TRIĒRĒS

TRIERES

Towards the development of a hydRogen valley demonstrating applications in an intEgRated EcoSystem in Greece

D5.2 Hydrogen Valley WIVA P&G HyWest

WP5 – Hydrogen Valley's connected

Co-funded by the European Union

The project is supported by the Clean Hydrogen Partnership and its members Hydrogen Europe and Hydrogen Europe Research under Grant Agreement No. 101112056

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BACKGROUND AND DISCLAIMER

Project Background

The TRIERES project – full title "Towards the development of a hydRogen valley demonstrating applications in an intEgRated EcoSystem in Greece" – was submitted in the call HORIZON-JTI-CLEANH2-2022-2, under the topic HORIZON-JTI-CLEANH2-2022-06-02 "Hydrogen Valleys (small-scale)". The project receives support by the *Clean Hydrogen Partnership* and its members *Hydrogen Europe* and *Hydrogen Europe Research* through the Grant Agreement No. 101112056.

Objective of Deliverable

The present deliverable, titled: "D5.2 Hydrogen Valley WIVA P&G HyWest" is the second deliverable of WP5 "Hydrogen Valley's connected".

Disclaimer

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Copyright message

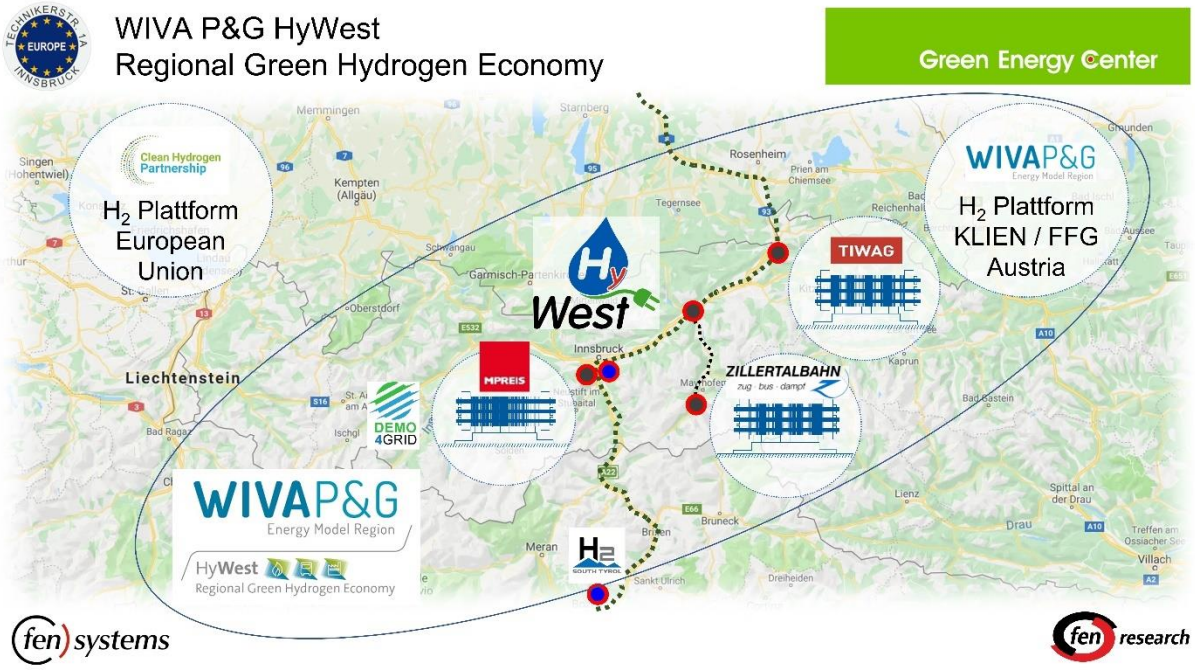
[1] Establishment of Austria's First Regional Green Hydrogen Economy: WIVA P&G HyWest; https://www.mdpi.com/2260342

Executive Summary

Close collaboration between the TRIĒRĒS Valley and the Austrian hydrogen valley WIVA P&G HyWest[2] is planned in Task 5.2 "Collaboration with existing WIVA P&G HyWest valley". To support the planned collaboration within this task, Deliverable 5.2 will provide lessons learned and input from the national R&D flagship project WIVA P&G HyWest, aiming to establish the first regional green hydrogen economy in western Austria.

It is noteworthy that the R&D flagship project WIVA P&G HyWest received funding from the Climate and Energy Fund[3] (KLIEN) and belongs to the national energy model region WIVA P&G[4] association (Hydrogen Initiative Austria Power and Gas). The WIVA P&G energy model region was officially announced as "European Hydrogen Valley of the Year 2023"[5] at the Clean Hydrogen Partnership awards 2023 in Brussels, Belgium. The FEN Research GmbH[6] (FEN Research), representing the Green Energy Center Europe[7] in Innsbruck/AUSTRIA and leader of Task 5.2 is one of the four research institutions within WIVA P&G.

Based on the current report (D5.2), a workshop with project partners and stakeholders will be developed and organized at the Green Energy Center Europe[7] in Innsbruck/AUSTRIA. This workshop will be documented in Deliverable 5.3 "Hydrogen Valley Workshop" and will focus on the valley's projects. These projects consist of the entire value chain from renewable hydrogen production from renewable energy sources (RES) focusing on hydropower, hydrogen storage, hydrogen refuelling stations (HRS) and the use of hydrogen for industrial processes. The latter include industrial heat. Hydrogen for mobility is focusing on heavy duty and a corresponding hydrogen logistics based on Multi Element Gas Containers (MEGCs).



[2] https://www.wiva.at/project/hywest/?lang=en
[3] https://www.klimafonds.gv.at/
[4] https://www.wiva.at/wiva/?lang=en
[5] https://www.clean-hydrogen.europa.eu/media/news/clean-hydrogen-partnership-awards-2023-celebrate-excellence-and-innovation-2023-11-24_en
[6] https://www.fen-research.org/
[7] https://www.green-energy-center.com/

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ABBREVIATIONS

Abbreviation	Explanation
ADR	Accord Dangereux Routier
BEV	Battery Electric Vehicle
CAPEX	Capital expenditures
CHP	Clean Hydrogen Partnership
CVD	Clean Vehicle Directive
DAF	Dutch truck manufacturing company
FCEV	Fuel Cell Electric Vehicle
GHG	Green-House Gas
HFS	Hydrogen Filling Station
HRS	Hydrogen Refuelling Station
HSS	Hydrogen Storage System
IIT	Institute for Innovative Technologies Ltd
iRES	intermittent Renewable Energy Sources
MEGC	Multi Element Gas Container
mobileHRS	mobile Hydrogen Refuelling Station
ÖVGW	Österreichische Vereinigung für das Gas- und Wasserfach Austrian Association for the gas and water industry
P2G	Power to gas
P2H	Power to heat
P2X	Power to X
PAE	Pressurized Alkaline Electrolyser
Power2eMob	Power to electric Mobility
R&D	Research & Development
RES	Renewable Energy Sources
TIGAS	Erdgas Tirol GmbH
TIWAG	Tiroler Wasserkraft AG
WIVA P&G	Wasserstoffinitiative Austria Power & Gas

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1 Introduction

The climate, energy, and resources strategy "Tyrol 2050 energy autonomous"[8] was adopted in 2014 by the regional parliament of Tyrol in Austria, with the long-term goal to become climate neutral and energy autonomous. In this strategic approach, electricity is the main building block through the "*Power on demand*" process, whereas the "*power-to-hydrogen*" process is employed to support the intrinsic lack of a long-term, large-scale storage of electricity[9]. Consequently, since 2016 several projects were initiated in western Austria representing the areas of green energy, green industry, and green mobility.

