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AMETHyST

Output 2.1

PILOTING H_2 TERRITORIAL ECOSYSTEM

Activity A.2.2: Local Alpine green hydrogen ecosystem: technical solution design

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Short Description
In this document it is outlined the overall concept of local Alpine green H2 ecosystems. For each pilot, an implementation plan is provided detailing the main objectives, the strategy which lies behind the pilot implementation in terms of renewable generation, end-use, H_2 production, storage, transport and supply chain. A roadmap highlighting the pilot implementation phases with related activities and expected deadlines is also provided. The implementation plan also comprises a risk assessment analysis and a plan for the allocation of financial resources.

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CONTENT

1.INTRODUCTION

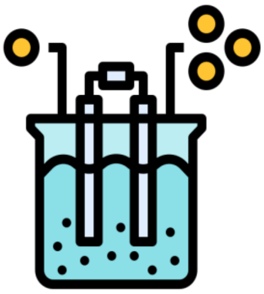
The project AMETHyST aims at evaluating, setting up and developing a common methodology for a “Green Hydrogen Alpine Ecosystem”, for future upscaling and replication throughout the entire Alpine Space territory.

But what exactly is a “Green Hydrogen Alpine Ecosystem”?

A Green Hydrogen Alpine Ecosystem is a bounded territorial system that is able to produce renewable energy, use a share of it to locally produce green hydrogen and supply it to local final consumers, all within one or few neighbouring valleys, in order to decarbonize the alpine economy. Such ecosystem, besides the obvious environmental benefits, has a relevant and immediate impact on the local economy, keeping the value on the territory through the circularity of cash flows, instead of letting it flow outside the defined area in exchange of energy commodities, which are mainly represented by fossil fuels.

RENEWABLE ENERGY PRODUCTION

Renewable energy sources are distributed all over the alpine territory and, when exploited correctly, could largely overshoot the local consumption. Especially regarding hydropower and wood biomass, the alpine territory has a long tradition of sustainable management of the local resources. With the price decrease of PV modules, solar energy became very attractive and competitive and, thanks to its modularity, even domestic households can contribute to the energy transition. A balanced energy mix can already decarbonize most of the alpine territory needs. While currently a lot of this power gets sold to the national grid and dispatched far away from the alpine valley, it is worth considering the idea to hold a share of that excess production to produce hydrogen and decarbonize the local hard-to-abate sectors.



GREEN HYDROGEN PRODUCTION

In a Green Hydrogen Alpine Ecosystem, it is fundamental that the production of hydrogen takes place locally. This is because of two main reasons. First, from an energy efficiency point of view it makes little sense to carry the local electricity somewhere far away, produce the hydrogen and then dispatch the hydrogen back to the valley. Second, by producing it locally, the economic benefits of the production and supply chain (extra-profits, additional occupation) stay within the territorial boundaries, even when the hydrogen is later sold outside the ecosystem. Last, it has to be mentioned that small-scale hydrogen production plants do not require a significant amount of space and can be easily deployed also in remote areas, as long as they respect a minimum safety distance from other buildings.

STORAGE & TRANSPORT

A key component of a Green Hydrogen Alpine Ecosystem is the hydrogen storage. Overall, the hydrogen production and consumption cycle imply relevant transformation losses, and therefore, when possible, the renewable electricity should be directly dispatched to local consumption. But since RES production is not constant throughout the year, it is necessary to take advantage of the peaks in electricity production and store hydrogen to optimally cover the yearly demand. Besides a first storage located next to the production facility, other storages should be built at the usage point locations (e.g. refilling stations) and/or in an additional location where a large storage is possible. All these storages should be dimensioned according to the refilling&transport strategy (i.e. weekly/monthly refill), that may differ for each end use and accordingly to the production pattern. For long-term future developments, a pipeline infrastructure can be foreseen.

HYDROGEN CONSUMPTION

Currently, there is little or no consumption of hydrogen in most of the Alpine Space territory. Therefore, in a Green Hydrogen Alpine Ecosystem the final energy demand should be created by converting end-uses to hydrogen consumption. This should happen accordingly to the production development and the seasonality of production. In fact, supply security and long-term symbiosis are fundamental pillars of such system. Starting with a couple of small projects and later upscaling and expanding allows to adjust the system design and avoid big mistakes and wrong investments. The target sectors are the so-called hard-to-abate ones, such as transport (especially heavy road transport, working vehicles) and some industrial processes. While the whole system develops and gains momentum, hydrogen will become a cheaper option and it will be more convenient for more final users to convert to it. At the same time, the diffusion of cheaper RES generation (prominently PV) will produce cheaper electricity peaks that can be exploited by hydrogen producers.

Overall, a Green Hydrogen Alpine Ecosystem aims at decarbonizing the alpine energy system while keeping the production and consumption inside a relatively small territory. In such way, besides the environmental benefits, marginal territories can exploit their characteristics in a circular economy and local innovation perspective.

2. EXECUTIVE SUMMARY

The following document provides the overall concept of local Alpine green H2 ecosystems together with the guidelines to shape an implementation plan for our project pilots: these are experimental solutions disseminated in the variuos regions that are participating to the AMETHySТ project.

Some of the following are projects in which hydrogen has already been implemented, in others it is being implemented (with projects already financed), while for the remaining ones we are thinking about possible implementations.

The study gives an insight and overview on the aims, strategies, roadmaps and risk assessment analysis for each project in the AMETHySТ framework.

The pilot projects investigated are the following:

- Auvergne Rhône Alpes region (France)
- Funivie Madonna di Campiglio Ski Area (Italy)
- Peio, Ronzo-Chienis and Fiera di Primiero (Italy)
- Arieshof organic farm and tourist accomodation (Italy)
- Valle del Bût hydrogen ecosystem (Italy)
- Maribor region H2 working group (Slovenia)
- WIVA P&G HyWest and H2Alpin projects (Austria)
- Das HAUS (Germany)
- Val de Bagnes hydrogen ecosystem (Switzerland)

3. PILOT PROJECT IMPLEMENTATION PLAN

A. AURA-EE and Tenerrdis (FRANCE)

AMETHyST PROJECT PARTNER	AURA-EE & Tenerrdis
PILOT PROJECT TITLE	AMETHyST project in Auvergne Rhône Alpes region
LOCATION	Départements of Savoie and Haute Savoie, with a focus on Tarentaise Vanoise territory (Auvergne Rhône Alpes, France)

OBJECTIVE(S)

The aim is to support the emergence of a renewable, low-carbon hydrogen ecosystem in the mountains, by creating links between public and private players, between users and potential producers of hydrogen, and by creating coherence between the various initiatives.

This support will involve raising awareness among local authorities, putting them in touch with private-sector players and assisting with practical projects in the pilot area.

To date, AURA-EE and Tenerrdis are supporting three initiatives in the region:

- Haute Tarentaise ecosystem project (conducted by Gaz Electricité de Grenoble, Tignes, Atawey): project launched in 2023: land has been identified + temporary station uses to be secured, launch of a a”small scale” ecosystem expected in 2025 with a temporary station, launch of the "large-scale" project expected in 2026 with a permanent station in the valley
  Aim: acquisition of at least 2 vehicles in ski resorts (bus, vehicle, LCV) and of at least 4 passenger transport vehicles (bus, coach)

  The aim is to set up 2 H2 projects, for which 2 feasibility studies have been carried out by GEG, Atawey and Régie de Tignes:
  1- Ecosystem project in the Haute Tarentaise:
  This would enable us to test uses in the field, remove supply bottlenecks and acculturate local residents to H2.
  And to test new opportunities in the resort:
  a. Snow groomers
  b. Tertiary use
  c. Generator
  > Need to acquire at least 2 vehicles in ski resorts (bus, machine, LCV), land secured

  2- Mobility project for passenger transport Moutiers, vallée-stations: regular lines between Moutiers and destinations in the resort or valley (e.g. Courchevel, Bourg-Saint-Maurice).

Will enable the launch of a local, collaborative dynamic around H2 mobility, pooling depot infrastructure, risk management and skills.

- ➢ Need to acquire 4 buses/cars

- Département de Savoie project of retrofitting a snow clearing vehicle with a hydrogen engine: In order to consider a pre-study on the feasibility of an H2 snow clearing vehicle on roads, the project would need to be presented to the Department's elected representatives
  Evian Hydrogen potential study: Study carried out in 2022-2023 on the potential of a local hydrogen ecosystem (focus on production + uses)

STRATEGY

1. RENEWABLE GENERATION.

The question of renewable hydrogen production in this region is currently being studied. Mountain areas have significant potential for renewable energy production, particularly solar and hydroelectric power. *Current/expected production profiles over a year*: hydropower: continuous generation; Solar: peak during summer months.

In this region, a recharging station designed to accommodate both light and heavy vehicles is in place at the entrance to the valley in the commune of Moutiers. This station stores hydrogen in compressed form, which is transported by tube-trailer. It can deliver both 350 and 700 bar and has a distribution capacity of 100 kg of hydrogen per day, which can be increased to 200 kg per day if demand is sufficient.

2. END-USE.

Selected hydrogen end-use: transport and industrial processes (snow groomers, tertiary use, generators).
Final users: private companies, public transport companies, Local authorities, ski resorts

The target use is mainly heavy mobility (transport of goods, transport of people and snow groomers) and light mobility.

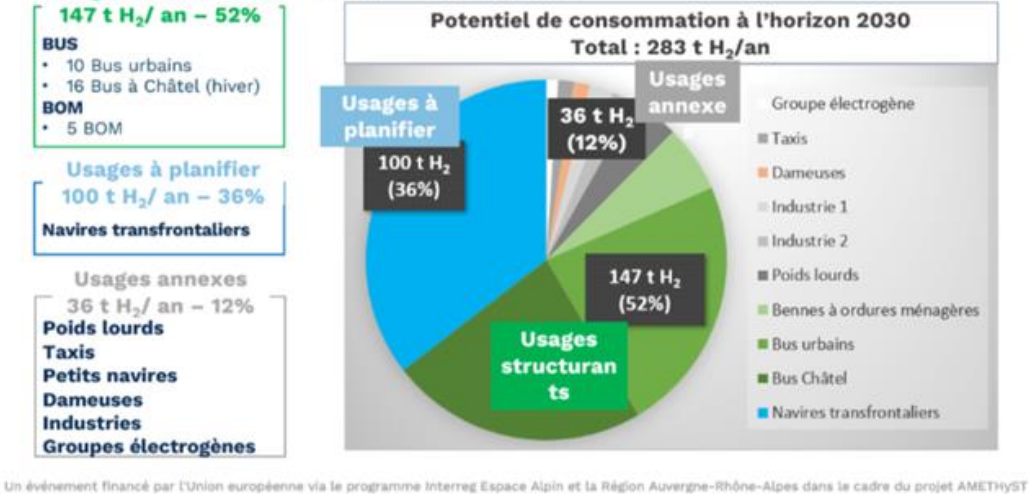
Several local authorities are carrying out potential and feasibility studies as part of the AMETHySТ project, in order to identify the relevant end uses and the production strategy to move towards.

- In the Haute Tarentaise area, a potential study was carried out in 2023. A feasibility study is about to be launched.
Targeted uses:
34% small vehicles
29% buses & coaches
22% large vehicles
9% snow groomers
6% residential garbage dumpster

End users : local authorities, carriers, ski resorts

- And a study has just been completed for the Communauté de communes du Pays d'Evian (CCPEVA):

Identified end-uses	**Identified final users**
Road mobility - light vehicles	municipal services, taxis
Road mobility - heavy vehicles	hauliers, manufacturers
Road mobility - refuse collection vehicles	Waste department of CCPEVA
Road mobility - buses and coaches	Ski resorts
Lake mobility: small vessels and passenger ships	
Specific mobility – snow groomers	Ski resorts
Stationary and industrial - generators	Ski resorts



Potentiel de consommation d'hydrogène

Usages structurants
147 t H_2/ an – 52%
BUS
- 10 Bus urbains
- 16 Bus à Châtel (hiver)

BOM
- 5 BOM

Usages à planifier
100 t H_2/ an – 36%
Navires transfrontaliers

Usages annexes
36 t H_2/ an – 12%
Poids lourds
Taxis
Petits navires
Dameuses
Industries
Groupes électrogènes

Un événement financé par l'Union européenne via le programme Interreg Espace Alpin et la Région Auvergne-Rhône-Alpes dans le cadre du projet AMETHySТ

Today, several vehicles circulate in the area, mainly saloon taxis from France or Switzerland (Geneva airport) to transport tourists to the Tarentaise and Haute Tarentaise ski areas. However, there are not enough of these vehicles to make the existing resort profitable or to encourage the installation of new infrastructure. Substantial investment will be required to roll out these uses.

3. H2 PRODUCTION.

Are there any relevant seasonal patterns/differences? Higher production during the summer due to increased solar output.

The pilot is not at this stage of development, but rather in the potential and feasibility study phase.

For the GEG project: no H2 production in the area, but supply from the Moutiers station.

4. STORAGE.

As part of the discussions currently underway, the issue of renewable hydrogen production and storage, as well as vehicle storage, is being examined.

Mountain areas face a number of challenges: lack of available land, land prices, geographical and climatic constraints, risk management and public acceptance.

The aim is to link this hydrogen issue to a wider reflection on the production and storage of renewable energy.

5. TRANSPORT.

These specific technical aspects are not yet on the agenda. The station of Moûtiers is supplied by tube trailers.

6. SUPPLY CHAIN.

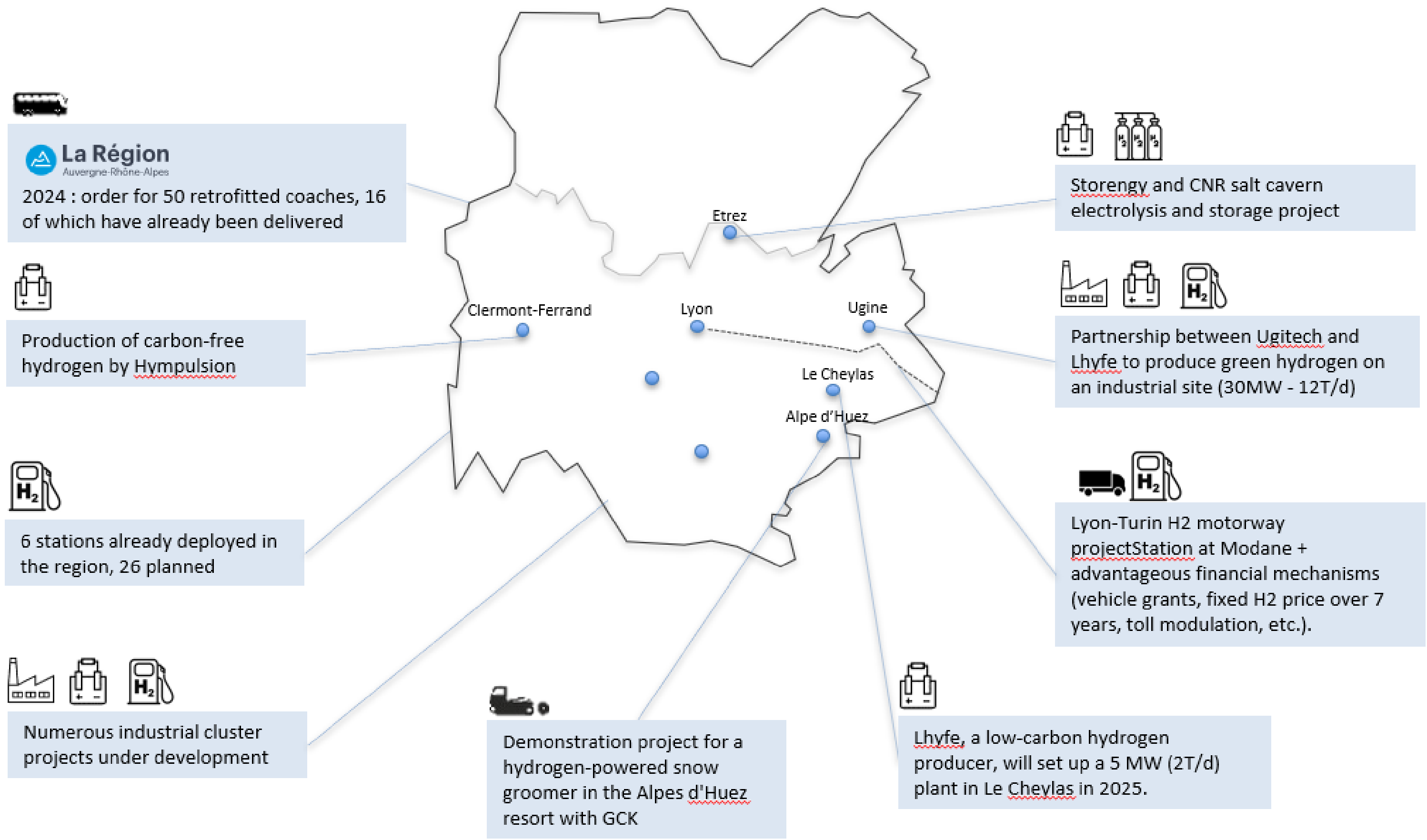
Electrolyzers: Local consortium
Storage units: Local consortium
RES plants: Public and private owners
End-use technologies: Private companies and public bodies
Hydrogen buyers: Private companies and public transportation agencies.

Who buys the hydrogen from whom? Final users (private and public) buy from the production consortium.

Minimal steps: production -> storage -> transport -> end-use.

7. FINANCIAL PLANNING.

Map produced for the Haute Tarentaise study, by GEG, Atawey and Tignes



2024 : order for 50 retrofitted coaches, 16 of which have already been delivered

Production of carbon-free hydrogen by Hympulsion

6 stations already deployed in the region, 26 planned

Numerous industrial cluster projects under development

Demonstration project for a hydrogen-powered snow groomer in the Alpes d'Huez resort with GCK

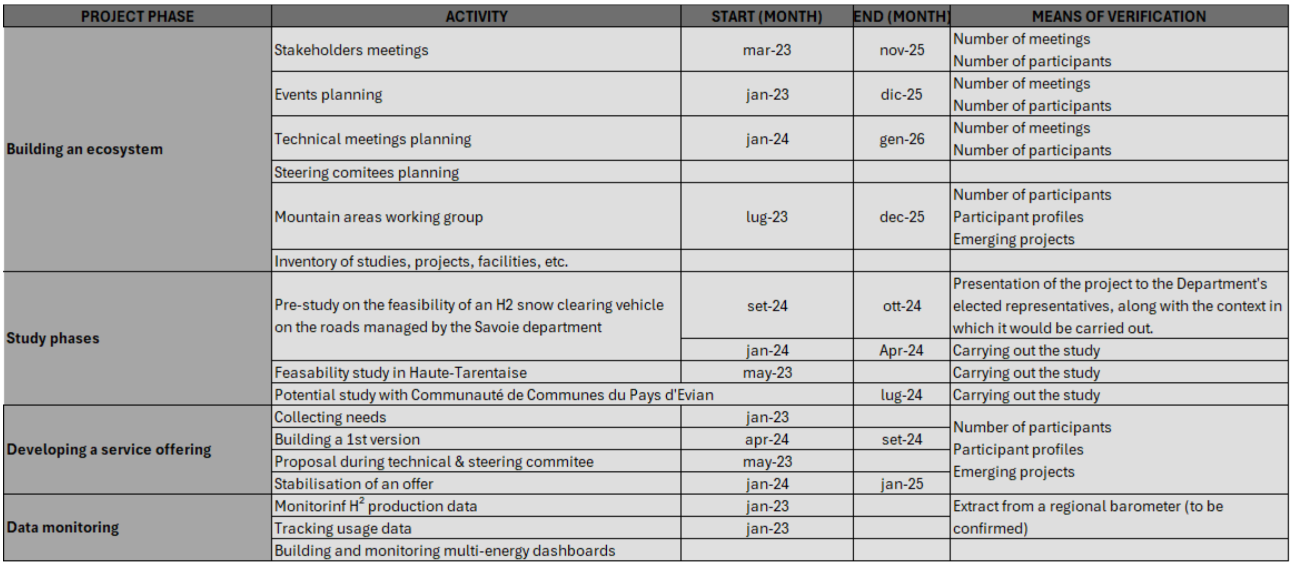
Lhyfe, a low-carbon hydrogen producer, will set up a 5 MW (2T/d) plant in Le Cheylas in 2025.

Storengy and CNR salt cavern electrolysis and storage project

Partnership between Ugitech and Lhyfe to produce green hydrogen on an industrial site (30MW - 12T/d)

Lyon-Turin H2 motorway projectStation at Modane + advantageous financial mechanisms (vehicle grants, fixed H2 price over 7 years, toll modulation, etc.).

