative storage material solutions.	Barcelona, ES	2013 - 2016	EU funding program
[39]	**GH2**	Production	H2 production (photocatalysis)	3-5	GreenH2 production from water and bio alcohols by full solar spectrum in a flow reactor. Using solar energy to split water into H2 is a process known as photocatalysis, but current efficiency is quite low. Also, separating the produced hydrogen from oxygen during water splitting can be quite expensive. The project is designed to address these challenges by utilizing the full solar spectrum (300-2500nm) instead of UV-visible light (300-700nm); coupling water splitting with biomass-derivative oxidation to avoid water oxidation; combining solid Z-scheme UV-visible photocatalysis and Infrared-driven thermal catalysis. The project also aims to the co-production of high-value chemicals (HVC) such as ethylene, propylene, benzene, toluene, xylene. Additionally, combining affordable and effective catalysts with innovative flow	n.a.	2022 - 2026	EU funding program (HORIZON Europe); state government funding (UK)

					reactors will ensure a steady and efficient production of hydrogen and HVCs.			
[40]	**H2MA**	Cross-cutting	Innovation capacity and awareness-raising	n.a.	The Green Hydrogen Mobility for Alpine Region Transportation project (H2MA) works to accelerate the transnational roll-out of green H2 mobility infrastructure in the Alpine region. Through the joint development of cooperation mechanisms, strategies, tools, and resources, the project will increase the capacities of territorial public authorities and relevant stakeholders to collaboratively plan and pilot test zero-emission hydrogen routes across the Alps. As a result, H2MA will improve the governance of green hydrogen mobility, boost the uptake of green hydrogen for heavy transport, unlock green financing, and strengthen the cooperation framework between public authorities and companies involved in green H2 mobility.	Alpine Space	2022 - 2025	Interregional funding program (Interreg Alpine Space)
[41]	**HyCARE**	Storage & Distribution/Transport	Metal-hydride H2 storage	3-5	The HyCARE (Hydrogen CArrier for Renewable energy Storage) project aims to develop a large-scale, innovative hydrogen storage tank using a solid-state carrier, based on metal hydrides. This tank integrates H2 and heat storage for enhanced energy efficiency and a reduced system footprint. Located at ENGIE Lab CRIGEN, the system is linked to a 55 kW PEM electrolyzer and a 20 kW PEM fuel cell. HyCARE's goals include storing over 50 kg of hydrogen at low pressures and temperatures, mirroring the energy density of liquid hydrogen storage, integrating thermal storage, and demonstrating real-world applications.	Test bed at ENGIE Lab Crigen in Stains (FR)	2019 - 2023	EU funding program (FCH JU)
[42]	**HyUSPRe**	Storage & Distribution/Transport	H2 underground storage	3-5	The HyUSPRe - Hydrogen Underground Storage in Porous Reservoirs project examines the viability of storing renewable hydrogen in Europe's porous reservoirs on a large scale. It focuses on identifying apt geological reservoirs and evaluating their technological and economic potential for hydrogen storage by 2050. The study addresses technical	n.a.	2021 - 2024	EU funding program (FCH JU)

					challenges and risks, offers economic insights, and integrates environmental, social, and regulatory viewpoints.			
[43]	**JIVE 2**	Use	Fuel-cell buses; HRS	9	Successor to the JIVE project, the JIVE 2 (Joint Initiative for hydrogen Vehicles across Europe) is Europe's most ambitious FC project, seeking to deploy 152 new zero emission fuel cell buses and associated refueling infrastructure across 14 European cities throughout France, Germany, Iceland, Norway, Sweden, the Netherlands, and the UK. Through this, JIVE 2 adds to JIVE's goals to address the main issues of fuel cell buses identified in high ownership costs (relative to conventional buses), obtaining public transport levels of availability and development of refueling infrastructure this. A comprehensive data monitoring and assessment exercise will capture the relevant evidence to inform next steps for the sector, and the project's impacts will be maximized by a high-impact dissemination campaign.	European cities throughout FR, DE, IS, NO, SE, NL, UK	2018 - 2025	EU funding program; state government and local funding
[44]	**MECCA**	Production	H2 production (biomethane cracking through non-thermal plasma)	1-2 --> 3-5	The MECCA project proposes hydrogen production from (bio)methane cracking, leveraging a novel technology that merges non-thermal plasma and nanocarbon catalysis in a continuous circulating bed reactor. This method produces pure H2, and carbon characterized by a nanofiber structure. The latter can be used as additive in the production of polymers and other materials to enhance their properties.	Prototypes at Centre for Sustainable Energy - Fondazione Bruno Kessler in Trento (IT) / Università degli Studi di Messina, Messina (IT)	2023 - 2025	State government funding (National Recovery and Resilience Plan - NRRP - Italy)
[45]	**MOSCA**	Production	Solid oxide fuel-cell	3-5	Throughout the MOSCA project Fondazione Bruno Kessler provides support to SOLID Power (currently Solydera, a small-medium enterprise based in Trento, Italy) in the testing phase of their innovative 3 and 6 kW solid oxide (SO) cell stacks. The cell tests will verify the management of stack polarization in electrolysis mode, under different temperature conditions and dynamic operation; the variability of the mixtures at the stack input and effects on its	n.a.	2021 - 2021	Private funding