As a result of the developed strategy and corresponding projects, the R&D flagship project WIVA P&G HyWest[2] was initiated in 2018 with the aim to establish the first sustainable, business-case-driven, regional, green hydrogen economy in Tyrol and Central Europe. This establishment is based on synergies between three ongoing complementary implementation projects developed and/or supported by the FEN Systems GmbH[10] (FEN Systems) and FEN Research[6], representing the Green Energy Center Europe[7] in Innsbruck/AUSTRIA. These projects are[9]:

- "**Green Hydrogen for MPREIS, Tyrol and Europe**" (MPREIS Hydrogen[11]), initiated in the frame of the European project "Demo4Grid"[12] and ongoing since **2016**.
- "**Hydrogen Valley Zillertal**" starting with the "Zillertalbahn 2020+ energy autonomous with hydrogen"[13] project ongoing since **2017**.
- "**Power2X Kufstein**"[14], construction of an innovative sector coupling power to x (P2X) plant ongoing since **2018**.

In this report, the problem-solving methodology and strategical approach using the example of the Tyrolean energy system in the framework of the WIVA P&G HyWest project is described, which is supported by the concept of a dynamic sustainability[9]. Based on the described strategical approach, cross-sectoral production, storage, and application of green hydrogen with focus on mobility and industry is then further investigated and described within each subproject of the hydrogen valley.

1.1 Scope of Work Package 5 – Hydrogen Valley's connected

The necessity to connect to existing and upcoming Hydrogen Valley's with an active know-how and experience exchange is addressed in this work package to strengthen the TRIĒRĒS Valley. Additionally, planned activities in this work package support emerging (regional/East Mediterranean) Hydrogen Valley's with the aim to connect with the TRIĒRĒS Valley. Other objectives in the framework of the Mission Innovation include connection to international Valleys.

[8] TIROL 2050—Unser Land Wird Energieautonom. Available online: https://www.tirol2050.at/
[9] Fleischhacker, N., Shakibi Nia, N., Coll, M., Perwög, E., Schreiner, H., Burger, A., Stamatakis, E., & Fleischhacker, E. (2023). Establishment of Austria's First Regional Green Hydrogen Economy: WIVA P&G HyWest. Energies, 16(9), 3619. https://doi.org/10.3390/en16093619
[10] https://www.fen-systems.com/
[11] https://www.mpreis.at/wasserstoff/projekt
[12] https://www.demo4grid.eu/
[13] https://www.hytrain.at/
[14] https://www.tiwag.at/unternehmen/energiewende/power2x-kufstein/

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1.2 Scope of Deliverable 5.2 – Hydrogen Valley WIVA P&G HyWest

Close collaboration between the TRIĒRĒS Valley and the Austrian hydrogen valley WIVA P&G HyWest[2] is planned in Task 5.2 “Collaboration with existing WIVA P&G HyWest valley”. To support the planned collaboration within this task, Deliverable 5.2 will provide lessons learned and input from the national R&D flagship project WIVA P&G HyWest, aiming to establish the first regional green hydrogen economy in western Austria.

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2 Energy and Hydrogen Strategy "Tirol 2050 Energy Autonomous"

The main objectives of the "Tirol 2050 Energy Autonomous" strategy are the reconstruction of the energy system by means of electricity from RES to achieve the long-term goals energy autonomy and climate neutrality.

As depicted in Figure 1, the energy demand has been growing exponentially in the last decades[9]. Electricity produced from chemical energy carriers such as oil, coil and gas were imported. The future energy system will be based on electricity from sun, wind and water identified as intermittent RES (iRES) due to their unpredictability in energy production. Hydrogen is therefore considered as a pivotal solution with the aim to bridge the gap between the fluctuating energy demand and supply on a large scale. By using electricity from renewable resources, surplus energy generated during summer is foreseen to be chemically stored in the form of hydrogen and further cover the energy demand in winter times.

The necessity for the management and optimization of energy processes to ensure stability and reliability is well shown in Figure 1, where both "*Power on Demand*" and "*Power to Hydrogen*" processes are considered as building blocks within "Tirol 2050 Energy Autonomous".

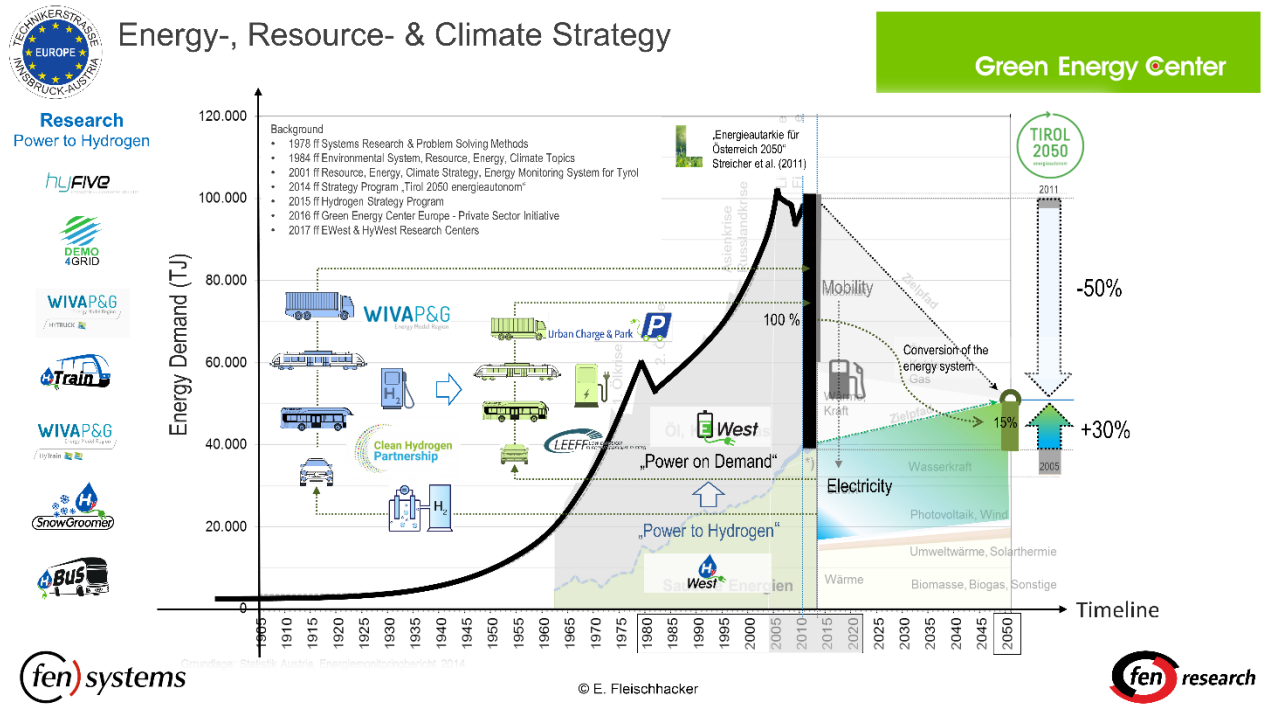

Figure 1 Energy and hydrogen strategy "Tirol 2050 Energy Autonomous"[9]

