Interreg Alpine Space

Co-funded by the European Union

AMETHySТ

Deliverable 2.4.1

# LOCAL ALPINE GREEN $H_2$ ECOSYSTEM IMPLEMENTATION REPORT

Activity A.2.4: Pilot implementation and assessment

European Regional Development Fund Support from the European Union: € 1,349.279,62

30th April, 2025

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

## *DOCUMENT CONTROL SHEET*

| **Project reference** | |
|---|---|
| **Full title of the project** | A MultipurposE and Tran sectorial Hydrogen Support for decarbonized alpine Territories |
| **Acronym** | AMETHyST |
| **Contract agreement n.** | ASP0100032 |
| **Duration** | 01.11.2022 – 30.10.2025 |
| **Project website** | https://www.alpine-space.eu/project/amethyst |
| **Project coordinator** | AURA-EE |

| **Short Description** |
|---|
| This report provides a comprehensive overview of how pilot projects have been implemented and a frame for assessing the achieved results. The document comprises a different section for each pilot project based on a common layout devised by APE FVG. |

| **Document Details** | |
|---|---|
| **Title of document** | Local Alpine green $H_2$ ecosystem implementation report |
| **Activity** | Pilot implementation and assessment |
| **Delivery date** | 30.04.25 |
| **File name** | D.2.4.1 Local Alpine green $H_2$ ecosystem implementation report |
| **Reviewers** | AURA - EE |
| **Dissemination** | Public |

| Version | Date | Author | Organization | Description |
|---|---|---|---|---|
| 1.0 | 25.06.2024 | MA | APE FVG | First draft template |
| 2.0 | 17.03.2025 | MA | APE FVG | Collection of contributions from PPs |
| 3.0 | 16.04.2025 | MA | APE FVG | Consolidation of final document |

## *RESPONSIBLE PARTNER FOR THE COMPILATION OF THIS DOCUMENT*

Agenzia per l'Energia del Friuli Venezia Giulia

Via Santa Lucia 19
33013 Gemona del Friuli
Udine – ITALY
Phone: (+39) 0432 980322
Email: matteo.depiccoli@ape.fvg.it

## *PROJECT LEAD PARTNER*

Auvergne-Rhône-Alpes Energy Environment Agency

Rue Gabriel Péri 18, 69100 Villeurbanne, France
Phone: (+33) 0478372914, +33 0472563365
Email: etienne.vienot@auvergnerhonealpes-ee.fr; noemie.bichon@auvergnerhonealpes-ee.fr

# TABLE OF CONTENTS



This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

# 1. INTRODUCTION

The Alpine region, with its unique environmental challenges and energy demands, represents both a testing ground and a beacon for Europe's green transition. In this context, the AMETHyST project—**Deploying Alpine Green Hydrogen Ecosystems for a Post-Carbon Future**—was launched under the Interreg Alpine Space Programme to support the development of resilient, sustainable hydrogen solutions tailored to Alpine territories.

AMETHyST strengthens the role of public authorities by increasing their capacity to design, support, and integrate green hydrogen ($H_2$) solutions within local and regional energy strategies. By placing a strong focus on touristic and mountainous areas—key economic drivers for the Alps—the project positions hydrogen as a flagship solution for clean mobility, energy autonomy, and carbon neutrality.

This report presents a series of nine pilot projects implemented across seven Alpine countries, each contributing to the shared vision of a decentralized, low-emission energy future. From ski resorts in France, Italy, and Switzerland pioneering $H_2$-powered snow groomers and mobility systems, to a smart, integrated energy lab in Germany, and a regional hydrogen roadmap in Slovenia, these pilots showcase a diverse range of real-world applications. Each factsheet details the pilot's objectives, progress, key achievements, encountered challenges, and lessons learned.

Taken together, these pilots form a practical knowledge base for public authorities, planners, and energy actors. They illustrate what is possible when ambition meets coordination and local context, and serve as a reference for replicating and scaling green hydrogen ecosystems across the Alpine region and beyond.

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

# 2. PILOT PROJECT IMPLEMENTATION REPORT

## AMETHYST PROJECT IN AUVERGNE RHÔNE ALPES REGION

## OVERVIEW

The AMETHySТ project in Auvergne-Rhône-Alpes aims to support the deployment of local hydrogen ecosystems in the territory of Savoie and Haute Savoie, promoting low-carbon mobility and energy solutions. The main goal is to assist pilota territories in structuring their hydrogen initiatives by providing technical expertise, coordination support, and strategic guidance.

Several territories have been involved in this initiative, including:

- CCPEVA (Communauté de Communes Pays d'Évian Vallée d'Abondance): Support in structuring hydrogen projects, assisting with technical studies and the organisation of knowledge-sharing events. Implementation of a hydrogen demonstrator project to assess hydrogen use in public transport.
- APTV (Assemblée du Pays Tarentaise Vanoise):
  - Engagement with regional decision-makers and integration of hydrogen solutions in local policies.
  - Project in Haute Tarentaise with Régie de Tignes, Atawey and GEG continue, working on mobility solutions
- CCPMB (Communauté de Communes Pays du Mont-Blanc): Feasibility study and stakeholder coordination for a multi-energy refueling station including hydrogen.
- Département de la Savoie: investigating hydrogen solutions for heavy-duty vehicles, including snow grooming machines and winter road maintenance equipment, especially for access to ski resorts.

The roadmap consists of territorial diagnostics, feasibility assessments, stakeholder engagement, and project structuring to facilitate hydrogen adoption in these pilot areas.

## ACTIVITY PROGRESS

Key activities have been carried out across the different pilot territories to accelerate hydrogen deployment:

- Stakeholder engagement: local authorities, industrial players, and mobility operators have been involved in workshops and working groups.
- Feasibility studies: technical and economic assessments have been conducted for hydrogen production, refuelling infrastructures, and vehicle deployment.
- Interregional collaboration: links have been established with European partners to share experiences and best practices.
- Coordination with regional policies: the project has ensured alignment with Zero Emission Valley (ZEV) and hydrogen strategy at the regional level.
- Support for project structuring: assistance in drafting technical specifications, funding applications, and business models for hydrogen projects.

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

By fostering synergies between public and private stakeholders, AMETHyST has reinforced the regional hydrogen ecosystem and prepared the ground for scaling up of the most hydrogen applications.

# ACHIEVEMENTS

The project has led to significant achievements across the different territories:

- Increased awareness and political support for hydrogen projects through engagement with local decision-makers.
- Technical and economic feasibility validated for key projects, including hydrogen transport hubs and multi-energy refuelling stations.
- Improved coordination between public and private actors, fostering investment opportunities and partnerships.
- Knowledge-sharing events and strategic workshops to exchange best practices and scale up solutions.

These achievements strengthen the region's position as a leader in hydrogen innovation for mountainous territories.

# DEVIATIONS

Several deviations occurred during the implementation of the pilot projects, mainly due to the early-stage maturity of hydrogen technology and market readiness:

- Projects are not fully mature yet: many pilot territories are still in the early phases of hydrogen adoption, requiring additional feasibility studies and strategic alignment.
  Delays in technological implementation: infrastructure development and vehicle availability have not always aligned with initial timelines, requiring adjustments in the project schedule.
- Adaptation of project scopes to better match local priorities and technical constraints.
- Adjustments in planned experiments (e.g., the bioGNV ans electric components of the CCPEVA demonstrator have been postponed to winter 2025).

Despite these modifications, the overall objectives remain on track, and corrective measures have been implemented to ensure project continuity.

# KEY LESSONS LEARNT

The AMETHyST project has provided valuable insights for the deployment of hydrogen solutions in mountainous regions:

- Hydrogen adoption requires strong local engagement: successful projects depend on active participation from local authorities, industries, and transport operators.
- Technical and financial feasibility must be carefully assessed: clear business models and funding strategies are crucial for long-term success.
- Coordination with regional and European policies enhances impact: aligning with existing strategies (e.g., Zero Emission Valley) facilitates financing and replication.

- Knowledge-sharing accelerates project maturity: exchanges between pilot territories help overcome technical and regulatory challenges.
- Pilot projects lay the foundation for large-scale deployment: these initial initiatives provide critical data and insights for future hydrogen expansion.

By integrating these lessons, AMETHyST can serve as a blueprint for other regions aiming to develop sustainable hydrogen ecosystems in complex geographical contexts.