ROADMAP



PROJECT PHASE	ACTIVITY	START (MONTH)	END (MONTH)	MEANS OF VERIFICATION
Building an ecosystem	Stakeholders meetings	mar-23	nov-25	Number of meetings Number of participants
	Events planning	jan-23	dic-25	Number of meetings Number of participants
	Technical meetings planning	jan-24	gen-26	Number of meetings Number of participants
	Steering comitees planning			
	Mountain areas working group	lug-23	dec-25	Number of participants Participant profiles Emerging projects
	Inventory of studies, projects, facilities, etc.			
Study phases	Pre-study on the feasibility of an H2 snow clearing vehicle on the roads managed by the Savoie department	set-24	ott-24	Presentation of the project to the Department's elected representatives, along with the context in which it would be carried out.
		jan-24	Apr-24	Carrying out the study
	Feasability study in Haute-Tarentaise	may-23		Carrying out the study
	Potential study with Communauté de Communes du Pays d'Evian		lug-24	Carrying out the study
Developing a service offering	Collecting needs	jan-23		Number of participants Participant profiles Emerging projects
	Building a 1st version	apr-24	set-24	
	Proposal during technical & steering commitee	may-23		
	Stabilisation of an offer	jan-24	jan-25	
Data monitoring	Monitorinf H^2 production data	jan-23		Extract from a regional barometer (to be confirmed)
	Tracking usage data	jan-23		
	Building and monitoring multi-energy dashboards			

RISK ASSESSMENT

RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
FINANCIAL	Insufficient funding Only public funding	4	4	Secure additional grants and investments	Coordinate and pool projects Monitor financing opportunities
TECHNICAL	Lack of vehicles availability Poor efficiency of the conversion chain (electrolysis + storage compression + fuel cell consumption) Only mobility uses	4	4	Identify needs and uses	Coordinate H2 sector Organise meeting between solution providers and public autorities and industriel partners Integrate industrial partners (decarbonizing industry, production and uses of H2)
ORGANISATIONAL	Staff shortage Dependencies	4	4		AMETHySST offers resources to support local authorities Have a H2 team Integrate a territorial H2 team
PILOT MANAGING	Not a fixed pilot area Public authorities explore H2 before engage a roadmap Identify AMETHyST team	2	2	Build a pilot H2 territory	Monitor roadmaps, studies, experimentations and projects Coordinate every projects and experimentations Identify a manager of H2 projects or decarbonizing mountain regions Continue communications strategy Organize events

B. FBK (ITALY)

AMETHyST PROJECT PARTNER	Fondazione Bruno Kessler
PILOT PROJECT TITLE	Funivie Madonna di Campiglio Ski Area
LOCATION	Madonna di Campiglio (Trento, Italy)

OBJECTIVE(S)

The main objective of this pilot project is to identify potential hydrogen solutions that could be implemented in the ski area of Funivie Madonna di Campiglio in order to reduce the greenhouse gas emissions associated with the main activities of the ski area. Considering energy consumptions and associated emissions, the most suitable hydrogen solutions are identified, taking into account technical and financial feasibility.

STRATEGY

1. RENEWABLE GENERATION.

Hydrogen could be produced in the pilot territory by electrolysis systems fed with electricity produced by photovoltaics (PV).

Currently no PV plant is available on site, but installation of PV panels is planned for 2025 (approximately 270 kW). The renewable power plant will be located in 8 sites around the ski area (on buildings roofs and ski lifts stations) and will be owned and manged by Funivie Madonna di Campiglio Spa (private stakeholder). Figure 1 shows the total expected electric energy production month by month (approximately 283 MWh/year). Given the high electricity consumption of the ski area, which uses electricity mainly for running ski lifts and for snow production, the PV plants are intended to be used for such end-uses fully.

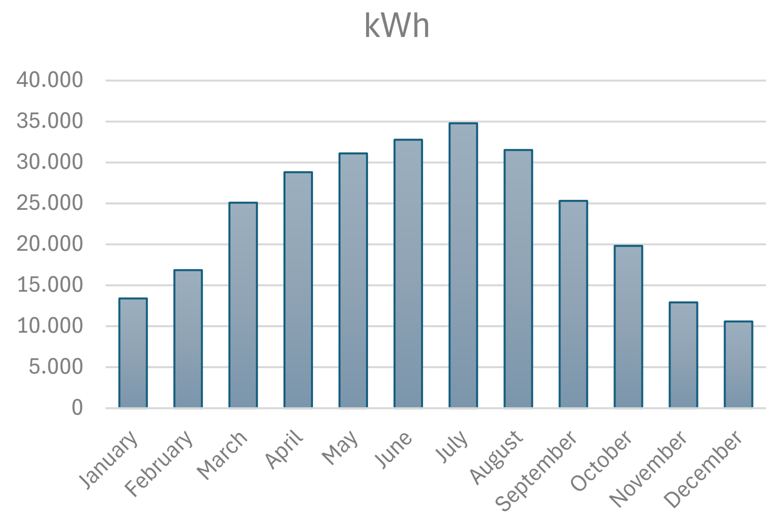


Figure 1. Expected electric energy production by PV plants to be installed in pilot territory.

The costs for the planned PV plants are expected to be partially covered by the European Regional Development Fund, with the remaining expenses being covered by Funivie Madonna di Campiglio Spa.

Additional renewable generation from PV could be dedicated to hydrogen production, but this would require large investments for the purchase and installation of the technology and infrastructure needed for the production, storage and distribution of hydrogen.

Other hydrogen production routes, for instance from biomass or waste, could be explored depending on local availability (e.g., lignocellulosic biomass from local forest maintenance activities).

2. END-USE.

Most CO_2 emissions in the ski area are attributable to electric energy consumption and use of diesel oil for private mobility (snow groomers, cars). Hydrogen could be used in the pilot territory for powering hydrogen-fuelled snow groomers (either fuel-cell or internal combustion engine vehicles). The buyer and final user would be Funivie Madonna di Campiglio Spa itself.

New vehicles (e.g., hydrogen-fuelled internal combustion engine snow groomers) and new infrastructure (hydrogen refuelling stations) for the storage and distribution of hydrogen would be needed. In order to keep a low level of infrastructure complexity, a loading bay coupled with a hydrogen refuelling station can be envisaged for the temporary storage and distribution of hydrogen (see section dedicated to hydrogen storage).

Considering a hydrogen-fuelled internal combustion engine snow-groomer with a consumption of approximately 16 kg of hydrogen per hour of operation and a typical daily operation of 7 hours (in the winter season), each hydrogen vehicle would require around 112 kg of hydrogen daily.

The introduction of new vehicles can be planned as a gradual process. This phased approach allows for thorough testing and integration into the existing fleet, ensuring safety and reliability. This also helps monitor the performance, address potential issues promptly, and optimize the overall implementation strategy.

3. H2 PRODUCTION.

Given that renewable electric energy production (through PV plants) would be reasonably used for ski lifts and snow production, hydrogen to fuel snow groomers can be expected to be purchased from outside. At the moment it is hard to identify any hydrogen supplier or exact place where the hydrogen could be produced.

If the electric energy generated by the planned PV plants (270 kW) was dedicated entirely to the production of green hydrogen, considering an electrolyzer efficiency of 50 – 55 kWh/kg_{H2}, around 5 – 6 tons of hydrogen could be produced yearly.

4. STORAGE.

Potential hydrogen production should be carefully paired with a suitable hydrogen storage solution to meet the hydrogen demand for snow groomers. Seasonal storage will likely be necessary since the peak hydrogen production from PV occurs in the summer season, when the use of snow groomers is limited or null.

Shorter-term storage would be needed also if the hydrogen was imported from external sources, for supporting the distribution of the fuel at the hydrogen refuelling station (HRS). A loading bay, serving as temporary hydrogen storage solution, can be designed for hosting gaseous hydrogen tube trailers (purchased from external suppliers) connected to the HRS. This solution can limit the complexity of the storage and distribution systems as well as the investment cost.

The sizing of the infrastructure dedicated to hydrogen storage and distribution depends mainly on the hydrogen demand, which is determined by the number of hydrogen snow groomers in use. In addition, considering that these snow groomers might require pressure levels as high as 700 bar, either higher pressure storage or compression systems would be necessary.

5. TRANSPORT.

Transportation of hydrogen from the production site to the hydrogen refuelling station would be required. Regular supply would be needed in the winter season for meeting the hydrogen demand of snow groomers. Transportation could be carried out in pressurized tube trailers working also as temporary hydrogen storage solution at a loading bay connected to the distribution system (see section dedicated to storage).

6. SUPPLY CHAIN.

Funivie Madonna di Campiglio would own the end-use technology (hydrogen snow groomers).

Energy sources (e.g., PV plants), hydrogen production (e.g., electrolyzers), and hydrogen transportation (e.g., tube trailers), would be the intermediate steps of the hydrogen supply chain to be managed by external stakeholders.

The distribution of hydrogen through hydrogen refuelling stations (HRS) for supplying the fuel to the snow groomers is a critical step of the supply chain. Establishing a privately-owned HRS within the ski area can offer greater operational independence and flexibility. However, this approach entails considerable technical and economic challenges, as well as safety concerns and compliance with permitting and regulatory standards.

7. FINANCIAL PLANNING.

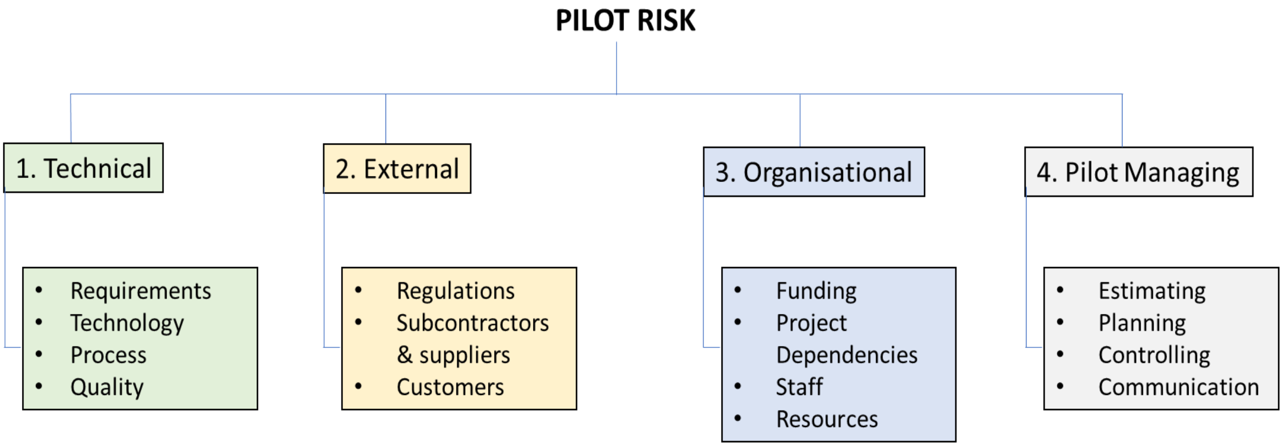
The implementation of the pilot project requires large investments (starting from the end-use application) and has not received any public funding yet. There is interest in the potential gradual introduction of hydrogen-fuelled snow groomers, but the technology will be ready for the market in a few years. In the short-term it could be an option to propose the pilot as a “living lab” for testing innovative technical solutions. Stakeholders (either local or not) to cover for all other steps of the hydrogen supply chain should be identified.

ROADMAP

PROJECT PHASE	ACTIVITY	START (MONTH)	END (MONTH)	MEANS OF VERIFICATION
SETTING UP THE SCENE	Raising local stakeholders’ interest	1	12	Regular meetings and roundtables
	Collecting data on local energy system	3	12	Availability of data and information on energy production and consumption systems in pilot territory
	Developing preliminary project concept: determining hydrogen demand and identifying potential production routes	9	15	Preliminary project design
PROJECT DEVELOPMENT	Techno economic feasibility	13	18	Techno-economic assessment
	Possible scenarios definition and analysis	13	18	Optimal scenario identification
	Identification of technology suppliers and stakeholders’ commitment	13	24	Letters of intent (LOIs) or Memorandums of Understanding (MoUs)
	Finalizing stakeholders’ role and investment capacity	13	24	Project governance plan

	Searching for funding opportunities	13	30	Documented list of funding sources and funding strategy document
	Developing monitoring and optimization strategies for project improvement and finalization	19	30	Definition of KPIs and metrics for monitoring
REALIZATION PHASE	Developing executive project plan	31	39	Executive project plan
	Permitting phase	34	39	Permit documents
	Realization of plants	37	45	Implementation of hydrogen solutions
OPERATIONAL AND MONITORING PHASE	Testing and monitoring	46	Continuously throughout project operational phase	Calculation of KPIs and benchmarking
	Optimization	Continuously throughout project operational phase		Identification and application of optimization strategies
	Communication and dissemination of activities	Continuously throughout project development and operational phase		Press releases, events organization, reporting

RISK ASSESSMENT



RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
Technical – Requirements Too high hydrogen demand for snow groomers operation	The installation of PV panels in the pilot territory will be dedicated to the production of electric energy to meet the electricity consumption of the ski area. The implementation of hydrogen-fuelled snow groomers requires the purchase of hydrogen from external sources.	5	4	Identification of technically and economically feasible solutions for the onsite production of hydrogen as well as possible alternatives.	Identification of potential hydrogen suppliers both local and not.
Technical – Technology Hydrogen snow groomers not ready for the market	Hydrogen snow-groomers are an emerging technology, still in the testing phase and might not be ready for the market as planned.	3	4	Connect and stay connected with technology providers for anticipating any delay and find appropriate solutions	Re-scheduling of implementation timeline and suggest the pilot territory as a tester for the new prototypes.

Technical – Technology Low energy performance and efficiency of hydrogen solutions impeding normal operations in ski area	Low TRL (Technological Readiness Level) hydrogen solutions (e.g., hydrogen-fuelled snow groomers) might result in poor performance in terms of efficiency or durability impeding normal operations in the ski area.	3	4	Identification and implementation of best available technologies; Monitoring of key energy performance indicators (KPIs) to anticipate any issue; Step-by-step introduction of new hydrogen-fuelled vehicles.	Use of spare vehicles, even if fossil fuel ones, for temporary operation.
External – Regulations Unclear safety requirements for implementation of hydrogen solutions might extend installation timing.	The implementation of specific hydrogen solutions requires the adoption of safety measures defined in standards and regulations that are not very clear or that do not explicitly include specifications about hydrogen. The difficulty in understanding the legislative requirements can extend the planned time for a safe implementation of hydrogen.	4	4	Start investigating and checking well in advance the safety requirements for a correct implementation of hydrogen solutions.	Re-scheduling of implementation timeline.
External – Subcontractors and suppliers Difficulties in finding green hydrogen suppliers	In a slowly developing hydrogen economy, the availability of green hydrogen suppliers is very limited, and it can be hard to find a local and affordable hydrogen supplier, especially as the local hydrogen market develops and new hydrogen projects are implemented.	4	5	Consider the installation of a local and private hydrogen production facility.	Use of fossil fuel vehicles or of non-green hydrogen while green hydrogen suppliers are found.

Organisational – Funding Missing funding	Planned funding might not be available or appropriate funding schemes could be missing, thus undermining the economic feasibility of the project.	2	5	Investigate all options for funding (at European, national and local level).	New funding resources should be found.
Organisational – Staff Difficulties in recruiting staff with proper qualification in hydrogen technologies	Given the innovation of the proposed solutions, it could be difficult to recruit staff with proper qualification in hydrogen technologies	2	3	Plan training of current staff on hydrogen technologies operation and maintenance.	Plan specific activities dedicated to the development of the necessary professional skills for the operation and the maintenance of hydrogen-fuelled snow groomers.
Pilot managing – Planning Inaccurate financial planning and analysis	Imprecise estimation of capital costs (CAPEX) for equipment, operating and maintenance costs (OPEX) or debt service conditions may jeopardize the financial equilibrium of the pilot if actual costs are higher than expected costs.	2	4	Sound data collection on CAPEX and OPEX reduce this risk.	Re-negotiate prices and/or debt service conditions; find new funding resources.

C. Province of Trento (ITALY)

AMETHyST PROJECT PARTNER	PAT
PILOT PROJECT TITLE	Hydrogen For Households' Heating Replacement
LOCATION	Provincia Autonoma di Trento

OBJECTIVE(S)

The main objectives of this projects are contributing to the compatibility analysis of the potential natural gas consumption and number of users potentially affected by the service, with the decarbonization goals, at 2030 and 2050, according to the current Provincial Law No. 17/2013. To calculate the final number of users is mandatory to take in consideration the analysis of the potential end-users that can be served with the upgrading of existing biomass district heating networks, setting the objective of prioritising the service dispensed by these networks over implementing solutions that involve the construction of new networks for the supply of natural gas(complying with the indications of Article 9, paragraph 3 of Ministerial Decree No. 226/2011)

The analysis of the technical-economic feasibility conditions for the extension of the distribution service, taking into account the rules dictated by ARERA for the eligibility of investments for the construction and operation of new networks for both gas distribution and transportation. The analysis takes into account the proposed development of the natural gas transportation network in the western territory of Trentino, indicated in the Ten-Year Development Plans of the transportation network, although their official approval has not yet taken place.

STRATEGY

1. RENEWABLE GENERATION.

What are the selected renewable sources chosen for hydrogen production?

For the first two pilot sites solar power plants are chosen. For the last one, Primiero, hydropower and solar power plants are chosen.

Are the power plants already available and running?

All the solar power plants are not available at the moment while the hydropower plant for Primiero is already running.

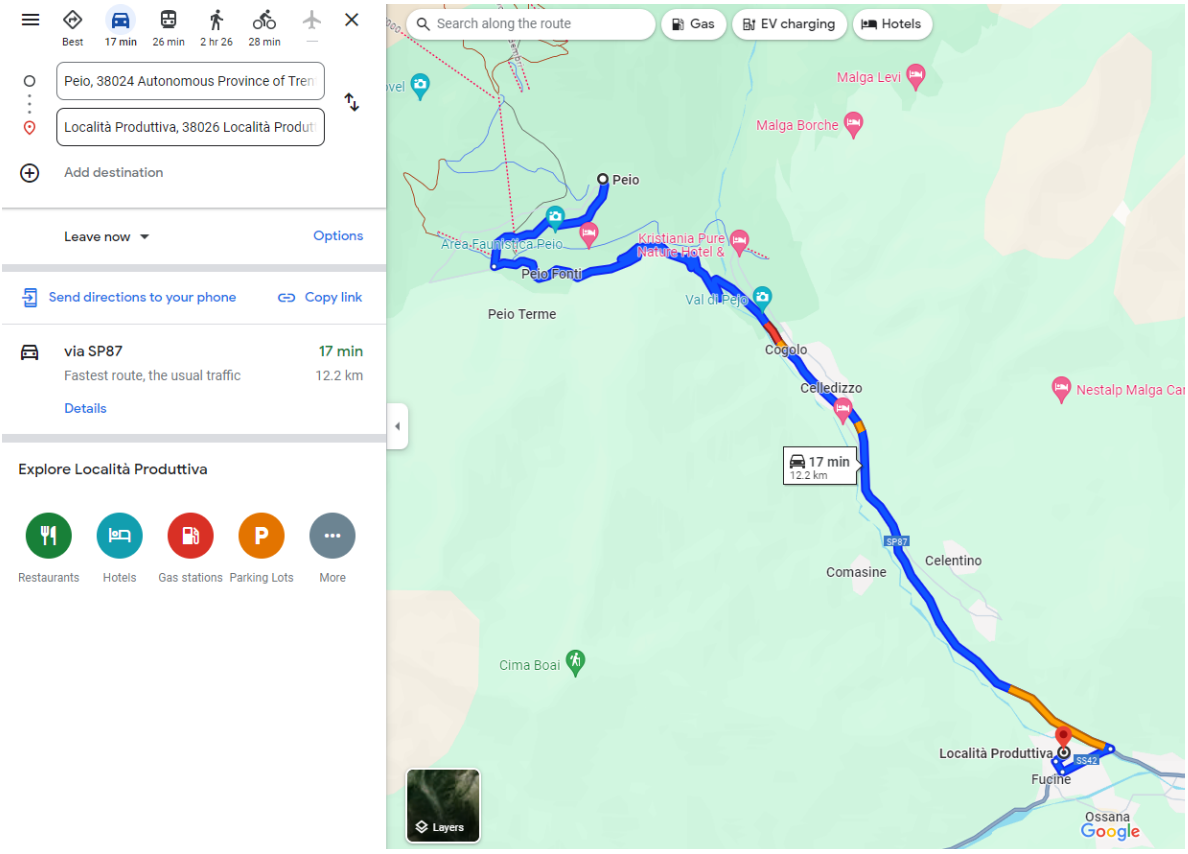
Who owns/will own the renewable power plant? Are they owned by a public body or by a private stakeholder?

The local private energy provider will own the plant.

Where are they located exactly?

PEIO

Peio PV plant is located in a factory area near Ossana, Val di Sole, 12 km south from Peio. The choice was made considering the space available and the better exposition to sunlight.



Peio, 38024 Autonomous Province of Tren

Località Produttiva, 38026 Località Produt

via SP87 17 min

Fastest route, the usual traffic 12.2 km

Figure 1 Peio PV solar plant location

RONZO-CHIENIS

The PV power plant in Ronzo Chienis is located approximately 500 m in the surroundings of the village border.