A multifaceted approach is considered within the region's strategy until 2050, including a substantial reduction of energy demand with a strong emphasis on reconstructing the transportation sector through a comprehensive transition. The expansion of energy production from locally available resources is foreseen to further reduce current greenhouse gas (GHG) emissions by 80 to 95 % through an almost 100 % share of renewable energies. This will result in a final energy consumption of around 48,000 TJ per year in comparison to 2005[9]. The establishment of a green hydrogen economy in western Austria and Central Europe is carried out according to the following sequence:

a. Strategy Development,
b. Project Development and Implementation,
c. Quality Assurance and Monitoring,
d. Dissemination, Exploitation of Results, and Training

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To fulfil steps “b” and “c” in this sequence, the licensed problem-solving methodology by E. Fleischhacker is used, which is based on the understanding of sustainability and a circular economy. For this purpose, an iterative process model for the “step-by-step processing” of the Tyrolean energy strategy is employed in the sense of a “balanced scorecard process”[9]. As a result, interrelations, and processes in the Tyrolean energy system are transparently shown.

Using an iterative approach, the management of all processes is carried out through the gradual identification of concrete problems and finding of necessary solutions within a “self-stabilizing circular model”. By incorporating the achieved results for a new system analysis, as iteration progresses, the involved risk in achieving the identified goals will significantly decrease. Consequently, the system state starts to converge towards the given target through a progressive decrease in uncertainties[9].

Within the described strategy “Tyrol 2050 energy autonomous”, sustainability is a dynamic system of ecology, economy, and social aspects. To ensure that the connection between these entities is never interrupted, and a constant balance is always maintained, it is necessary that these three components constantly work together. Therefore, the energy system within this strategy further overlays with the explained dynamic sustainability and is identified as a logistics system (see Figure 2).

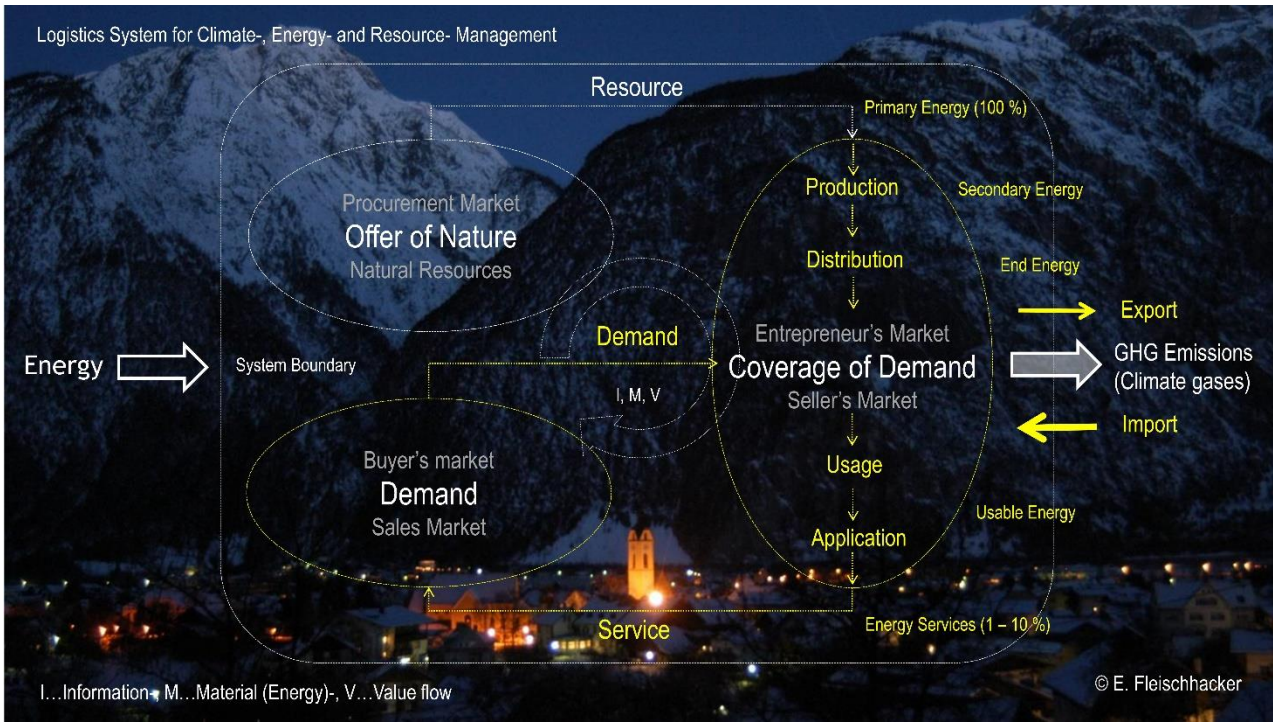

Figure 2 Logistics system: Schematic presentation based on the sustainability approach[9]

The depicted logistics system can be employed for any comprehensive multidisciplinary strategy, project, and product development and resource management tasks. This system implies that[9]:

The right goods (service) in the adequate condition (e.g., qualitatively impeccable) and the proper quantity (neither shortage nor surplus) at the time of request (e.g., according to daily demand) to the place of demand (e.g., household) at the minimum cost is to be delivered. The system consists of the sub-systems ***resource*** *(procurement market),* ***demand*** *(entrepreneur market), and* ***coverage of demand*** *(sales market), which are functionally connected via the flow of materials, values, and information.*

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Therefore, in a defined system boundary (community, region, country) without external dependencies, the circular economy is achieved once three subsystems of ***resource***, ***demand*** and ***coverage of demand*** operate sustainably.

The Tyrol region is defined as the boundary of the system in case of the "Tyrol 2050 energy autonomous" strategy and the identified subsystems are:

- Ecology (***resource***)
- Social (***demand***)
- Economy (***coverage of demand***)

In this case, the establishment of a circular economy can only be achieved when the required sustainability is maintained between the three identified sub systems. In general, sharing the responsibility for the stability maintenance of the system under development confirms the crucial importance of this conceptual model in the implementation of projects.