# PEIO,RONZO CHIENIS AND FIERA DI PRIMIERO

## OVERVIEW

The pilot project aims to develop an integrated and sustainable energy solution in Trentino, focusing on renewable energy sources, green hydrogen production, and optimizing energy distribution. The initiative aligns with European and national decarbonization goals, promoting climate neutrality by 2050. The project leverages renewable energy sources, particularly photovoltaic (PV) systems, to produce green hydrogen. This hydrogen will be utilized in multiple ways, including direct residential heating, blending with the natural gas grid, and supplying district heating networks. The primary objective of the project is to create a secure, efficient, and interconnected energy network for the Provincia Autonoma di Trento. This will be performed extending the natural gas distribution to non-methanized municipalities, developing a provincial hydrogen roadmap to integrate hydrogen as an alternative energy carrier and optimizing renewable energy use through photovoltaic installations and hydrogen storage.

The Peio pilot project focuses on the development of a dedicated hydrogen network for residential heating, as there is currently no natural gas infrastructure in the area. The main objectives are to establish a hydrogen pipeline network to supply residential heating systems, install buffer and seasonal hydrogen storage units to ensure continuous supply, even during peak demand. The goal aims to cover 50% of total thermal demand, the PV plant and electrolyser are located in Ossana due to better solar exposure

The Ronzo Chienis pilot project aims to integrate green hydrogen into the existing local natural gas network by blending it with methane. This initiative supports the decarbonization of energy systems, leveraging renewable hydrogen production to reduce fossil fuel dependency while utilizing current gas infrastructure. The target is to blend at least 20% of hydrogen with natural gas. The steps to achieve this goal are to establish a photovoltaic plant for renewable energy generation, install an electrolyser to produce green hydrogen,set up buffer and long-term hydrogen storage facilities and finally develop a mixing pipeline for injecting hydrogen into the existing methane network.

To conclude, the main goal of the Fiera di Primiero project is to integrate hydrogen into the existing district heating network, reducing reliance on fossil fuels such as diesel and enhancing sustainability through renewable energy sources. The project aims to develop a hydrogen generation and storage system to complement the region's biomass-based heating infrastructure. The steps to achieve this goal are utilize excess renewable electricity for hydrogen production, ensuring energy efficiency, implement seasonal hydrogen storage to balance energy demand.

## ACTIVITY PROGRESS

In Trento, the project has undertaken several key activities to foster synergies with local and regional actors, engaging relevant stakeholders across various target groups. On October 16, 2024, Trento hosted the midterm conference titled "Hydrogen for the Future of the Alps." This event convened approximately 150 stakeholders, including local and European leaders, researchers, and industry experts, to discuss the role of hydrogen in advancing a sustainable energy transition in the Alpine region. The conference featured presentations on the project's progress, panel discussions on topics such as skills development, safety, and funding in the hydrogen value chain, and the launch of the SkHyline platform—a collaborative initiative designed to unite efforts across regions, fostering knowledge-sharing and accelerating hydrogen deployment in sectors essential to the Alpine economy.

In Trento, the working group includes representatives from public authorities, private companies, research institutions, and industry experts, all collaborating to foster the uptake of hydrogen technologies in the region.

Partnerships with Local Institutions: The Autonomous Province of Trento and the Bruno Kessler Foundation have become partners in the AMETHyST project, focusing on developing strategies and solutions for green hydrogen in Alpine tourist areas. This partnership aims to support the implementation of hydrogen solutions as a key factor for decarbonization and increased energy efficiency in the region.

During this conference, a panel titled "Hydrogen in Trentino: An Overview by Policy Makers, Research Institutions and Industries" facilitated a comprehensive discussion among policymakers, researchers, and industry leaders, highlighting the collaborative efforts in advancing hydrogen development in Trentino.

Additionally, on March 26, 2024, the "Zero Carbon Community" meeting was organized by The European House – Ambrosetti in collaboration with Trentino Sviluppo and FBK, hosted at FBK's Povo premises. This event served as a platform to discuss strategies for fostering industrial initiatives aimed at developing hydrogen valleys, with a focus on opportunities within the Provincia Autonoma di Trento's ecosystem. The meeting featured contributions from various stakeholders, including representatives from PAT, Trentino Sviluppo, and Confindustria Trento, underscoring the region's commitment to sustainable energy solutions.

Through these initiatives, PAT and Trentino Sviluppo have effectively engaged with Confindustria Trento and other key stakeholders, fostering a collaborative environment to advance hydrogen development in the region.

# ACHIEVEMENTS

Domenico Borello, an Associate Professor at Sapienza University of Rome specializes in decarbonization technologies, including hydrogen production and $CO_2$ capture. ACSM Fiera di Primiero is a company based in Trentino that focuses on the production, distribution, and sale of thermal energy through biomass district heating plants in San Martino di Castrozza and the Primiero valley.

Domenico Borello and ACSM in these days are meeting and deepening the analysis of the 4th scenario with a more detailed evaluation of the hydropower utilization . The different sub-scenarios (4a, 4b, and 4c) rely on hydropower from the San Silvestro run-of-river hydroelectric plant, with 4c also incorporating photovoltaics. It would be valuable to study how the seasonal variations in water flow affect the stability and efficiency of hydrogen production, ensuring that the system remains reliable throughout the year.

Another crucial aspect is the performance and sizing of the electrolyzer. In Scenarios 4a and 4c, the electrolyzer operates based on electricity price thresholds (PUN), while in Scenario 4b, it runs continuously for self-consumption. A deeper simulation of different electrolyzer sizes and operational strategies could help determine the most efficient approach, balancing energy costs and hydrogen output.

Beyond the technical aspects, an in-depth cost-benefit analysis would provide clearer insights into the financial feasibility of the project. This includes examining capital investments, operational costs, and potential savings from reducing diesel consumption.

To refine the scenario further, advanced modeling and simulation using MATLAB/Simulink, along with real-time hydropower data, could provide a more accurate picture of its viability. By combining technical, economic, and environmental perspectives, the project can be fine-tuned to ensure its long-term success.

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

# DEVIATIONS

Peio and Ronzo Chienis will not proceed with hydrogen implementation primarily due to economic and infrastructural limitations.

In Peio, the initial plan involved building a hydrogen pipeline network to supply residential boilers. However, the area already has a well-established district heating network powered by biomass, particularly in the hamlet of Cogolo. Since biomass is readily available and does not pose significant environmental concerns, transitioning to hydrogen was deemed unnecessary and economically unfeasible at the actual production costs.

In Ronzo Chienis, the plan was to integrate hydrogen into the existing natural gas grid by blending it at 20% concentrations. However, the project faced several challenges, including the high costs of infrastructure modifications, storage requirements, and uncertainties in energy supply stability. Additionally, the municipality has a low population density, making the demand for hydrogen relatively small compared to the required investment.

Ultimately, the economic, infrastructural, and logistical constraints in both locations led to the decision not to move forward with hydrogen implementation.

# KEY LESSONS LEARNT

The design of hydrogen projects in alpine villages have provided several key lessons that can be applied when transferring and replicating similar initiatives in other pilot territories.

One of the most significant takeaways is that fully meeting thermal energy needs with hydrogen requires nowadays substantial investments, which may not always be feasible for small communities. Instead, a more practical approach is to integrate hydrogen into existing district heating systems to enhance efficiency and reduce reliance on fossil fuels.

The availability of local infrastructure plays a crucial role in determining the viability of hydrogen solutions. In areas where natural gas distribution lines exist, blending hydrogen into the grid can be a cost-effective way to introduce this energy source. However, in locations without such infrastructure, hydrogen distribution should be limited to small, concentrated user clusters with minimal overall demand. Even in such cases, using hydrogen for district heating tends to be the most practical and efficient option.

Another key lesson is the challenge of balancing energy production and demand. In scenarios relying on photovoltaic energy for hydrogen production, a significant mismatch was observed between solar energy availability and actual energy needs, necessitating large storage volumes. This issue highlights the importance of considering alternative renewable sources, such as hydropower, which can offer more consistent and predictable energy generation throughout the year.

Additionally, environmental and regulatory constraints must be carefully evaluated. Large-scale photovoltaic installations, for example, can face land use restrictions and visual impact concerns, making them less suitable for certain regions. When planning hydrogen projects in new areas, it is essential to ensure minimal infrastructure impact and compliance with local land use policies.

For successful replication in other territories, hydrogen projects should be tailored to local energy demand, available infrastructure, and renewable energy resources. Conducting feasibility studies, modelling energy consumption patterns, and ensuring appropriate storage solutions are critical steps in developing a sustainable and economically viable hydrogen ecosystem.