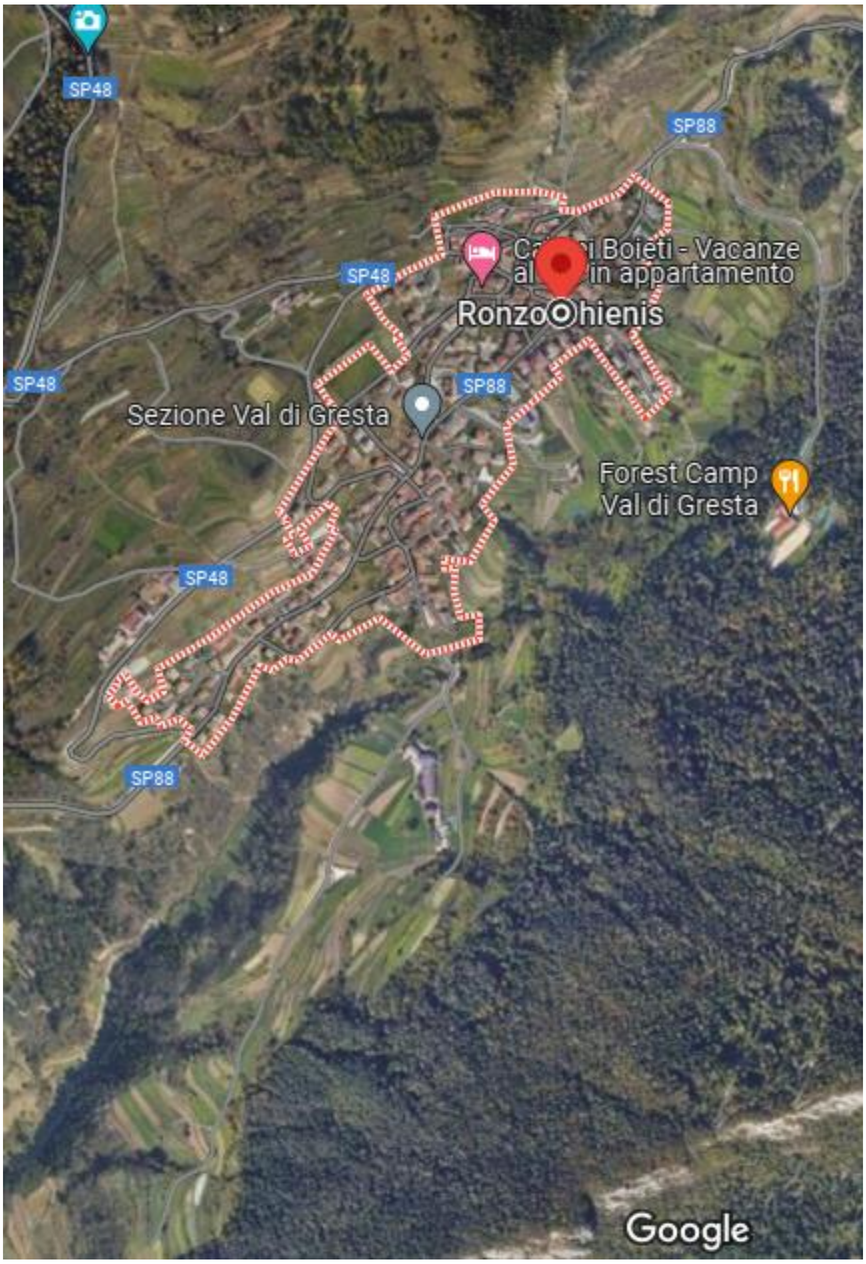


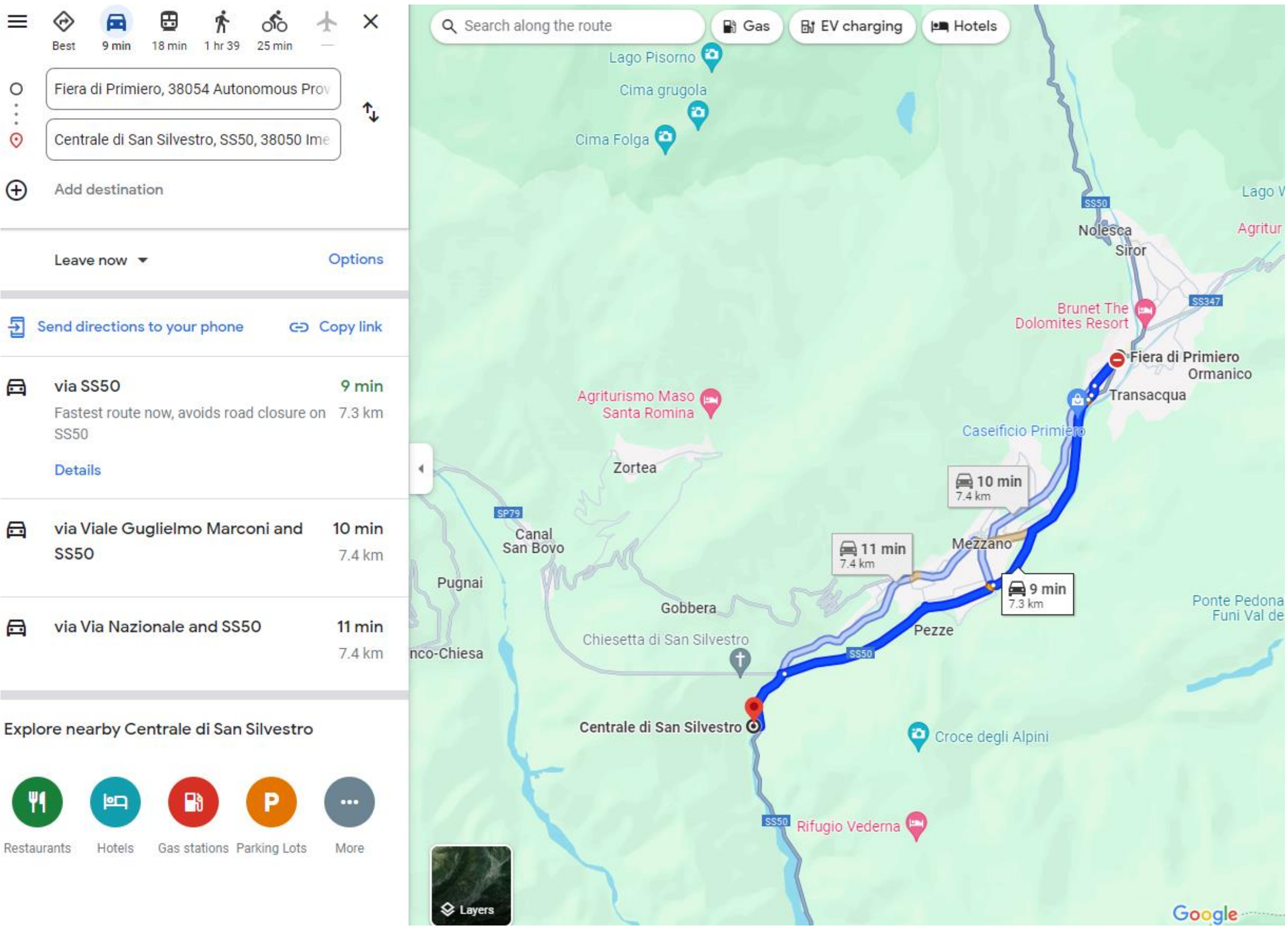
Figure 2 Ronzo Chienis PV solar plant approximately location

FIERA DI PRIMIERO

Fiera di Primiero has three different subcases.

All those cases are designed to substitute the back up for the existing biomass power plant.

The scenario 3 is about PV generation only.Scenarios 4a and 4b involve the use of hydropower alone from the San Silvestro run-of-river hydroelectric power plant, part of the Primiero Energia group, and located in the municipality of Imer, in the Province of Trento. Scenario 4c involves electricity production from both hydroelectric and photovoltaic sources. The hydroelectric power plant consists of a free-stream tunnel with a length of 11200 m and a maximum flow rate of 8 m3/s. The penstock connecting the pipeline to the power plant has a length of 525 meters and a diameter of 2.25 m, for a gross water head of 306 meters.



Fiera di Primiero, 38054 Autonomous Prov

Centrale di San Silvestro, SS50, 38050 Ime

via SS50 9 min
Fastest route now, avoids road closure on SS50 7.3 km
Details

via Viale Guglielmo Marconi and SS50 10 min
7.4 km

via Via Nazionale and SS50 11 min
7.4 km

Explore nearby Centrale di San Silvestro

Figure 3 Fiera di Primiero and San Silvestro hydropower plant.

What are the current/expected production profiles over a year? What share of the production is/will be available for hydrogen production?
All the PV solar power plant are specifically designed to satisfy the hydrogen production for the pilot sites except San Silvestro hydropower plant which will use about 10% of its yearly energy production

If built, how long will it take to have them up and running? What is approximately the cost of the planned plants and who will bear it?
The costs are detailed below and they will probably be sustained by the local energy distributor

Cost M€	Scenario 1	Scenario 2A (10% blending)	Scenario 2B (20% blending)	Scenario 3
PV	21.2	0.63	1.36	2.5
Electrolizer	21.2	0.63	1.36	2.5
Compressor	0.06	0.018	0.01	0.02
Buffer	0.25	0.007	0.016	0.03

Seasonal accumulation	20.9	0.655	1.417	2.5
Transport works	2.48	0.12	0.12	0.12
Civil works and plants	6.4	0.2	0.4	0.8
TOTAL COSTS	**72.5**	**2.3**	**4.7**	**8.4**

Cost M€	Scenario 4a	Scenario 4b	4c
PV	0	0	0.95
Electrolizer	1.7	0.7	1.13
Compressor	0.02	0.02	0.02
Buffer	0.02	0.02	0.02
Seasonal accumulation	2.66	2.55	2.16
Transport works	0.12	0.12	0.12
Civil works and plants	0.3	0.1	0.3
TOTAL COSTS	**4.8**	**3.5**	**4.7**

2. END-USE.

What is the selected hydrogen end-use? Who are the final users, private companies or public bodies?

The end use of the hydrogen will be for household consumption. The aim is to replace the actual heating and cooking system with hydrogen ready appliances.

Is the final user also the hydrogen producer?

No, it will be the local energy provider/producer that will produce and distribute the hydrogen.

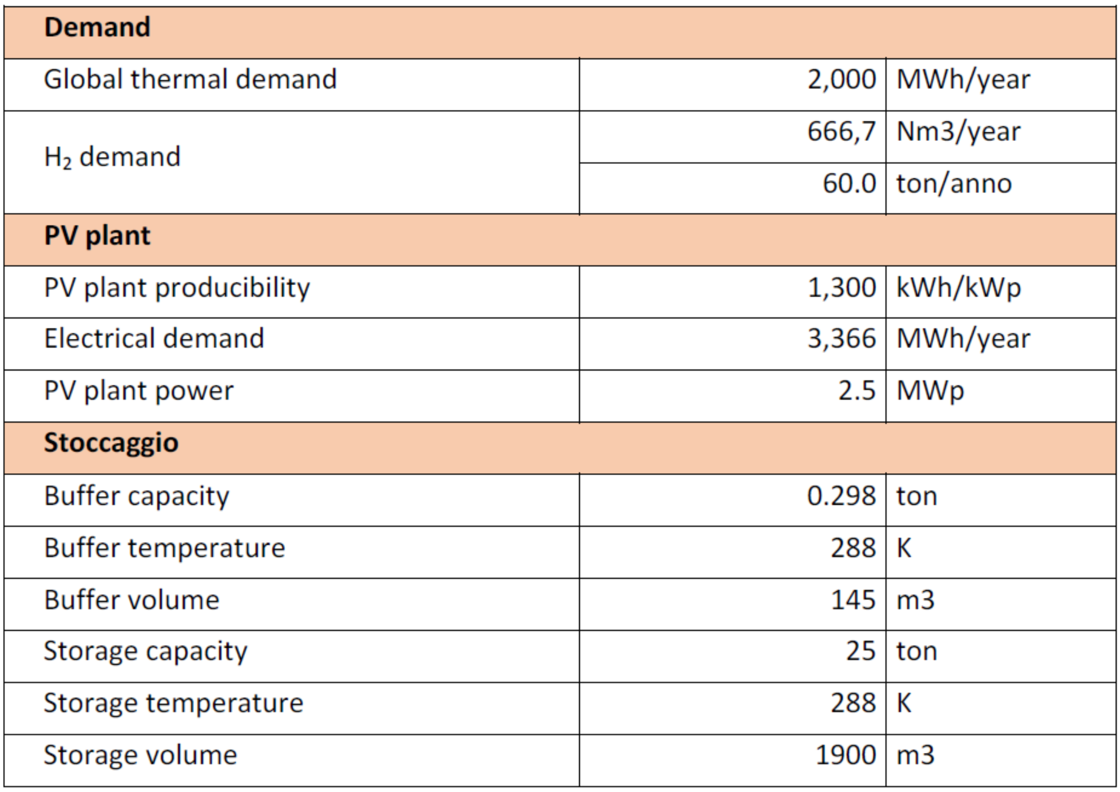
What is the expected yearly consumption?

Demand		
Global thermal demand	15,573	MWh/year
H_2 demand	5,190,972	Nm3/year
	466.7	ton/anno
PV plant		
PV plant producibility	1,200	kWh/kWp
Electrical demand	25,498	MWh/year
PV plant power	21.2	MWp
Storage		
Buffer capacity	2.506	ton
Buffer temperature	288.00	K
Buffer volume	1,000	m3
Storage capacity	209	ton
Storage temperature	288.00	K
Storage volume	12,507	m3

Figure 2 Peio

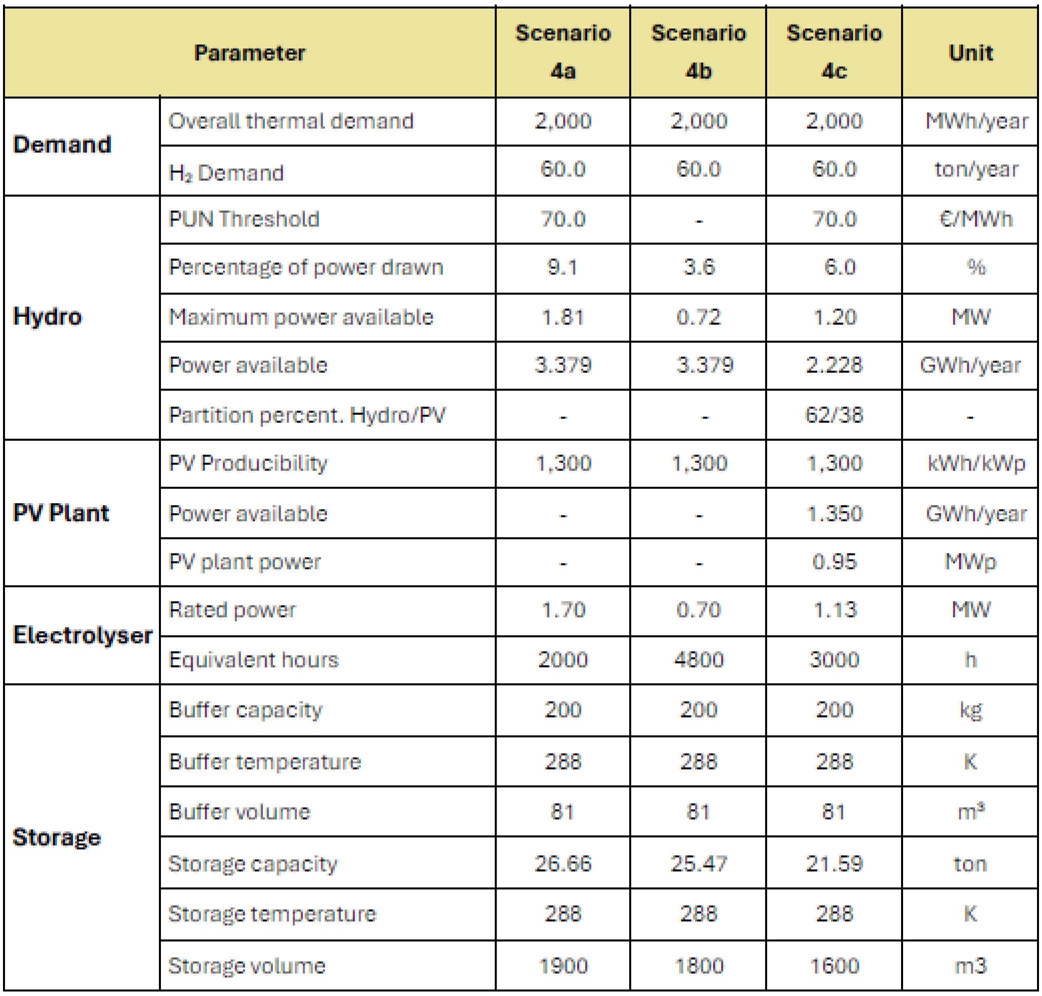
Demand	a	b	unit
Global thermal demand	15,942	15,942	MWh/year
Blended gas demand	1,724,186	1,864,105	Nm^3/year
H_2 demand	172,419	372,821	Nm^3/year
	15.50	33.52	ton/year
PV plant	a	b	unit
PV plant producibility	1345	1345	kWh/kWp
Electrical demand	891.7	1849	MWh/year
PV plant power	0.63	1.36	MW
Storage	a	b	unit
Buffer capacity	73.60	163.4	kg
Buffer temperature	288	288	K
Buffer volume	40	65	m^3
Storage capacity	6.5	14.1	ton
Storage temperature	288	288	K
Storage volume	550	1200	m^3

Figure 3 Ronzo Chienis



Demand		
Global thermal demand	2,000	MWh/year
H_2 demand	666,7	Nm3/year
	60.0	ton/anno
PV plant		
PV plant producibility	1,300	kWh/kWp
Electrical demand	3,366	MWh/year
PV plant power	2.5	MWp
Stoccaggio		
Buffer capacity	0.298	ton
Buffer temperature	288	K
Buffer volume	145	m3
Storage capacity	25	ton
Storage temperature	288	K
Storage volume	1900	m3

Figure 4 Fiera di Primiero PV only



Parameter		Scenario 4a	Scenario 4b	Scenario 4c	Unit
Demand	Overall thermal demand	2,000	2,000	2,000	MWh/year
	H_2 Demand	60.0	60.0	60.0	ton/year
Hydro	PUN Threshold	70.0	-	70.0	€/MWh
	Percentage of power drawn	9.1	3.6	6.0	%
	Maximum power available	1.81	0.72	1.20	MW
	Power available	3.379	3.379	2.228	GWh/year
	Partition percent. Hydro/PV	-	-	62/38	-
PV Plant	PV Producibility	1,300	1,300	1,300	kWh/kWp
	Power available	-	-	1.350	GWh/year
	PV plant power	-	-	0.95	MWp
Electrolyser	Rated power	1.70	0.70	1.13	MW
	Equivalent hours	2000	4800	3000	h
Storage	Buffer capacity	200	200	200	kg
	Buffer temperature	288	288	288	K
	Buffer volume	81	81	81	m^3
	Storage capacity	26.66	25.47	21.59	ton
	Storage temperature	288	288	288	K
	Storage volume	1900	1800	1600	m3

Figure 5 Fiera di Primiero Hydropower plant scenarios

Is it necessary to buy new vehicles or build new infrastructure?
Yes, for almost all those case studies the hydrogen will not be produced in the same place where it will be consumed and carriers are needed to transport it.

What is approximately the expected investment to be made?
It is explained above in the previous question.

3. H2 PRODUCTION.
Who will own and manage the H2 production plant?
As for the PV plant the H2 production plant will be managed and owned by a local energy producer.

Where will the hydrogen production take place exactly?
The electrolyzer and seasonal storage will be located in the area adjacent to the PV plant, due to the need for electrical coupling between the two sections of the system and to reduce visual impact.
For Peio the hydrogen pipeline will be installed entirely in the municipality of Peio, more specifically in the municipal area called "Peio Alta," where residential heating systems currently consist mainly

of pellet or oil-fired boilers. The hamlet of the municipality of Peio Cogolo is currently equipped with a district heating network fed by pellet burners, and therefore it is not considered prioritized to intervene
with the modification of this network since the biomass resource is widely available in the area and does not present environmental criticalities. The connection between the hydrogen production and storage area and the starting area of the hydrogen pipeline will be discontinuous, i.e., made through a land transportation system by means of tank cars (trailers), which will take a given amount of gas from the long-term storage unit and transport it to a short-term storage unit located at Peio Alta

For Ronzo-Chienis, Fiera di Primiero and San Martino di Castrozza the connection between the long-term hydrogen storage and the gas network will be continuous, i.e.,made by means of a mixing station that will take a certain amount of hydrogen from the long-term storage unit and inject it into the methane network.

Is the land plot already owned by the local stakeholder consortium?

At the moment there isn't a stakeholder consortium and the land chosen for the Electrolizer is mainly industrial land for all the three pilot cases.

Are there any relevant seasonal patterns/differences?

The main seasonal pattern between the three pilot cases is that Peio and San Martino di Castrozza are quite important ski places while Ronzo Chienis is less touristic during the winter periods. Moreover, San Martino di Castrozza is the only one among the other two which will benefit from energy produced by the hydropower plant.

What is more or less the installed electrolyser power?

Scenario 1 - Peio	Value	Unit
Equivalent thermal power installed	11.50	MW
Hydrogen coverage factor	50%	%
Equivalent hours of operation	2708.33	h/year
LHV H_2	33.33	kWh/kg
	3.00	kWh/m3
Electrolyzer specific consumption	51.28	kWh/kg
Electrolyzer efficiency	65%	%
Global efficiency	61%	%
Global specific consumption	54.64	kWh/kg

Scenario n°2 – Ronzo - Chienis	a	b	Unit
Number of diffuse generators	565.00	565.00	-
Diffuse generators power	14.90	14.90	MW
Contemporaneity factor	40%	40%	%
Equivalent hours of operation	2708.33	2708.33	h/year
LHV H_2	3.00	3.00	kWh/m^3
LHV CH_4	9.94	9.94	kWh/m^3
Blending percentage	10.00%	20.00%	$\%_{vol}H_2$
LHV blended gas	9.25	8.55	kWh/m^3
Electrolyzer specific consumption	54.64	54.64	kWh/kg
Electrolyzer efficiency	65%	65%	%
Global efficiency	61%	61%	%
Global specific consumption	54.64	54.64	kWh/kg

Scenario 3 – San Martino & Fiera	Value	Unit
Equivalent thermal power installed	0.74	MW
Hydrogen coverage factor	100%	%
Equivalent hours of operation	2708.33	h/year
LHV H_2	33.33	kWh/kg
	3.00	kWh/m3
Electrolyzer specific consumption	51.28	kWh/kg
Electrolyzer efficiency	65%	%
Global efficiency	61%	%
Global specific consumption	54.64	kWh/kg

A rough estimate of the investment?
It is explained above in the previous question.