As a result of the developed strategy and corresponding projects, the R&D flagship project WIVA P&G HyWest[2] initiated in 2018 and is based on synergies between three ongoing complementary implementation projects developed and/or supported by FEN Systems GmbH[15] and FEN Research GmbH[6], representing the Green Energy Center Europe[7] in Innsbruck Austria. These projects are[9]:

- "**Green Hydrogen for MPREIS, Tyrol and Europe**" (MPREIS Hydrogen[16]), initiated in the frame of the European project "Demo4Grid"[17] and ongoing since **2016**. Implementation of a 3 MW pressurized alkaline electrolyser (PAE) at the production facility of MPREIS in Völs (Tyrol, Austria). For the first time in the region of Tyrol, high quantities of green hydrogen for industrial use as well as for heavy-duty mobility applications will be supplied.
- "**Hydrogen Valley Zillertal**" starting with the "Zillertalbahn 2020+ energy autonomous"[18] project ongoing since **2017**. Development of a holistic approach including required hydrogen infrastructure and business cases focusing on but not limited to hydrogen electric trains since this project serves as a basis for the establishment of the hydrogen valley Zillertal.
- "**Power2X Kufstein**"[19], construction of an innovative sector coupling power to x (P2X) plant ongoing since **2019**. This includes a hydrogen center in the southwest of Kufstein near the TIWAG (Tiroler Wasserkraft AG) hydro power plant in Langkampfen in Tyrol is planned.

Overview of the three complementary projects; "MPREIS Hydrogen" in Völs, "Zillertalbahn 2020+ energy autonomous" in Jenbach, and Power2X in Kufstein, within WIVA P&G HyWest as well as a chronicle overview of finalized and ongoing projects within the European Green Corridor from Munich to Verona in western Austria are depicted in Figure 3.

The developed logistics system within the WIVA P&G HyWest project, as the main outcome regional energy and hydrogen strategy, aims to assure the high availability of the green hydrogen with the required purity and the necessary quantity (neither shortage nor surplus), at the time of request (in both peak and crisis times) and the place of demand (locations Innsbruck, Jenbach and Kufstein) at the minimum cost.

[15] https://www.fen-systems.com/
[16] https://www.mpreis.at/wasserstoff/projekt
[17] https://www.demo4grid.eu/
[18] https://www.hytrain.at/
[19] https://www.tiwag.at/unternehmen/energiewende/power2x-kufstein/

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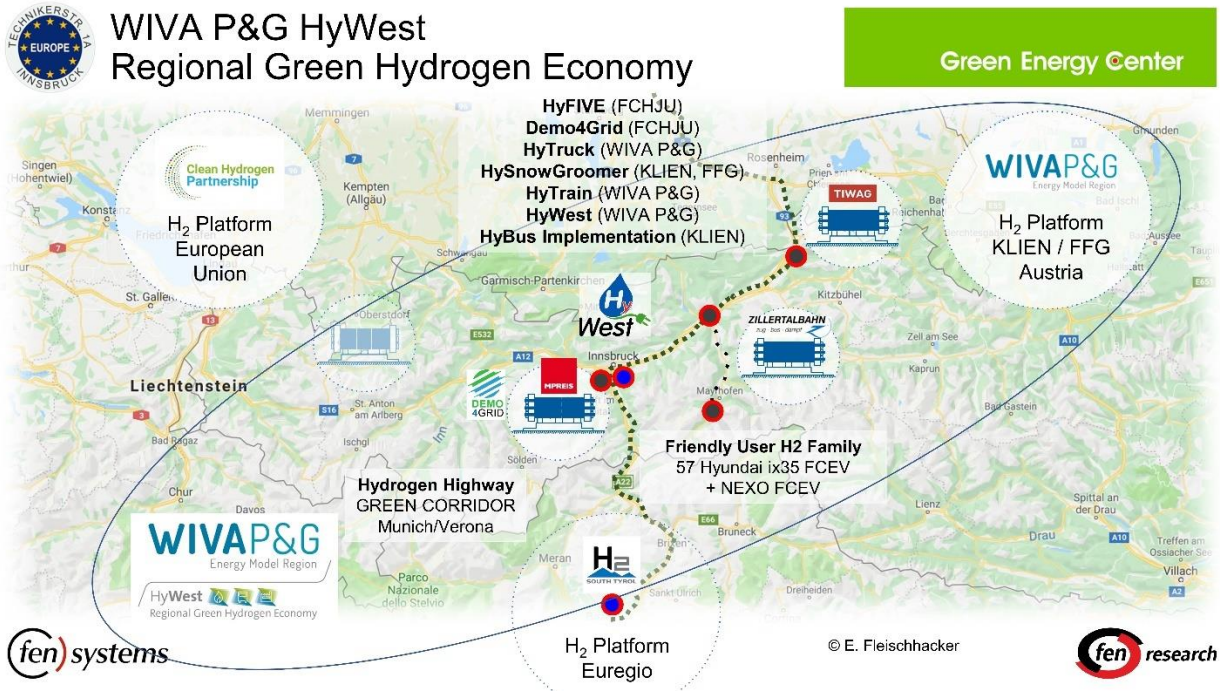

Figure 3 Overview of the three complementary projects within WIVA P&G HyWest[9]

Several noteworthy green hydrogen projects have already been implemented in the region by the private initiative of the Green Energy Center Europe in Innsbruck. These include the establishment of hydrogen highway from Munich to Verona since 2014 with the first fuel cell electric vehicles (FCEVs) in Europe, ordered from Hyundai. This establishment initiated in the framework of the EU project HyFIVE[20] for the Euregio Tyrol along the "Green Corridor" of the European regions Tyrol/South Tyrol/Trentino, including the required filling stations which were pioneered for the first time at the international level. The gained experiences from this establishment resulted in the development of the "Friendly User FCEV Roll-Out" strategy by FEN Systems for Hyundai Austria (see Figure 3).

Other examples include national R&D projects such as HyTruck[21], in which FEN Systems instrumented fleet vehicles and recorded real-life driving data of 2 trucks from MPREIS and 43 DB Schenker trucks over 2 months, accompanied by a corresponding simulation of power demands (see Figure 3).

Developed since 2019 and as part of the regional green hydrogen economy, the R&D flagship project HySnowGroomer[22] was coordinated by FEN Systems as well. This project resulted in the development and commercialization of a mobile hydrogen refuelling system (mobileHRS) by project partners Schmidberber/EDC/Wolftank, equipped with both 350 and 700 bar refuelling hoses, with the aim to further supply snow groomers from project partner Kässbohrer with green hydrogen from the region (see Figure 3).

Other examples of implementation in the region include HRS, the construction of the first green hydrogen production and logistic center in central Europe, the development of an energy – autonomous public transport systems, and the establishment of innovative "Power to X" projects that efficiently convert surplus electricity into hydrogen or other valuable commodities.

[20] https://cordis.europa.eu/project/id/621219
[21] https://www.wiva.at/project/hytruck/
[22] https://www.hysnowgroomer.com/

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3 Green Hydrogen for MPREIS, Tyrol and Europe

To date, "**Green Hydrogen for MPREIS, Tyrol and Europe**" (MPREIS Hydrogen[11]) is the leading project among the three implementation projects that are part of the hydrogen valley WIVA P&G HyWest projects.