# ANALYSIS OF AN APPLICATION OF STATIONARY USE OF HYDROGEN TO DECARBONISE AN ORGANIC FARM AND TOURIST ACCOMMODATION IN THE ITALIAN ALPS

## OVERVIEW

The pilot site “Arieshof”, in St. Lorenzen (Italy), has been in operation from the start of the project and serves to demonstrate the lessons learnt from the implementation of a stationary hydrogen ecosystem at a farm and accommodation structure in the Italian Alps. The system combines production, storage and consumption of hydrogen to increase the energy autonomy of the building. The objectives of the analysis of this case study are to assess the performances, and deduce recommendations from the experiences made during implementation and operation of the project.

## ACTIVITY PROGRESS

The pilot “Arieshof” is a project already in operation. All facilities are on site and owned and operated by a private owner/investor. The electrolyser is powered by a 206 kWp (230 MWh) PV plant installed on the roofs of the building complex. The project is one of the first of its kind in the region, meaning that the involvement of different stakeholders during the planning and authorization process was vital. The experiences from the implementation and operation of the project provide recommendations which are outlined in the following chapters.

## ACHIEVEMENTS

The pilot project is already in operation since the start of the project; during the AMETHyST project there was merely performed an analysis of the energy system and the key performance indicators. It is important to note that the H2 technology in use is sold as ready-to-use integrated unit on the market.

## DEVIATIONS

none

## KEY LESSONS LEARNT

The following lessons/recommendations emerge from the experience with the pilot:

- The technology used at the pilot is most suitable for a) Island solutions, and b) Micro-grids. For single buildings the cost of the investment is still too high compared to alternative solutions.
- Importance of adapting regulations and ensuring smooth certification processes for hydrogen applications, in particular with regards to safety standards.
- Growth of the supply chain. Support the growth of all elements of the supply chain. In particular, the cost of hydrogen needs to be reduced. Trade-offs between financial/economic aspects and performance may need to be accepted.

- It is important to identify **priorities**. Also, identification of what is convenient (ex. connection to the grid vs. stand-alone system)
- Importance of pioneers and best practices to show what is possible (even if cost-benefit is not optimal)

# UPPER BÛT VALLEY HYDROGEN ECOSYSTEM

## OVERVIEW

The goal of the pilot coordinated by APE FVG is the development of a "hydrogen ecosystem" that allows for the production and use of green hydrogen in the context of an alpine valley of Friuli Venezia Giulia.

One of the identified users is the Zoncolan ski resort that aims to become the first zero-emission resort in the Alps. APE FVG, in collaboration with PromoTurismo FVG and SECAB - observers in the Project - has devised the pilot project to enable the set up and development of a local hydrogen supply chain fuelled 100% with renewable energy. The chairlifts and the snowmaking equipment at the Zoncolan ski resort are already supplied by SECAB, first cooperative-based company in Friuli Venezia Giulia and located in Paluzza, which produces renewable energy from hydroelectric and photovoltaic. The major fossil fuel consumption currently concerns the snow groomers. The local consortium plans to use the surplus of renewable production of SECAB for the production of hydrogen to be used, for the first stage of the pilot, on a snow groomer (See Fig.1 1) that will be operated by PromoTurismo FVG on the ski resort. As a matter of fact, the South Tyrolean company Prinoth (current supplier of PromoTurismo FVG) already produces hydrogen-powered snow groomers, supporting a 100% Italian supply chain. It is also important to note that PromoTurismo FVG is part of the SECAB corporate structure by self-consuming the energy produced by the corporate plants.

In this way, the aim is to increase the added value for SECAB by using part of the extra production of green energy, today fed in the Terna (national TSO) grid and sold on the national market, to locally produce an energy vector (hydrogen) to be used for the local operation of heavy vehicles - one snow groomer in the winter season and local public transport buses operated by TPL FVG in the other seasons. The added value for PromoTurismo FVG would be the visibility as a supporter of environmental sustainability and as the first 100% renewable ski resort of the Alps from the energy supply perspective. The added value for TPL FVG is the possibility of sourcing an alternative energy vector, which is currently scarce, in the local supply chain and at market prices.

Other scenarios for the decarbonization of local public transport have also been analyzed, targeting future scenarios in which industry will be able to contribute to the increase in demand, allowing the sustainable development of the alpine green hydrogen ecosystem of Carnia and Friuli Venezia Giulia. In fact, a growing demand for this energy vector is expected in various sectors of activity where decarbonization alternatives are limited: "hard-to-abate" industry, heavy logistics, heavy transport vehicles (trucks, buses, etc.). From this point of view, there are several potential synergies to be established with the ambitious project of the North Adriatic Hydrogen Valley in a system logic and on a larger scale.

The Upper But Valley pilot has the strength to encompass all the components of a hydrogen ecosystem in a relatively small territorial area, constituting an ideal pilot case where the availability of green energy is already present and guaranteed throughout the entire solar year, within a local production and distribution system entirely managed by the cooperative.

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

# ACTIVITY PROGRESS

The implementation of the pilot has benefitted deeply from the knowledge and experience exchange among regional and national stakeholders operating in the hydrogen sector.

Since the beginning of the AMETHyST project, several meetings have been organized for networking reasons with Prinoth, MetHydor, SolydHera, Faber, and Toyota Material Handling. Good relationships have been established with many companies operating in the sector, from production to demand, by participating in thematic events including Key Energy 2024 in Rimini and the Hydrogen Expo 2024 in Piacenza.

APE FVG is also in contact with the regional representatives of the NAHV - North Adriatic Hydrogen Valley initiative - aiming at creating a hydrogen-based economic, social and industrial ecosystem between Friuli Venezia Giulia, Croatia, and Slovenia.

Since March 2024, APE FVG has been associated with H2IT as responsible for the Hydrogen Table of Renael, the National Network of Local Energy Agencies. In this frame, APE FVG is currently coordinating a cycle of events called *H2InComune* in collaboration with H2IT and with the patronage of MASE (Ministry of Environment and Energy Security) to spread the culture of hydrogen and prepare local public administrations for the development of innovative projects in the territory. The initiative, which started in February 2025 with the first event held in Friuli Venezia Giulia, consists of an informative tour in five stages throughout the national territory and will see the participation not only of local authorities, but also of companies and the academia.

# ACHIEVEMENTS

The pilot project has successfully demonstrated the feasibility of hydrogen production and utilization in the Upper But Valley, leveraging surplus renewable energy from SECAB's hydroelectric and photovoltaic plants. The implementation has provided valuable insights into the integration of hydrogen as a decarbonization solution for public transportation and winter tourism in a mountainous region.

A key achievement is the **detailed analysis of surplus energy availability**, which confirmed that the cooperative produces over 24,000 MWh annually, ensuring a stable and continuous hydrogen production throughout the year. This surplus energy, which would otherwise be injected into the grid, is now effectively repurposed to power the electrolysis process, optimizing local renewable energy use.

The project evaluated the **potential hydrogen demand** for replacing diesel in key transport applications. Specifically, the transition to hydrogen-powered vehicles, including **three school buses** - serving Treppo, Ligosullo, Ravascletto, and Paluzza - as well as **one hydrogen snow groomer for the Zoncolan ski resort**, was analyzed. The results indicate a significant reduction in $CO_2$ emissions, contributing to the decarbonization of local mobility.

A major technical achievement has been the **scalability assessment** of the hydrogen production system. Two scenarios were analyzed:

- **120 kW electrolysis system**, producing **14 tons of $H_2$ per year** with minimal impact on SECAB's grid integration. The system would operate for **7,168 hours annually**, with a high utilization rate of 6,783 hours at full capacity.

- **2 MW electrolysis system**, producing **210 tons of $H_2$ per year**, utilizing **12,000 MWh** of renewable electricity, approximately 50% of SECAB’s annual surplus. This setup demonstrated that a significantly larger plant could still maintain high operational efficiency.

The **hydrogen storage solution** was designed in compliance with the safety requirements of the Directive 2012/18/EU or the Seveso-III Directive, using high-pressure FABER cylinders. The modular storage system can scale from **468 kg to 1,872 kg**, ensuring compliance with regulatory limitations while maintaining operational flexibility.

Overall, the pilot has proven the technical viability of a **hydrogen ecosystem in a mountainous setting**, offering a pathway for energy self-sufficiency and sustainable mobility. It provides a replicable model for remote alpine regions where electrification is not always feasible, reinforcing the role of hydrogen in **local energy resilience and decarbonization strategies**.