4. STORAGE.
   According to seasonal patterns, approximately how big will the storage be (time-wise and kg of H2)?
   Think about the logistics. Will it be located next to the production site? Or next to the end-user?
   All the above questions are answered in the previous tasks.

   At what pressure will it be stored?
   The Buffer has a pressure of 15/30 bar while the long-term storage has a pressure of 200 bar

   Are the selected locations far enough from other buildings? How, if necessary, will they be made safe?
   Due to lack of legislation about H2 it is difficult to understand how many metres are enough to be considered safe. Despite this, the H2 production and storage are located mostly on industrial fields

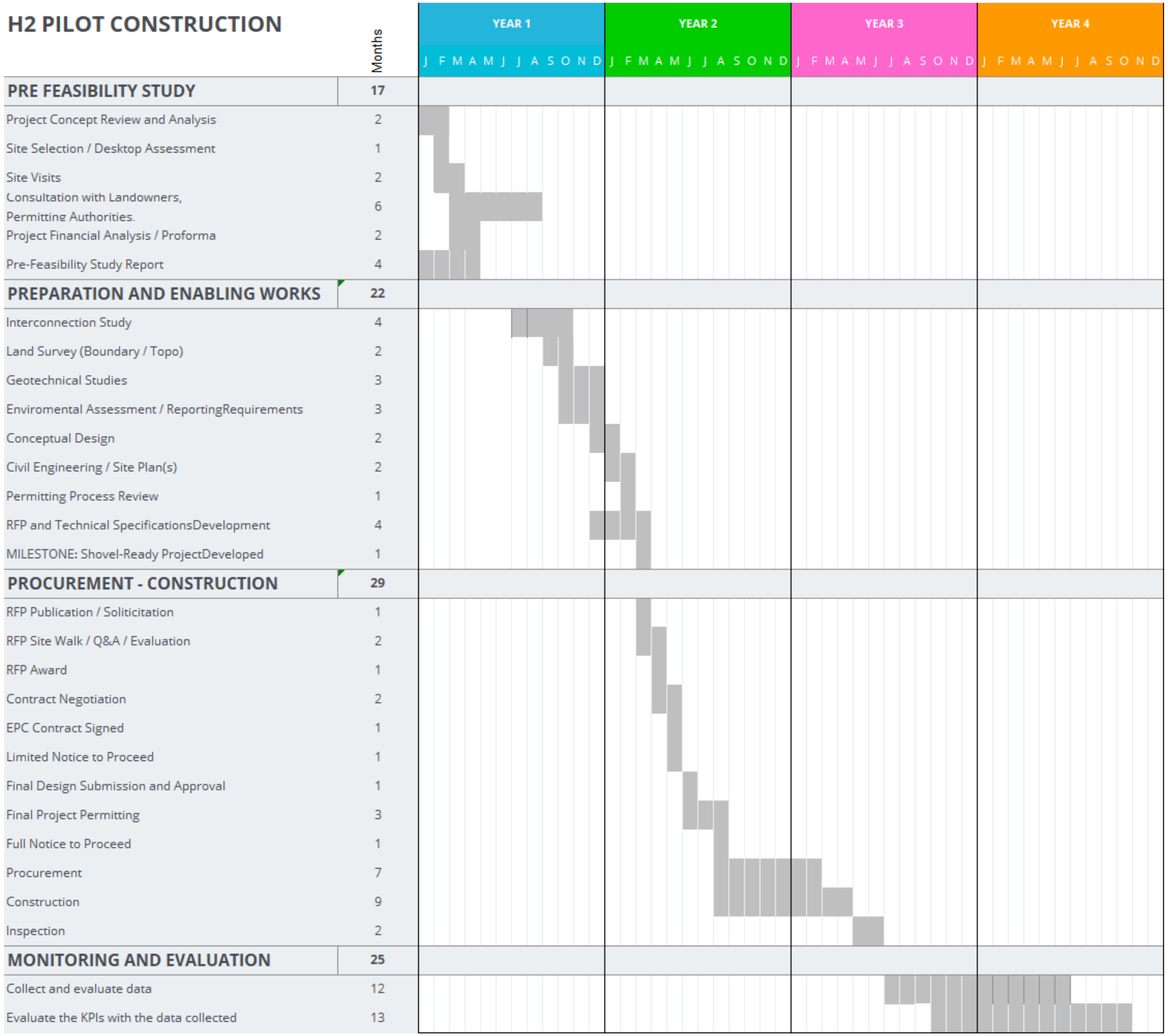
5. TRANSPORT.
   How will the H2 move from one storage to the other? Is a new infrastructure required? Or new vehicles? Or will smaller H2 tanks be moved with a regular truck? Who will be in charge of the transport?
   For Peio and San Martino di Castrozza H2 will be transported by H2 truck carriers.
   For Ronzo Chienis H2 will be blended in the local gas pipeline.

6. SUPPLY CHAIN.
   -

7. FINANCIAL PLANNING.
   Analyse available resources and allocate them according to planned activities. Is the project already partially or totally funded by some public entity?
   The project is at the feasibility stage now. No public tender nor a more detailed technical proposal have been made.

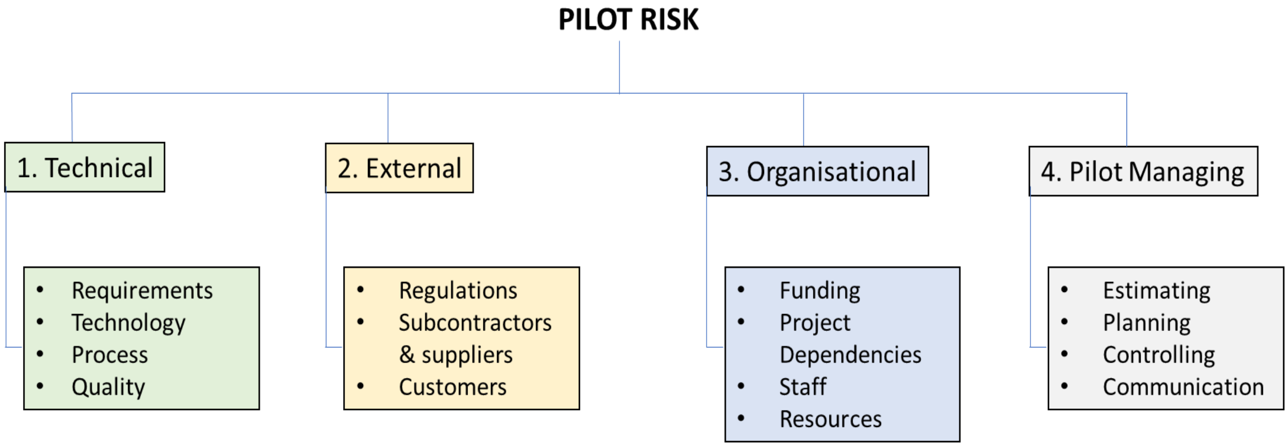
ROADMAP

H2 PILOT CONSTRUCTION



H2 PILOT CONSTRUCTION	Months
PRE FEASIBILITY STUDY	**17**
Project Concept Review and Analysis	2
Site Selection / Desktop Assessment	1
Site Visits	2
Consultation with Landowners, Permitting Authorities.	6
Project Financial Analysis / Proforma	2
Pre-Feasibility Study Report	4
PREPARATION AND ENABLING WORKS	**22**
Interconnection Study	4
Land Survey (Boundary / Topo)	2
Geotechnical Studies	3
Enviromental Assessment / ReportingRequirements	3
Conceptual Design	2
Civil Engineering / Site Plan(s)	2
Permitting Process Review	1
RFP and Technical SpecificationsDevelopment	4
MILESTONE: Shovel-Ready ProjectDeveloped	1
PROCUREMENT - CONSTRUCTION	**29**
RFP Publication / Soliticitation	1
RFP Site Walk / Q&A / Evaluation	2
RFP Award	1
Contract Negotiation	2
EPC Contract Signed	1
Limited Notice to Proceed	1
Final Design Submission and Approval	1
Final Project Permitting	3
Full Notice to Proceed	1
Procurement	7
Construction	9
Inspection	2
MONITORING AND EVALUATION	**25**
Collect and evaluate data	12
Evaluate the KPIs with the data collected	13

RISK ASSESSMENT



RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
SITE SELECTION	Site selection and in particular ensuring the suitability of the site on which a hydrogen project is to be located is key. Site selection is not simply a question of making sure the land area is sufficient to accommodate the plant and any associated infrastructure but it also goes to the ability to obtain necessary planning and building permits, consents and approvals in a speedy and efficient manner and with a minimum number of conditions needing to be satisfied. It is also helpful if the site chosen is close to necessary infrastructure, which includes generation capacity/grid connection, water sources, port infrastructure and downstream markets or at least transportation to enable downstream markets to be readily accessed. Such proximity mitigates to some extent certain construction and operational risks.	2	2	Careful planning and site visit will reduce the risk to choose an area not well insulated, with low water availability and with high risk of permission refusal. Meet all the land owners and make them sign a pre-approval agreement to ensure the land acquisition once all the permits are granted.	In the planning phase find another spot as an alternative. Make some more meetings with the public authority to understand if and how to solve the issues.
TECHNOLOGY	Technology risks can also arise during the lifetime of a hydrogen project. In the early stages, inaccuracies in planning are a major risk which may not only cause delays later on but which could ultimately threaten the successful implementation of the entire project. Uncertainties about durability, e.g. due to limited experience with large-scale applications of the technology, damage to physical assets and defective components can also delay the construction of the hydrogen project site or halt the production of green hydrogen.	3	2	Use literature research and hire a specialised engineering firm in the hydrogen sector. Hire also another different engineering firm to double check the project.	Ensure more than one producer and supplier in case of technical issues.

RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
REGULATORY FRAMEWORK	The regulatory framework for renewable hydrogen is still developing. In practice, long-term offtake, which is usually a prerequisite for making renewable hydrogen projects bankable, is difficult to secure under conditions of uncertainty. In addition, the length of approval processes can lead to significant delays in the implementation of projects	3	3	Establish temporary guidelines that outline safety, storage, transportation, and usage standards based on best practices and existing regulations in related industries (e.g., natural gas). Reduction of the permitting and construction periods via facilitated permitting processes.	Conduct thorough risk assessments for different aspects of the hydrogen supply chain, including production, storage, transport, and utilization. Multilateral development banks and export credit agencies can provide political risk insurance that may not be available from the insurance market, or available only at a cost that makes the project non bankable
SUPPLY CHAIN	Supply chain-related risks include shortages in resources for hydrogen generation, shortages and unavailability of technological parts and replacements, and limitations in terms of infrastructure. Insufficient green electricity supply and insufficient water supply are two possible shortages of essential feedstock for hydrogen generation with severe consequences.	1	4	To reduce the likelihood to happen, more renewable sources should be considered.	The existing power sources should be used more efficiently

RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
FUNDINGS	Financing risks predominantly occur in the early stages, i.e. before the operational phase, because renewable hydrogen projects, like most other renewable energy projects, have high up-front costs and therefore require reliable and preferably long-term funding in order to be successfully implemented. Further financing risks include unexpectedly high costs of capital, insufficient financial expertise of the project partners and insufficient managerial know-how. Recently, rising interest rates in combination with inflation and supply chain challenges have led to higher-than-anticipated capital costs of renewable energy projects	3	4	Facilitating investments via unlocking funds and foreign investment initiatives. Reducing financing costs via enabling access to low-cost finance. Creating a level-playing field for green hydrogen via operational subsidies until at least late 2030s. Creation of demand for green hydrogen via sectoral initiatives and obligations	To mitigate macroeconomic risks, private lenders and equity providers construct comprehensive financial models and sensitivity analysis using variables like interest rates, inflation rates, and foreign exchange rates to test the economic robustness of a project and seek financial coverage. To avoid interest fluctuation the loan should have a fixed interest rate for at least 15/20 years.
STAFF	One of the main concerns of project management, especially in the case of technologically demanding tasks, is the scarcity of skilled workers, and green hydrogen projects are no exception to this. Due to a possible scarcity, higher wage levels than expected can also be an occurring risk. Furthermore, the scarcity can be exacerbated by an unavailability of training and educational programmes	2	2	Hire with adequate salary, good grow expectation and build a comfortable working space. Improve education workshops and	Use network connection to find a suitable candidate among the university, meetings and hire a headhunter.

RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
				university master degrees.	
POWER PRICE	The issue of a suitable power supply goes beyond volume and reliability – there is also the question of price and indeed stability of price over a long term. Power constitutes a significant operating cost for any hydrogen plant and therefore locking in a competitive price for a number of years is an important operational issue.	4	4	Make a very accurate multiparameter analysis in the pre-feasibility stage considering the impact of a growth in the power price. Try to make a long-term agreement with the power supplier and to bargain a cap to the energy price.	Ensure cooperation with the public authority and give access to subsidies while the power price will come to a reasonable price again. Allow a temporary use of other and cheaper energy sources.
GANTT CHART	One of the most common issues about the time planning is about the weather conditions and the resource procurement.	4	2	Make strong contracting with the supplier to make them respect all the deadlines.	Plan to work on multiple shifts, even during night time, after several weeks of bad weather conditions.

RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
MONITORING KPIs	KPIs could be designed beforehand with low or no consciousness about the real impact of the project. Where technical and environmental KPIs are more solid and literature based, the social KPIs for this project might be an issue	3	1	Conduct a social impact analysis before or during the project design and understand what could be the social impact on the population.	Try to organise workshops and meetings to inform the population about the long term benefit for the hydrogen transition and about the low or no consequences on their daily life.

D. CasaClima (ITALY)

AMETHyST PROJECT PARTNER	Energy Agency South Tyrol - CasaClima
PILOT PROJECT TITLE	**Analysis of an application of stationary use of hydrogen to decarbonise an organic farm and tourist accommodation in the Italian Alps**
LOCATION	St. Lorenzen, Bolzano, Italy

OBJECTIVE(S)

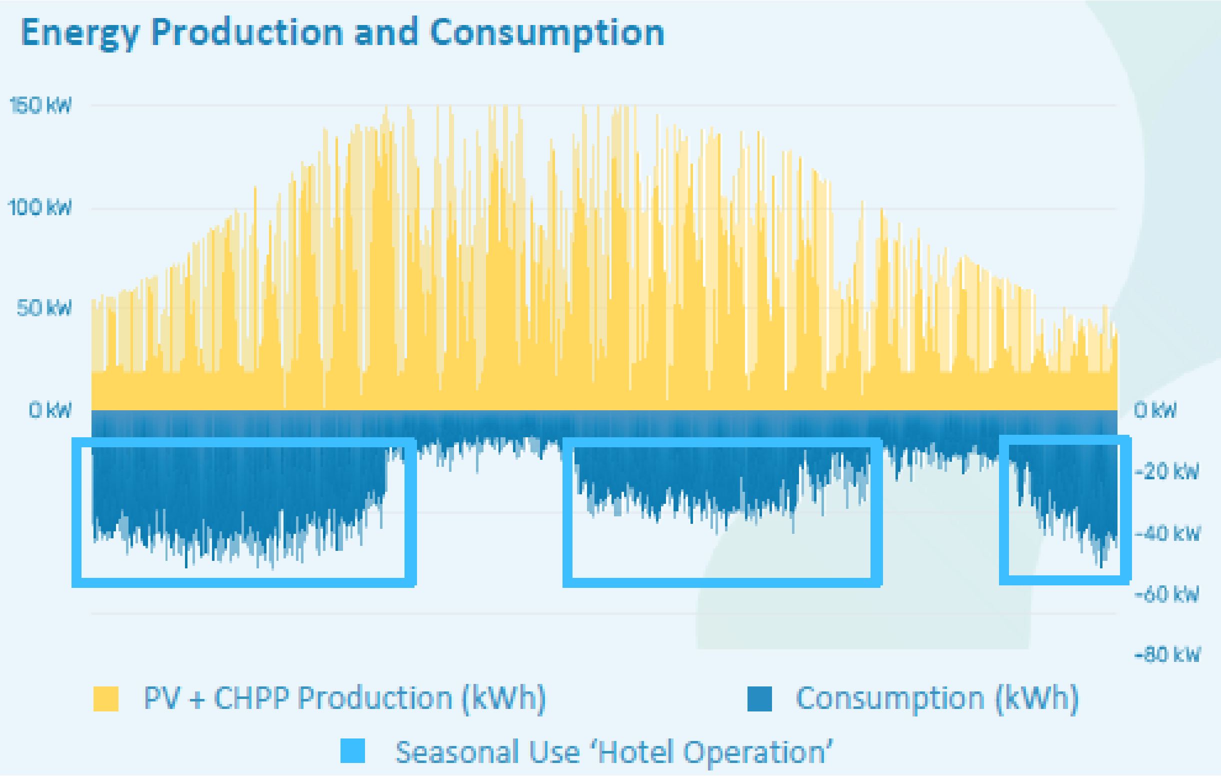
The pilot shall demonstrate the lessons learnt from the implementation of a stationary hydrogen ecosystem at a farm and accommodation structure in the Italian Alps. The system combines production, storage and consumption of hydrogen to increase the energy autonomy of the building. The objectives of the analysis of this case study are to assess the performances, and deduce recommendations from the experiences made during implementation and operation of the project.

STRATEGY

1. RENEWABLE GENERATION.

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. Retrieving power from the grid is technically possible, however the purpose of the pilot is to use excess electricity from PV to produce and store green hydrogen. Excess electricity is plentiful in summer (theoretical global irradiation 924 kWh per sqm between May and October; peak 178 kWh in July), but insufficient in winter (535 kWh per sqm between November and April; lowest value 32 kWh in December. Data source PVGis).

Source: [*http://webgis.eurac.edu/solartirol*](http://webgis.eurac.edu/solartirol)



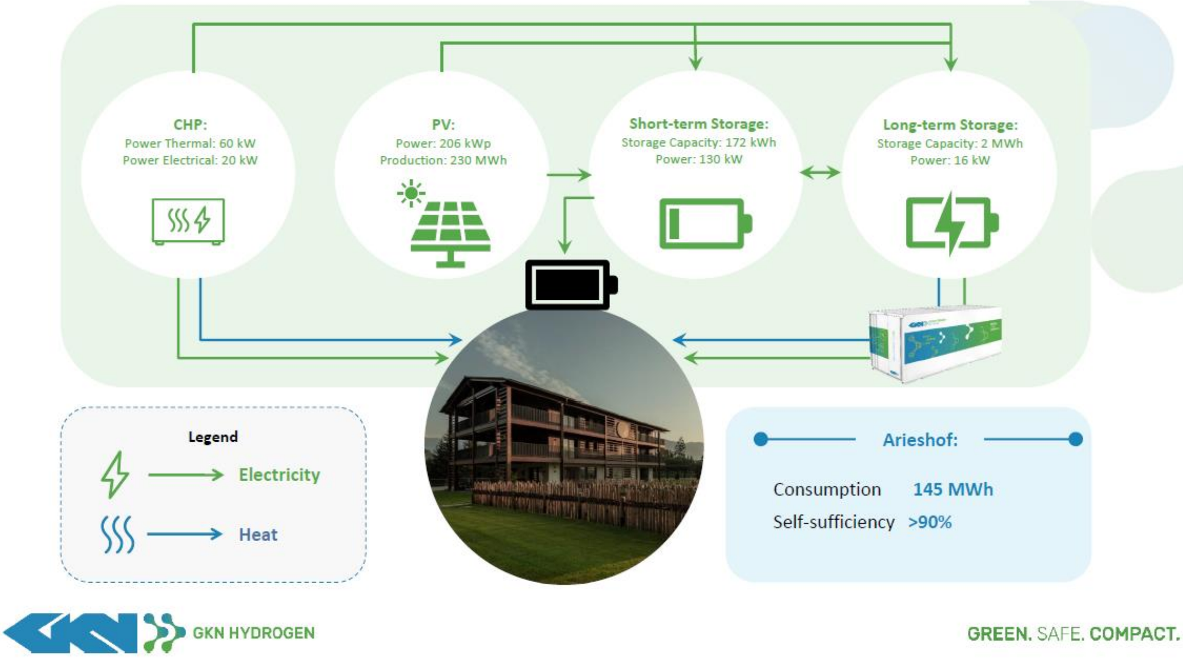
Source: GKN Hydrogen

2. END-USE.

The general intention and the technical challenge of the pilot was to make the entire site again as self-sufficient as possible in terms of energy management and energy supply. To achieve this, mainly renewable energy sources are used, and surplus energy has to be stored for short (batteries) and long-term buffering (metal hydride storage).

The hydrogen end-use is to provide electricity (and heat as a by-product) to the business during peak demand. Hydrogen is chemically stored in metal hydride batteries and can be released to a fuel cell on request. This takes place during hours of high demand (e.g. restaurant kitchen, hotel operation). Being a chemical process triggered by heating/cooling of the metal hydrides, the process is not suitable for frequent short-term cycles of charge and discharge. For this purpose, the system is flanked by an external NiMH battery pack. The pilot integrates all elements of the H2 value chain on site: PV power generation, H2 production, storage, fuel cell, utilization of excess heat.

