Interreg Co-funded by the European Union

Alpine Space

H2MA

Deliverable D.2.2.2

Compilation of territorial green H2-route designs

Activity 2.2

June, 2024

DOCUMENT CONTROL SHEET

Project reference	
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Acronym	H2MA
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Lead partner	KSSENA

Short description

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

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This document is issued by the consortium formed for the implementation of the **H2MA** project, and made by the following partners:

- PP1 (LP) Energy Agency of Savinjska, Saleska and Koroska Region (SI)
- PP2 BSC, Business Support Centre, Ltd, Kranj (SI)
- PP3 EUROMETROPOLE DE STRASBOURG (FR)
- PP4 Lombardy Foundation for the Environment (IT)
- PP5 Cluster Pole Vehicule du Futur (FR)
- PP6 Turin Metropolitan City (IT)
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- PP9 Lombardy Region (IT)
- PP12 Codognotto Italia (AT)
- PP11 Italian German Chamber of Commerce Munich-Stuttgart (DE)

Responsible Partner/s for the compilation of this document

- PP7 Climate Partner Südbaden (DE) (formerly Upper Rhine Valley)

CONTENT

1. INTRODUCTION

The Deliverables 2.2 are split into two separate tasks, of which KPO is covering D2.2.2, as can be seen in the excerpt below taken from the H2MA application form.

Deliverables 2.2			
Running number	Deliverable	Description	Delivery period
D.2.2.1	Summary report of Local Working Group meetings	PVF will collect input from all meetings, to be used for summarising the lessons learnt of the meetings, focusing on participants' experiences with the design of territorial green H2 networks.	Period 3 , 13 - 18
D.2.2.2	Compilation of territorial green H2 route plans /designs	KPO will collect and present each territory's designs for green H2 routes, focusing on the nodes each LWG opted to interconnect for the purposes of optimising existing with future infrastructure.	Period 3 , 13 - 18

For D2.2.2 the H2-infrastructure scenarios prepared by each partner using the H2MA tool have been collected. Each partner selected input values based on their regional circumstances, predictions and regional or national H2-strategies. The results of the H2MA tool optimization of each region have been exported and saved in a specific folder available to the consortium via a Teams Sharepoint (Compilation of green H2 routes). Additionally, each partner described the H2-routes of their region in a PowerPoint presentation, which is also available in the same folder. This document gives a summary of the regional scenarios.

2. COLLECTION OF TERRITORIAL GREEN H2-ROUTE DESIGNS

All partners were asked to choose the scenario which they rate as the most viable scenario, i.e. the scenario with the most reliable data input for the H2MA tool, considering their national and regional H2 circumstances, strategies and predictions. The resulting H2-infrastructure suggested by the H2MA tool was used for developing H2 routes that consider factors such as the TEN-T corridors in the region and existing infrastructure.

In the description of the scenario, the partners were asked to rate the confidence level of their scenario on a scale from 1 to 10, where a value of 1 indicates allow confidence related to uncertain boundary conditions, and a value of 10 resembles very reliable boundary conditions and results with a high likelihood of realization.

The timeframe of the scenario was a free choice for each partner, as H2-demand and speed of infrastructure development may differ between regions.

The maps created by the H2MA tool with existing and future hydrogen refueling stations (HRS), hydrogen production sites and H2 delivery pipelines were used as a base to mark the H2-routes, with a focus on TEN-T corridors and neighboring H2 infrastructure.

In order to give an overview of the H2-scenarios, the following table shows the inputs used by each region and key results.

2.1 Overview table of H2-mobility parameters for scenario optimization in the H2MA tool

Partner	Region	Year	FCEV vehicle share	regional H2 demand	Delivery method	Number of planned HRSs	TEN-T corr. respected	Confidence rating (1-10)
1 KSSENA	SI03	2030	0,0047-0,0082	1 kt/y	pipelines	21	Yes	3
2 BSC	SI04	2030-2050	0,0047-0,0082	2 kt/y	pipelines	10	Yes	6
4 FLA & 9 RL	ITC4	2030	0,002-0,02	21 kt/y	trucks	16	Yes	5-7
5 PVF & 3 EMS	FRC2/ FRF1	2030	0,005-0,1	1,4 kt/y	trucks	7	Yes	7
6 CMT	ITC1	2030	0-0,0025	2 kt/y	trucks	18 → 4	Yes	3
7 KPO	DE13	2030	0,005-0,01	18 kt/y	pipelines	26	Yes	3
8 4ER	AT22	2040	0,01-0,25	17 kt/y	pipelines	16	Yes	2
10 COD	AT13	2030	0-0,2	7 kt/y	pipelines	4	Yes	7
11 ITALCAM	DE11	2030	0,005-0,01	27 kt/y	pipelines	30	Yes	3

Main points to note:

- Most partners chose the year 2030 for developing their scenarios
- Expected share of fuel cell electric vehicles varies greatly. This factor is decisive for demand calculation, but many partners state uncertainties in future market acceptance and predictions of H2-based mobility.
- Demand per region and thus requirements for the number of HRSs and H2-production facilities varies greatly between regions. An extreme examples is the scenario of KSSENA in Slovenia: An annual demand of 1 kt/y is distributed over 21 suggested HRSs, meaning an equivalent of ca. 47 kg H2 as average consumption per HRS. Such a result of the H2MA tool

is unrealistic, as a long distance truck is equipped with an 80 kg H2-tank (e.g. Mercedes Truck - Link) and half a tanks filling per year will not create a business model for a refueling station.

- Most regions chose pipelines as preferred delivery method, however, all partners explain that rural regions will benefit from truck delivery.
- All partners succeed in including the TEN-T corridors in their H2-routes.Overall the confidence rating in the described scenarios relying on the H2MA tool are low. The confidence rating is only set to reasonably reliable, if partners did extensive rework on the scenario with their local working groups (LWG).

3. PRESENTATION OF TERRITORIAL GREEN H2-ROUTE DESIGNS

In the following paragraphs an overview of the most viable territorial green H2-route designs of each region is presented. To define the most viable design the results were compared to each other and particular attention was given to a) how well the designs consider the relevant TEN-T corridors in the region and b) how existing and future infrastructure can be combined. Finally, an overview of the H2-routes in a transalpine overview is given.

3.1 Comparison of H2-route designs and TEN-T corridors

All partners succeed in respecting and including the TEN-T corridors of their region (refer to overview table above). In all regions HRSs in the vicinity of TEN-T corridors have been suggested, but most HRS locations need to be repositioned for actual projects. The number of HRSs are always sufficient to meet the AFIR requirement of min. 1 HRS per 200 km of TEN-T road. However, the minimum daily capacity of H2 is not met by some scenarios optimized by the H2MA tool.

3.1.1 Vzhodna Slovenija (SI03; Eastern)

The main H2-route of the NUTS 2 region SI03 Eastern Slovenia, follows the Slovenian highway sections: A1, A2, A4 and A5, which is also a part of the Baltic Sea – Adriatic Sea TEN-T corridor. The chosen H2 route represents the most transit route, which also connects the 3 largest cities in Slovenia: Ljubljana, Maribor, and Celje. The H2 route connects central Slovenia with Croatia in the south, Hungary in the East, and Austria in the north.

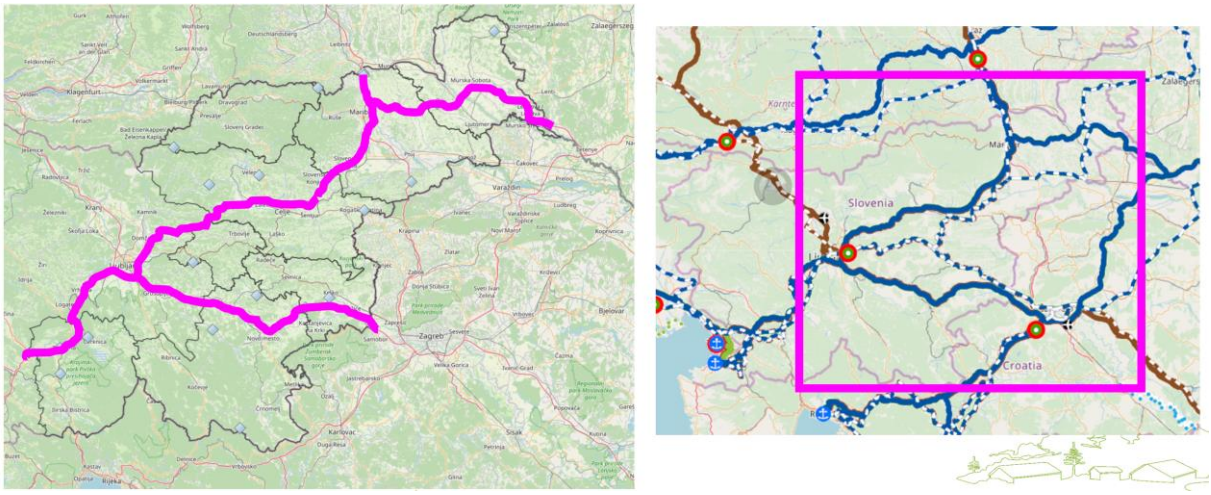


Figure 1: Baltic Sea – Adriatic Sea TEN-T corridor (Source: https://webgate.ec.europa.eu/tentec-maps/web/public/screen/home, 2024)

The H2MA tool suggests a total of **21 new HRSs**. Of those, 8 are positioned on the main road connections - 7 of those are located directly on the TEN-T core network (Baltic Sea – Adriatic Sea corridor), 2 in the vicinity of the main road connections, others are near cities or in rural areas, where the traffic frequency and transit are low, and the H2 demand will also probably be on a low level.

The proposed scenario was generated by the H2MA tool based on data taken from the Action program for alternative fuels in traffic for years 2022 and 2023 and the 2023 data on the number of registered vehicles per category, from SURS – Statistical office of Republic of Slovenia.