# DEVIATIONS

During the implementation of the pilot, some deviations from the initial concept design and roadmap were identified, mainly due to technical, economic, and regulatory constraints. These deviations were carefully assessed, and appropriate corrective measures were taken to ensure the project's success while maintaining its feasibility and sustainability.

One key deviation arose in the scaling of the hydrogen production system. While the initial concept considered a modular approach, the feasibility analysis revealed that a 2 MW electrolysis system would significantly impact SECAB’s energy surplus availability. Given that the cooperative currently injects around 24,000 MWh/year into the grid, a 2 MW system would consume nearly 50% of this surplus. This raised concerns about grid stability and potential limitations in electricity availability during peak demand periods. As a result, the project opted for a staged implementation, starting with a 120 kW system, which allows for gradual scaling while ensuring minimal impact on SECAB’s operations.

Another deviation was related to hydrogen storage capacity and regulatory constraints. The original concept considered larger on-site storage solutions; however, to comply with the Seveso-III Directive, a maximum of 1,872 kg of hydrogen storage was implemented, limiting the number of storage units deployed simultaneously. To address this, the project optimized storage logistics, ensuring that hydrogen refueling infrastructure remains operational without exceeding regulatory thresholds.

Additionally, the initial roadmap envisioned a broader fleet conversion, including multiple hydrogen-powered snow groomers and additional public transport vehicles. However, after conducting a demand analysis, it became clear that hydrogen consumption is highly seasonal, with peaks during winter (due to school transport and ski resort operations) and negligible demand in summer. To maintain economic feasibility, the project prioritized three school buses and a single snow groomer, ensuring that early deployment remains cost-effective and aligned with real demand patterns.

Despite these deviations, the project successfully validated the feasibility of an alpine hydrogen ecosystem and demonstrated a replicable model for similar remote regions. By adopting a phased approach to electrolysis capacity, optimizing storage logistics, and focusing on high-impact applications, the pilot remains aligned with its overarching goal: decarbonizing mobility in mountainous areas using surplus renewable energy.

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

# KEY LESSONS LEARNT

The design and implementation of the pilot provided valuable insights that can guide the replication of similar hydrogen-based ecosystems in other remote or mountainous areas. The key lessons learnt include:

**Scalability and Phased Implementation**

A modular approach to hydrogen production is essential for balancing energy availability and demand. Starting with a 120 kW system instead of directly deploying a 2 MW system allowed the project to test feasibility, minimize risks, and adapt to local constraints before scaling up. This stepwise approach can be applied in other territories with variable renewable energy generation and evolving hydrogen demand.

**Optimized Use of Renewable Surplus Energy**

The pilot demonstrated that leveraging surplus renewable electricity (in this case, from SECAB's hydro and solar plants) is a viable strategy for local hydrogen production. However, careful monitoring of energy injection into the grid and seasonal variations is necessary to avoid overcommitment of electricity resources. Other regions considering similar projects should assess their grid constraints and ensure long-term surplus availability.

**Hydrogen Storage and Regulatory Considerations**

Compliance with the Seveso-III Directive and local safety regulations influenced the storage capacity, limiting on-site hydrogen reserves to 1,872 kg. This highlights the need for early engagement with regulatory bodies and a flexible storage strategy, potentially combining distributed storage or smaller decentralized refuelling points to meet operational needs while complying with safety requirements.

**Seasonality of Hydrogen Demand**

A crucial lesson was recognizing that hydrogen demand in alpine areas is highly seasonal, with peaks during winter (school transport, snow grooming) and minimal use in summer. This underscores the importance of matching production with actual consumption patterns, potentially integrating hydrogen use in off-season applications (e.g., summer tourism, backup power, or local industry) to enhance economic feasibility.

**Targeting the Right Applications for Maximum Impact**

The initial roadmap included a broader vehicle fleet conversion, but the pilot prioritized the most impactful applications first, starting with three hydrogen-powered school buses and one snow groomer. Other regions should similarly focus on high-usage, high-impact sectors (e.g., public transport, municipal fleets, off-grid applications) before expanding into additional areas.

**Economic Viability and Long-Term Sustainability**

While hydrogen is a promising decarbonization tool, its economic competitiveness remains a challenge. In remote areas, public-private partnerships, subsidies, and incentive mechanisms are crucial to ensure financial viability. Future projects should explore synergies with existing renewable energy cooperatives and identify long-term funding strategies to maintain project sustainability.

This pilot demonstrated that local hydrogen ecosystems can be successfully deployed in remote alpine regions, provided that they are designed with flexibility, aligned with local energy availability, and scaled in response to demand. The lessons learnt here descibed offer a replicable framework for other territories, emphasizing gradual implementation, regulatory alignment, and the strategic selection of hydrogen applications to maximize environmental and economic benefits.

# FUNIVIE MADONNA DI CAMPIGLIO SKI AREA

## OVERVIEW

The primary goal of this pilot project is to explore and evaluate potential hydrogen-based solutions that can be integrated into the operations of the Funivie Madonna di Campiglio ski area to significantly reduce greenhouse gas emissions. By analyzing current energy consumption patterns and associated emissions, the project aims to identify the most effective hydrogen applications that align with both environmental sustainability and operational efficiency.

Key considerations include the technical feasibility of implementing hydrogen-powered systems as well as the financial viability of these technologies.

## ACTIVITY PROGRESS

Progress has been made in fostering collaborations with key stakeholders to explore hydrogen solutions for the ski area. Regular communication has been maintained with the company managing the ski area (an SME), ensuring their active participation in events organized within the AMETHyST framework and they were also engaged in discussions with the snow-groomers provider (Prinoth) that is developing hydrogen-powered snow-groomers. This is, in fact, the most suitable hydrogen application for the ski area in the short- and medium- term. The snow-groomer provider is currently testing hydrogen snow groomers (hydrogen-fueled internal combustion engines), aiming to bring them to market in the coming years.

## ACHIEVEMENTS

Given the early-stage development of hydrogen-powered snow groomers, it is currently premature for the ski area to plan an immediate replacement of its existing diesel-fueled fleet. The technology is still evolving, with ongoing testing and optimization required to ensure reliability, efficiency, and operational feasibility in demanding alpine conditions.

However, continuous engagement with the snow groomer provider will be maintained to stay informed about technological advancements, performance improvements, and market readiness. This ongoing dialogue will enable the ski area to assess the right timing and conditions for a potential transition.

Furthermore, Funivie Madonna di Campiglio has the potential to play a role as a pilot site for real-world testing of hydrogen-powered snow groomers. By offering a controlled yet operationally relevant environment, the ski area could contribute to refining the technology, gathering critical performance data, and demonstrating the viability of hydrogen solutions in alpine tourism. Such a collaboration would position the ski area as a leader in sustainable innovation while supporting the broader decarbonization of winter sports infrastructure.

## DEVIATIONS

Due to the evolving maturity of hydrogen snow groomer technology and the ongoing development, immediate deployment is not yet feasible. To address this, the focus has been placed on continuous monitoring and stakeholder engagement rather than immediate planning for fleet replacement. Regular discussion with the snow groomer provider can ensure that the ski area remains up to date on technological advancements, allowing for a well-informed transition strategy whether technology becomes market ready.

Additionally, the possibility of Funivie Madonna di Campiglio serving as a pilot site for early testing could be a strategic opportunity, allowing for a gradual, data-driven approach to hydrogen integration.

# KEY LESSONS LEARNT

The design of this pilot has provided valuable insights that can inform the transfer and replication of hydrogen-based solutions in other similar contexts.

- Technology readiness and market Timing. While hydrogen-powered snow groomers represent a promising decarbonization solution, their commercial availability is still limited. Ski areas looking to adopt hydrogen solutions should closely monitor technological advancements and align their transition strategies with market readiness.
- Stakeholder engagement. Early and continuous collaboration with key stakeholders, including ski area operators, technology providers, and regional authorities, is essential. Open dialogue ensures alignment on feasibility, infrastructure needs, and long-term sustainability goals.
- Infrastructure and logistics considerations – The successful integration of hydrogen-powered equipment requires careful assessment of refueling infrastructure, energy storage, and supply chain logistics. Strategic planning is needed to ensure long-term operational viability.
- Phased approach. Given the evolving nature of hydrogen technologies, a gradual transition (from pilot testing to phased implementation) is more effective than an immediate full-scale shift. This approach minimizes financial and operational risks while allowing time for necessary adaptation.