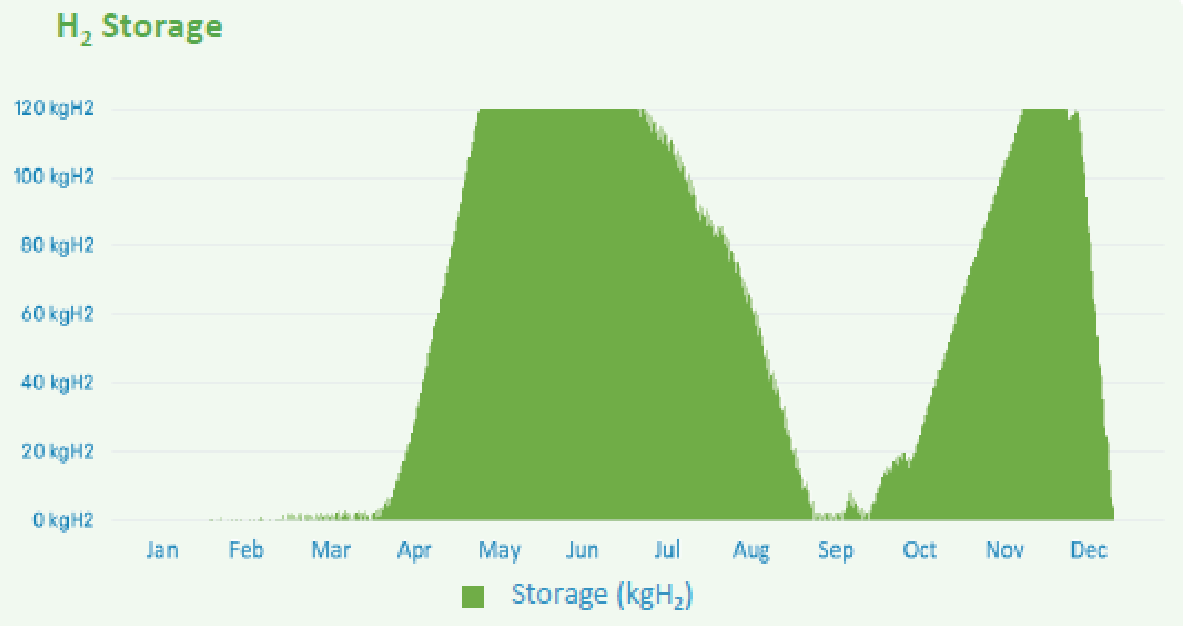
The yearly consumption is on average 145 MWh. The energy scheme of the pilot is shown in the graph below. On average, the system provides a degree of self-sufficiency of approx. 90%.



Source: GKN Hydrogen

3. H2 PRODUCTION.

Ownership and management of the plant are in the hands of a single investor/owner, and all elements of the system are operative on site. The electrolyser power is 24 kW. The fuel cell has an output of 16 kW. The graph below highlights the hydrogen production and storage profile of a typical year. Very notable is the seasonal difference due to limited PV output in the winter months. High season for the hotel operation, and hence the energy consumption, are the winter months (skiing season) and the summer months. In the intermediate seasons the hydrogen storage is replenished. Starting in April for the summer season; due to the good PV capacity in summer – for 1) direct use, for 2) charging of the NiMH batteries, and for 3) powering the electrolyser – the H2 storage remains full for several months, until it is depleted towards the end of the summer. Starting in October, the storage is once again fully repleted. Due to the very low PV capacity during winter, at the start of winter business operations in December the hydrogen stock is quickly used up.



Source: GKN Hydrogen

4. STORAGE.

Please refer to section 3 for H2 production and storage profiles. The adopted system combines all technological elements of the hydrogen ecosystem within a single 20ft shipping container. The metal hydride allows for the storage of 120 kg H2, i.e. 2.0 MWh of hydrogen, at a pressure up to 40 bar. The storage at relatively low pressures poses virtually no safety risks (compared to high-pressure tanks), as approx. 96% is stored as a solid, only the remaining 4% as gas. At current, however, in the pilot country there are no specific safety standards and certification rules for such an application, which is why more restrictive safety precautions had to be adopted.

172 kWh (130 kW) is the capacity of the external NiMH accumulator batteries for short term storage. The internal battery has a capacity of 19 kWh.

5. TRANSPORT.

Due to the nature of the pilot, no transport is required. Production, storage and consumption of hydrogen all take place within the unit.

6. SUPPLY CHAIN.

All processes of the value chain take place on site. The entire system is privately owned by the same investor and already in operation, hence there is no need for supply contracts and/or agreements.

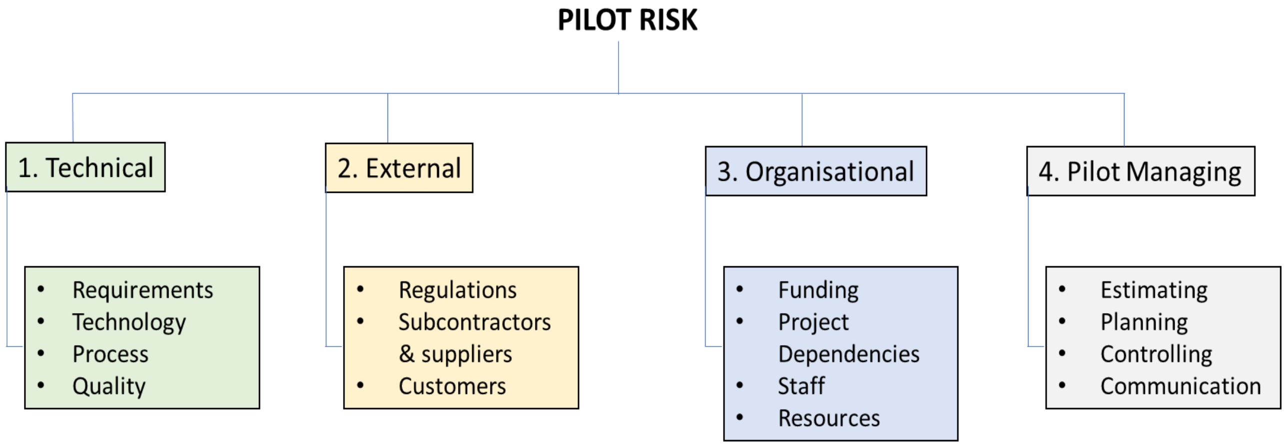
7. FINANCIAL PLANNING.

The project is a private initiative by an investor and shall be considered a pioneer project. The total investment cost in the specific project is not disclosed at this point.

ROADMAP

The pilot project is already in operation, there is no information about the single steps of the Roadmap. It is important to note that the H2 technology in use is sold as ready-to-use integrated unit on the market.

RISK ASSESSMENT



The risk assessment is carried out from the perspective of the pilot in operation.

RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
Pilot managing – inefficient utilization of the H2 system	In order to optimise the utilization of the system, it needs to be constantly monitored and energy consumption adapted to current energy availability	4	3	-	Communication and staff training can lead to behavioural changes that optimise the performance of the energy system.

External - Regulations	Uncertainty of regulatory framework / Overly restrictive regulations and regulatory bodies hinder the implementation of the project	5	4	Adopt early exchange with regulatory bodies and authorities (e.g. fire brigades, municipalities, certification bodies)	-
Technical – Maintenance	The high complexity of the system may potentially lead to high maintenance costs, especially when parts or components start becoming obsolete. Given that the system is new, there is insufficient data about this.	3	4	Perform thorough risk assessment including scenarios with related costs	Monitor the system and carry out regular ordinary maintenance. Seek constant exchange with technology providers.

E. APE FVG (ITALY)

AMETHyST PROJECT PARTNER	APE FVG
PILOT PROJECT TITLE	AMETHyST project in Friuli Venezia Giulia
LOCATION	Valle del Bût

OBJECTIVE(S)

The pilot aims at creating a complete self-sustained ecosystem located in the But Valley, in Friuli Venezia Giulia region, to prove that the decarbonization of the Alpine Valley is possible: production, storage, transport and utilization of hydrogen will be all located inside the same valley.
The main objective is the production of green hydrogen with the surplus energy derived from the hydroelectric power plants owned by the SECAB cooperative, situated in the municipality of Paluzza. The hydrogen production site is only 1km away from SECAB's headquarter. The users will be the Zoncolan ski resort, located at a distance of 10 km from the production site, and some buses for the school line transiting in the But Valley.

STRATEGY

1. RENEWABLE GENERATION.

The project is based on the water molecule, from cradle to grave: we bring energy from the hydroelectric power plant running in the But Valley owned by SECAB, a century-old cooperative which started the first plant in 1917 in the «Fontanone» site; a cooperative is "an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically-controlled enterprise".

SECAB is currently running six plants for a total of 8,5 MW installed producing and distributing 44 GWh of electric energy each year (on average) in the But Valley. All plants are a run-of-river hydroelectic plant type: the turbines are located in Timau (2 Frencis), Paluzza (3 Pelton), Cercivento (3 Frencis), Comeglians (3 Frencis, 1 Pelton), Noiariis (2 plants, with 2 Frencis and 1 Kaplan); on one hand, these kind of plants limit the impact on the environment and on the river itself, on the other hand the absence of basins or dams limits the possibility to store water: in an droughty year the production could be halved; this happened in 2022, the first year since 1917 that registered such a low production. The disposable energy is, on average, 24 GWh: that could ideally cover the production of roughly 440 tonnes of hydrogen a year. We estimate to start with the pilot construction on 2025 and get it running for 2026. The cost of the preliminary project would be around 850k €.

SECAB

Impianti e centrali

1 - Fontanone - Timau
In servizio dal 1913
Potenza installata 380 kW

2 - Enfretors - Paluzza
In servizio dal 1959
Potenza installata 2.296 kW

3 - Museis - Cercivento
In servizio dal 1986
Potenza installata 1.800 kW

4 - Mieli - Comeglians
In servizio dal 1991
Potenza installata 3.640 kW

5 - Noiariis - Sutrio
In servizio dal 2004
Potenza installata 2.576 kW

6 - Noiariis 2 - Sutrio
In servizio dal 2021
Potenza installata 144 kW

2. END-USE.

The end use will be ideally the hydrogen snowgroomer assuming the possibility to acquire it by 2026; other option will be heavy duty track and buses and logistics functions in the industrial area of the nearby town of Tolmezzo (forklifts).

The final users will be regional participates (TPL, Promoturismo) and privates/companies, while hydrogen will be produced and sold by SECAB.
Expected consumption: around 20 tonn/yearly for the snowgroomer (from November to April).
Infrastructures and veichles must be built and bought from scratch.
For the snowgroomer there is not still a clear price, could be around 1 billion €.

3. H2 PRODUCTION.

The production plant will be owned and managed by SECAB, and will be located in a field of SECAB property between the municipalities of Paluzza and Treppo Carnico.
Around 10 km far from the renewable production sites.
The expected yearly hydrogen production of the pilot in a first configuration will be about 13 ton without backup batteries for the elctrolyser.
Usually the plant experiences a null or poor production in winter.
Electrolyser in a first configuration will be of 120 kW.
Cost with compressor unit about 400k €.

4. STORAGE.

Storage will be designed when real demand is going to be clearer: need more info about logistic of transportation. For the pilot we think about a conventional storage, pressure depends from need of seasonal storage. If seasonal storage is needed, probably the pressure will be 200 or 500 bars, if otherwise there will be no need for storage the pressure could be also 45 bar, like the electolyser operational pressure. A first storage will sure be in production site. The second one in Zoncolan depending from the choice of the refuelling station (fixed or mobile). In any case there is enough space to get far from other buildings in a safe condition.

For a bigger configuration the hybrid metal storage will be considered.

5. TRANSPORT.

Hydrogen will be moved by heavy truck, the road from the production site to the distribution in the Zoncolan ski-resort is sufficienly wide, so no new infrastructure will be required.
As for now it hasn't yet been identified who will be in charge of the transport.

6. SUPPLY CHAIN.

SECAB will own the elctrolyser, the storage in the production site and obviously the RES plants. In the case of the snowgroomer the owner will be Promoturismo which in this configuration will buy the hydrogen from SECAB with no intermediate steps.

Yes, a contract would be preferable.

7. FINANCIAL PLANNING.

The construction of the production plant is not funded at the moment.
Investment and operational costs will be funded by the stakeholders for each part of interest, where possible public funds will be exploited, both for production and usage of hydrogen.
Local stakeholders have the required stability to sustain the investment costs.

ROADMAP

PROJECT PHASE	ACTIVITY	START (MONTH)	END (MONTH)	MEANS OF VERIFICATION
SETTING UP THE SCENE	RAISING LOCAL STAKEHOLDERS' INTEREST;	1	12	
	COLLECT DATA ON LOCAL ENERGY SYSTEM;	3	9	
	DEVELOP PROJECT CONCEPT	6	12	
	…………			
PROJECT DEVELOPMENT	TECHNO ECONOMIC FEASIBILITY	15	30	
	SCENARIOS;	15	30	
	STAKEHOLDERS' COMMITMENT	36+	36+	
	FINALIZE ROLES AND EACH STAKEHOLDER'S INVESTMENT;			
	DEVELOP MONITORING AND OPTIMIZATION STRATEGY	27	36	
REALIZATION PHASE	TENDER (*if necessary*)	20	36	
	DEVELOP EXECUTIVE PROJECT PLAN;	20	36+	
	REALIZE PLANTS	36+	36+	
OPERATIONAL AND MONITORING PHASE	MONITOR;			
	CALCULATE KPIs			
	………………………			
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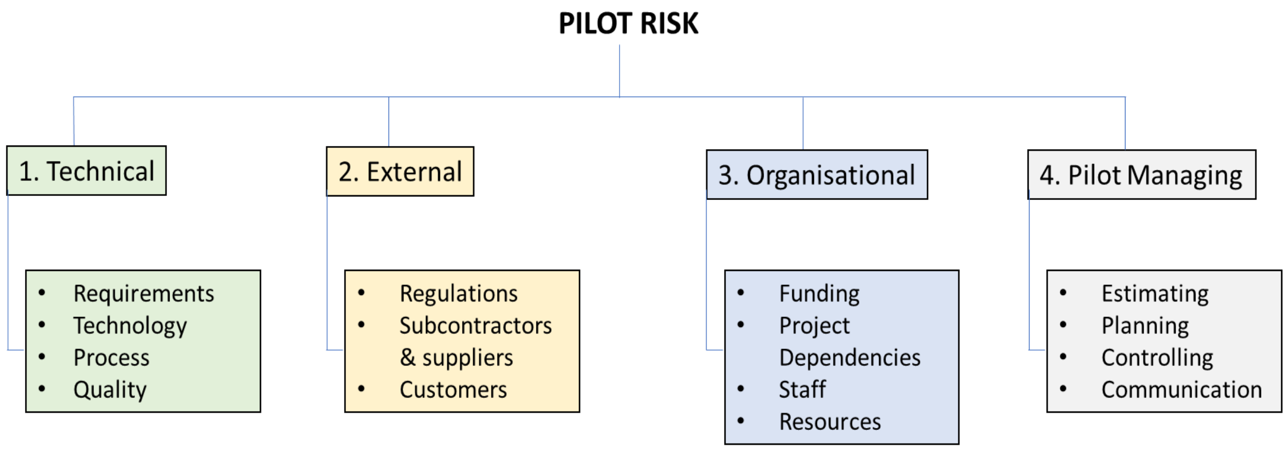
RISK ASSESSMENT



RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
Risk type: Technical _ Quality Relevant risk description: **Components Lifetime**	Lifetime components do not cover the whole duration of the pilot	3	2	Find the best suppliers	Get information directly from the suppliers, speak with technicians other than commercials, keeping abreast of technological developments
Risk type: External _ Regulations Relevant risk description: **missing/incomplete/incorrect safety permissions for H2 production and storage in the pilot area**	If the standards and requirements defined by safety regulations for H2 production and storage in the pilot area are not met the plant risks to be shut down.	2	5	Verify what are the technical requirements foreseen by the relevant legislation and regulations. Verify that all the requirements are met and that the system's compliance is complete. In the case of an external contractor this should be inserted in the contract and a specific guarantees/insurance coverage should also be required.	None, if the plant does not comply with the regulations it cannot operate, therefore all necessary measures have to be carried out in order to gain the necessary compliance. A specific insurance could be foreseen in order to cover financial losses. In the case of a General Contractor, penalties for late delivery /installations due to regulation non-

					compliance should be foreseen in the awarding contract.
Risk type: External _ Customers Relevant risk description: **Lack of demand**	There is the need that a hydrogen economy starts to work. Without a real demand (buses, industry, etc), distributed in the whole year the storage facilities will be too large and expensive (snowgroomers work in winter only)	3	3	Contact as much stakeholders as possible, both public and private; engage with other hydrogen initiatives and networks; involve industries and public administration at all levels	Ensure the demand with written contracts, when possible; ensure at least a part of the demand with confirmed technology (highest TRL possible)
Risk type: Technical _ Technology Relevant risk description: **Technology development**	Costs are still too high, more than a 20€ gap between green and gray hydrogen. Without a technology development and better performances will be difficult experience a gap decrease	4	4	Making lobby action, pushing for incentives in hydrogen technology development at local, national and European level	Start with a little project as a pilot for reducing risks, leave free space for an easy upgrade

F. ENERGAP (SLOVENIA)

AMETHyST PROJECT PARTNER	ENERGAP
PILOT PROJECT TITLE	REGIONAL H2 WORKING GROUPS
LOCATION	Podravska region, Municipality of Maribor Slovenia.

OBJECTIVE(S)

The main objectives of our pilot project are to establish a regional hydrogen working group, foster knowledge exchange among stakeholders, develop local hydrogen technology guidelines, 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 in hydrogen technologies.

Through pilot in MARIBOR we would like to demonstrate how the region without prior knowledge of H2 projects could organize them-self to make step towards the production and use of H2.

STRATEGY

STRATEGY
Our pilot project focuses on establishing and managing a regional hydrogen (H2) working group in the Maribor region, Slovenia. The strategy involves the following key aspects:

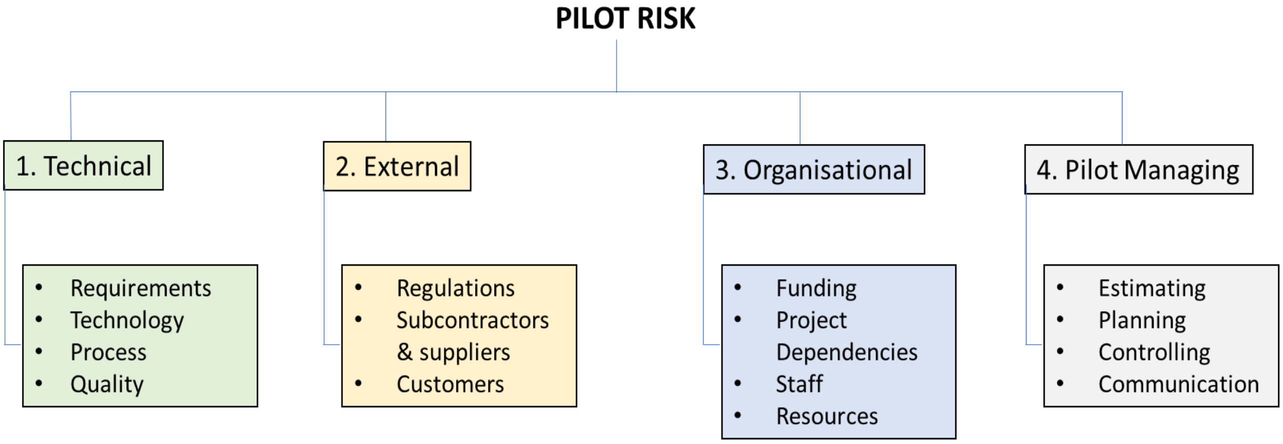
- **Stakeholder Engagement**: The H2 working group includes diverse stakeholders from local authorities, research institutions, public enterprises, and private companies. Regular weekly meetings are held to discuss the significance of hydrogen, its potential applications, and strategies for its implementation.
- **Knowledge Exchange and Best Practices**: The working group fosters knowledge exchange through workshops, discussions, and study visits. For example, the workshop "Challenges and Opportunities of Green Hydrogen" held on November 23, 2023, at Hotel Habakuk in Maribor, covered topics such as decarbonization, technical characteristics of hydrogen, strategic frameworks, and practical examples of hydrogen use in Slovenia and the EU.
- **Study Visits and Practical Insights**: Study visits, such as the one to Bolzano on June 13, 2024, provide practical insights into hydrogen projects. Stakeholders observed successful projects at GKN Hydrogen in Pfalzen and the hydrogen pilot project at Arieshof in St. Lorenzen, enhancing their understanding of operational best practices.
- **Development of Guidelines and Strategies**: The working group aims to develop materials and guidelines for the advancement of hydrogen technologies locally. These guidelines will be shared with the European Commission and other EU institutions involved in hydrogen initiatives.
- **Identification of Potential Projects**: The working group identifies and explores potential hydrogen-related projects within the region, supporting the development and implementation of practical hydrogen solutions that contribute to the region's decarbonization goals.

As the ENERGAP pilot involves the establishment of an H2 working group, the specific questions related to production, storage and trasport are not applicable.