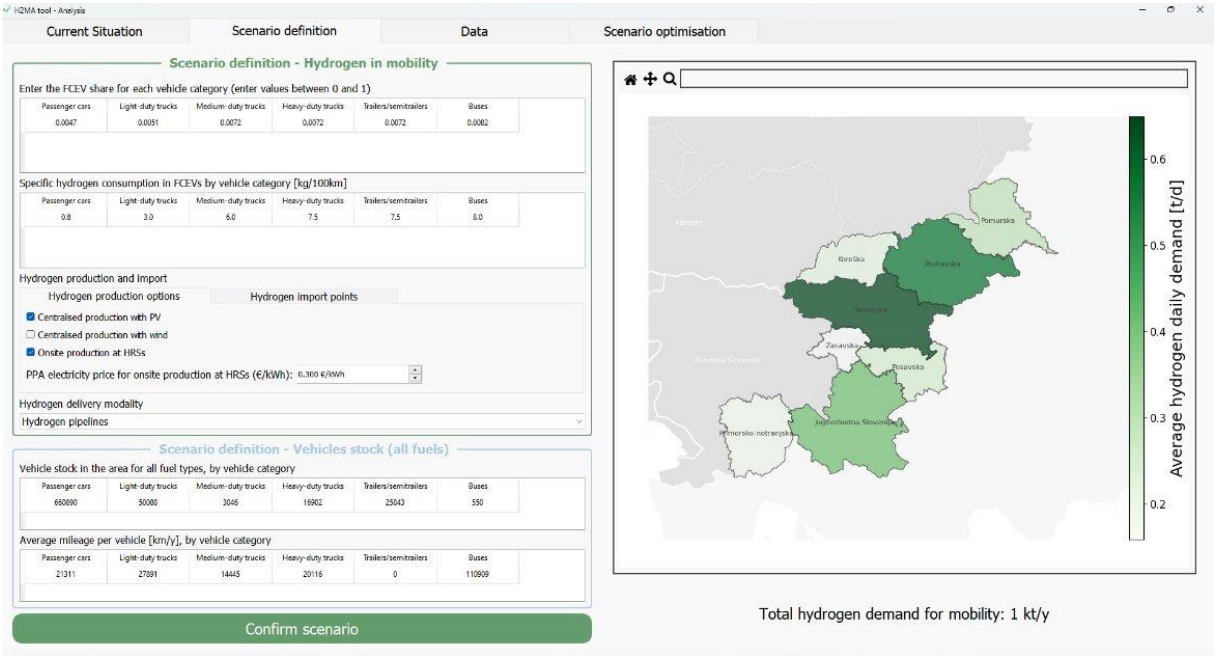


Figure 2: Input data for the scenario for Vzhodna Slovenija region

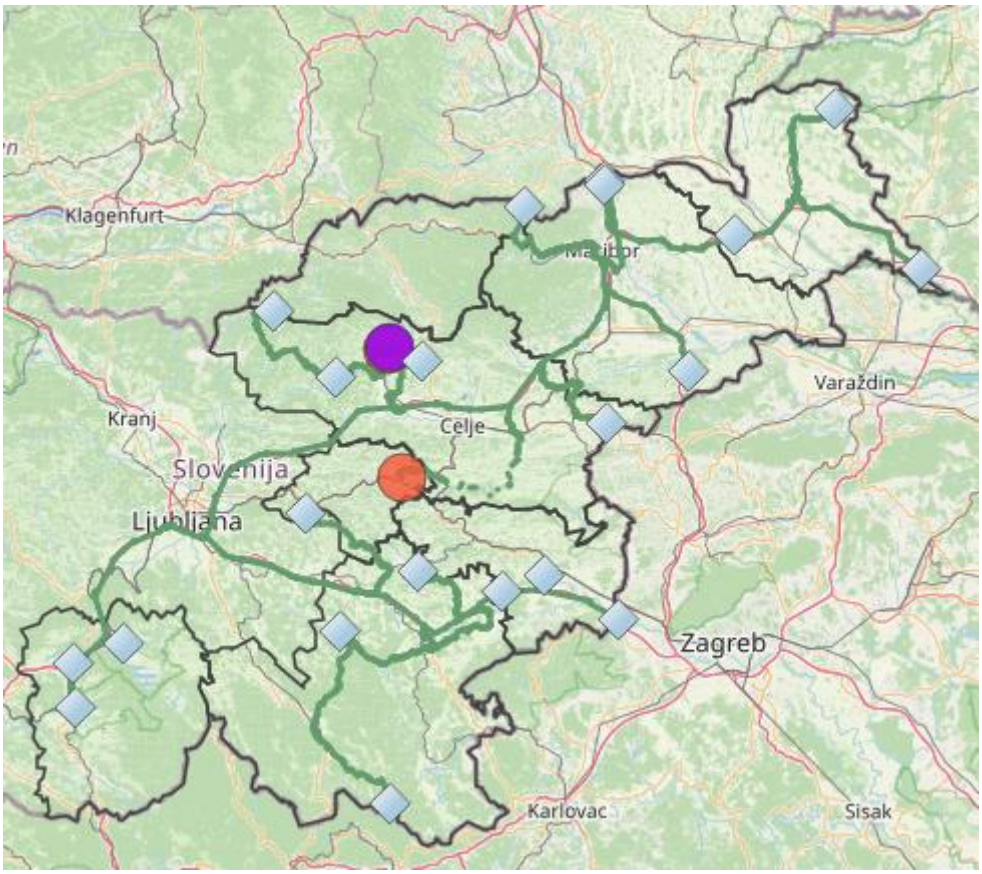


Figure 3: Locations of HRS and hydrogen pipelines suggested in the Vzhodna Slovenija region adjusted with input from LWG meetings

As visible, there are zero HRSs currently located in the EASTERN SLOVENIA cohesion region.

The exact locations will need to be further examined with the potential investors and owners of the existing filling stations on TEN-T corridors and on the transport nodes near major cities. The scenario seems plausible, but not comprehensively realistic.

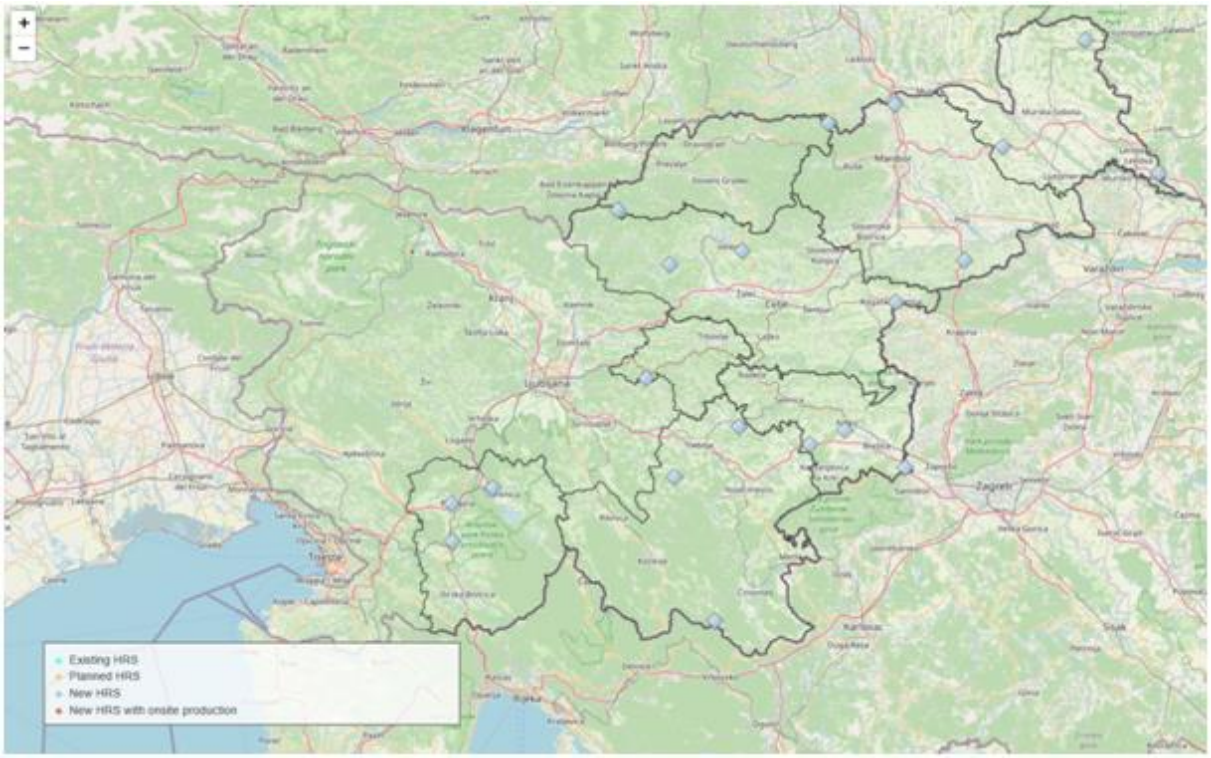


Figure 4: H2MA tool scenario, existing and planned and proposed new HRS, with pipeline H2 distribution. (Source: H2MA project, 2024)

Pipelines and **onsite production** were chosen as the delivery method. As the tool suggested pipelines should be located along the Baltic Sea – Adriatic Sea TEN-T corridor. This aligns with the expert suggestion, proposing that the H2 pipeline is build next to the existing natural gas pipeline. The operators of the natural gas distribution system are preparing for the upcoming H2 technology, but also emphasize high CAPEX and OPEX investments related to the H2 pipelines. The current distribution gas network in Slovenia could intake only 5-7% of H2. However, the EU directive limits the blending of the two gases up to 2%. The distribution by trucks is a cheaper option and more plausible short term. In the initial state, most HRSs will likely operate with onsite production or with centralized production.

3.1.2 Zahodna Slovenija (SI04; Western)

The main H2-route follows 2 TEN-T corridors Baltic to Adriatic Sea, A1 highway and E61 highway and Western Balkans to Eastern Mediterranean A2 highway and E61 highway.