# MARIBOR REGIONAL H2 WORKING GROUP

## OVERVIEW

The main objectives of our pilot project are to establish a regional hydrogen working group, foster knowledge exchange among stakeholders, develop regional hydrogen strategy, explore best practices and identify potential hydrogen projects. These efforts support the region's transition to a green hydrogen ecosystem through regular meetings and collaborative activities, ensuring ongoing engagement and strategic development as well as planning the projects suitable for regional conditions.

Through the pilot in Maribor we demonstrate how the region without any idea about the $H_2$ projects could organize them-self to make step towards the production and use of $H_2$.

The goal was achieved. Maribor has very good working group already working on the draft of regional H2 strategy, $H_2$ linked project was prepared and approved and in March 2025 the first talks about implementing the green $H_2$ production with electricity from PV is under preparation together with very important stakeholders Messer, the biggest international company in the field of gases including H2. Stakeholders are connected and they are becoming part of national and EU initiatives like National working group on H2 at National Energy Chamber and national platform National Association for H2 Slovenia as a part of Hydrogen Europe.

## ACTIVITY PROGRESS

The most important activities were:

1. **Stakeholders mapping**: to identify all stakeholders on local, regional and national lelev
2. **Stakeholder Engagement**: The $H_2$ working group includes diverse stakeholders from local, regional and national authorities, development and research institutions, public enterprises and private companies. Regular meetings were held to work step by step.
3. **Knowledge building and exchange of experiences**: the working group fostered knowledge building and exchange through workshops, discussions, and study visits. The identification of gaps and SWOT analysis were prepared to tailor the workshops and organize study visits. The expert from country and abroad were invited to participate. Different topics such as decarbonization, technical characteristics of hydrogen, strategic frameworks, safety issues, handling with high pressure technologies and practical examples of hydrogen use in Slovenia and the EU were covered. The working group has cooperated with all national projects dealing with H2 and some international like Green Hydra (Interreg Europe) and H"SCALE (Interreg Danube Region).
4. **Study visits and practical Insights**: 2 study visits were organized to provide practical insights into hydrogen projects and enhancing their understanding of operational best practices. Stakeholders observed successful implemented projects, discussed about planning the strategy and preparing action plan, developing the projects as well as searching for financial sources.
5. **Development of the regional $H_2$ strategy**: the working group has developed materials as an initial input for regional strategy. Slovenia has no national strategy yet therefore the initial info are needed. Stakeholders were invited and they have joined different national and EU initiatives like National working group on H2 at National Energy Chamber and national platform National Association for H2 Slovenia as a part of Hydrogen Europe.
6. **Identification of potential projects**: The working group has identified and explored potential hydrogen-related projects within the region and looked for financial sources.

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme

# ACHIEVEMENTS

The main achievements in Maribor region are:

- Regional working group was established. Following stakeholders are engaged: ENERGAP, Ministry of Slovenia for environment, climate and energy, Municipality of Maribor, including the vice mayor, Regional utilities for electricity, gas and district heating and waste management, Regional development agency, national research Institute Jozef Stefan, University of Maribor, regional Chamber of Commerce, regional Business zone Cona Tezno, Messer Slovenia and some stakeholders that cooperate within specific activities (companies that already have experiences with hydrogen)
- 1 strategic workshop was organized to identify gaps and build SWOT analysis
- 2 knowledge workshops were organized to explore hydrogen strategies and technologies in other countries and safety issues linked with H2.
- 3 study visits were organized – one in Italy (GKN Hydrogen in Pfalzen and the hydrogen pilot project at Arieshof in St. Lorenzen) and one in Hungary (University of Pecs), one in Sofia, Bolgaria enhancing their understanding of operational best practices. One more visit is under the development – visit to production site in Innsbruck and visit to INNO company that produces big heating system suitable for H2.
- Initial inputs for regional H2 strategy were prepared for discussion
- One project for H2 production with green electricity from FV in Maribor is developing.
- One project proposal was prepared and was successful in Interreg Europe programme where the region is preparing the proposal for investment project for H2 kick-off.
- Many different information and educational materials were prepared
- ENERGAP and some other stakeholders has become the members of National working group on H2 at National Energy Chamber and national platform National Association for H2 Slovenia as a part of Hydrogen Europe.

# DEVIATIONS

There were no deviations from the planned activities.

# KEY LESSONS LEARNT

The most important lessons learnt are:

1. Many stakeholders have to be involved in activities from regional and national levels.
2. Stakeholders have to have or get good knowledge and experiences on the subject to be able to plan strategies and activities.
3. Stakeholders have to cooperate actively within the group and also be a part of other national or international initiative.
4. Within the working group it is good to have different organisations like authorities, research, project developers and companies dealing with gases, heat and electricity production.
5. The group needs facilitator to keep the activities going on.
6. The stakeholders have to participate to different event on regional, national and international levels like conferences and workshops and give feed back to the group.

7. Identification of the knowledge gaps and SWOT analysis is important when building a plan for projects implementation.
8. Exchange of experiences and study visits are very important for stakeholders that have no real cases or experiences with the hydrogen – to see how production, storage, transportation and use on the ground. The discussion with peers is very important to get insights of the process and methods
9. The strategy preparation needs some time and money. It is very good if national strategy is prepared which is not the case for Slovenia.
10. It is very good to have some EU funded projects to overcome initial barriers and share the experiences or start to build pilot or small projects and get stakeholders and potential companies involved.
11. The lack of money is not a big problem. The biggest problem is knowledge and cooperation as well as legislative and administrative barriers.

# WIVA R&D HYWEST

## OVERVIEW

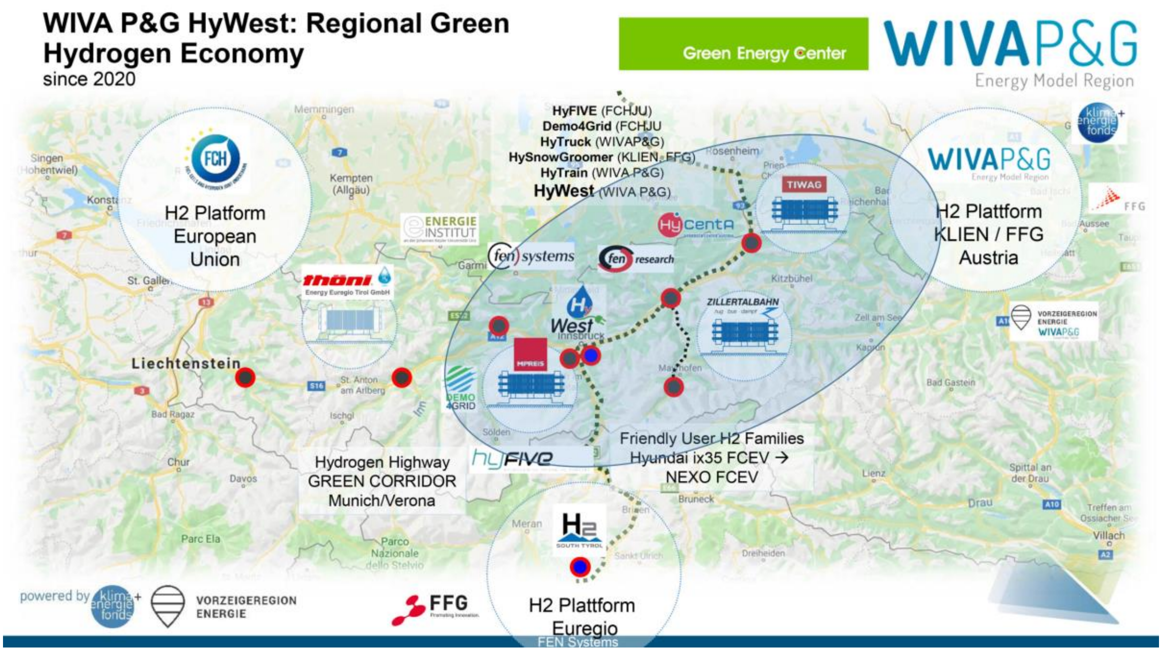
The R&D flagship project HyWest serves as a model for the development of a largely autonomous regional green hydrogen economy. The main focus is the investigation of cross-sectoral production, storage and application of green hydrogen.

- Production, methanation and feed-in of green hydrogen
- Fuel cell systems based on renewable energy sources
- Green hydrogen in industrial processes

The aim of this lighthouse project is to create a business-oriented hydrogen region in Tyrol, linking the green energy, green mobility and green industry sectors at regional level.