ROADMAP

PROJECT PHASE	ACTIVITY	START (MONTH)	END (MONTH)	MEANS OF VERIFICATION
SETTING UP THE SCENE	RAISING LOCAL STAKEHOLDERS' INTEREST	1	6	
	COLLECT DATA ON LOCAL ENERGY SYSTEM	5	12	
	DEVELOP PROJECT CONCEPT	6	24	
	………….			
PROJECT DEVELOPMENT	TECHNO ECONOMIC FEASIBILITY	-	-	
	SCENARIOS	24	30	
	STAKEHOLDERS' COMMITMENT	24	30	
	FINALIZE ROLES AND EACH STAKEHOLDER'S INVESTMENT			
	DEVELOP MONITORING AND OPTIMIZATION STRATEGY	28	30	

RISK ASSESSMENT



This risk assessment is tailored to the hydrogen working group pilot project, focusing on the organizational risks associated with funding, project dependencies, staff, and resources. By identifying and implementing measures to reduce the likelihood and impact of these risks, the project aims to ensure successful execution and achieve its objectives.

RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
Organisational _ Funding	Lack of financial resources may hinder the organization of workshops, study visits, and regular meetings, reducing the effectiveness of the working group and limiting stakeholder engagement.	3	4	Secure a variety of funding sources from both public and private sectors. Conduct thorough financial planning and budgeting	Prioritize essential activities and seek alternative funding sources. Maintain active engagement with stakeholders to ensure ongoing interest and support.
Organisational _Project Dependencie	There is a risk that the established hydrogen working group (H2) could dissolve once the project funding ends, undermining the long-term sustainability of the initiative.	3	5	Ensure strong stakeholder commitment and engagement from the outset. Develop a clear plan for post-project activities and seek long-term funding sources.	Establish the working group's value proposition to ensure continued relevance and support.

Organisational _ Resources	Insufficient or misallocated resources can hinder project progress, affecting the implementation and overall success of the hydrogen working group initiatives.	3	4	Maintain a flexible resource management plan to adapt to changing needs and circumstances.	Develop contingency plans to address resource shortages or reallocations efficiently.
Organisational _ Staff	Insufficient personnel, lack of expertise, or inadequate allocation of time dedicated to hydrogen-related activities can hinder the effective operation of the H2 working group.	3	4	Conduct comprehensive workforce planning to ensure adequate staffing levels. Implement targeted recruitment to bring in necessary expertise. Provide ongoing training and professional development to enhance existing staff skills in hydrogen technologies. Allocate specific time slots for staff to focus on H2 tasks and avoid overloading them with additional responsibilities.	Regularly assess and adjust staffing requirements based on project needs. Develop a backup plan to quickly address staff shortages, such as temporary hires or cross-training existing staff to cover multiple roles. Foster a supportive work environment to retain talent and prevent burnout.

G. SAT (AUSTRIA)

First pilot project

AMETHyST PROJECT PARTNER	Standortagentur Tirol
PILOT PROJECT TITLE	WIVA P&G HyWest
LOCATION	Tyrol, Austria

OBJECTIVE(S)

Within the long-term climate, resource and energy strategy “Tyrol 2050 energy autonomous”, the national R&D flagship project WIVA P&G HyWest[1] aims at the establishment of the first sustainable, business-case-driven, regional, green hydrogen economy in central Europe, and bring the complementary “power-to-hydrogen” process for the reconstruction of the energy system to existence. 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.

STRATEGY

1. RENEWABLE GENERATION.

A. What are the selected renewable sources chosen for the hydrogen production?
B. Are the power plants already available and running?
C. Who owns/will own the renewable power plant? Where are they located exactly? Are they owned by a public body or by a private stakeholder?
D. What are the current/expected production profiles over a year?
E. What share of the production is/will be available for hydrogen production?
F. If to be built, how long will it take to have them up and running? What is approximately the cost of the planned plants and who will bear it?

MPREIS Hydrogen:

Ad A: The hydrogen production of MPREIS Hydrogen is based on a pressurised alkaline electrolyser installed within the EU project Demo4Grid[2] “Demonstration for Grid Services”. Hence, the main source of power for the electrolyser is electricity from the grid in times of surplus, e.g. when energy prices are low. During the development phase of the project, direct power connection without the necessity of grid fees to the newly build hydropower plant “KW Sellrain” was also envisioned. However, this could not be realised.

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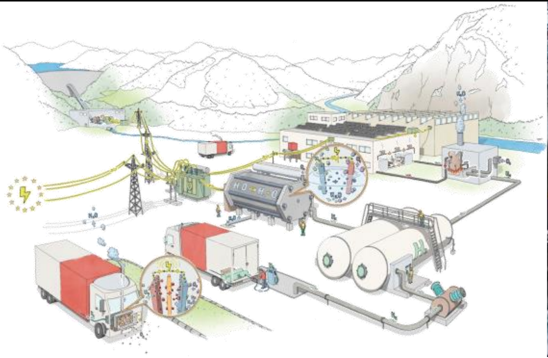
[1] WIVA P&G HyWest: https://www.hywest.at/, https://www.wiva.at/project/hywest/, https://projekte.ffg.at/projekt/4083349

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



Ad B: The power plants are already available and running.

Ad C: Since the electricity is purchased on the electricity market at times of surplus, e.g. low energy prices, these power plants are owned by different companies. Hence, no exact location can be provided. The ownership structure is also manifold. In order to guarantee a green electricity purchase at all times, an agreement with the local energy company TIWAG is in place.

Ad D, E and F: Based on answer C D, E and F are not applicable.

Zillertalbahn 2020+ energy Energy autonomous Autonomous with Hydrogen

Ad A: The power plant portfolio of Verbund within the Zillertal Valley was foreseen as a renewable energy source for hydrogen production. [3]

Ad B: The power plants are already available and running.

Ad C: VERBUND Hydro Power AG owns the Mayrhofen power plants which are located in the Tyrolean Zillertal. VERBUND AG is a public body.

Ad D: The current production capacity is 355 megawatts [4].

Ad E: Mainly to cover the energy demand for the Zillertalbahn.

TIWAG Power2X Kufstein:

Ad A: For this project renewable electricity from the grid and, in the future, from the TIWAG run of river power plant in Langkampfen will be supplied via a direct line.

Ad B: Yes.

Ad C: The power plant Langkampfen is owned by Tiroler Wasserkraft AG (TIWAG) and located in Langkampfen. TIWAG is a public body.

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[3] Zillertaler Mobilitätsplam: https://mobilitaetsplan.at/das-spricht-fuer-den-wasserstoffantrieb/

[4] Power Technology-Power plant profile: Mayrhofen, Austria: https://www.power-technology.com/marketdata/power-plant-profile-mayrhofen-austria/?cf-view

Ad D: The Langkampfen power plant has a capacity of 31.5 megawatts, with a water flow rate of 425,000 liters per second, generating up to 169 gigawatt-hours of electrical energy annually.[5]

Ad E: Due to the much larger power capacity compared to the hydrogen generation, all necessary power can be supplied.

2. END-USE.
   A. What is the selected hydrogen end-use?
   B. Who are the final users, private companies or public bodies? Is the final user also the hydrogen producer?
   C. What is the expected yearly consumption?
   D. Is it necessary to buy new vehicles or build new infrastructure? What is approximately the expected investment to be made?

MPREIS Hydrogen:

Ad A: The hydrogen produced is used in mobility and industry.

Ad B: The end-user is MPREIS itself including its own truck fleet and the Therese Mölk bakery for heat. MPREIS is a private company and also the H2 producer. [6] In addition, the hydrogen is also sold to third parties via a trailer filling station and corresponding Multi Element Gas Containers (MEGCs).

Ad C: The expected yearly consumption is currently 14 tonsH2 per year (40 kgH2 per day x 360 days per year)[6] and foreseen to increase to a total production of 1300 kgH2 per day or approximately 475 tonsH2 per year.

Ad D: One Hyzon fuel cell electric (FCE) truck (tractor model 4 x 2) was ordered and is operational as of January 2023 in the region of Tyrol for food distribution. A hydrogen refuelling station (HRS), operating at 350 bar including pre-cooling and a trailer filling station, was built at MPRIES site in Völs. 10 trucks can be refuelled back to-back with a refuelling time of 15 min per truck.[7] Part of the H2 is used to heat the ovens of the company's Therese Mölk bakery. A dual-fuel burner is used that can be operated with either hydrogen or natural gas.[6] The price for one FCE Truck is currently between 550 000 and 900 000 € net.

Zillertalbahn:

Ad A: The main end-use is mobility – first hydrogen-powered narrow-gauge railway in the world.

Ad B: The end-user is Zillertaler Verkehrsbetriebe AG, a private company while the H2 producer is Verbund AG.

Ad C: The expected yearly consumption is 292 tonsH2 (= 800 kgH2 per day x 365 days).[8] An average of 800 kgH2 per day is required for regular operation of 4 hydrogen electric multiple units on the 32 km long route between Jenbach and Mayrhofen.**Errore. Il segnalibro non è definito.**

Ad D: A tailor-made 760 mm narrow gauge train has to be purchased. Cost figures are not disclosed.

TIWAG Power2X Kufstein

Ad A,B : The H2 end-user and end-users are as follow. They are not the hydrogen producer.[9]

- Gas: hydrogen is planned to be injected into the natural gas grid

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[5] Waymaking-Laufkraftwerk Langkampfen: https://waymarking.com/waymarks/WMGW1R_Laufkraftwerk_Langkampfen_Bezirk_Kufstein_Tirol_A

[6] MPREIS Wasserstoff: https://www.mpreis.at/wasserstoff

[7] Establishment of Austria’s First Regional Green Hydrogen Economy: WIVA P&G HyWest: https://www.mdpi.com/1996-1073/16/9/3619

[8] Zillertaler Mobilitätsplam- DAS SPRICHT FÜR DEN WASSERSTOFFANTRIEB: https://mobilitaetsplan.at/das-spricht-fuer-den-wasserstoffantrieb/

[9] TIWAG P2XKufstein https://www.tiwag.at/unternehmen/energiewende/power2x-kufstein/

- Mobility: Refuelling of FCE Cars and Trucks with 700 bar and 350 bar.
- Purchase of green hydrogen via a trailer filling station
- Heat: The possibility is created to use the hydrogen and the additional oxygen produced during electrolysis in the nearby sewage treatment plant.
- Mobility: Max. 17 direct current fast charging points at the public area of the plant

Ad C: The expected yearly consumption cannot be estimated yet.

Ad D: It is foreseen to build a HRS and trailer filling station. Cost figures are not disclosed.

3. H2 PRODUCTION.

A. Who will own and manage the H2 production plant? Where will the hydrogen production take place exactly?
B. How far is it from the renewable production?
C. Is the land plot already owned by the local stakeholder consortium?
D. What is the expected yearly hydrogen production? Are there any relevant seasonal pattern/ differences?
E. What is more or less the installed electrolyser power? A rough estimate of the investment?

MPREIS Hydrogen:

Ad A: MPREIS owns and manages the H2 production plant located at the MPREIS production site in Völs, Tyrol, Austria.

Ad B: Since the energy is taken from the grid, the distance between RES and production can vary from hour to hour.

Ad C: The land plot is long-term rented by MPREIS.

Ad D: The nominal production rate for full operation is 1300 kgH2 per day and correspondingly 468 tons of H2 per year (= 1.3 tonsH2 per day x 360 days). [6] There are no relevant seasonal pattern differences.

Ad E: A 3 MW pressurized alkaline electrolyser (PAE), built within the scope of “Demo4Grid”. A second electrolyser is planned to be built in order to fulfil the required hydrogen demand in the region.[7] Since the plant was implemented by a consortium within the Demo4Grid project, the exact cost cannot be given, but including storage and etc., the cost was beyond € 10 million.

Zillertalbahn:

Ad A: The plant was foreseen to be operated by Verbund AG, the user of the Ziller valley resources. It was foreseen to be located at the Zillertaler Verkehrsbetriebe AG (ZVB) railway station in Mayrhofen and to be integrated into the Zillertal power plant group.

Ad B: Only a few kilometres.

Ad C: No.

Ad D: The expected yearly hydrogen production 292 tonH2 per year (= 800 kgH2 per day x 365 days). [7] Due to the necessity of cooling in summer and heating in winter, hydrogen demands of up to 1300 kgH2 per day are foreseen on very hot and very cold days.

Ad E: A 6 MW electrolyser (3+1 containerized systems, type is not yet decided) was planned.[7] The infrastructure should have been financed via the so-called medium-term investment programs (MIP). These are funded by the federal government, the state and funds from the Zillertal Valley Treaty. The investment volume in the infrastructure is 158.3 million euros in the period from 2021 to 2030. The funds come from the 9th MIP and 10th MIP. The new transport services contract (VDV) was foreseen to provide around 260 million euros from 2027 to 2036. The “WIVA P&G HyTrain” research project provides additional funds. The climate fund is making 3.1 million euros available for further research work in the hydrogen sector.[10]

TIWAG Power2X Kufstein:

Ad A: It is foreseen that TIWAG owns and manages the H2 production plant located in the southwest of Kufstein near the TIWAG (Tiroler Wasserkraft AG) hydro power plant in Langkampfen in Tyrol.

Ad B: Only a few kilometres from Langkampfen. When energy from the grid is used, the distance between RES and production can vary from hour to hour.

Ad C: Yes.

Ad D: Maximum production capacity at 8,760 operating hours per year is up to 900 tonsH2.[9] It cannot be foreseen if there are relevant seasonal differences.

Ad E: A PEM electrolyser up to 5 MW is planned.[9] Cost figures are not disclosed.

4. STORAGE.
   A. According to seasonal patterns, approximately how big will the storage be (timewise and kg of H2)? Think about the logistics. Will it be located next to the production site? Or next to the end-user? Or a third location is required for seasonal storage?
   B. At what pressure will it be stored?

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[10] Zillertaler Mobilitätsplam- HÄUFIG GESTELLTE FRAGEN: https://mobilitaetsplan.at/faq/#1581931924195-18e34be1-1ffc

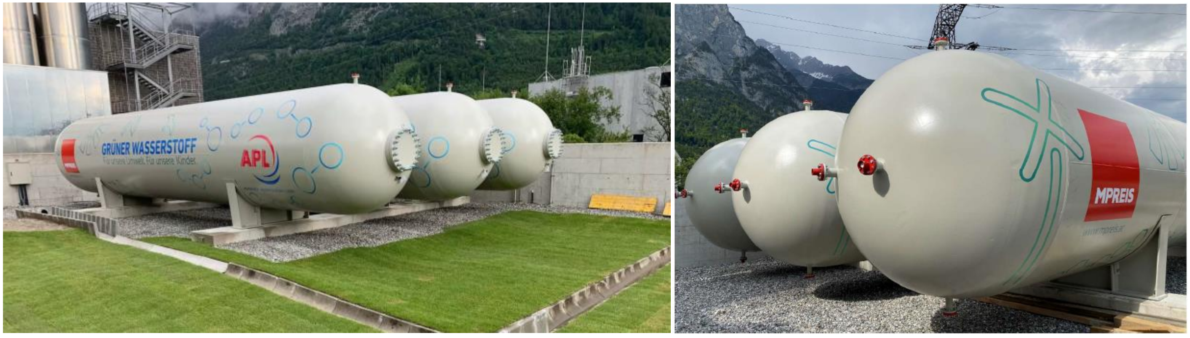
C. Are the selected locations far enough from other buildings? How, if necessary, will they be made safe?

MPREIS Hydrogen:

Ad A: 700 kgH2 can be stored on site in three hydrogen storage vessels located next to the production site.[6]An extension to 9 vessels is approved.

Ad B: 30 bar without compression.[6]

Ad C: With a concrete wall and additional panels.



Zillertalbahn:

Ad A: A storage 3000 kgH2was foreseen on site in Mayrhofen next to the hydrogen demand.[8]

Ad B: At 500 bar in 40-foot MEGCs.[8]

Ad C: Yes.

TIWAG Power2X Kufstein:

Ad A: below 5 tonsH2.

Ad B: 500 bar
Ad C: Yes.

5. TRANSPORT.
   A. How will the H2 move from one storage to the other?
   B. Is a new infrastructure required? Or new vehicles? Or will smaller H2 tanks be moved with a regular truck?
   C. Who will be in charge of the transport?

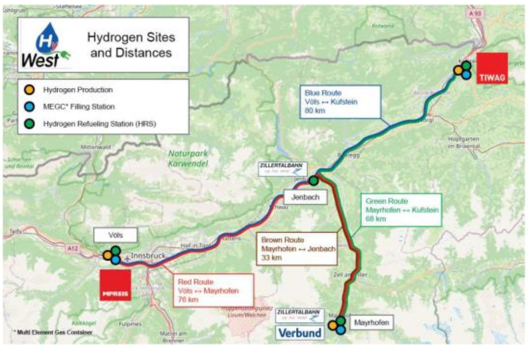
As a consequence of the short distances between involved hydrogen production sites and the need of being able to transport the hydrogen in both directions between all project partners, the economically viable solution for a first WIVA P&G HyWest hydrogen logistic system is road based.[7]

MPREIS Hydrogen:

Ad A: According to the current plan, a hydrogen distribution system based on MEGCs was identified as the favourable solution.[7]

Ad B: MPREIS has already ordered and received a 20-foot hydrogen storage container from UMOE Advanced Composites for the setup of the exchange platform. Each container will provide a storage capability of approximately 300 kg of hydrogen.[7]

Ad C: The containers will be exchanged between project partners using freight forwarders with the required ADR (Accord Dangereux Routier, European agreement concerning the international transport of dangerous goods by road) permissions and certified truck.[7]



Zillertalbahn:

Ad A: The hydrogen MEGC from MPREIS was foreseen to be further employed in the national R&D WIVA P&G HyTrain project, in a rail-based hydrogen logistic.[7] In this pan, transport was foreseen to be only necessary for backup and the main supply of HRS for trains was envisaged via a short H2 pipeline.

Ad B: Yes.

Ad C: This was not defined.

TIWAG Power2X Kufstein:

Ad A: The refuelling option of mobile storage units, also known as "trailers", enables external partners and customers to be supplied with renewable hydrogen.[9]

Ad B: In order to meet the need for sustainable mobility for cars, trucks and buses, drop-off points for refuelling hydrogen vehicles as well as a powerful charging infrastructure for electric vehicles will be built on site. Filling station for mobile storage solutions (trailer) at 500 kg / 300 bar will be built.[9]

Ad C: External service partners capable of carrying out ADR transport.

6. SUPPLY CHAIN.
   A. What are the roles of the different stakeholders within the whole supply chain?
   B. Who owns the electrolysers, the storage units, the RES plants, the end-use technologies?
   C. Who buys the hydrogen from whom?
   D. How many intermediate steps are there?
   E. Can you expect the stakeholders to sign a 5- or 10-year supply contract?

MPREIS Hydrogen:

Ad A: Production, storage and usage; sale of hydrogen to third party.

Ad B: Electrolyser owned by MPREIS; storage owned by MPREIS; RES plant owned by various parties; end-use technologies owned by MPREIS and third party.

Ad C: MPREIS only sells hydrogen; it can buy hydrogen in the future to ensure high availability.

Ad D: Normally only 1 and maximum 2 intermediate steps.

Ad E: No.

Zillertalbahn:

Ad A: Production by Verbund; storage and end-use by Zillertalbahn.

Ad B: Electrolyser owned by Verbund; storage owned by Zillertalbahn; RES plant owned by Verbund; end-use technologies owned by Zillertalbahn.

Ad C: Zillertalbahn buys hydrogen from Verbund

Ad D: Normally only 1 and maximum 2 intermediate steps.

Ad E: No.

Power2X Kufstein:

Ad A: Production, storage by TIWAG, end-use by various parties.

Ad B: Electrolyser owned by TIWAG, storage owned by TIWAG; RES plant owned by TIWAG and various parties; end-use technologies owned by third party.

Ad C: Third party end-users.

Ad D: Normally only 1 and maximum 2 intermediate steps.

Ad E: No.

7. FINANCIAL PLANNING.

A. Analyse available resources and allocate them according to planned activities. Is the project already partially or totally funded by some public entity?
B. Who will bear the different investment costs? And the O&M costs of the different plants/components?
C. Is there any public support for the investments? And for the renewable energy production? And for the H2 production?
D. Do local stakeholders have the stability/equity to sustain such investment and not pull out from the project in the near future?

Explain here

MPREIS Hydrogen:

Ad A: The project is funded by various funding agencies such as FFG via Climate and Energy Funds, KPC, aws (national) and CH JU (EU).

Ad B: MPREIS will bear the costs.

Ad C: See A.

Ad D: Yes.**Zillertalbahn:**

Ad A: The project is funded by Climate and Energy Funds via FFG.

Ad B: ZVB and Verbund will bear the costs.

Ad C: See A.

Ad D: No, as the project was terminated.

Power2X Kufstein:

Ad A: The project is funded by Climate and Energy Funds via FFG and KPC

Ad B: TIWAG will bear the costs.

Ad C: See A.

Ad D: Maybe.

Second pilot project

AMETHyST PROJECT PARTNER	Standortagentur Tirol
PILOT PROJECT TITLE	H2Alpin
LOCATION	Tyrol/AUSTRIA

OBJECTIVE(S)

H2Alpin takes advantage of Tyrol's location in the heart of the Alps to test fuel cell buses and trucks under specific conditions such as winding mountain roads, transit passes and extreme weather conditions. At the same time, the aim is to make hydrogen-powered mobility economically viable throughout the province. This will be achieved firstly via two procurement platforms for ordering and hiring heavy-duty vehicles and secondly by ensuring suitable hydrogen logistics by 2035. The knowledge gained, overall evaluations of the system solutions and simulations of the mobility transition and the resources and framework conditions required for this should enable a rapid roll-out of hydrogen-powered mobility in Tyrol.[11]

STRATEGY

1. RENEWABLE GENERATION.

Not applicable, since there is no production for H2Alpin foreseen.

2. END-USE. What is the selected hydrogen end-use? Who are the final users, private companies or public bodies? Is the final user also the hydrogen producer? What is the expected yearly consumption? Is it necessary to buy new vehicles or build new infrastructure? What is approximately the expected investment to be made?