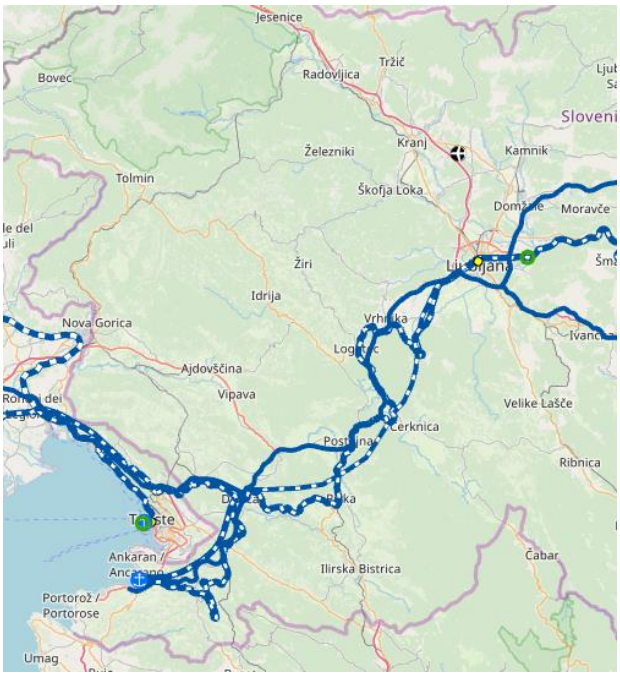


Figure 5: Baltic to Adriatic Sea TEN-T corridor (Source: https://webgate.ec.europa.eu/tentec-maps/web/public/screen/home, 2024)

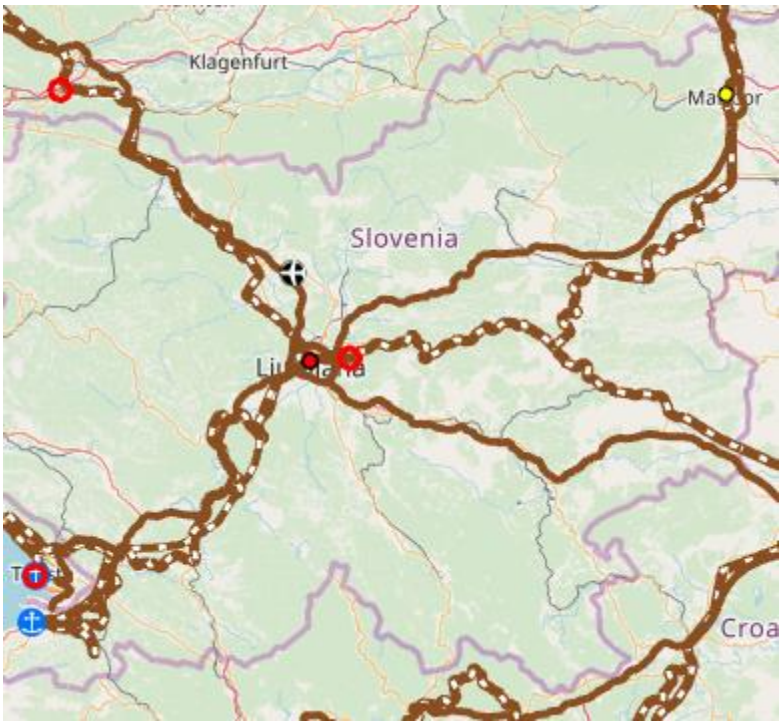


Figure 6: Western Balkans to Eastern Mediterranean TEN-T corridor (Source: https://webgate.ec.europa.eu/tentec-maps/web/public/screen/home, 2024)

The base data upon which scenario was generated by the H2MA tool were taken from the Action program for alternative fuels in traffic for years 2022 and 2023 and the 2023 data on the number of registered vehicles per category, from SURS – Statistical office of Republic of Slovenia.

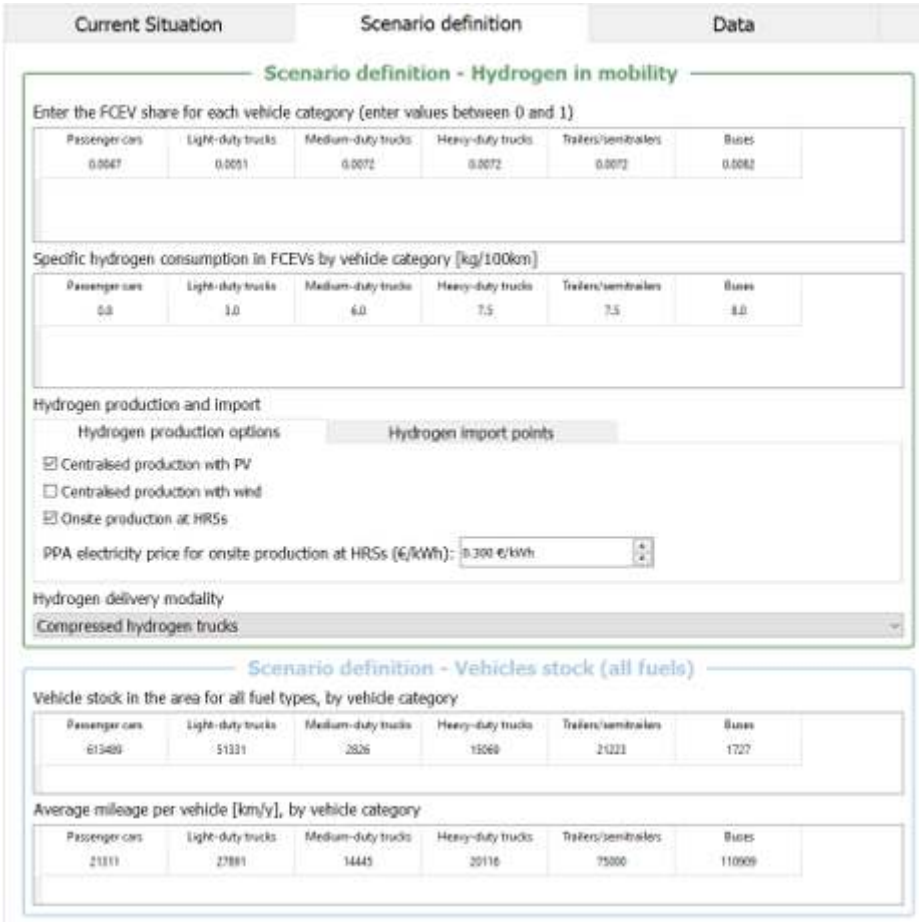


Figure 7: Input data for the scenario (Source: H2MA project, 2024)

The H2MA tool proposed **10 new HRS**, however, not all have been positioned correctly. Two scenarios were made, one for distribution of H2 by pipelines and one with the distribution of H2 by trucks. All other parameters stayed the same. The positioning of the HRS was in both cases the same.

In Gorenjska region there is one onsite production facility for green H2 in construction. One HRS is located in Lesce, Gorenjska region. In Goriška region, Deskle, another H2 production site and HRS is positioned.

The proposed HRS are positioned closer than every 200km. According to the H2MA tool the proposed capacity is less than 1t H2 per fuelling station. The EU directive states that the minimum capacity should be 1t of H2 per refuelling station daily.

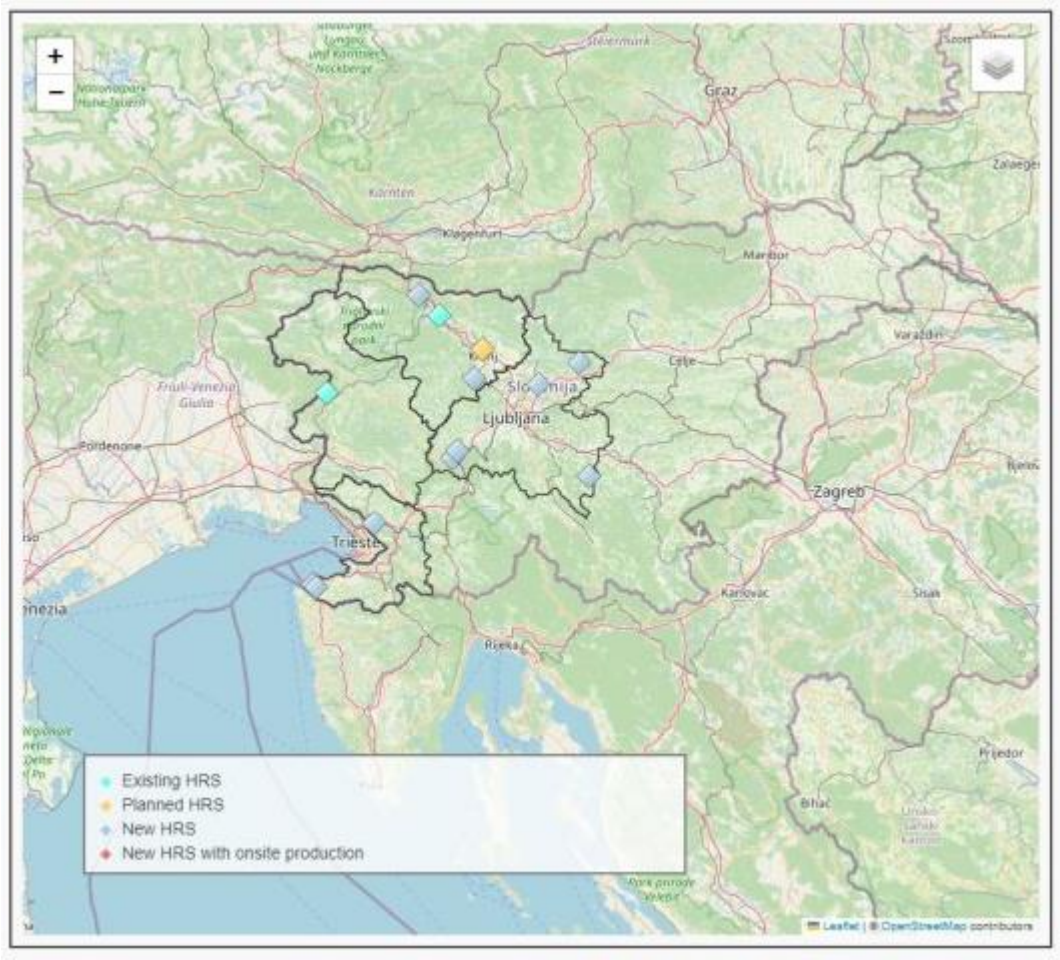


Figure 8: H2MA tool scenario, existing and planned and proposed new HRS, with pipeline H2 distribution. (Source: H2MA project, 2024)