					operation; long-term degradation phenomena. The tests will mainly concern the SOEC mode (electrolyzer) and will investigate its long-term performance for continuous operation of no less than 3000-5000 hours.			
[46]	**NEWELY**	Production	AEM electrolyzer	1-2 --> 3-5	NEWELY aims at redefining Anion exchange membrane water electrolysis (AEMWE). The project works on the design, component, and material development of a new AEM water electrolyzer prototype, demonstrating long-term durability at relevant operating conditions.	Prototype at Centre for Sustainable Energy - Fondazione Bruno Kessler in Trento (IT) / India	2019 - 2022	EU funding program (FCH JU)
[47]	**PROMETEO**	Production	Solid-oxide electrolyzer	3-5	PROMETEO (PROduction by MEans of solar heat and power in high TEmperature Solid Oxide Electrolysers) seeks to produce green H2 using high temperature electrolysis from renewable heat & power sources in areas with low-cost electricity from photovoltaic or wind energy. Solid Oxide Electrolysis (SOE) efficiently converts heat & power into H2 but faces challenges when aligning with intermittent heat sources like solar heat. PROMETEO aims to optimize the coupling of the SOE with non-programmable renewable electricity and high-temperature solar heat from Concentrating Solar (CS) systems with Thermal Energy Storage (TES) to supply solar heat when power is made available. This optimized system will cater to user needs, sustainability, regulations, and scalability.	Prototype in industrial context at Capital Energy in Madrid (ES)	2021 - 2024	EU funding program (FCH JU)
[48]	**STORMING**	Production	H2 production (methane cracking)	4 --> 5	STORMING (Structured unconventional reactors for CO2-free methane catalytic cracking) will develop breakthrough and innovative structured reactors heated using renewable electricity, to convert fossil and renewable CH4 into CO2-free H2 and highly valuable carbon nanomaterials for battery applications.	n.a.	2022 - 2025	EU funding program (HORIZON Europe)
[49]	**SWITCH**	Production	Solid-oxide fuel-cell	3-5 --> 6-8	Solid Oxide (SO) Cells efficiently convert renewable electricity into green H2 and can be used reversibly with sources like methane for consistent hydrogen	Demonstrator at HyGEAR in Arnhem (NL)	2021 - 2024	EU funding program (FCH JU)

					production. The SWITCH (Smart Ways for In-Situ Totally Integrated and Continuous Multisource Generation of Hydrogen) project aims to develop this solution, ensuring a reliable and primarily green production of H2, heat, and power. Central to this is a reversible Solid Oxide module based on anode-supported electrolyte. The module is complemented by an advanced fuel processing unit for steam generation and high efficiency methane reforming along with a purification unit to guarantee highly pure H2. The project's goal is to demonstrate a 25kW (SO fuel cell)/75kW (SO electrolyzer cell) system for 5000 hours in an industrial setting, targeting a hydrogen price below 5 €/kg.			
[50]	**THOTH2**	Storage & Distribution/Transport	H2 transport	3-5 --> 6-8	To support European energy system decarbonization, it's essential to blend hydrogen (H2) into natural gas (NG) networks effectively through a systemic, multi-disciplinary approach to make NG infrastructure resilient to the challenges of tomorrow. THOTH2 addresses this by focusing on the accurate measurement of hydrogen-natural gas (H2NG) mixtures with rising hydrogen content up to 100%. The consortium aims to define standards to evaluate the metrological performances of measuring devices at different H2 blending rates (up to 100%); verify safety and durability of the same devices and suggest future needs to overcome the observed barriers and limitations.	n.a.	2023 - 2025	EU funding program (HORIZON Europe)
[51]	**TITAN**	Production	H2 production from biogas	3-5	TITAN (Direct biogas conversion to green H2 and carbon materials by scalable microwave heaTed catalytic reacTor for soil Amendment and silicon carbide production) will develop an innovative process that will enable production of cost-competitive hydrogen together with integrated carbon sequestration. It will be achieved by the direct conversion of biogas into H2 and valuable carbon materials.	n.a.	2022 - 2026	EU funding program (HORIZON Europe)

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3 Final insights

Across the Alpine Space regions, a strong push towards hydrogen, and especially towards its use for mobility, is deduced from the intercepted projects and initiatives, with many of them prioritizing the development of crucial infrastructure. This push is supported by diverse funding origins, encompassing both private and public sectors, the latter spanning from the European Union to national and regional scales, suggesting hydrogen's strategic role attributed by varied stakeholders.

Regions like South Tyrol and southern Germany have emerged as pioneering forces, showcasing an inclination for innovation and demonstrating a relevant role in the European hydrogen landscape. Given the examples of cross-border collaborative projects such as the North Adriatic Hydrogen Valley, it can be stated that hydrogen ecosystems' development benefits from transnational collaborations. This might also be true vice versa in that commercial and institutional ties could benefit from hydrogen ecosystems.

All macro-regions analyzed showcase a comprehensive approach to the development of green hydrogen ecosystems, in that they are not only developing solutions for one aspect of the hydrogen ecosystem but are looking at a holistic solution from production to distribution and end-use, to build the whole value chain. This is a very important aspect, but also a challenge for new initiatives that struggle in finding ways to match supply and demand.

Proving the commitment of Alpine regions to sustainability, all P&Is that involve hydrogen production are firmly rooted in renewable energy sources, with hydropower often playing an important role. There is, in fact, a strong and inherent correlation between green hydrogen and renewable energies development. This should be taken into consideration in the development of business cases, as it adds to the complexity and costs of the necessary infrastructure.

In conclusion, there is a clear and growing momentum in the Alpine regions towards the development and deployment of hydrogen ecosystems. Despite the presence of challenges, the attempt to diversify applications, combined with diverse funding mechanisms and regional collaborations, suggest a concerted effort to make hydrogen a significant part of the sustainable energy future in Europe and also in the Alpine Space area.