3.1 Green hydrogen & green mobility

The efforts for this project initiated in 2016 in the frame of the European project "Demo4Grid"[12], in which a 3 MW PAE at the production facility of MPREIS in Völs (Tyrol, Austria) was implemented, characteristics of which are given in Table 1.

Table 1 Characteristics of the "MPREIS hydrogen" production site in Völs[9].

Electrolyser supplied from Sunfire	Comments & Values
PAE	Single stack
Status	Up and running on trial runs
Electrolyser Power	3 MW
Production rate	1300 kg per day
Hydrogen quality	4.7 according to ISO 14687-2:2012
Hydrogen output pressure	30 bar – with additional compression

In the first quarter of 2022 green hydrogen was produced for the first time in the region of Tyrol. In the second quarter of 2022, the HRS for heavy-duty applications operating at 350 bar was commissioned at MPREIS premises in Völs, Austria (see Figure 4). For the validation of the full functionality of the refuelling protocol and safety functions, a dummy of a FCE truck Hydrogen Storage System (HSS) was provided by Hyzon Motors. Hyzon HYMAX truck, delivered to Völs at the same time (see Figure 5). Shortly after this delivery, the test truck could be refuelled with approximately 15 kg of green hydrogen[9]. Further test operations in the frame of quality assurance and optimization are currently ongoing, results of which are communicated to Hyzon Motors for the implementation in the next production series.

Figure 4 HRS at MPREIS site in Völs, Austria, with a dispenser operating at 350 bar[23]

[23] https://fuelcellsworks.com/subscribers/linde-engineering-builds-europes-most-powerful-hydrogen-truck-filling-station-for-mpreis/

Figure 5 Hyzon FCE truck tractor model 4 x 2 at MPREIS premises[24]

This test truck was further employed for the training of local service technicians and drivers of MPREIS. All training programs were organized and conducted by FEN Sustain Systems GmbH. The functional specifications of the Hyzon FCE truck are summarized in Table 2.

Table 2 Functional specifications of the FCE truck delivered by Hyzon Motors

Hyzon HYMAX FCE Truck	Model 4 × 2, Tractor
Wheelbase dimensions (mm)	3800
Length/Width/Height (mm), (incl. trailer/body)	16,500/2584/3962
Max. Permissible total weight (kg)	18,000
Max. Gross combination weight (kg)	40,000
Maximum speed (km/h)	85
Fuel cell stack	120 kW
Battery	700 V/140 kWh
Motor	350 kW/3000 Nm
Transmission	DAF transmission
Hydrogen tank capacity	38 kgH_2
Max. Driving Range (km)	410

3.2 Green hydrogen logistics

Primarily, all three projects intend to use the produced hydrogen from their own facilities. However, backup solutions are foreseen to guarantee an uninterrupted hydrogen supply to those sites in demand. Therefore, standard operating logistics procedures for hydrogen refuelling backup solutions were investigated. The economically viable hydrogen logistics system solution within the WIVA P&G HyWest hydrogen valley is road transport as a consequence of short distances between involved hydrogen production sites. Hydrogen distribution based on multi element gas containers (MEGCs) is therefore planned as the favourable solution[9].

Currently two 20-foot hydrogen storage containers (see Figure 6) are available at MPREIS site which were ordered and received from UMOE Advanced Composites for the setup of exchange platform. Functional specifications of these containers are summarized in Table 3.

[24] https://www.hywest.at/mpreis-nimmt-ersten-hywest-wasserstoff-lkw-osterreichs-in-betrieb/

Figure 6 MEGC from MPREIS, Supplier: UMOE[9]

The exchange of containers between partners will be carried out using freight forwarders with the required ADR (Accord Dangereux Routier) permissions and certified trucks. The latter is based on the European agreement concerning the international transport of dangerous goods by road. The purchase of industrial gases from available suppliers is considered as the second backup solution[9].

The main technical topic regarding the MEGCs currently under investigation is the connectivity from MPREIS site to the other hydrogen filling stations (HFS) in order to ensure an effective exchange of hydrogen. Various types of interface connectors were evaluated so far to standardize interfaces between the filling/discharging stations and the MEGCs, based on the hypothesis that all three sites employ the same type of MEGC. As a result, connection cables using modular plugs were identified as the most flexible and favourable option. More details regarding the assignment of plugs is currently under further investigation with the Austrian association for the gas and water industry (ÖVGW), the results of which will be made available to the project consortium[9].

Table 3 . Functional specifications of hydrogen storage containers received from UMOE[9]

MEGC Parameters supplied from UMOE	Comments & Values
Material	glass fiber
Standard length	20 ft
Number of hydrogen pressure vessels and type	11 x type IV
Total mass	17 tons
Working pressure at 15 °C	nominal 300 bar, minimum 20 bar
Filling pressure at 65 °C	355 bar
Operating temperature	− 40 °C to + 65 °C
Filling rate	55 kg H_2 per hour
Filling connection	M36 × 2 LH (metric, left-handed)
Drain connection	M40 × 2 LH (metric, left-handed)
H_2 connector	Loading/Unloading

The hydrogen storage on site at MPREIS includes three hydrogen storage vessels that can be regulated at different pressures for storing hydrogen. In case of excess quantities of produced green hydrogen that are not being used on-site, a virtual hydrogen platform concept is under development to further provide the produced hydrogen on the market.

Other technical research and optimization topics such as low-grade waste heat from the electrolysis process at the MPREIS site are under investigation. For this purpose, key performance indicators (KPIs) have been identified and a first concept for the life cycle management was developed[9].

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4 Zillertalbahn 2020+ energy autonomous with hydrogen

The second project of the Austrian hydrogen valley WIVA P&G HyWest "Hydrogen Valley Zillertal" initiated with the commercial project "Zillertalbahn 2020+ energy autonomous with hydrogen" since 2017. This commercial project is one of the three pillars of the Zillertal mobility plan[9]:

a. the new Zillertal railway ("Zillertalbahn 2020+ energy autonomous" project),
b. a holistic mobility concept consisting of bus, train, and road, and
c. the guest card as a travel pass.

4.1 WIVA P&G HyTrain and HyBus Implementation

With the aim to make Zillertal valley a pioneer for innovative and sustainable mobility, the new Zillertal railway is planned to be combined with an adapted bus service. In order to support the commercial project "Zillertalbahn 2020+ energy autonomous with hydrogen", FEN Sustain Systems GmbH initiated the R&D flagship project WIVA P&G HyTrain[25] with the following objectives and goals:

1. Establishment of the state of the art for hydrogen (narrow gauge) trains by means of:
   - Train simulation & test bench operations
   - H_2-Infrastructure concept development and simulation
2. Determination of criteria & parameters (standards) for the quality assurance and risk minimization process for Hydrogen Trains and corresponding H_2-Infrastructure regarding:
   - Tendering & Contracting
   - Commissioning,
   - Acceptance,
   - Operation and
   - Guaranty
3. Application of findings & results to the implementation project "Zillertalbahn 2020+ with hydrogen" if possible.