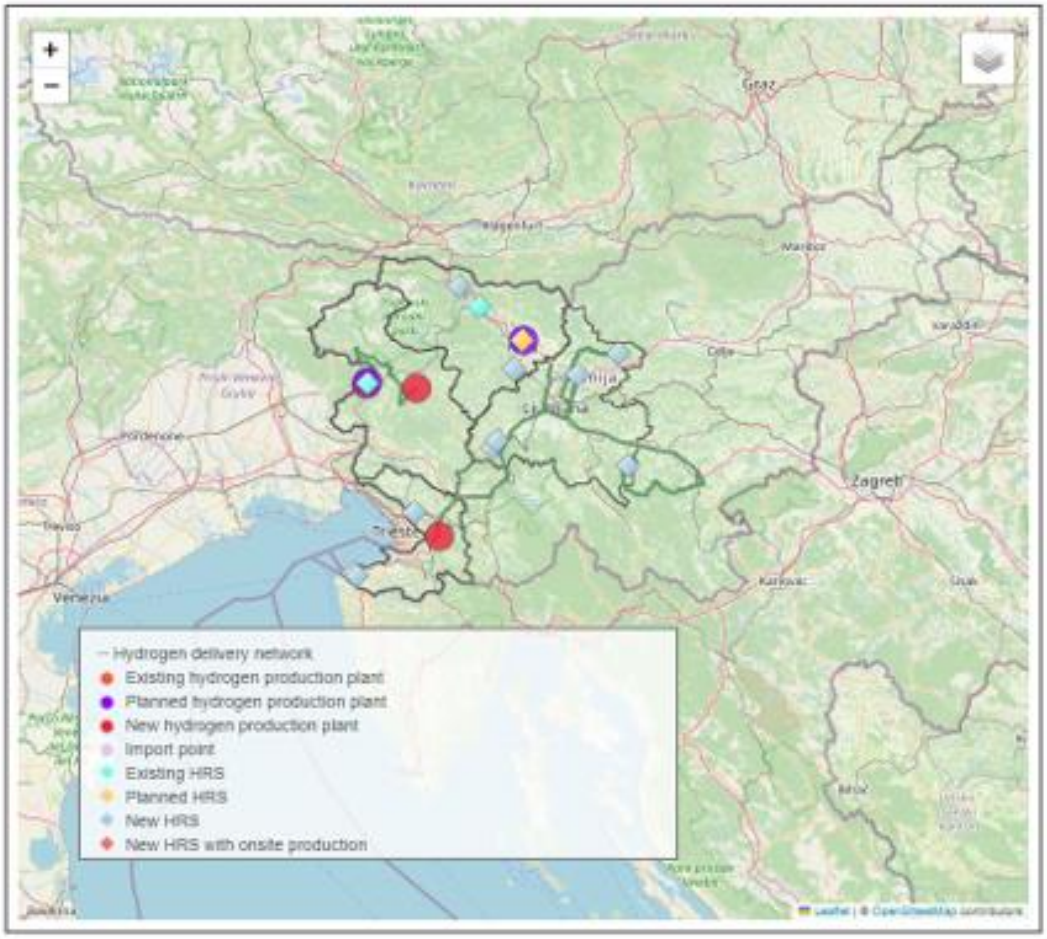


Figure 9: H2MA tool scenario with truck H2 distribution, existing and planned and proposed new HRS, existing and planned H2 production plants, new HRS with onsite production. (Source: H2MA project, 2024)

The main refuelling stations proposed for the Western cohesion region by the tool are located near the Austrian-Slovenian border by the highway, near the main national airport, near the highway near the border between Western and Eastern cohesion region, toward the south, direction Koper, near the capital city of Ljubljana (2 HRS), and two HRS are proposed near Koper. Toward Croatia, on A2 one HRS is proposed relatively near to the nuclear production plant Krško.

The demand capacity proposed by the H2MA tool scenario daily is the highest in the Central-Slovenia region and the lowest in Goriška region.

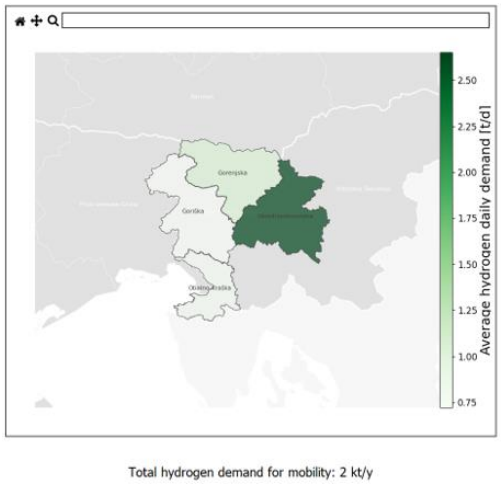


Figure 10: Average H2 daily demand in tonnes (Source: H2MA project, 2024)

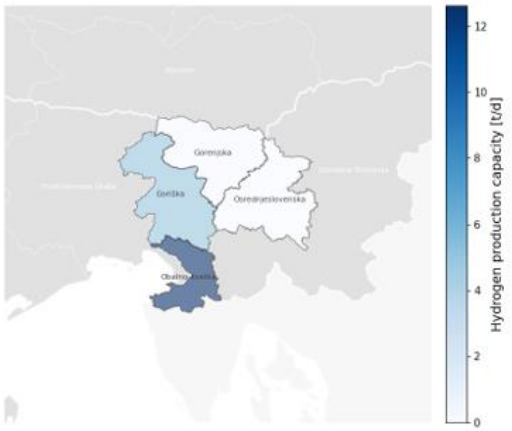
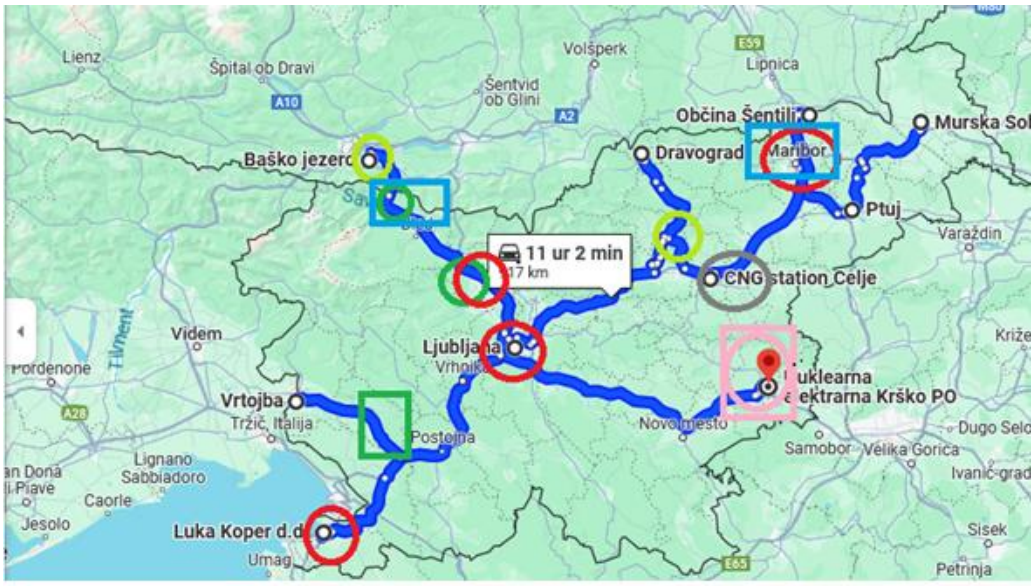


Figure 11: H2 production capacity.(Source: H2MA project, 2024)

The H2 production capacity, according to the H2MA tool should be in Obalno-Kraška (Coast-Kars) region and the lowest production of H2 should be in Gorenjska and Central-Slovenian region.

Taking into consideration other sources of energy production for H2 production, wind, water and nuclear power, other production locations could be a viable option.



	The area of planned public HRS, capacity in AT not known, capacity in Slovenia 5t of H2.
	Existing public HRS or under construction.
	Strategic locations where HRS should be positioned, from N to S: Maribor – second largest city with an airport; Ljubljana – first largest city; Luka Koper – the biggest port in Slovenia and logistic hub; Airport Jožeta Pučnika in Gorenjska region – the biggest national airport and logistic hub.
	Possible H2 production and HRS of grey H2.
	Possible HRS of pink H2.
	Planned production of pink H2.
	Potential for production of green H2 from RES - wind
	Potential production of renewable H2 form Hydroelectric production plants.

Figure 12: Possible sources for H2 production sites for Slovenia (Source: H2MA project, BSC, Ltd, Kranj, 2024)

The combination of tool scenarios and local working group meetings, with relevant stakeholders, proposes more elaborated scenario for the production, distribution, storage and refuelling stations of H2.

In Gorenjska region the H2 demand to one point will be catered by the on-site production of green H2 and delivered to the HRS, which are not directly connected to the production site, by trucks. There is one already existing production site of grey H2, with the capacities to produce green H2 by demand and one production site in construction less than 100km apart.

However, the majority of H2 production will probably be done outside Western Cohesion region. Therefore, for the most probable scenario the whole Slovenia should be considered. This is important also for the possibility to distribute part of the H2 by pipelines. One scenario proposes to build new pipeline next to existing natural gas pipeline, going in

direction of Baltic to Adriatic Sea TEN-T corridor, turning west in Coastal-Kars Region towards Vrtojba/Nova Gorica (Goriška region). In terms of Slovenia, 252 km of pipeline could be built for the hydrogen, from Spielfeld/Šentilj to Vrtojba/Nova Gorica/Gorizia.

Figure 13: Proposal of H2 pipeline (Source: Plinovodi, 2024)

3.1.3 Lombardy (ITC4)

As shown in Figure 14 the used input data leads to a result of a hydrogen demand for the mobility sector of 21.000 tons per year. The highest daily demand of around 13 tons per day is expected to be in the Milan area.

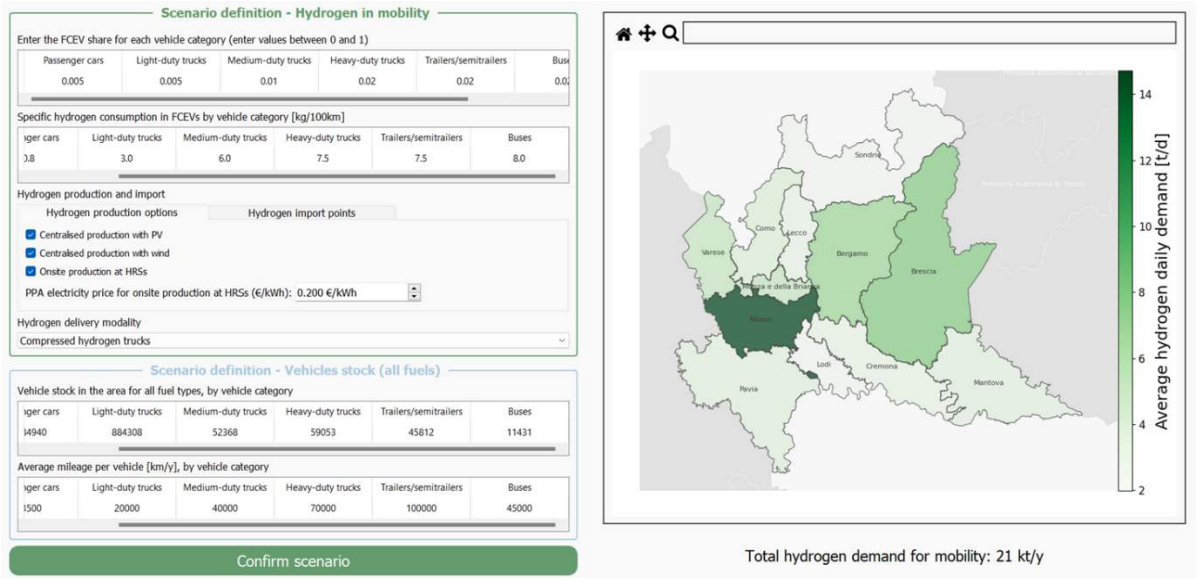


Figure 14: Input data for the scenario for Lombardy region

Based on the input data and the results by the H2MA tool locations for pipelines and HRS are shown in Figure 15.