This project is mainly based on the logistic principle and is a result of synergies between three ongoing complementary implementation projects:

1. MPREIS Hydrogen
2. Zillertalbahn 2020+ Energy Autonomous with Hydrogen
3. TIWAG Power2X Kufstein.




Ad1) Construction of an alkali-pressure electrolysis plant for the production of green hydrogen and control of the power grid

The aim of the EU project "Demo4Grid" is to build a PAE electrolysis plant (Pressurized Alkaline Electrolyser) to research and demonstrate power grid balancing services under real operating and market conditions while simultaneously producing green hydrogen to green industrial processes. The plant was built at the production and logistics center of the local food supplier MPREIS in Völs near Innsbruck and is the spearhead for the development of a green regional hydrogen economy in Central Europe. The HyWest research center is the catalyst and the Green Energy Center Europe in Innsbruck is the distribution point for this pioneering hydrogen project for the conversion of the energy system to climate neutrality and autonomy.

Ad 2) HyTrain: Zillertalbahn 2020+ energy-autonomous with hydrogen

The project "Zillertalbahn 2020+, energy-autonomous with hydrogen" has been developed since 2016 as part of the green hydrogen economy currently being developed in Central Europe. The activities required for this are bundled in numerous international and national research competition projects in the hydrogen center "HyWest" at the Green Energy Center Europe in Innsbruck.

Since 2020, the Federal Ministry for Climate Protection has been using the Climate and Energy Fund to promote the development of a drive train including refueling for a hydrogen train with the "WIVA P&G HyTrain" project, which is to become a reality with the Zillertalbahn 2020+, the world's first hydrogen-powered narrow-gauge railway. In the related lighthouse project of the Hydrogen Initiative Model Region Austria " WIVA P&G ", Austrian know-how is being built up for the development, quality assurance and risk minimization of the procurement, takeover, operation and guarantee processes.

Ad 3) Tiwag Power2X Kufstein

Innovative Sector Coupling Plant with Hydrogen Center

HyWest intends to create a business case driven Green Hydrogen Region in Tyrol/Austria in the area of Kufstein close to the international road transport axis Munich - Verona.

It will integrate the sectors green energy, green mobility and green industry at a regional level with hydropower as the primary energy source and PV as a future supplement.

The sector coupling focus is on greening public gas supply by green hydrogen and green synthetic natural gas, green heat and green hydrogen for regional and international transport purposes as well as e-mobility.


The green power source for the PEM electrolysers with an installed capacity of in total up to 4 MWel is the 30 MW run-of-river-plant Langkampfen and a 25 kV backup connector to the public grid.

The P2X facility will be essential for greening Tyrol’s gas supply. For this purpose, it will be interconnected with the gas backbone as well as with the local gas distribution infrastructure.

# ACTIVITY PROGRESS

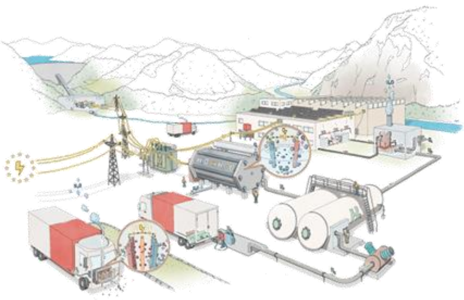
On March 2, 2023, the Tyrolean food retailer MPREIS officially opened its own hydrogen electrolysis plant and ceremoniously put the first hydrogen truck with the associated hydrogen logistics facilities into operation, thus adding the final building block to a self-functioning green local hydrogen economy and its own hydrogen business case. The H2 truck is the first of three vehicles co-financed by the Austrian Climate and Energy Fund as part of the national research competition project “WIVA P&G HyWest”. The H2 truck runs on green hydrogen from its own alkaline pressure electrolysis plant, which was built as part of the EU competition project “Demo4Grid” and co-financed half by the EU’s Clean Hydrogen Partnership and half by the Swiss state.

First HyWest hydrogen truck including hydrogen logistics put into operation at MPREIS
Release date: March 3, 2023

The MPREIS hydrogen project is the spearhead for the development of a green regional hydrogen economy in Central Europe, which has been systematically developed at the HyWest research center since 2016 and is being driven forward by the privately organized Codex partnership of the Green Energy Center Europe with real economy projects.

Research and financing partnership in the “WIVA P&G HyWest” project: Green Energy Center Europe, Fen-Systems, Climate and Energy Fund, FEN Research, HyWest Research Center HyWest”, Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology, Tiwag, Tinext, Zillertaler Verkehrsbetriebe – ZVB,

MPreis Hydrogen:
The hydrogen production of MPREIS Hydrogen is based on a pressurised alkaline electrolyser installed within the EU project Demo4Grid[1] “Demonstration for Grid Services”.




Pictures: Demo4grid – Alkaline Electrolyze – Mpreis Hydrogen, Völs

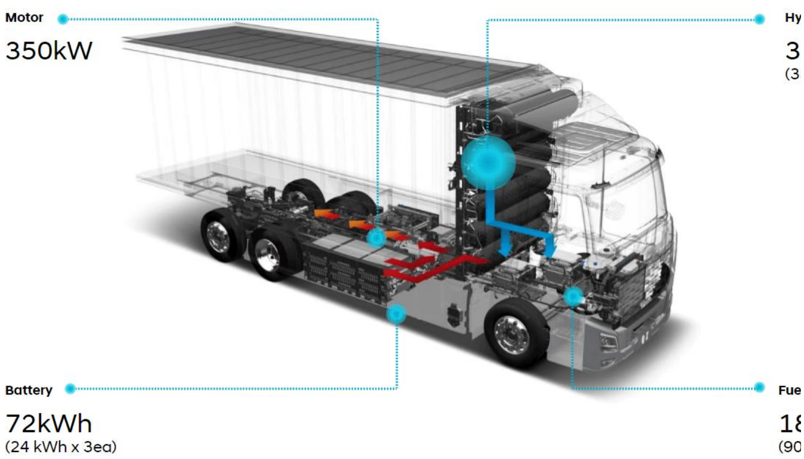
[1] Demo4Grid: https://www.demo4grid.eu/projektinformationen/

# ACHIEVEMENTS

Mobility – MPREIS Hydrogen:

The MPREIS-owned hydrogen filling station is able to refuel 40 trucks a day at one pump works since 2023.

The first Hyzon brand fuel cell truck was put into operation in 2023.  The truck was in use until 09/2024 and was further developed. Hyzon withdrew from Europe at the end of 2024, the test drives were discontinued, and the truck was returned. In January 2025, the first Hyundai fuel cell truck was delivered to JuVe-Automotion, a spin-off of MPreis. Further vehicles are being planned.


# DEVIATIONS

Zillertalbahn 2020+, energy-autonomous with hydrogen

The project "Zillertalbahn 2020+, energy-autonomous with hydrogen" has been developed since 2016 as part of the green hydrogen economy currently being developed in Central Europe. The activities required for this are bundled in numerous international and national research competition projects in the hydrogen center "HyWest" at the Green Energy Center Europe in Innsbruck.

The project was discontinued in 2024 and the variant with battery-electric battery trains is being implemented.

Power2X-Kufstein:

The planning and approval phase has been completed. The start of construction planned for 08/2024 has been postponed indefinitely. The reason for this is the lack of demand for green hydrogen, mainly in the mobility sector. Work is underway on follow-up projects.

# KEY LESSONS LEARNT

This text was published on the website of the Green-Energy-Center Europe, Innsbruck and summarizes the "lessons learned" from the Wiva P&G HyWest project. You will also find the video in the link.