To support the ongoing developments regarding hydrogen buses in the region in combination with the new Zillertal railway, the roll-out of FCE buses in Austria, from Hyundai (Hyundai ELEC CITY FCE), initiated in 2021 in the framework of a national R&D project HyBus Implementation[26] under coordination of FEN research GmbH and is currently further in progress. Three cases under development in this project are urban (Wien), regional (Graz) and alpine (Zillertal) cases (see Figure 7).

The goal of this project is to take part in the implementation of the European Clean Vehicle Directive (CVD) in Austria through the large-scale demonstration of first 700-bar FCE buses and to establish the required know-how[9]. The first bus was successfully placed into operation on Wiener Linien in urban areas in December 2021, where the company's own hydrogen tank infrastructure was also implemented at the same time. The commissioning of the second hydrogen bus for regular service in Graz took place in July 2023[26]. In addition, successful test drives were completed in the Alpine region (Tyrol and Vorarlberg)[9].

[25] https://www.hytrain.at/
[26] https://www.hybus.eu/

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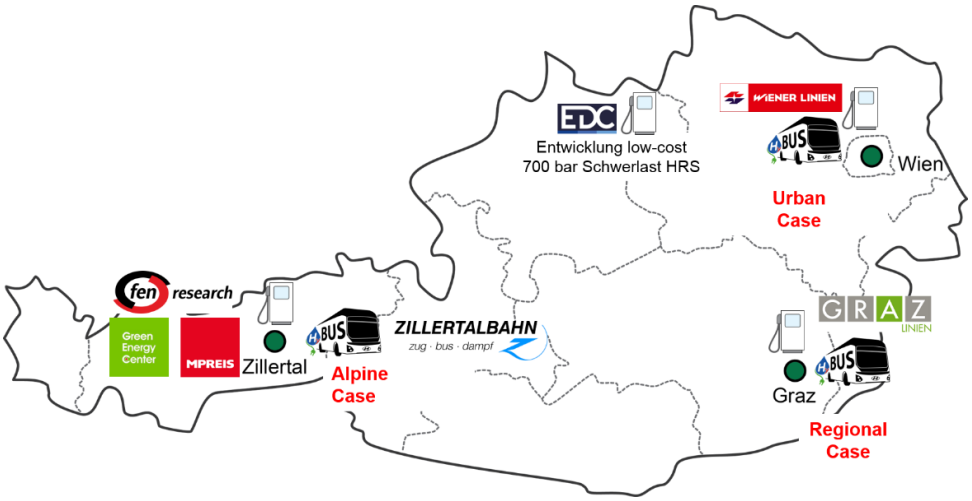

Figure 7 Implementation of the first three hydrogen buses in Austria in real operation[26]

4.2 Hydrogen Valley Zillertal

The schematic presentation of the Hydrogen Valley Zillertal depicted in Figure 8 shows the holistic approach in this project regarding the green mobility and hydrogen logistics. The outcome from the R&D national projects involved in the current development of the valley, such as HySnowGroomer[22], HyBus Implementation[26] and WIVA P&G HyTrain[13] is currently input for ongoing European projects. As an example, in the MOST-H_2 project, where novel adsorbents for efficient storage of hydrogen are under investigation, technoeconomic analysis of this hydrogen storage system for railways and heavy-duty road transport sector will be carried out.

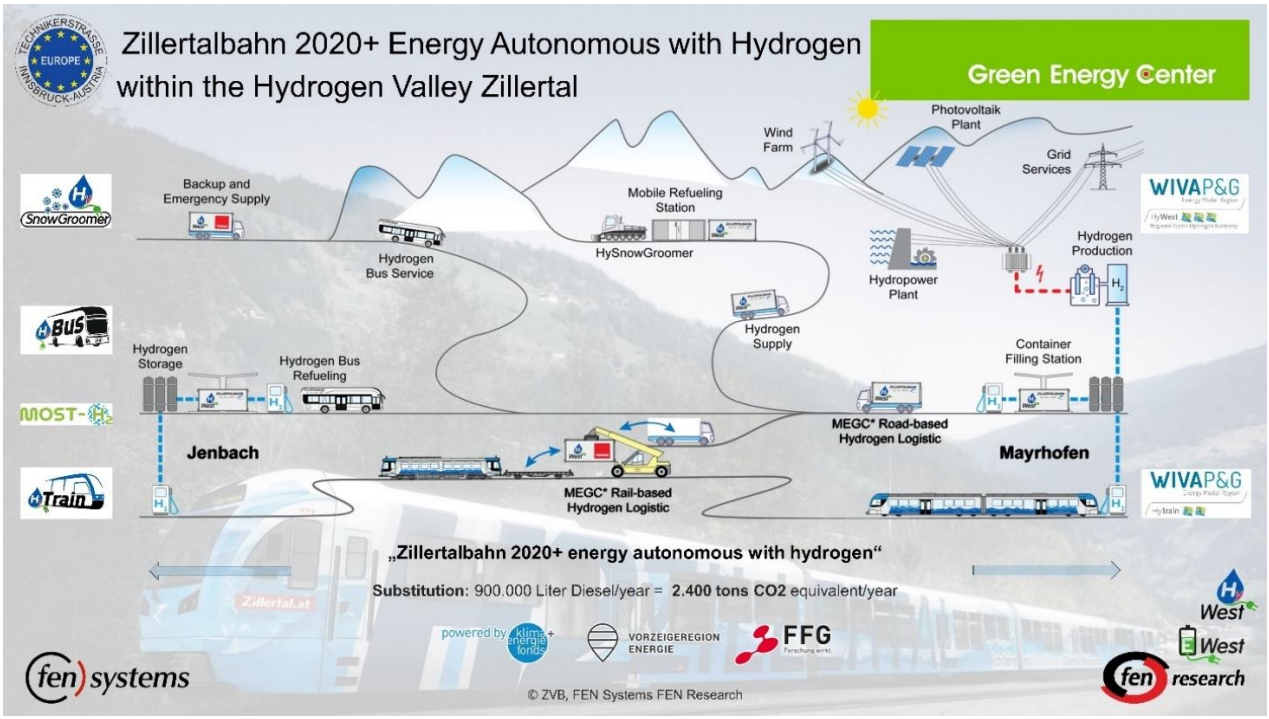

Figure 8 Planned Hydrogen Valley Zillertal in Tyrol, Austria.

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5 Power2X Kufstein

The TIWAG project, "**Power2X Kufstein**"[27], aims for the construction of an innovative sector coupling P2X plant including a hydrogen center in the southwest of Kufstein near the TIWAG hydro power plant in Langkampfen in Tyrol (see Figure 9).

As a key technology in the energy transition, sector coupling (P2X) connects the electricity, heating and gas grids as well as the mobility sector in line with demand and requirements in combination with emission-free mobility from electricity and hydrogen[27].