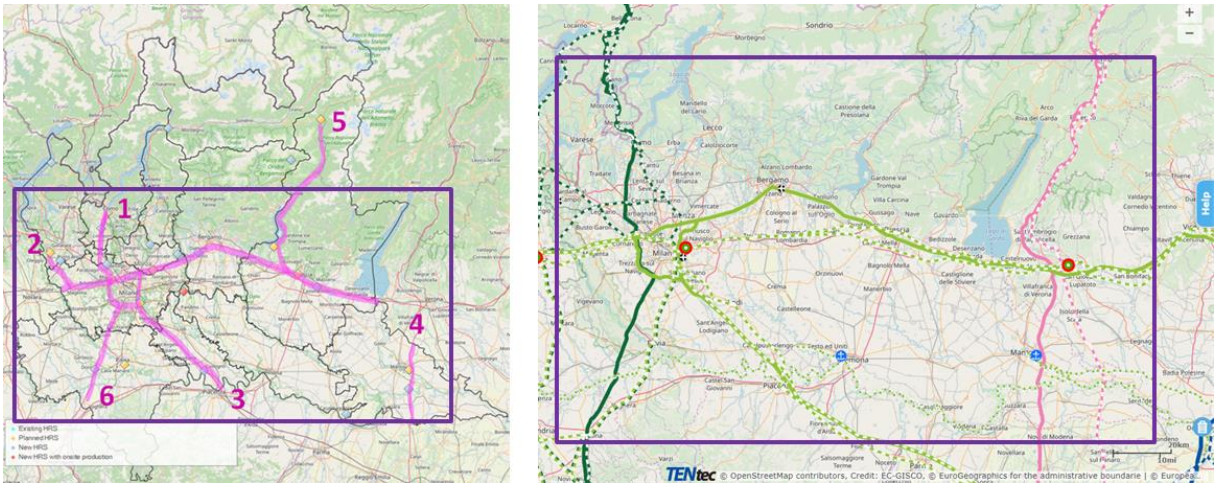


Figure 15: Locations of HRS and hydrogen pipelines suggested in the Lombardy region in comparison with the regional TEN-t network

The H2-routes 1 and 6 connect A7 highway with A8 and A9 highways, which are part of the North Sea-Rhine-Mediterranean TEN-T corridor. The H2-route 2 is an important west-east corridor that go through the main provinces of Region: Milano, Bergamo, Brescia. H2-route 3 follows the A1 highway, a main axis of the Italian motorway network. Route 2 and 3 are part of the TEN-T Mediterranean corridor.

H2-route 4 is part of Scandinavian-Mediterranean TEN-T route.

The H2MA tool suggest a total of **16 new HRSs**. Of those, 7 are in the vicinity of the main H2-routes. 2 HRSs are closed to Switzerland and 3 HRSs are closed to the neighbouring region Emilia Romagna.

The H2-route is based first of all on the main highways that **connect the capital city of Milan** to:

- **Switzerland (1)**
- **Piedmont and Malpensa airport** in the west and **Venice** in the east **(2)**
- Bologna, in the direction of **Rome (3)**
- Genoa and the **Tyrrenian sea (6)**

In addition, a hydrogen route is located on the road between Germany and Bologna, crossing the Lombard territory **(4):** here a hydrogen valley is currently planned, next to the city of **Mantova**.

Another hydrogen route has been drawn **from Brescia to Edolo (5),** on the route of the H2-Iseo project (hydrogen trains; project plans also bus refuelling stations)

Other HRS drawn by H2MA tool outside these tracks seem less prioritary.

3.1.4 Franche-Comté (FRC2)

In the following graphic the input data for the scenario for Franche-Comté region is shown. Trucks were chosen as delivery method in the region.

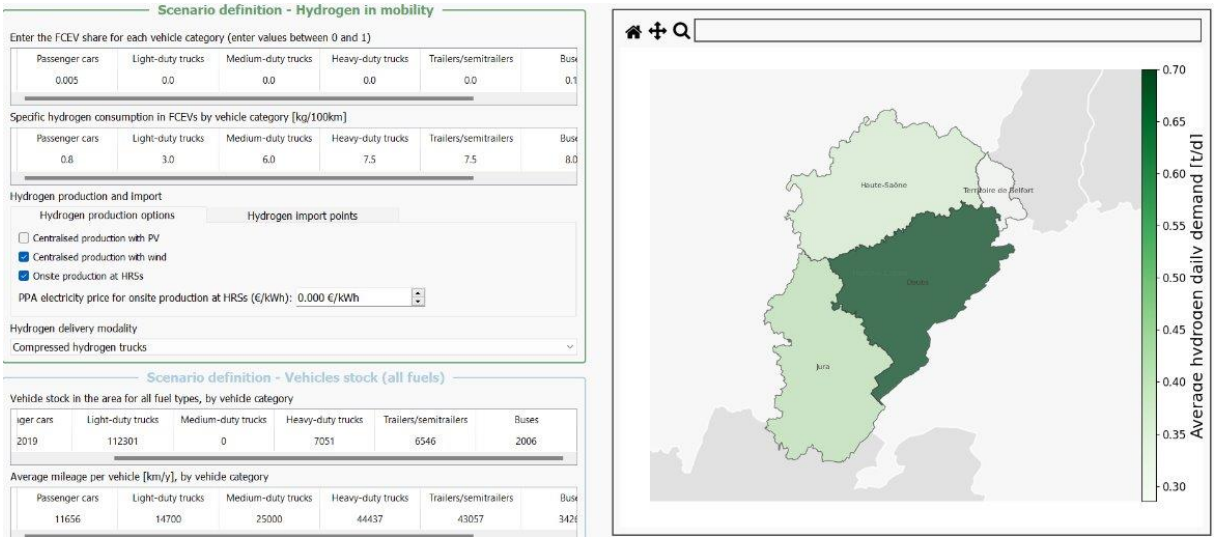


Figure 16: Input data for the scenario for Franche-Comté region

For this region, Pipelines are not considering for the short-term period that is why delivery by trucks was considered. The only pipeline project existing is linked to the European project Hy-FEN.

There would be an entry point from the region Auvergne-Rhône-Alpes region at ETREZ (with underground storage) and which, for the time being, would only cross the region without any identified use.

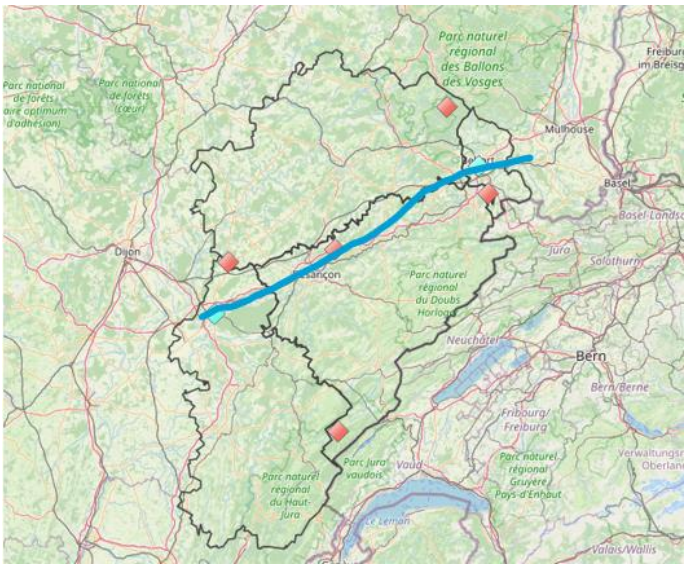


Figure 17: Results of the H2MA tool regarding HRS and pipeline network in the Franche-Comté region

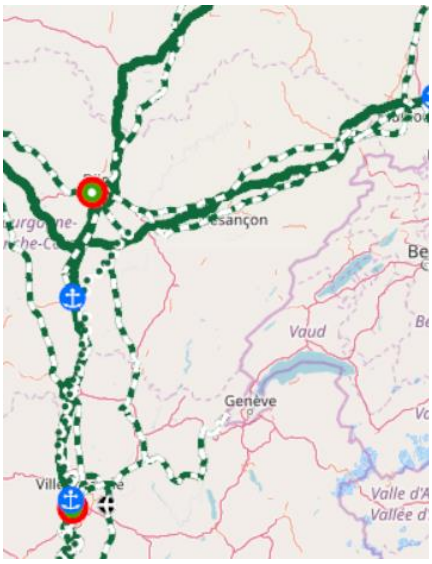


Figure 18: TEN-t network in the Franche-Comté region

Planned route align with Ten-T corridors considering the city the main hub Besançon which is a strategic point to connect with other regional hubs like Belfort and Dole.

Five new HRS with onsite production are identified, three of them are strategically located near the two main hubs and H2 routes. The 2 remaining HRS are located further from H2 route taking into consideration nearest regions but will require a more detailed evaluation to determine their feasibility.

There are only two HRSs currently installed in the region. These are directly on the H2 routes (Dole and Belfort). Two existing HRSs are installed very close to the region in Alsace (FR) and Switzerland (CH), which need to be more closely examine.

The main H2-route in the Franche-Comté region passes through Besançon and follows the A36 highway, which is part of the north sea – rhine-meditteranean TEN-T corridor. This route is strategically significant as it connects key cities and economic hubs within the region, including Belfort.

The H2MA tool suggest a total of **5 new HRSs**. Of those, 3 are in the vicinity of the main H2-routes. 8 HRSs in rural areas and close to neighbouring regions and the neighbouring regions in France(Alsace) and Switzerland need specific planning.

3.1.5 Alsace (FRF1)

The main H2-route 1 follows the River Rhine and the A5 highway, part of the North Sea-Rhine-Mediterranean TEN-T corridor for cross-border transport. H2-route 2 links the south of Alsace with the other region “Franche Comté” and Switzerland. The main road from Strasbourg to Mulhouse, for example, is important for trucks because, unlike in Germany, they do not pay highway tolls.