The end-use is mobility for heavy duty mobility applications: FCE Buses and Trucks.

3. H2 PRODUCTION. Who will own and manage the H2 production plant? Where will the hydrogen production take place exactly? How far is it from the renewable production? Is the land plot already owned by the local stakeholder consortium? What is the expected yearly hydrogen production? Are

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[11] PROJEKTBESCHREIBUNG FÜR FÖRDERUNGSANSUCHEN DES PROGRAMMS ZERO EMISSION MOBILITY IMPLEMENTATION

there any relevant seasonal pattern/differences? What is more or less the installed electrolyser power? A rough estimate of the investment?

Hydrogen used in this project is from HyWest project. See explanation above.

4. STORAGE.

Not applicable, since there is no dedicated storage for H2Alpin foreseen.

5. TRANSPORT.

Not applicable, since there is no dedicated logistics for H2Alpin foreseen.

6. SUPPLY CHAIN

Not applicable, since there is no dedicated logistics for H2Alpin foreseen.

7. FINANCIAL PLANNING.
   A. Analyse available resources and allocate them according to planned activities. Is the project already partially or totally funded by some public entity?
   B. Who will bear the different investment costs? And the O&M costs of the different plants/components?
   C. Is there any public support for the investments? And for the renewable energy production? And for the H2 production?
   D. Do local stakeholders have the stability/equity to sustain such investment and not pull out from the project in the near future?

Explain here

Ad A: Funding from Climate and Energy Funds provided within H2Alpin by FFG and KPC.

Ad B: JUVE Automotion GmbH will bear the cost for the FCE Trucks and Postbus for the FCE Buses.

Ad C: See A.

Ad D: No.

H. EWO (GERMANY)

AMETHyST PROJECT PARTNER	Energiewende Oberland
PILOT PROJECT TITLE	“Das HAUS”
LOCATION	Irschenhausen, Germany

OBJECTIVE(S)

The “HAUS” shows the change from an analogue energy supply based on fossil fuels to a digital, networked energy supply based on renewable energies and self-made green hydrogen. It tests the interaction of different technologies from the electricity, heat and mobility sector (sector coupling) via an intelligent, digital overall control of PV system, storage, electrolyser, fuel cell and heating system including data acquisition and data analysis. The aim is to test the self-sufficiency of a single household by implementing hydrogen storage systems and using smart control and tracking.

STRATEGY

1. RENEWABLE GENERATION

In Irschenhausen, 20 kilometers south of Munich, the self-sufficient energy management of the future can already be experienced. The HAUS generates its own green hydrogen using its own PV electricity and an electrolyzer. By storing the energy and optimizing control with the so called weEMS software, the aim is to reduce consumption and increase self-sufficiency.

The hydrogen can later be converted back into electricity using a fuel cell, thus supplying the house at night and in winter. The fuel cell is not yet connected. For this reason, the current results on hydrogen applications are based on simulations. The fuel cell is to be connected this year, which will provide real practical results. Innovative technology for the direct thermal use of hydrogen will be used to heat the house. The “HAUS” is a show case as well as research and development laboratory of the company ‘white energy’.

The electricity requirements of the household and the heat pump are partly covered by the self-generated electricity from the photovoltaic system. An electricity storage unit is used for short-term storage.

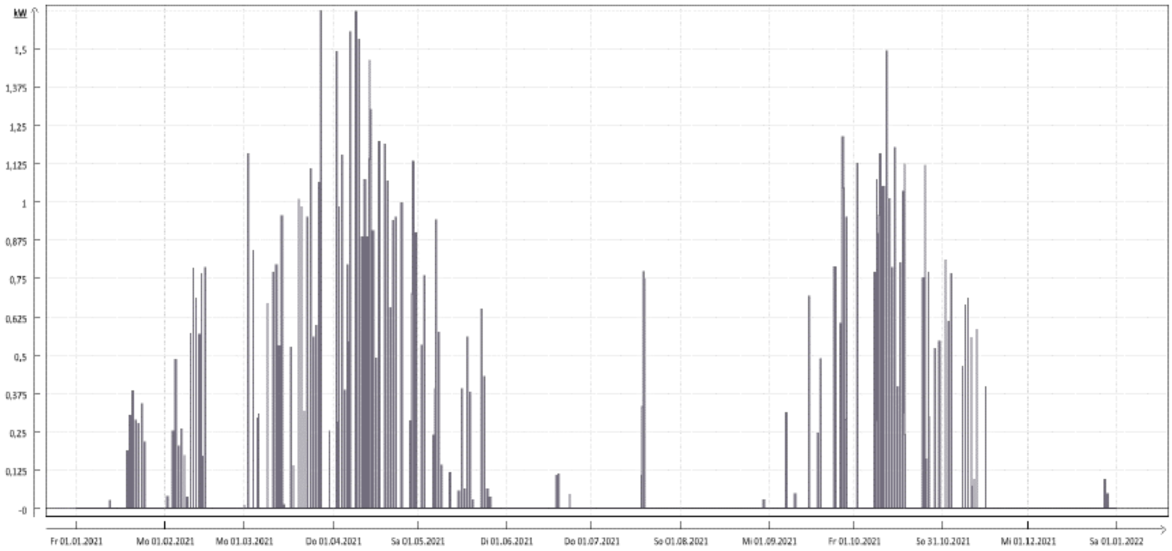
- Power of the PV system: 29,82 kWp
- Solar collector Inclination angle: 10°
- Azimuth angle of PV system: East/West
- Electricity generated by PV system East: 9,05 MWh/a
- Electricity generated by PV system West: 8,96 MWh/a

2. END-USE.

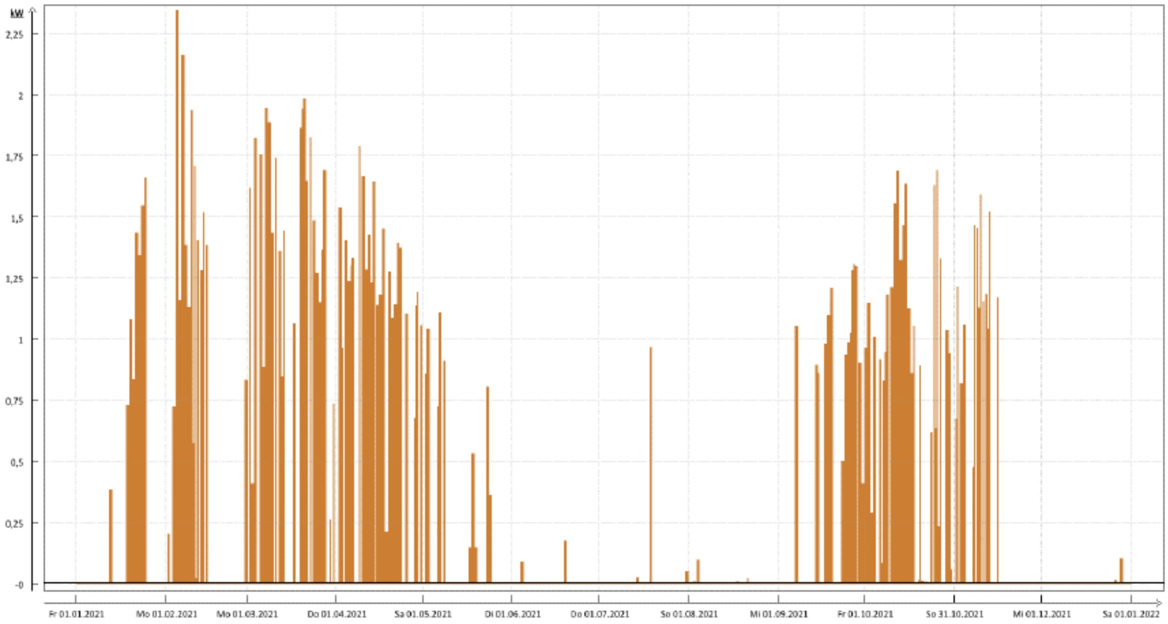
The surplus PV electricity is converted into hydrogen by electrolysis and stored in a hydrogen storage unit. The remaining surplus electricity is fed into the grid. The stored hydrogen will be used to generate electricity in a fuel cell, mainly in fall and winter (September to December), in order to cover the electricity demand. Waste heat is going to be generated in the fuel cell during the energy conversion process. This waste heat can be used to cover part of the heat requirement for heating and domestic hot water. The remaining heat requirement is covered by an air/water heat pump. Results from the simulations:

electricity consumption electrolyzer	1,62 MWh/a
Electricity generated by fuel cell	0,49 MWh/a
hydrogen produced by electrolyzer	1,01 MWh/a

Generated electricity in fuel cell:



Generated heat in fuel cell:



3. H2 PRODUCTION.

A hydrogen application is being tested at household level. This means it will be privately owned. However, such local applications are also conceivable for smaller commercial users such as hotels,similar areas or district solutions, although a different scale is required. So far, the "HAUS" is being managed by a specialist company called "WhiteEnergy". Hydrogen production and consumption all take place within the house. Production also takes place on the PV system on the roof of the house (29.82 kWp). The entire site of the test station is privately owned. In 2021, a total of 1.01 MWh of hydrogen was produced and stored in the gas cylinders at 35 bar.

electricity balance	
Electricity generated by photovoltaic system "east"	9,05 MWh/a
Electricity generated by PV system "west"	8,96 MWh/a
Electricity generated by fuel cell	0,49 MWh/a
Electricity purchase from the electricity supplier	4,94 MWh/a
electricity consumption house	4,07 MWh/a
electricity consumption heat pump	8,89 MWh/a
electricity consumption electrolyzer	1,62 MWh/a
Feeding electricity into the grid	8,63 MWh/a
Self-consumption rate	52%
self-sufficiency	66%

heat balance	
Heat output delivered by heat pump	36,4 MWh/a
Heat output delivered by fuel cell	0,49 MWh/a
Heat output from gas boiler	0 MWh/a
Heat output from electrolyzer	0,60 MWh/a
Heat consumption The House	36,70 MWh/a

4. STORAGE.

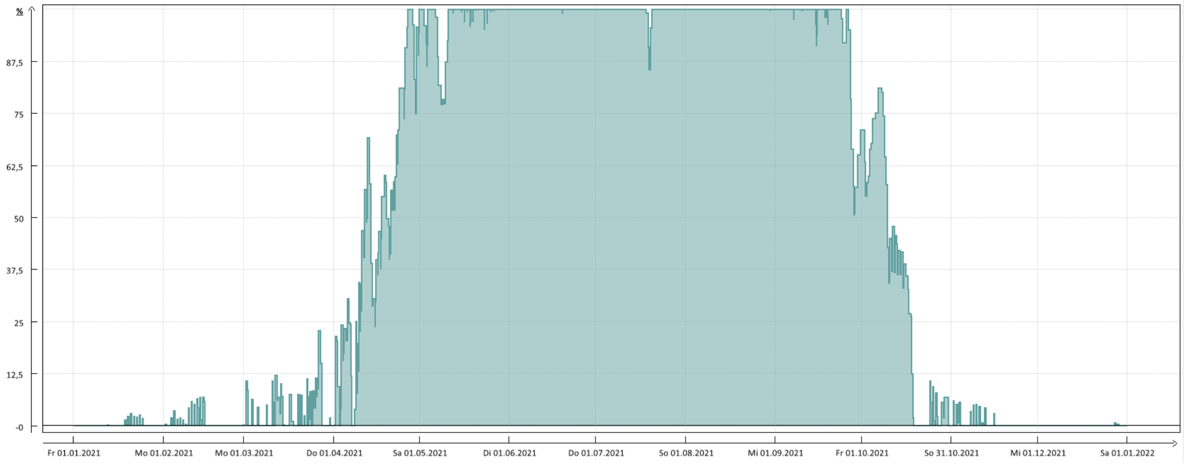
The electricity requirements of the household and the heat pump are partly covered by the self-generated electricity from the photovoltaic system. An electricity storage unit is used for short-term storage. The surplus PV electricity is converted into hydrogen by electrolysis and stored in a hydrogen storage unit next to the house. On particularly sunny days, the remaining surplus electricity is fed into the grid.

The stored hydrogen is used to generate electricity in a fuel cell, mainly in the fall and winter (September to December), in order to cover the electricity demand (Until today just simulations -> Instalation of the fuel cell should happen in 2024).

It is a local hydrogen storage tank with 35 bar. This consists of 2x 12 bund storage tanks with 0.6m² -> 12 cylinders of 50 liters each)

Waste heat is generated in the fuel cell during the energy conversion process. This waste heat can be used to cover part of the heat requirement for heating and domestic hot water. The remaining heat requirement is covered by an air/water heat pump, which is operated via the PV system on the roof.

The annual fill level of the hydrogen storage tank is as illustrated below:



In summer, a lot of electricity is produced by the PV system, which means that the surplus electricity can also be converted into hydrogen and stored. The storage tank is almost completely refilled between May and October Between October and November, the storage tank is completely used up and is refilled from spring onwards with the system's own PV electricity. In winter, not enough PV electricity can be generated to produce hydrogen due to the reduced hours of sunshine and weather conditions.

As the storage site is located in the immediate surroundings of the PV system and the electrolyzer, there are almost no transportation distances. On the other hand, huge safety precautions are required to fulfill the safety standards of hydrogen storage connected to a residential building.

5. TRANSPORT.

The hydrogen produced on site is stored at the house and used in the fall and winter. Therefore, no transportation is necessary. The hydrogen is stored in 2x12 bund storage tanks (0.6m³ with 12 bottles of 50l each).

Currently the company WhiteEnergy is in charge of controlling the hole system.

6. SUPPLY CHAIN.

As the “HAUS” is a show case as well as research and development laboratory of the company ‘white energy’ there are no other stakeholders. The electrolyzer, the storage units, the PV systems and the end-user technologies all belong to white energy. However, models within the framework of energy communities would certainly be conceivable in order to implement this system in apartment buildings, for example.

7. FINANCIAL PLANNING.

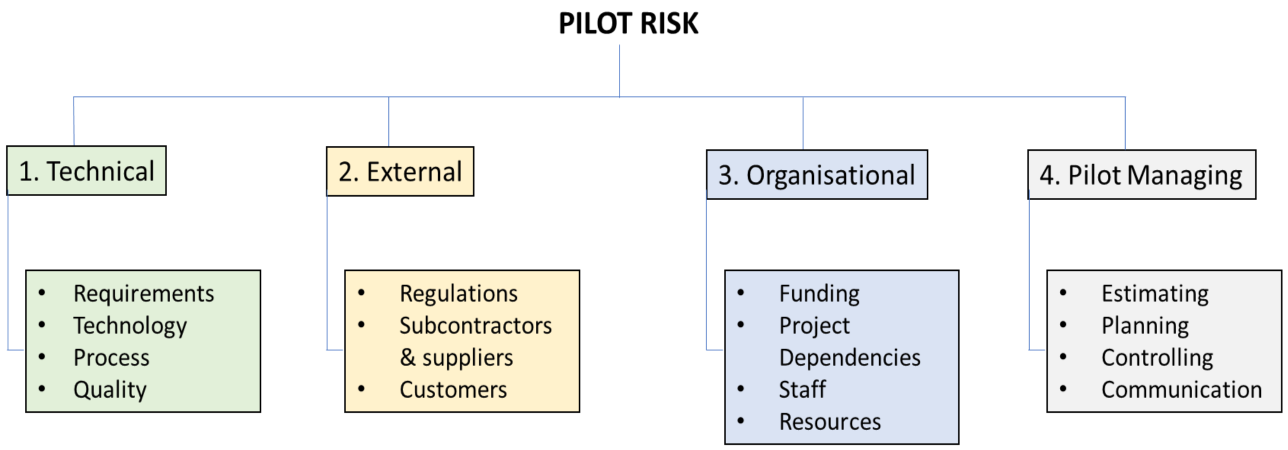
The Irschenhausen hydrogen house has so far been a show case as well as a research and development laboratory for the company white energy. Unfortunately, the technologies are not yet ready for the market and implementation is not yet financially feasible for private households as they are far too expensive.

Recently, there is a provider in Germany that offers H2-ready heating systems, and there is the possibility of subsidies (70%) for the additional costs of hydrogen capability. To do this, the system must be operated with 100 percent hydrogen immediately after installation.

ROADMAP

PROJECT PHASE	ACTIVITY	START (MONTH)	END (MONTH)	MEANS OF VERIFICATION
SETTING UP THE SCENE	RAISING LOCAL STAKEHOLDERS' INTEREST	1	12	STAKEHOLDER-LIST
	COLLECT DATA ON LOCAL ENERGY SYSTEM	1	6	REPORT ON ENERGY SYSTEM
	DEVELOP AN UNDERSTANDING OF PROJECT CONCEPT	1	3	MEETING WITH RESPONSIBLES
	INFORM STAKEHOLDERS ABOUT PILOT PROJECT	6	9	MAIL CAMPAIGN
PROJECT DEVELOPMENT	EXCHANGE WITH RESPONSIBLE STAFF ABOUT PROGRESS AND NEW FINDINGS	3	18	MAIL CAMPAIGN
	COMPILE NATIONAL KNOWLEDGE	6	9	WRITE SUMMARY
	PLAN HYDROGEN EXCURSION TO PILOT PROJECT	6	9	CONSULTATION WITH PILOT PROJECT
REALIZATION PHASE	CHECK FEASIBILITY (TECHNOLOGIC/FINANCING)	12	18	EVALUATION OF THE TECHNICAL AND FINANCIAL SITUATION
	REALIZATION OF HYDROGEN EXCURSION	9	10	DOCUMENTATION EXCURSION
	COMPARSION WITH NATIONAL KNOWLEDGE	9	15	SUMMARY REPORT
OPERATIONAL AND MONITORING PHASE	CONSULTATION WITH PILOT PROJECT ON POSSIBLE IMPROVEMENTS TO THE SYSTEM	9	18	MEETING WITH RESPONSIBLES
	ANALYZING TRANSFERABILITY AND POTENTIAL BENEFITS FOR THE REGION	12	18	SUMMARY REPORT
	FORMULATING POTENTIALS AND LIMITS OF THE SYSTEM	15	18	SUMMARY REPORT

RISK ASSESSMENT



RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
Risk type: Technical _ Technology Relevant risk description: **Hydrogen conversion efficiency too low**	Project should show whether hydrogen applications make sense at this level. Just because the efficiency of the conversion is low and possibly not for the masses in single-family households, the project has not failed. The aim is to increase efficiency and identify sensible fields of application.	5	4	Monitoring and continuous improvement of the technology is necessary over a longer period of time in order to increase efficiency. Application examples can be worked out to show under which conditions the efficiency increases and in which niches this application could make sense in the future.	If the objectives of the project are clearly defined, it will be easier to monitor and stick to them.
Risk type: Technical _ Requirements Relevant risk description: **Storage capacity of hydrogen limited**	The idea is to increase self-sufficiency at household level by storing energy. However, it could happen that hydrogen storage in particular requires too	5	4	To reduce the likelihood of space for hydrogen storage becoming a problem, sufficient space must be planned. However, current results show that the storage tank is already emptied in	The influence of the low storage capacity can be mitigated by additional generation methods in winter (e.g. wind) or by increasing the efficiency of storage (amount of energy per area).

(Winterlow cannot be compensated with current technology)	much space, which means that not enough energy can be stored for the winter. There are also concerns about the safety of storing hydrogen in residential buildings.			the early winter months. Other storage methods could be considered, e.g. with higher hydrogen pressure, but this would create new problems with safety factors.	
Risk type: Organisational _ Financing Relevant risk description: **Current monitoring results show that it is not cost-effective**	With regard to the transfer of the hydrogen implementation approach to household level, the initial research results raise major questions in terms of economic feasibility. The systems, which are integrated into the house, are associated with very high initial costs. In addition, the current efficiency in energy conversion is still very low, which means large energy losses. The low storage capacity leads to a continued low level of self-sufficiency of 66% over the year 2021. This means that the approach is currently not economically viable. The added value of the	2	4	Measures to increase cost-effectiveness go deep in the technical direction. It is about refining and improving efficiencies within the process in order to increase energy conversion losses and storage capacity. A reduction in external electricity purchases can increase economic efficiency	The pilot project is not about making a direct economic profit, it is about testing the storage capacity of hydrogen electrolysis at household level. The impact on profitability is currently too big to be considered an economic possibility.

	entire project for research should therefore not be underestimated.				
Risk type: Organisational _ Staff Relevant risk description: **High demand for specialists/maintenance/monitoring in the process**	The pilot project is characterized by high-tech applications. It is a complex system that requires enormous expertise to understand the connections. If such systems were to be introduced in practice, a huge number of specialists and technicians would be needed to set up, test and, ideally, improve the systems.	3	4	In order to minimize such problems, it is necessary to carry out a lot of in-depth research and, in the best case, to develop a system that is transferable to different initial situations. Nevertheless, many contacts and technicians would be relevant in practice.	If these storage systems should find a realistic application in practice in the future, the specialists must also be trained in the same step to ensure technological installation and maintenance work.
Risk type: Organisational _ Resources Relevant risk description: **Only sun as an energy source too fluctuating/seasonal**	The example from Irschenhausen shows that such a self-sufficient storage system makes more sense if the generation methods are not one-dimensional. The pilot project only involves PV production, which does not yet allow for self-sufficiency over the entire year.	4	4	To minimize this impact, approaches should be tested and compared where other renewable energy generation methods may be applicable, such as wind and hydropower. This could reduce the winter periods in which external electricity has to be purchased.	Diversification of energy production if possible in order to better fill gaps in supply.