Challenges for Green Energy Centre Europe's Codex Partnership

***Challenges for Green Energy Centre Europe's Codex Partnership***

*Veröffentlichungsdatum: 13.03.2025*

*The transition to a sustainable and climate-neutral energy system is a fundamental challenge of our time. The Green Energy Center Europe, through its Codex Partnership, is committed to overcoming obstacles in the energy transformation and advancing green energy solutions. This report highlights the challenges and progress in building a bridge to a sustainable future, with a focus on flagship projects such as Green Hydrogen for MPREIS, Tyrol and Europe and the Zillerbalban 2020+ energy autonomous with Hydrogen project.*

*Challenges in the Energy Transition: The shift towards a green and autonomous energy system faces multiple hurdles, including technical, market, financial, and political challenges. The Green Hydrogen for MPREIS project demonstrates that innovation is possible despite these barriers. However, the Zillerbaliban 2020+ project illustrates the risks posed by these challenges. After eight years of development, the project was halted, resulting in financial losses and setbacks in the hydrogen economy and the Tirol 2050 energy autonomy strategy.*

*A major factor in this disruption was the influence of disinformation and polarized debates, which prevented the implementation of newly developed hydrogen trains and their associated infrastructure, despite official inclusion in national and regional government programs. This case underscores the necessity of clear communication, stakeholder engagement, and a supportive regulatory environment.*

*Lessons Learned and Future Strategies: The experience gained from past challenges has emphasized the importance of integrating practice and research. The Codex Partnership of the Green Energy Center Europe is leveraging these lessons to drive sustainable energy solutions forward. Key initiatives to drive the power-to-hydrogen process include*

- *H2 Brenner Valley: Advancing the use of hydrogen in the Alpine region.*
- *European Hydrogen Bus: Promoting hydrogen-powered public transport solutions.*
- *Hydrogen Truck Expansion: Enhancing the role of hydrogen in heavy-duty transportation.*

*By fostering collaboration between industry, research institutions, and policymakers, the Codex Partnership is laying the groundwork for a sustainable and self-sufficient energy future.*

*Conclusion:*

*The journey toward a climate-neutral and autonomous energy system is complex and fraught with challenges. However, with dedicated efforts, continuous innovation, and strong partnerships, a green future is within reach. The Codex Partnership of the Green Energy Center Europe is demonstrating that the bridge to a self-sustaining energy future is not just a vision but a reality in the making.*

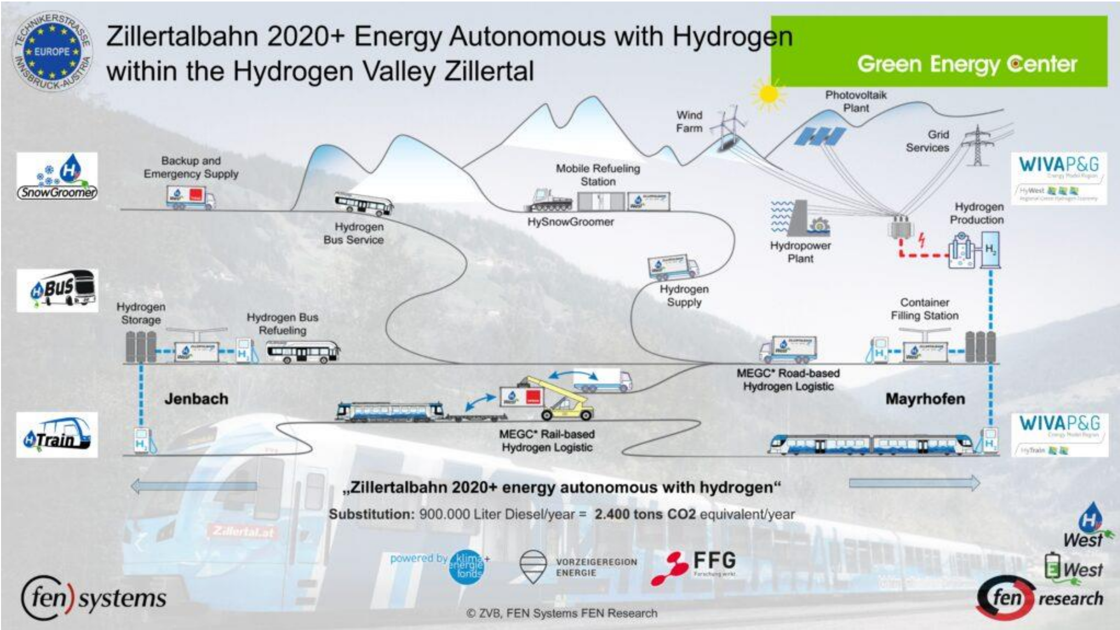



Bild: Das Projekte “Zillertalbahn 2020+ energieautonom mit Wasserstoff” im Ramen der “Wasserstoffregion Zillertal” als wesentlicher Bestandteil des “Aufbaus der grünen Wasserstoffwirtschaft in Zentraleuropa”

# DAS HAUS

## OVERVIEW

The **"HAUS"** project demonstrates the transition from a fossil-fuel-based, analogue energy supply to a digital, networked system integrating renewable energy and self-produced green hydrogen. As a laboratory experiment, it tests the interaction of electricity, heating, and mobility technologies through sector coupling, using an intelligent digital control system to manage and optimize PV systems, energy storage, electrolysis, fuel cells, and heating. The main goal is to evaluate the feasibility of a self-sufficient household by implementing hydrogen storage and smart control technologies. Specific objectives include testing sector coupling, validating hydrogen storage and fuel cell performance, optimizing energy efficiency, assessing self-sufficiency, and utilizing data analysis for continuous improvements. While hydrogen application has only been simulated so far, the installation was set to be completed in 2024, with the first real-world trials taking place in winter 2024/2025. The project aims to maximize system efficiency and autonomy, setting a precedent for future household-level hydrogen applications in the shift toward renewable and intelligent energy solutions.

## ACTIVITY PROGRESS

The most important activities performed in the **"HAUS"** project include the complete digitization of the household energy system, the installation of a **PV system** on the roof, and the integration of a **heat pump**. Additionally, the necessary infrastructure for **hydrogen application** was implemented, including an **electrolyser, storage tanks, and a fuel cell** for reconversion into electricity, although these components have not yet been connected. To assess the system's functionality, **simulations** of the full energy system, including hydrogen integration, have been conducted. In terms of synergies with local and regional actors, the project has remained largely **self-contained**, as all activities take place within the premises of the company **WhiteEnergy**, without significant external collaboration. While there have been a **excursion within the project for stakeholders** to visit the building, no substantial partnerships or interactions with the immediate surroundings have been established. The relevant stakeholders involved primarily belong to the **energy sector**, including researchers, technology developers, and industry professionals interested in decentralized renewable energy solutions.

## ACHIEVEMENTS

Successes to date include the installation of the complete energy system and the complete calculation of the hydrogen application. In addition, the simulation can already be considered a success. The simulation results were presented in the last report on the pilot project. The region's H2 Working Group was able to visit the building in March to inspect the installation and exchange ideas.

This project is co-financed by the European Regional Development Fund
through the Interreg Alpine Space programme


# DEVIATIONS

In March 2024, a visit was conducted with the region's hydrogen network as part of the AMETHyST project's hydrogen excursion, during which the plant was presented. While the full equipment for the hydrogen system has already been in place and was expected to be connected in 2024, a **strategic shift** occurred within **WhiteEnergy**. The company decided to **refocus its research priorities**, shifting away from hydrogen applications towards **holistic building energy management** and, in particular, the **development of proprietary energy management software**. This software aims to **monitor and control energy flows** while also supporting **tenant electricity projects**, including aspects like billing and system optimization. As a result, no further progress has been made in fully commissioning the **hydrogen plant in Icking**, particularly regarding the **integration of the fuel cell for reconverting hydrogen into electricity**. In the short term, no additional commissioning measures are planned, as the company's resources are now being directed toward **software development and project planning** for tenant electricity solutions.

# KEY LESSONS LEARNT

One of the key lessons learned from the design and implementation of the **"HAUS"** pilot is that such an ambitious project requires **highly motivated pioneers**, but the **strategic focus of research companies can shift significantly over time**. Initially, the project was titled **"The Hydrogen House,"** with a clear objective of integrating hydrogen applications at the household level, following a structured timeline for the installation and testing of the electrolyser and fuel cell. However, during the course of the project, **priorities changed**, and the focus on hydrogen was reduced, leading to the renaming of the project to **"The House"** and a shift toward holistic energy management rather than hydrogen applications. As a result, **no real-world hydrogen trials** have been conducted, and only **simulated data** is available for evaluation. These simulations indicate that while hydrogen storage could have **improved self-sufficiency**, it would not have enabled **complete year-round energy independence**. The results also reveal that while **hydrogen tanks can effectively store excess PV electricity** in the summer, the stored energy is depleted within approximately **one month in the fall**, leaving no possibility for refilling until spring. This highlights the **challenges of long-term hydrogen storage** at the household level. Additionally, the project demonstrated that while hydrogen has **technical potential**, its **economic feasibility remains a major hurdle**, as the costs associated with hydrogen storage and conversion make it **uneconomical for individual households**. These findings suggest that **hydrogen may be better suited for larger-scale applications** rather than single-home energy systems.

# VAL DE BAGNES

## OVERVIEW

We have successfully established a network of key stakeholders around hydrogen in our region, including Alpiq, H2 Energy, Microcity, as well as potential end users such as Buchard (a bus company) and the Municipality of Val de Bagnes.