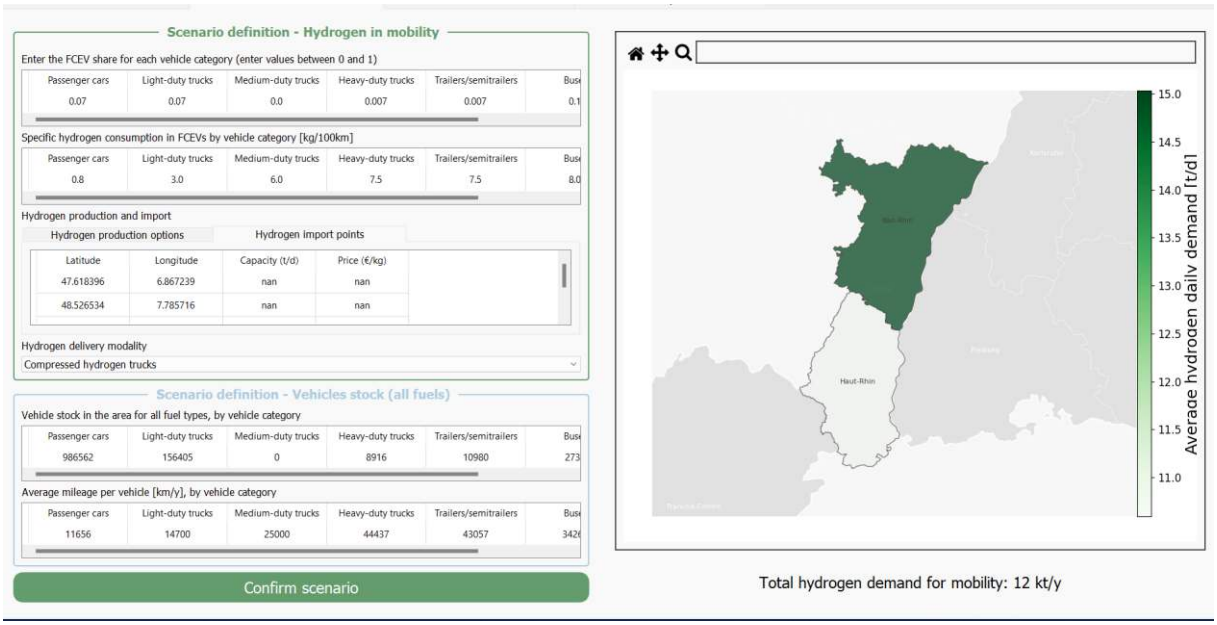


Figure 19: Input data for the scenario for Alsace region

The scenario for the Alsace region is based on data shown in Figure 19 total hydrogen demand for mobility is estimated to be 12.000 Tons per year with the highest demand in the north of the region with around 14 tons per day. Compressed hydrogen trucks were chosen as delivery method.

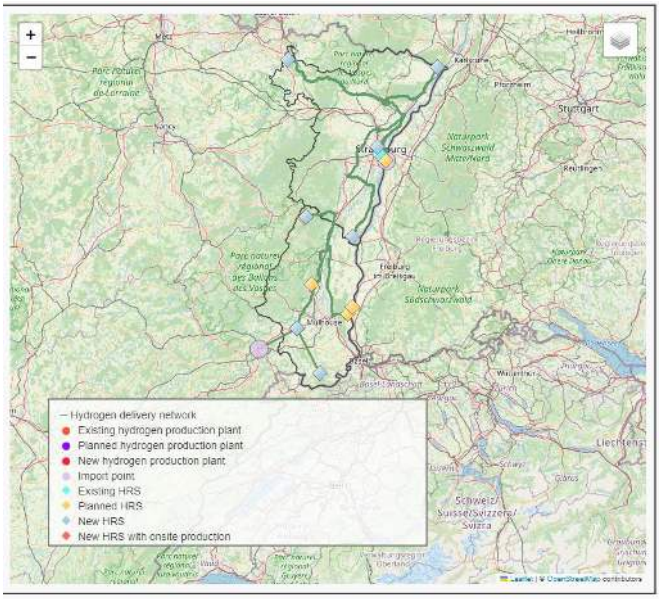


Figure 20: Hydrogen delivery network with import points and HRS (existing, planned) for Alsace region (considering the already planned production plant located near Strasbourg and the existing Production plant in Belfort in the nearby region (Franche - Comté FRC2)

Figure 21: H2-routes based on the main highways that connect the hub Strasbourg to Mulhouse (3) and the Ten-t network connecting Germany to France. (1 and 2)

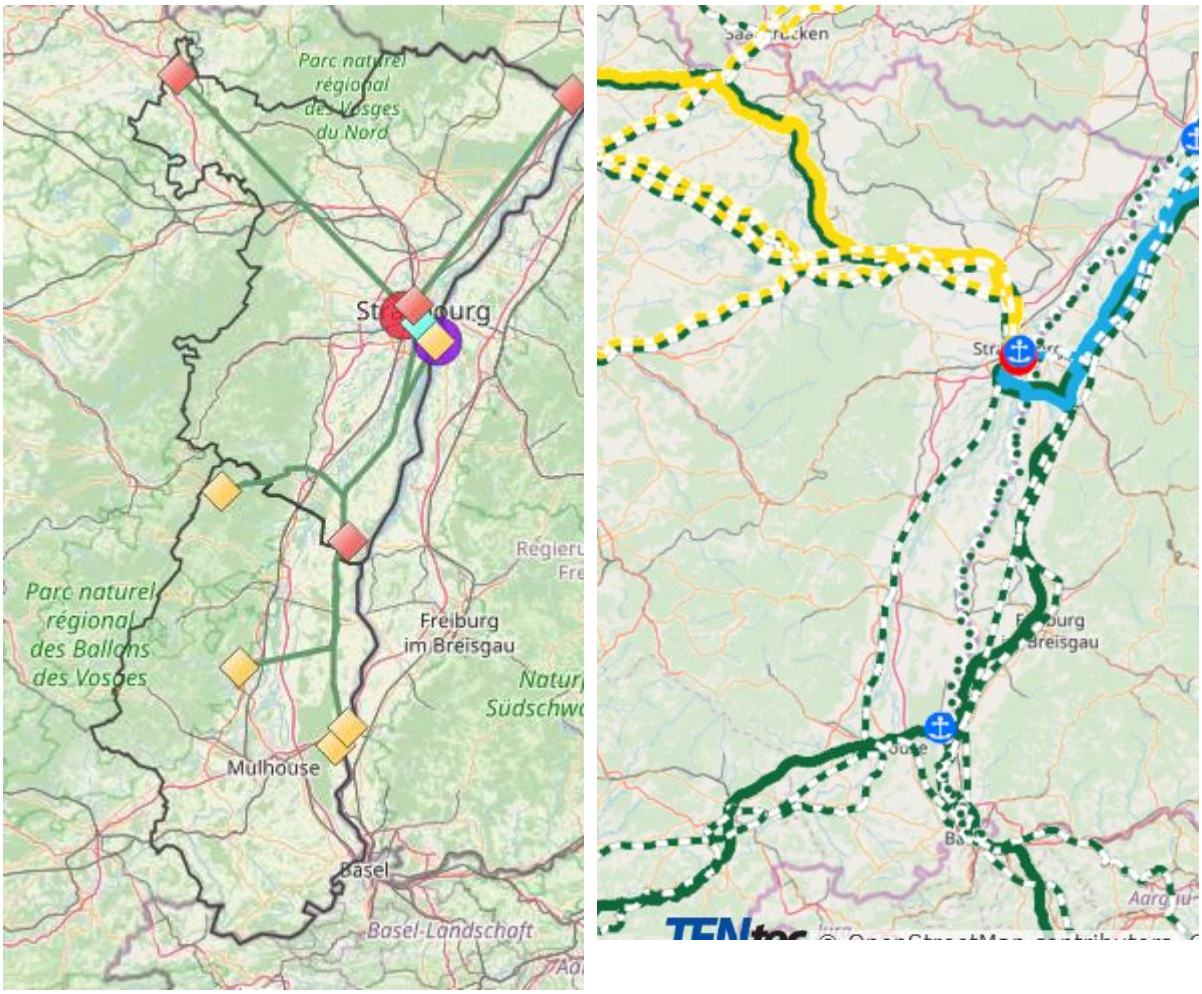


Figure 22: Locations of HRS and hydrogen pipelines suggested in the Alsace region in comparison with the regional TEN-t network

The H2MA tool suggest a total of **7 new HRSs**. Of those, 3 are in the vicinity of the main H2-routes. 4 HRSs in rural areas and close to neighbouring regions and the neighbouring states France and Switzerland need specific planning.

3.1.6 Piemonte (ITC1)

The results are based on the following sources and data:

Italian National Resilience and Recovery Plan:

As part of Italy's National Resilience and Recovery Plan, a number of Hydrogen Refueling Stations (HRS) are currently under construction across the country. By March 2024, these initiatives aim to significantly enhance the hydrogen refueling infrastructure to support the growing demand for hydrogen fuel cell vehicles (FCEVs).

HYMPULSION:

In the Lyon region of France, the HYMPULSION project is progressing well with its Hydrogen Refueling Station (HRS) network. As of May 2024, this network is set to play a crucial role in supporting hydrogen mobility in the region, catering to both light and heavy-duty vehicles.

HYDROSPIDER:

Similarly, in Switzerland, the HYDROSPIDER project has been developing an extensive HRS network. By May 2024, this network aims to support the increasing number of hydrogen-powered vehicles, ensuring that Switzerland remains at the forefront of hydrogen mobility in Europe.

Heavy Duty Vehicles Transit Passages:

Data from BD3Piedmont and AISCAT indicates a significant number of average daily transit passages of Heavy Duty Vehicles (HDV, category N3) on sections of the regional highway network. This data is crucial for planning and optimizing the placement of hydrogen refueling stations to support HDVs effectively.

Estimated HDV and LDV Hydrogen Fuel Cell Vehicles by 2030:

According to HYDROGEN EUROPE (February 2024), it is estimated that a substantial number of Heavy Duty Vehicles (HDVs) and Light Duty Vehicles (LDVs) will be powered by hydrogen fuel cells by 2030. This transition is essential for reducing emissions and achieving sustainability goals within the transportation sector.

Estimated LDV Sales by Province and Fuel Category:

Data from ANFIA for the years 2022 and 2023, distributed by province based on registered vehicle stocks as of 2023 (ACI/ANFIA data), provide an estimate of LDV sales per year by fuel category. This information helps in understanding market trends and planning for future infrastructure needs.

Average Refueling Quantity Benchmark:

The average refueling quantity benchmarks for different types of vehicles are established to optimize refueling processes. For Heavy Duty Vehicles (HDVs), the average is based on models like IVECO and Hyundai tractor H2 6x2. For Light Duty Vehicles (LDVs), the benchmark is based on the OPEL E-H2 Vivaro. These benchmarks are critical for designing efficient and user-friendly refueling stations.