The core of the hydrogen supply in the *Power2Gas* sector will be modular, expandable PEM electrolysers that will produce hydrogen using electricity from renewable energy. To meet the demand for sustainable mobility for cars, trucks and buses, on-site refueling stations for FCEVs and an efficient charging infrastructure for battery electric vehicles BEVs will be set up. To increase the energy efficiency of the sector coupling plant, the waste heat from the electrolysis plants will be brought up to the temperature level of the district heating network using heat pumps and fed into the network. In addition, it will be possible to use the hydrogen and the additional oxygen produced during electrolysis in the nearby sewage treatment plant[27].

Figure 9 Visualization of "Power2X Kufstein", Source TIWAG[27]

5.1 Implementation concept

The P2X system has a modular structure and combines the electricity, gas, heat and mobility sectors "The basic concept of sector coupling" depicted in Figure 10 shows the *Power2Gas (P2G)*, *Power2Heat (P2H)* and *Power2eMob (P2eMob)* modules together with the respective sectors. The *Power2Gas* module includes the coupling of the gas/heat, electricity and mobility sectors. The *Power2Heat* module links the electricity and gas/heat sectors. The *Power2eMob* sector links the electricity sector with mobility.

[27] https://www.tiwag.at/unternehmen/energiewende/power2x-kufstein/

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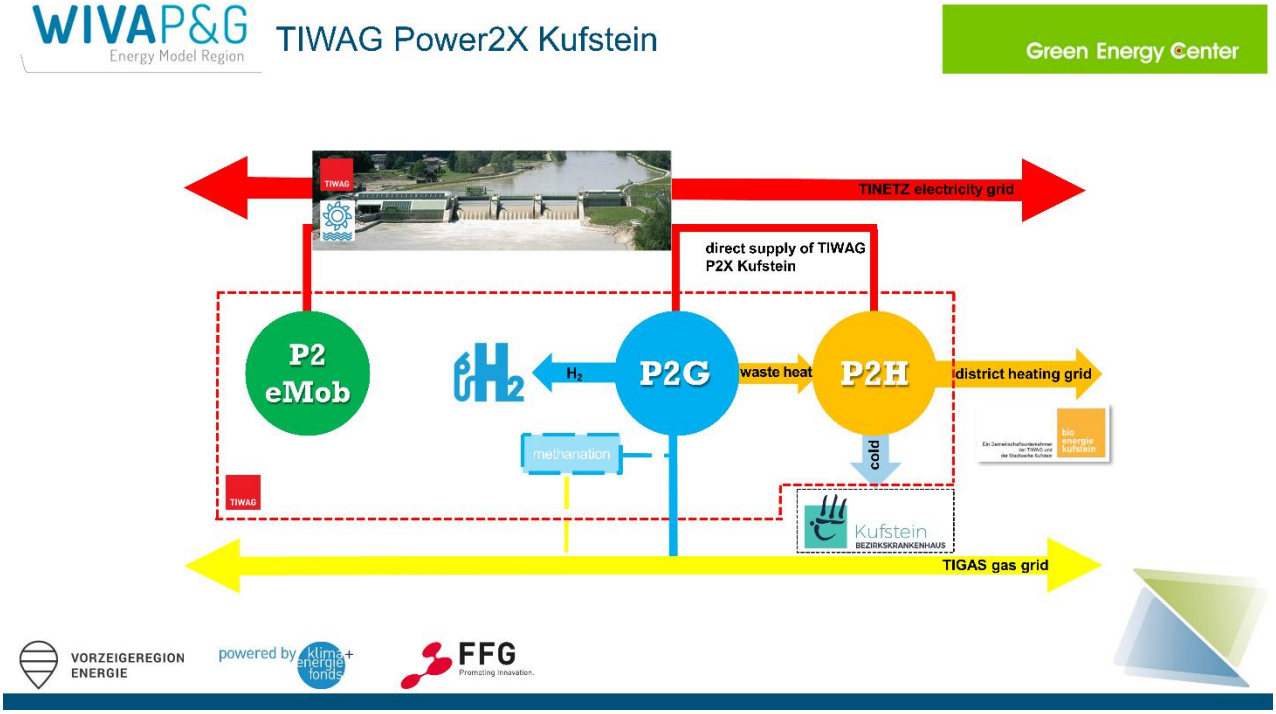

Figure 10 The basic concept of sector coupling at TIWAG[27]

Currently, the "P2X Kufstein" project is experiencing individual approval procedures by the authorities. Meanwhile, a joint project initiated between INNIO Jenbacher[28] (Jenbach, Tyrol) and TIWAG as of September 2022, which is described in the next section.

5.2 P2X Jenbach

By the end of the third quarter of 2022, INNIO and TIWAG announced their intention to supply INNIO's main operating site in Jenbach with green hydrogen as part of a cooperation with TINEXT[29], a subsidiary of TIWAG[30]. As a result of this cooperation, an electrolysis plant of 2 MW will be built on TIWAG's Achensee power plant site with the aim to convert electricity from renewable energy into green hydrogen.

On its part, TINEXT will build the compressor and storage terminals. The produced hydrogen will be transported in a pipeline from TINEXT to INNIO's main plant in Jenbach, where it will be used in particular for test runs of hydrogen engines[30].

[28] https://www.innio.com/de
[29] https://www.tinext.at/geschaeftsfelder/
[30] https://www.tinext.at/geschaeftsfelder/wasserstoff/projekte/p2x-jenbach/

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6 Correlations between WIVA P&G HyWest and TRIĒRĒS valley

The main correlation between the WIVA P&G HyWest valley and the TRIĒRĒS valley is the establishment of the green hydrogen economy. In line with the main objectives of the energy and hydrogen Strategy "Tirol 2050 Energy Autonomous", the TRIĒRĒS project aims to actively create and develop a hydrogen market in Greece which will be the basis for its further dynamic expansion to the Balkans, Southeastern Europe, and the Eastern Mediterranean. Similar to the WIVA P&G HyWest valley, the establishment of the hydrogen economy in the TRIĒRĒS project is based on *hydrogen production*, *hydrogen logistics* and *hydrogen end-users*. An active exchange of know-how, experiences and state of the art databases within these categories is therefore planned. The overlaying elements from each category are listed below:

Hydrogen production

Similar to the MPREIS hydrogen project, an alkaline electrolyser with a higher nominal power of 30 MW will be operated for the production of 2.410 tons of renewable hydrogen per year (EU project EPHYRA Grant agreement ID: 101112220). It is noteworthy that the nominal power of the PAE electrolyser in case of MPREIS hydrogen is an order of magnitude less compared to the one integrated into the refinery ecosystem.

Hydrogen logistics

The green hydrogen logistics of the TRIĒRĒS valley consists of loading, transportation and distribution. All in all, 5 HRS at dual pressures of 350 and 700 bar are planned for the refuelling of light-duty and heavy-duty vehicles.

Hydrogen end users

Industry: Use of the produced renewable hydrogen by the Motor Oil Hellas refinery in Ag. Theodoroi and the lubricant refinery of LPC in Aspropyrgos.

Road Mobility: Operation of three (3) urban hydrogen buses within the metropolitan area of Athens.