Concretely, we explored the possibility of producing green hydrogen locally, notably through a proposed solar power plant on an alpine site, combining renewable energy production with strong local relevance. The ambition was clear: to create a localized, sustainable hydrogen value chain with Verbier ski resort as a main client, particularly for powering snow groomers (ratracks).

However, we encountered a major obstacle: the current technological maturity is not sufficient to:

1. Build a reliable and transparent business model for local authorities;
2. Ensure dependable after-sales support for infrastructure maintenance.

These gaps forced the municipality to slow down its interest in hydrogen, as it was not possible to offer a stable, pre-defined price based on a credible business case. Without that clarity, introducing a new and complex energy technology becomes extremely difficult — no matter how promising it may be.

That said, we are not stepping away from hydrogen. Instead, we have reoriented our efforts along two complementary paths:

1. Developing battery storage systems to increase grid flexibility and help manage peak electricity demand;
2. Maintaining an active presence in the hydrogen sector to stay connected and ready to relaunch when technological and economic conditions improve.

To keep momentum and nurture collaboration, we have also initiated quarterly discussion sessions with both the municipality and the local energy producer. These meetings serve as a shared platform to exchange updates, monitor progress, and maintain alignment between political will, technical readiness, and long-term vision.

In summary, while hydrogen may not yet be viable for immediate deployment in our area, we have laid the groundwork for a resilient and responsive ecosystem — staying engaged, informed, and positioned for action when the time is right.

## ACTIVITY PROGRESS

During the reporting period, several key activities were carried out with the aim of structuring the project around local dynamics and strengthening synergies with relevant territorial stakeholders.

We first established a structured network of local and regional actors around the topic of hydrogen. This network includes:

- Industrial and technological stakeholders such as Alpiq, H2 Energy, and Microcity;

- Potential end-users, including Buchard Transports (a regional bus company) and the municipality of Val de Bagnes;
- Public sector representatives and research institutions, such as EPFL Valais Wallis.

A series of working meetings and thematic workshops enabled us to assess:

- the specific needs and expectations of the territory,
- the opportunities for hydrogen deployment,
- and the technical and economic constraints identified by stakeholders.

This collaborative work led to the initial mapping of potential use cases, as well as a preliminary feasibility assessment for local hydrogen production, notably through a proposed photovoltaic installation in a mountain area.

To ensure continuity and coordination, we set up quarterly follow-up meetings between our team, the municipality, and the local energy provider. These sessions serve to:

- maintain an ongoing operational dialogue between partners;
- share updates on technological and regulatory developments;
- and realign the strategic direction of the project based on evolving local context.

Through this process, we identified two complementary areas of development:

1. The deployment of battery storage systems, aimed at increasing flexibility in the local power grid and managing peak demand;
2. The maintenance of an active presence in the hydrogen sector, allowing us to remain strategically positioned and ready to reactivate a hydrogen-focused pilot as soon as the technical and economic conditions improve.

In summary, these activities have allowed us to:

- actively engage key local stakeholders from the early stages of the project,
- strengthen the territorial coherence of our intervention,
- and lay the groundwork for a shared governance model, which is essential for the success of regional energy transition initiatives.

## ACHIEVEMENTS

Within the implementation phase of our pilot, several concrete achievements were reached, contributing to both the operational progress and strategic positioning of the project within the local ecosystem.

1. **Establishment of a regional hydrogen stakeholder network**
   We successfully brought together key stakeholders from the public and private sectors, including Alpiq, H2 Energy, Microcity, Buchard Transports, and the municipality of Val de Bagnes. This network serves as a foundation for long-term collaboration and future deployment initiatives.
   *Evidence:* Participation lists, meeting minutes, and formal expressions of interest from key actors.
2. **Feasibility assessment for local hydrogen production**

A detailed analysis was conducted to evaluate the technical and economic viability of producing green hydrogen using solar energy from an alpine photovoltaic installation.
*Evidence:* Technical pre-study documents, cost-benefit analyses, and site suitability assessments.

3. **Identification of technological and operational barriers**
   The pilot revealed several limitations in current hydrogen infrastructure, including uncertainty around after-sales support and the lack of a stable, scalable business model adapted to municipal procurement constraints.
   *Evidence:* Feedback from municipal decision-makers, risk assessments, and supplier interviews.
4. **Strategic reorientation toward complementary solutions**
   As a result of these challenges, we initiated a parallel workstream focused on battery storage to increase grid flexibility. This pivot ensures the relevance and continuity of the project's energy resilience goals.
   *Evidence:* Internal project documentation, design briefs for the storage system, and alignment with municipal energy plans.
5. **Institutionalized stakeholder dialogue**
   We implemented a quarterly coordination mechanism involving the municipality and local energy provider. These recurring meetings facilitate knowledge sharing, governance alignment, and adaptive project planning.
   *Evidence:* Calendar of meetings, agendas, and follow-up reports documenting decisions and action points.

# DEVIATIONS

During the implementation phase, several deviations occurred in relation to the initial concept design and timeline of the pilot. These changes were driven primarily by technological constraints and evolving stakeholder feedback, and led to a strategic realignment of certain pilot objectives.

1. **Postponement of hydrogen infrastructure deployment**
   The original roadmap envisioned the initiation of a local hydrogen production and consumption chain, including potential end-users such as public transport and ski infrastructure. However, due to the current lack of mature, affordable, and service-supported hydrogen technologies, particularly in rural and mountainous contexts, it was not possible to proceed as planned.
   - Justification: No viable business model could be confirmed, and the absence of reliable after-sales service posed significant risks for long-term municipal investment.
   - Measure taken: We shifted focus toward preparatory work (feasibility studies, stakeholder engagement, technical assessment) while redirecting operational efforts toward battery storage, which presents fewer implementation barriers in the short term.
2. **Adjustment of stakeholder engagement timeline**
   Engagement of key stakeholders, particularly at the municipal level, took longer than expected due to internal decision-making cycles and a need for broader consultations.
   - Justification: Ensuring local alignment and political support required additional time, particularly given the uncertainty surrounding hydrogen viability in the region.
   - Measure taken: We implemented quarterly coordination meetings and adopted a more flexible, adaptive engagement strategy tailored to each stakeholder group's pace and readiness.
3. **Reprioritization of implementation components**

The roadmap initially placed hydrogen production infrastructure at the center of the pilot. This has now shifted toward an incremental, modular approach, starting with battery storage and maintaining a watchful presence in the hydrogen sector.

- Justification: This allows the pilot to deliver tangible results (e.g., improved grid flexibility) while keeping the door open for future hydrogen integration once market conditions evolve.
- Measure taken: The technical team is developing updated planning scenarios that incorporate both short-term deliverables and long-term hydrogen readiness.

# KEY LESSONS LEARNT

The design and implementation of our pilot provided valuable insights that may prove highly relevant for other territories considering similar initiatives, particularly in rural or mountainous contexts.

1. **Technological readiness must be evaluated in context, not in theory**
   While hydrogen technologies show great potential at national and industrial levels, their deployment in remote, decentralized areas requires additional infrastructure, long-term support guarantees, and cost stability — none of which were currently available in our region.
   → *Lesson*: Before launching, it is crucial to assess not only the technical feasibility but also the logistical and operational maturity of the technology within the specific local context.
2. **Stakeholder alignment is not a checkbox — it's a process**
   Engaging municipalities, private sector actors, and local communities takes time and trust-building. Initial assumptions about stakeholder readiness can prove optimistic.
   → *Lesson*: Allocate sufficient time and flexibility for progressive engagement, and consider creating multi-phase roadmaps that accommodate varying levels of stakeholder commitment over time.
3. **Flexibility is key to resilience**
   Due to unforeseen constraints, we shifted our primary focus from hydrogen deployment to battery storage development. This pivot allowed us to maintain project momentum and deliver concrete results without losing sight of long-term goals.
   → *Lesson*: Successful replication depends on the ability to adapt the pilot scope dynamically while preserving its strategic intent.
4. **Governance mechanisms must be embedded early**
   Our quarterly coordination meetings with local authorities and energy providers have proven essential in keeping the project grounded, responsive, and inclusive.
   → *Lesson*: Establishing a formal, recurring dialogue structure from the beginning helps align expectations, resolve uncertainties, and maintain momentum.
5. **Territorial identity matters**
   The pilot's relevance was greatly enhanced by rooting it in local needs, geography, and cultural expectations. Attempting a one-size-fits-all model would likely have failed.
   → *Lesson*: Any replication effort must be adapted to local realities, not merely duplicated.