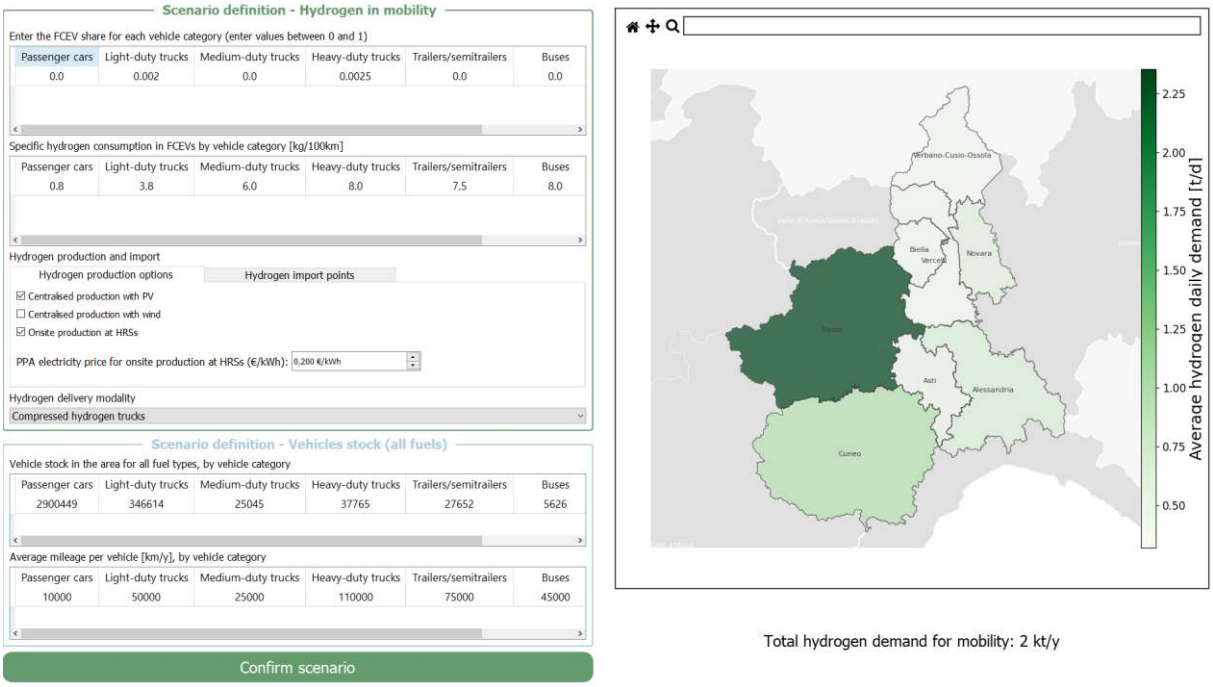


Figure 23: Input data for the scenario of Piemonte region

As shown Figure 23 in the hydrogen demand for Piemonte region is expected to reach 2000 tons per year. The highest daily demand is expected for the Torino area with around 2 tons per day.

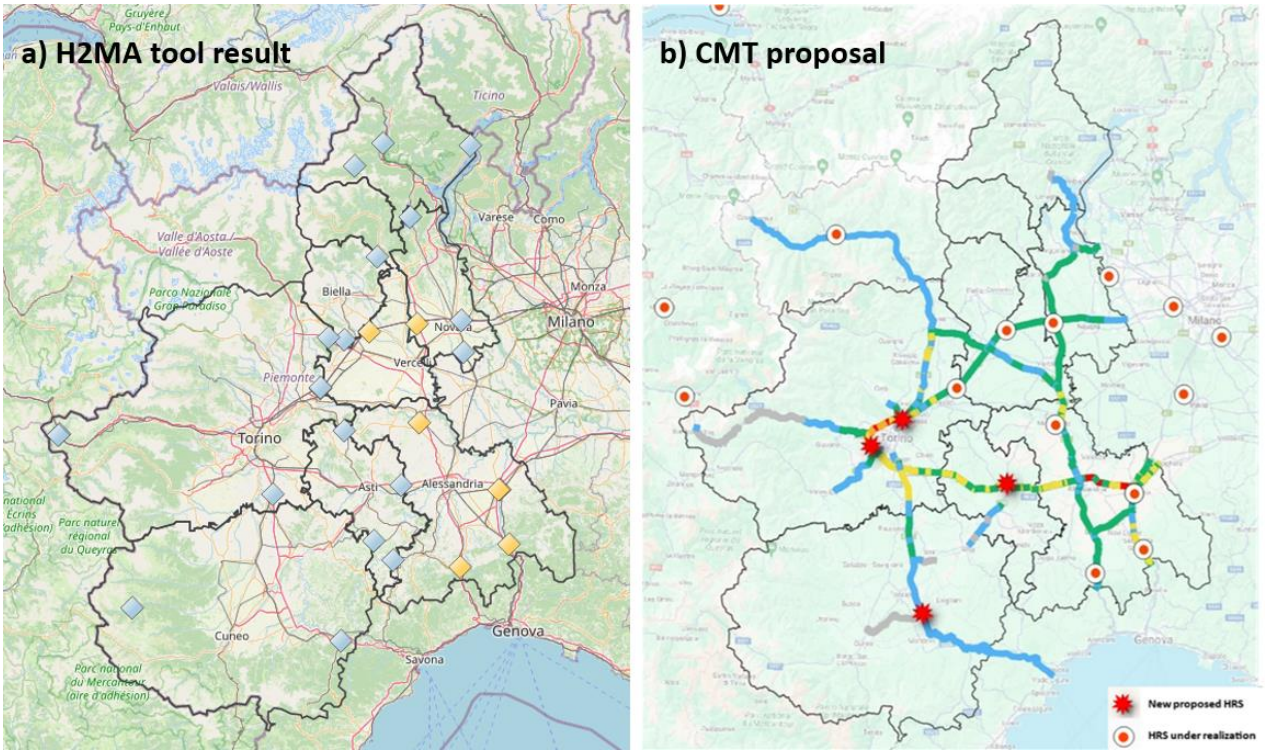


Figure 24: Locations of HRS and hydrogen pipelines suggested in the Piemonte region in comparison with the regional TEN-t network

A comparison of figures a) and b) show, that extensive analysis and discussion happened while planning the H2-route and of **18 HRSs** proposed by the H2MA tool, only 4 HRSs with adjusted positions are proposed for the H2-route of the Piemonte region.

Main investment are needed:

- to complete the MED TEN corridor with an HRS in Torino
- Rhine Alpes already accomplishes to AFIR

Proposed 3 other routes:

- E70 from Torino to Bologna
- E25 Form T1 Mont Blanc to Torino
- E 717 from Torino to Vado (large COSCO container port in W Italy)

The four new stations proposed will make HRS density alongst TEN to AFIR under a transnational and trans regional approach.

Using a “redundancy“ approach, a second HRS is expected in the Torino Urban area ensuring fuel availability under all conditions.

3.1.7 Freiburg (DE13)

The scenario for the Freiburg region is based on data shown in Figure 25. The total hydrogen demand for mobility is estimated to be 18.000 Tons per year with the highest demand in the Ortenaukreis with 9 tons per day. Pipelines were chosen as delivery method.

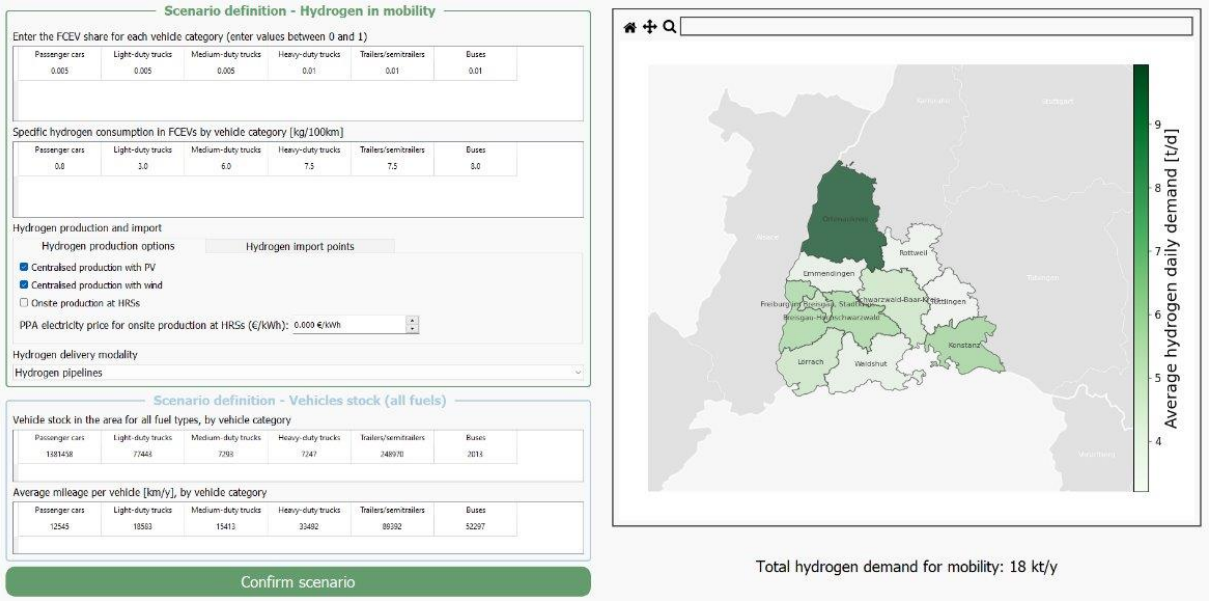


Figure 25: Scenario definition for Freiburg region

The tool suggested more pipeline kilometres than experts think will reasonably and cost-effectively be built. Along the main TEN-T corridor the pipeline makes sense, in more rural areas the concepts needs to be discussed.