Similar to the WIVA P&G HyWest project, the TRIĒRĒS project foresees the technoeconomic sustainability studies of hydrogen use in various applications. Furthermore, communication and dissemination initiatives aim to increase the public awareness of the project within the scientific, industrial and social target groups and audiences.

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7 Conclusions

The first obtained results in the framework of the Austrian hydrogen valley WIVA P&G HyWest are reported in this deliverable.

The green hydrogen economy developed within "**MPREIS Hydrogen**", the furthest progressed project to date among the three complementary "power-to-gas" implementation projects, includes:

- A 3 MW PAE system
  - Capacity of 1.3 tons of hydrogen production per day
- Three hydrogen storage vessels at 30 bar
  - Store a half a day of full production
  - With possibility of regulation at different pressures
- Europe's most powerful heavy-duty HRS operating at 350 bar including
  - precooling and
  - a trailer filling station
- Austria's first hydrogen semi-trailer truck (tractor plus trailer) from Hyzon Motors
- Two MEGCs (20-foot hydrogen storage containers)

With the trailer filling station, 10 trucks can be refuelled back-to-back with a refuelling time of 10 minutes per truck).

It is noteworthy that this project builds upon components and systems that are still in the phase of prototyping and first small-scale production. Consequently, prices of all components are factors higher compared to state-of-the-art options. This leads to significant capital expenditures allowing only for long-term "business cases" that are supported by contributions[9].

Regarding the "**Hydrogen Valley Zillertal**" project, test drives with a Hyundai ElecCity FCE bus were performed in alpine terrain. This bus was made available by Graz Linien, Graz/AUSTRIA from the HyBus Implementation[26] project which could also be refuelled at the MPREIS heavy-duty HRS. As of now, collection of required parameters for the operation optimization of the hydrogen buses under various conditions has resulted in the planning of the first series production of hydrogen buses suited for Europe by Hyundai. The experiences with the operation of FCE buses in steep terrain environment is interesting for the bus operator OSY in Athens, where some very steep slopes exist.

To fulfil the logistic principle foreseen as the main outcome of WIVA P&G HyWest, other complementary projects of the valley are being further implemented. Accompanying industrial research and monitoring of results as well as related investigations are ongoing. These ongoing activities aim to improve the current processes within all projects in order to guarantee that green hydrogen – with the required purity and the necessary quantity, at the time of request and the place of demand, at the minimum cost – is highly available[9] (see Figure 11).

The projects described in this deliverable will be the basis for the planned workshop at the Green Energy Center Europe in Innsbruck/AUSTRIA (earlier than initially planned in Month 12) within Deliverable 5.3. A preliminary plan for the workshop includes excursions and visits to Demo4Grid and WIVA P&G HyWest project plant at MPREIS[31][32] and potentially the Hydrogen Center IIT in South Tyrol.

Further investigations regarding costs or innovation curve of the individual technology components are planned which could be then compared with the general data in the data registry of the CHP.

[31] https://www.youtube.com/watch?v=uu1VXSiZt24
[32] https://www.youtube.com/watch?v=m9-5WU2_4pA

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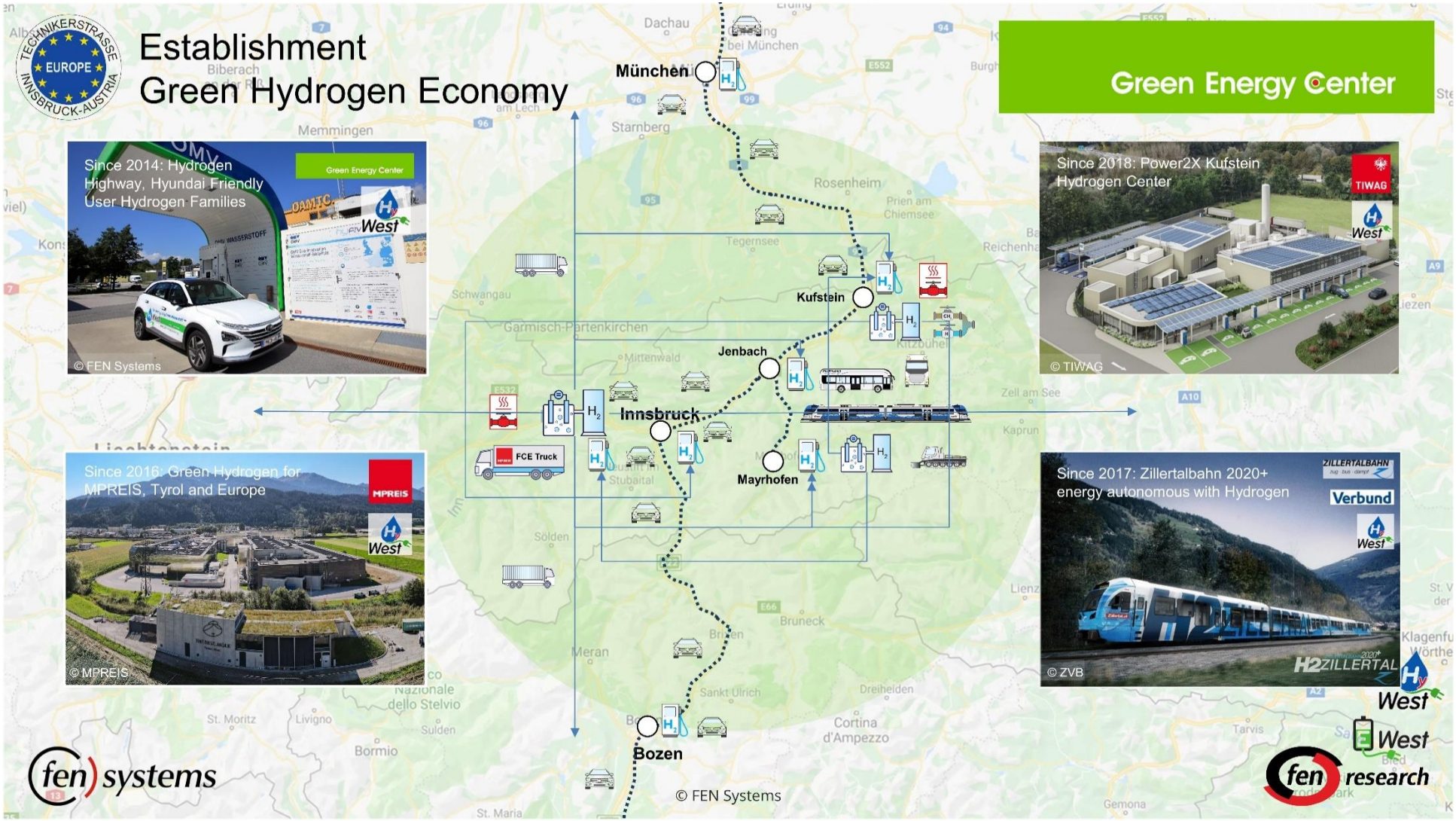

Figure 11 Establishment of the green hydrogen economy in western Austria and central Europe.

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