I. BAE (SWITZERLAND)

AMETHySD PROJECT PARTNER	BlueArk
PILOT PROJECT TITLE	Hydrogen Alpin
LOCATION	Val de Bagnes (Switzerland)

OBJECTIVE(S)

Our pilot project's main objectives include:

1) Decarbonization by adopting green hydrogen technologies, including hydrogen-powered snow groomers and local production facilities;

2) Promoting technological innovation through advanced hydrogen storage and distribution systems;

3) Ensuring economic viability and creating local jobs;

4) Engaging and educating the community on hydrogen benefits;

5) Enhancing energy independence via a hydrogen microgrid for resilience and reliability.

STRATEGY

1. RENEWABLE GENERATION

Share of Production Dedicated to Hydrogen

The alpine solar park will be specifically dedicated to hydrogen production, ensuring that the majority of the energy produced will be converted into hydrogen to meet local needs.

Renewable Sources for Hydrogen Production

We have chosen solar energy and energy regulation as the primary sources for hydrogen production. Initial tests for alpine solar production have already been conducted, leveraging the abundant solar resources available in the alpine environment and the ability to deploy these in an already industrialized zone.

Current Status of Power Plants

The preliminary tests for the installation of a solar production zone have been carried out on a site selected by the municipality. However, no plant is yet fully operational. Construction of the new solar plants is planned to begin once the projects are concretely validated by the municipality and budgets are approved by the banks.

Ownership and Location of Renewable Power Plants

The ownership of the plants will be determined once the projects are validated. Currently, the Municipality of Val de Bagnes and Altis, the local energy provider, have shown significant interest in this project. The alpine solar plants will be situated near the hydrogen site and close to the snow groomers' storage areas, in an already industrialized zone.

Development of the Hydrogen Production Zone

The establishment of the hydrogen production zone is still under study. This zone needs to cover an annual requirement of 100,000 kg of hydrogen for the snow groomers. There are still too many uncertainties to immediately commence construction, such as the cost at which we can offer hydrogen to clients (e.g., ski lifts) and the concrete timeline and cost for acquiring hydrogen snow groomers. We anticipate implementation within five years.

Public and Private Stakeholders

The installations will likely be managed in partnership between the Municipality of Val de Bagnes, Altis, and other potential investors such as Alpqie, depending on the municipality’s decisions. This collaborative approach will ensure operational efficiency and balance between public and private interests.

Current and Expected Annual Production Profiles

Energy production will be variable, depending on seasonal conditions, but the goal is to produce 100,000 kg of hydrogen per year to meet the annual needs of the hydrogen snow groomers.

Timeline and Costs for New Installations

The construction of the alpine solar park, which has already been selected, is expected to be completed within two to three years from the start of the work. The exact cost will be defined once funding requests are processed. Regarding hydrogen production, current technology is still lagging behind for concrete calculations. Therefore, we plan to implement the hydrogen solution within a five-year timeframe, supported by a feasibility study initiated by the municipality.

Cost Distribution

The financing of this project is under discussion between the Municipality of Val de Bagnes, Altis, and banking institutions. The goal is to find a balanced and sustainable financing model with the support of all stakeholders. Due to the technical uncertainties, a preliminary study will be launched to estimate the costs of the operation.

This strategic approach to hydrogen production aims to enhance the energy self-sufficiency of Val de Bagnes while promoting sustainability and resilience through cutting-edge hydrogen technologies.

2. END-USE

Selected Hydrogen End-Use

The selected end-use for the produced hydrogen is primarily for snow groomers in the Val de Bagnes region. Additionally, we are exploring its use for other industrial and community applications within the local infrastructure.

Final Users

The final users of the hydrogen will be both public bodies and private companies. The primary users include ski resort operators for snow groomers, with the possibility of extending its use to local transportation services and other industrial applications in the future.

Hydrogen Producer

While the municipality and local energy provider, Altis, are heavily involved in the project, the final user (e.g., ski resorts) may not necessarily be the direct hydrogen producer. However, partnerships and agreements will be in place to ensure smooth operations and supply chains.

Expected Yearly Consumption

The expected yearly consumption is estimated at 100,000 kg of hydrogen to adequately power the snow groomers and meet the additional demands of any supplementary applications.

Need for New Vehicles or Infrastructure

To support the hydrogen end-use, it is necessary to purchase new hydrogen-powered snow groomers. Additionally, new infrastructure such as hydrogen refueling stations and storage facilities will need to be built. This also includes the construction of the alpine solar park dedicated to hydrogen production.

Expected Investment

The total expected investment, including new vehicles, refueling infrastructure, production facilities, and storage solutions, is projected to be several million euros. Detailed cost estimates will be finalized once feasibility studies and funding strategies are completed. This investment will be shared among the municipality, private stakeholders (such as Altis), and financial institutions through a combination of public funding, private investments, and potential grants.

3. H2 PRODUCTION

Ownership and Management of the Hydrogen Production Plant

The hydrogen production plant will likely be owned and managed by a consortium composed of the Municipality of Val de Bagnes and Altis, the local energy provider. This public-private partnership will enable a combination of resources and expertise, ensuring efficient management and operation of the plant.

Location of Hydrogen Production

Hydrogen production will take place near the alpine solar production site and the snow groomer facilities, in an already industrialized zone of Val de Bagnes. This strategic location minimizes transport distances, reducing associated losses and costs.

Proximity to Renewable Production

The hydrogen production site will be situated just a few kilometers from the alpine solar park. This close proximity allows for efficient transfer of the renewable electricity needed to power the electrolysers.

Land Ownership

The land designated for the hydrogen production plant is already owned by the local stakeholder consortium, which includes the Municipality of Val de Bagnes, Altis, and the ski lifts. This pre-ownership facilitates the quick commencement of construction once approvals are obtained.

Expected Yearly Hydrogen Production

The plant is expected to produce around 100,000 kg of hydrogen annually. This production volume is aligned with the projected needs for the hydrogen-powered snow groomers and other potential future applications.

Seasonal Patterns and Differences

The production of hydrogen will experience seasonal variations corresponding to the availability of solar energy. Production will peak in the summer months when sunlight is abundant and will decrease during the winter. These variations will be managed by optimization through regulation and energy storage systems.

Installed Electrolyser Power

The installed electrolyser power is anticipated to be approximately 2 MW. This capacity will be sufficient to meet the required hydrogen production while providing some flexibility to handle demand peaks.

Investment Estimate

The rough estimate for the investment needed to establish the hydrogen production plant and associated infrastructure is around €8 million. This budget includes costs for construction, electrolysers, hydrogen storage, and distribution systems, as well as necessary infrastructure adaptations.

This significant investment

will be shared between the municipality and potentially other private investors and financial institutions, ensuring a robust and sustainable financial model for the project. However, at the moment, it is impossible to build concrete elements while we remain uncertain about the technical aspects.

4. STORAGE. According to seasonal patterns, approximately how big will the storage be (time-wise and kg of H2)? Think about the logistics. Will it be located next to the production site? Or next to the end-user? Or a third location is required for seasonal storage? At what pressure will it be stored? Are the selected locations far enough from other buildings? How, if necessary, will they be made safe?

Storage Capacity

Based on the seasonal variations in hydrogen production, the storage capacity must be sufficient to balance periods of low production in winter and high production in summer. We estimate that the storage will need to accommodate approximately 75,000 kg of hydrogen to ensure a consistent supply throughout the winter. This volume should provide flexibility and security of supply.

Logistics and Location

The hydrogen storage will be strategically located next to the hydrogen production site. This proximity allows for efficient transfer of hydrogen from production to storage, minimizing transport logistics and associated costs.

Storage Pressure

The hydrogen will be stored at a high pressure of around 350 to 700 bars. This range ensures a high storage density while maintaining safety standards and operational efficiency.

Safety and Location Considerations

The selected storage locations will be adequately distanced from other buildings and residential areas to ensure safety. Specifically:

- The primary storage facility next to the production site will be designed with significant buffer zones to mitigate any potential risks.

- Buffer storage near the end-user locations will incorporate robust safety measures, including reinforced containment systems and regular inspections.

To ensure safety, the following measures will be implemented:

- *Robust Containment Systems: Hydrogen storage tanks will be equipped with state-of-the-art containment technology to prevent leaks and withstand high pressures.*
- *Safety Barriers and Buffer Zones: Physical barriers and buffer zones around the storage facilities will reduce the risk of accidental impact or explosion.*
- *Regular Safety Inspections: Routine safety inspections and maintenance will be scheduled to detect and address any potential issues promptly.*
- *Emergency Response Plan: A comprehensive emergency response plan will be established, including training for local emergency services and regular drills to ensure preparedness.*

This multifaceted approach to hydrogen storage logistics and safety will ensure a reliable and secure hydrogen supply chain, supporting the smooth operation of hydrogen-powered snow groomers and other applications in Val de Bagnes. However, until the analysis is completed, we cannot guarantee this production site.

5. TRANSPORT.

Hydrogen Transport Method

In our setup, hydrogen transport will be facilitated by a dedicated network of pipelines, eliminating the need for vehicular transport. This network will directly connect the hydrogen production site to the end-user locations, ensuring a seamless and efficient flow of hydrogen.

New Infrastructure Requirements

To enable this, we will need to construct a new pipeline infrastructure, including:

Hydrogen Pipelines: High-pressure pipes designed to safely transport hydrogen from the production site to the consumption areas. Compression Stations: Facilities along the pipeline to maintain the necessary pressure for efficient transport.

Who Will Be in Charge of the Transport

The management and maintenance of the hydrogen pipeline network will be overseen by a consortium that includes the Municipality of Val de Bagnes, Altis, and likely another entity with expertise in this technology. This ensures coordinated efforts across production, transportation, and consumption.

Safety Considerations for Pipeline Transport

- High-Quality Materials: Pipelines will be constructed using materials specifically designed to handle high-pressure hydrogen, ensuring durability and safety.
- Regular Monitoring: The pipeline network will be equipped with sensors and monitoring systems to detect pressure changes, leaks, or any anomalies in real time.
- Emergency Shutdown Systems: Automatic shutdown mechanisms will be in place to quickly isolate sections of the pipeline in case of a detected leak or malfunction.
- Safety Inspections: Routine safety inspections and maintenance checks will be conducted to ensure the integrity of the pipeline infrastructure.

Proximity and Route Planning

The hydrogen production site will be located near the primary consumption zones, such as the snow groomer depots. This arrangement minimizes the distance hydrogen needs to travel, enhancing efficiency and reducing potential risks.

By implementing an advanced pipeline network for hydrogen transport, we will ensure a continuous, safe, and efficient supply of hydrogen directly from the production site to the end-users. This strategy supports the smooth operation of hydrogen-powered snow groomers and other applications within Val de Bagnes while maintaining the highest safety standards.

6. SUPPLY CHAIN. What are the roles of the different stakeholders within the whole supply chain? Who owns the electrolysers, the storage units, the RES plants, the end-use technologies? Who buys the hydrogen from whom? How many intermediate steps are there? Can you expect the stakeholders to sign a 5- or 10-year supply contract?

Municipality of Val de Bagnes

- Role: Oversight and coordination of the entire project, ensuring alignment with regional development plans and sustainability goals.
- Responsibilities: Facilitation of land use approvals, regulatory compliance, and engagement with local communities.
- Ownership: Potential co-owner of the hydrogen production plant, storage units, and involvement in the management of the pipeline infrastructure.

Altis (Local Energy Provider)

- Role: Technical expertise and management of energy production and storage.
- Responsibilities: Operation and maintenance of the solar power plants, electrolysers, and hydrogen storage facilities.
- Ownership: Co-owner of the renewable energy sources (RES plants) and electrolysers, with a strategic interest in expanding their renewable energy portfolio.

Private Investors

- Role: Financial investment and provision of capital required for infrastructure development.
- Responsibilities: Funding of infrastructure projects and potential technological input or partnerships in innovative solutions.
- Ownership: Possible co-owners of the hydrogen production and storage installations, incentivized by profitability and sustainable development goals.

Hydrogen Technology Suppliers

- Role: Supply and maintenance of critical technology and equipment.
- Responsibilities: Providing electrolysers, storage solutions, hydrogen refueling stations, and ensuring ongoing technical support and upgrades.
- Ownership: Typically, technology ownership is transferred to operational stakeholders upon installation.

End-Users (e.g., Ski Resort Operators)

- Role: Utilization of hydrogen for snow groomers and other relevant end-use technologies.
- Responsibilities: Purchasing hydrogen, operating the hydrogen-fueled equipment, and ensuring efficient use in daily operations.
- Ownership: Owners of the hydrogen-powered snow groomers and other end-use technologies procured for their operations.

Supply Chain Process

- Renewable Energy Production: Solar energy is harvested by the solar plants owned and managed by Altis with investments from the Municipality and private stakeholders.
- Hydrogen Production: Electrolysers, co-owned by Altis and other investors, use the solar-generated electricity to produce hydrogen.
- Hydrogen Storage: Hydrogen is stored in high-pressure units, located adjacent to the production site, managed jointly by Altis and the Municipality.
- Hydrogen Distribution: A pipeline network overseen by the consortium (Municipality and Altis) ensures seamless transportation of hydrogen to end-user locations.
- Hydrogen Utilization: End-users, such as ski resort operators, own and operate hydrogen-powered snow groomers, purchasing the necessary hydrogen from the storage facilities.

Purchasing Roles

- End-users (ski resort operators) will be the primary buyers of the produced hydrogen, ensuring a sustainable demand for the hydrogen generated. The financial investment from Altis and other private investors, combined with municipal support, will ensure the infrastructure for this supply chain is robust, efficient, and sustainable.

By designing a cohesive supply chain structure with clearly defined stakeholder roles and responsibilities, we ensure a smooth and efficient operation of the hydrogen production, storage, distribution, and utilization processes within the Val de Bagnes region.

At this stage, we are working on assumptions because since the technology is not sufficiently developed, it is difficult to have a viable business model. Such an operation can only take place once the technology is ready to be implemented.

7. FINANCIAL PLANNING

Resource Analysis and Allocation

At the current stage, the technology for hydrogen-powered snow groomers is not yet fully developed to create a complete and reliable supply chain. The existing prototypes do not meet the specific needs of Verbier's alpine environment. Consequently, it is not possible to secure financing for this project without a viable business model and proven technology. This technological gap also impacts our ability to persuade banks, the municipality, private investors, and ski resort operators to convert their vehicles to hydrogen.

Given these challenges, we are encouraging the municipality to undertake a comprehensive study on hydrogen usage to determine the cost per kilogram of hydrogen. This study aims to provide a clearer financial framework and support future decision-making.

Project Funding

Currently, the project is not partially or totally funded by any public entity. Securing funding is contingent on the successful completion of the hydrogen study, which will determine the feasibility and financial requirements of the project.

Investment and Operational Costs

Initial Investment Costs: The investment costs will likely be shared among the Municipality of Val de Bagnes, Altis, and potential private investors. Without a viable hydrogen technology and a clear business model, it remains challenging to secure definite commitments from these stakeholders.

Operation and Maintenance (O&M) Costs: Similar to the initial investments, the O&M costs for the various plants and components will also need to be covered by the consortium, including the municipality and Altis. Determining these costs requires a detailed understanding of the technology and operational requirements, which the study aims to resolve.

Public Support for Investments

Investment Support: The project will seek public support, potentially through grants and subsidies, once it has demonstrated a viable business model and technological feasibility.

Renewable Energy Production: Public support for renewable energy production will be critical. Potential subsidies and incentives for solar power generation could be leveraged to minimize the financial burden on local stakeholders.

Hydrogen Production: Similarly, support for hydrogen production, possibly through government programs aimed at encouraging clean energy, will be sought. However, such support is contingent on the successful demonstration of feasible technology and financial models.

Stability and Equity of Local Stakeholders

Local stakeholders, including the Municipality of Val de Bagnes and Altis, are committed to the project. However, their ability to sustain investment and avoid withdrawal in the near future depends heavily on:

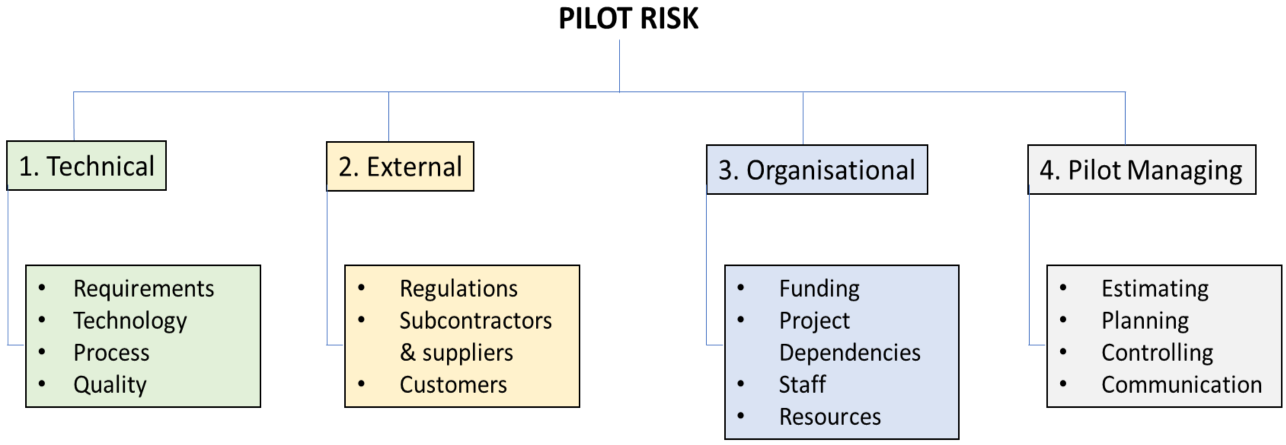
- The outcomes of the comprehensive hydrogen study.
- The development of a viable and stable business model.
- Proven technological feasibility that meets Verbier's alpine requirements.

In summary, while there is strong local interest and potential for public support, the financial viability of the hydrogen project hinges on overcoming current technological obstacles and establishing a robust business model. The forthcoming study is a critical step towards achieving these objectives, providing the necessary data to secure financing, operational stability, and stakeholder commitment.

ROADMAP

PROJECT PHASE	ACTIVITY	START (MONTH)	END (MONTH)	MEANS OF VERIFICATION
SETTING UP THE SCENE	RAISING LOCAL STAKEHOLDERS' INTEREST	1	6	
	COLLECT DATA ON LOCAL ENERGY SYSTEM	3	9	
	DEVELOP PROJECT CONCEPT	6	24	
PROJECT DEVELOPMENT	TECHNO ECONOMIC FEASIBILITY	12	24	
	SCENARIOS	12	16	
	STAKEHOLDERS' COMMITMENT	12	20	
	FINALIZE ROLES AND EACH STAKEHOLDER'S INVESTMENT			
	DEVELOP MONITORING AND OPTIMIZATION STRATEGY	15	20	
REALIZATION PHASE	TENDER (*if necessary*)			
	DEVELOP EXECUTIVE PROJECT PLAN	15	Undetermined	
	REALIZE PLANTS	15	Undetermined	
OPERATIONAL AND MONITORING PHASE	MONITOR	Undetermined	Undetermined	
	CALCULATE KPIs	Undetermined	Undetermined	

RISK ASSESSMENT



RISK TYPE	Further explanation	Risk likelihood	Risk impact	Measure(s) for likelihood reduction	Measure(s) for impact mitigation
The technology for hydrogen-powered snow groomers is still in the prototype stage and has not yet been adapted to the harsh alpine environment of Verbier	Prototypes have not yet proven reliable under the specific conditions required for effective operation in alpine settings like Verbier.	4	5	Invest in R&D to adapt technology, and establish collaborations with manufacturers and hydrogens experts.	Continue to explore alternative low-carbon technologies and maintain flexibility in the operational plan.
Without a viable business model and proven technology, securing financing from banks and private investors is challenging.	Financial institutions require clear evidence of potential return on investment and technological viability for large-scale funding.	3	5	Conducting comprehensive feasibility studies and creating a robust business plan that includes various revenue streams.	Seek phased funding approaches, starting with smaller pilot projects to build evidence of success before full-scale investments.

Lack of concrete engagement from local stakeholders, including the municipality, private investors, and ski resort operators.	Successful implementation depends on active and sustained involvement of all parties to ensure financial and operational support.	2	4	Regular engagement activities, transparent communication, and demonstrating potential benefits.	Strengthen communication strategies and use initial small-scale project successes to build confidence and commitment.
Potential delays in obtaining necessary permits and regulatory approvals for constructing hydrogen production and storage facilities.	Regulatory processes can be slow and complex, impacting project timelines significantly if not managed proactively.	3	4	Early engagement with regulatory bodies, ensuring all compliance is addressed promptly.	Adjust project timelines as necessary and maintain open communication with stakeholders on updated schedules.
Uncertainty about the market demand for hydrogen in the local context, especially if end-users (e.g., ski resorts) are hesitant to convert their vehicles.	Switch to hydrogen requires significant investment and change management, and end-users may be reticent without clear incentive structures.	3	3	Conduct thorough market analysis, engage in direct discussions with potential end-users, and clearly communicate the benefits.	Diversify potential hydrogen applications to spread demand risks and ensure economic viability.
Potential operational challenges related to the maintenance and safety of hydrogen production and storage facilities.	Hydrogen facilities require meticulous maintenance and safety protocols to prevent accidents and ensure constant, reliable operation.	4	4	Implementing stringent safety protocols, regular maintenance schedules, and thorough training for all personnel.	Establish an emergency response plan and engage external experts for troubleshooting and swift resolution of issues.