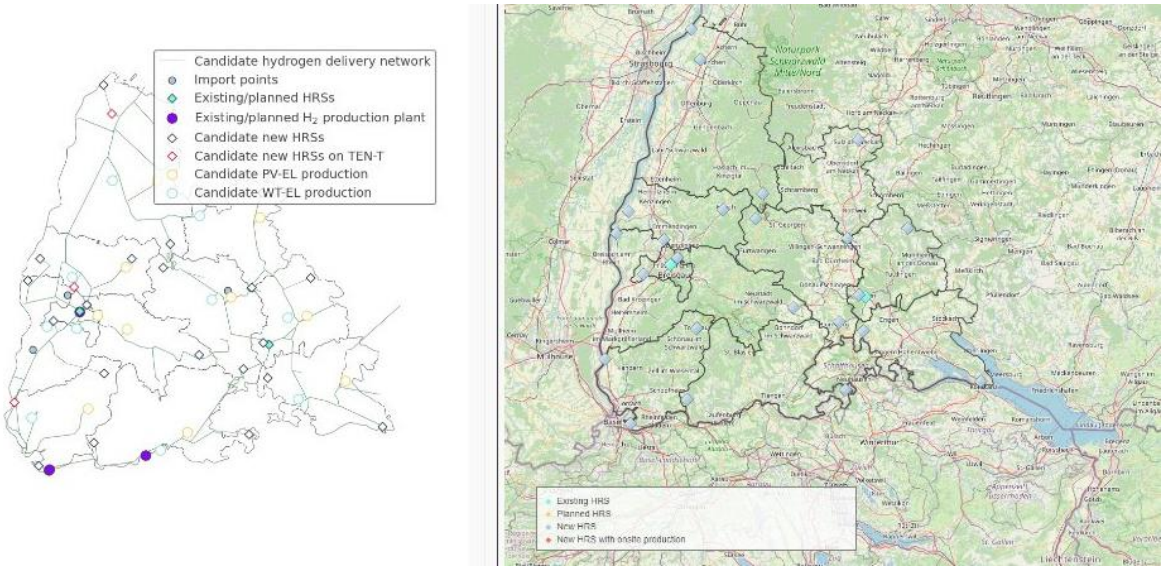


Figure 26: Results for candidate hydrogen delivery network and HRS generated by the H2MA tool

By the comparison of the results with the regional TEN-t network there are three main H2-pipeline-routes with are shown in Figure 27.

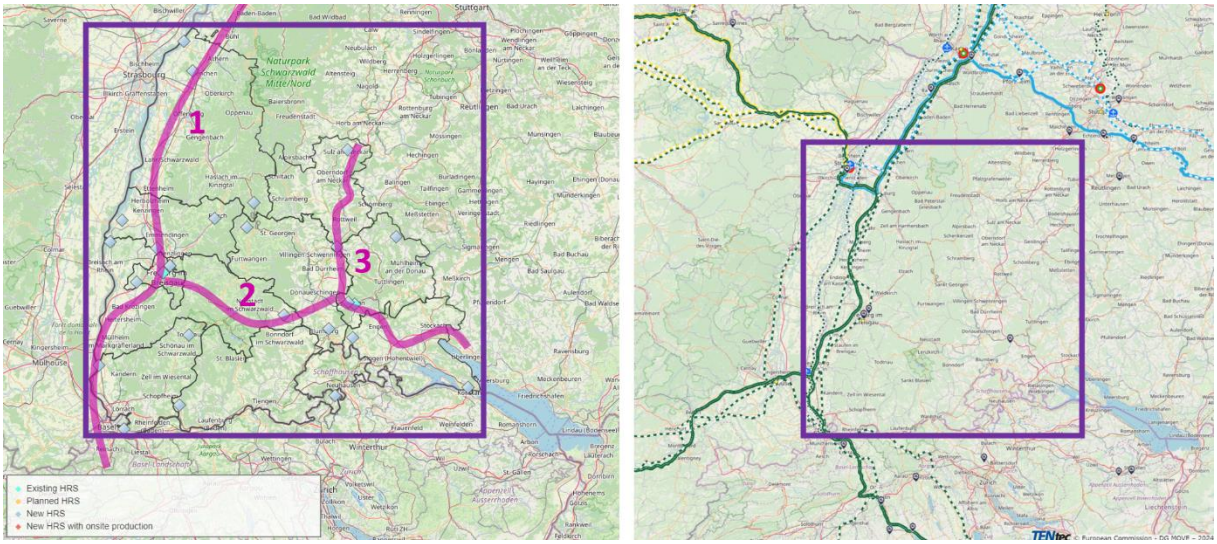


Figure 27: Locations of HRS and hydrogen pipelines suggested in the Freiburg region in comparison with the regional TEN-t network

The main H2-route 1 follows the river Rhine and the highway A5, which is part of the North Sea-Rhine-Mediterranean TEN-T corridor. The H2-route 2 is an important west-east connection. H2-route 3 follows the highway that connects the mobility hub Stuttgart with the Lake Constance area and Switzerland, which is relevant for the Danube TEN-T corridor. The H2MA tool suggest a total of **26 new HRSs**. Of those, 16 are in the vicinity of the main H2-routes. 8 HRSs in rural areas and close to neighbouring regions and the neighbouring states France and Switzerland need specific planning.

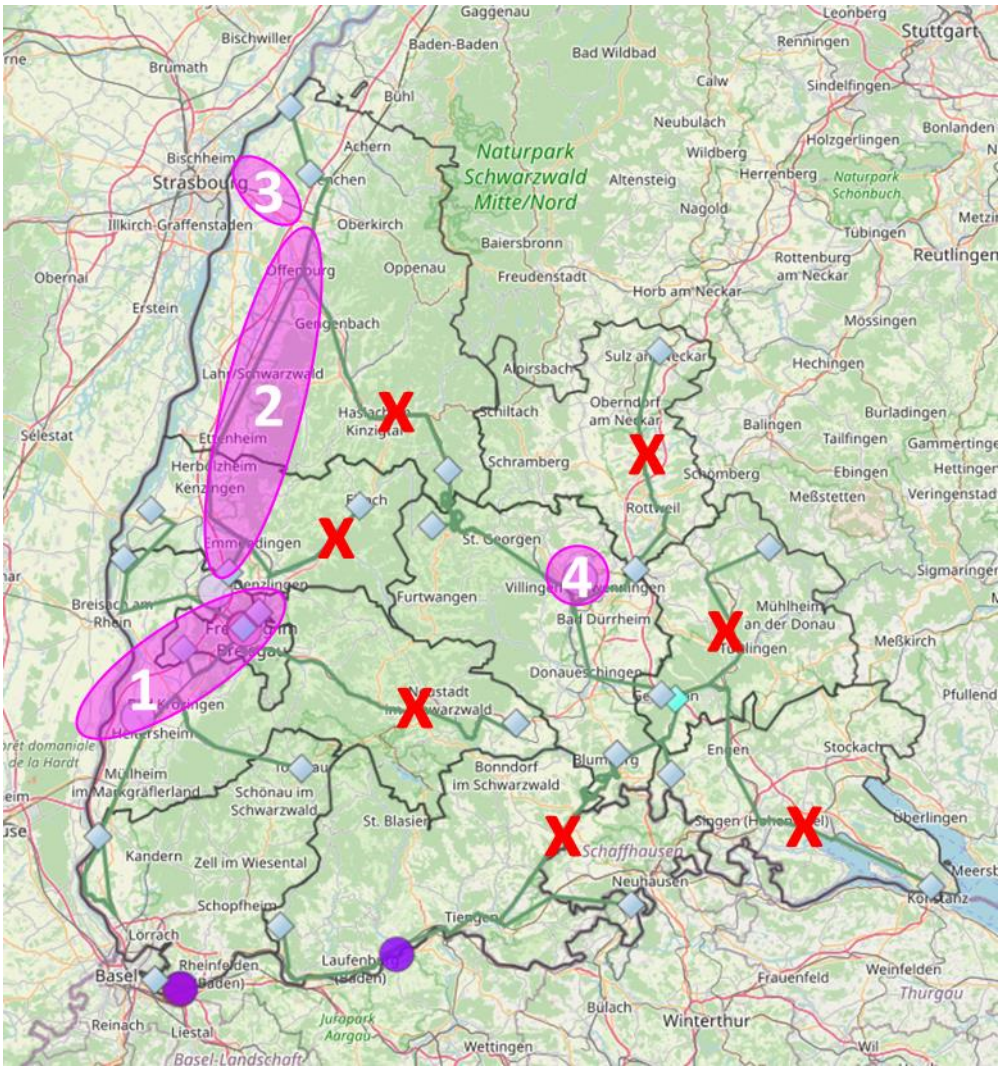


Figure 28: H2-Hubs with pipelines and HRS along the TEN-T corridor in the Freiburg region; Pipelines in the Black Forrest Mountains due to geographical issues unlikely to realise

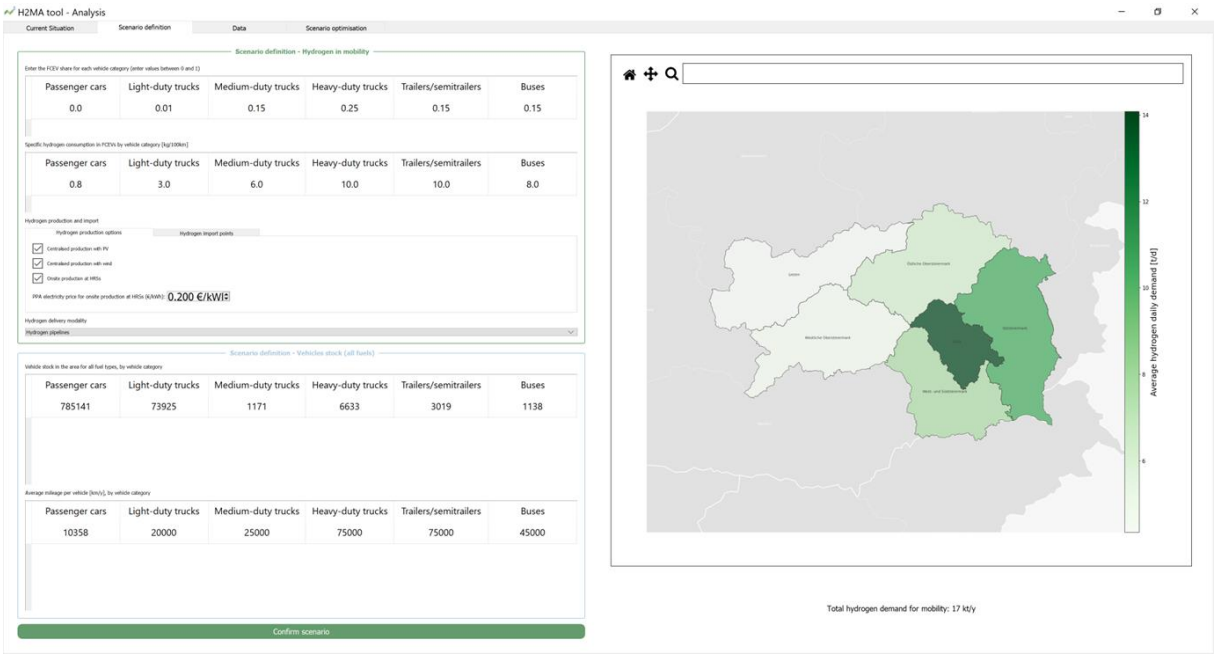
With regard to the German H2 backbone, the pipeline of the project RhynInterco has been approved (1).

An additional extension from Freiburg to Offenburg is likely (2), potentially a further extension to Kehl is possible (3).

Other pipelines, particularly in rural areas, will need to present a strong business case and are rather unlikely (X). Regional concepts, like the H2-trailer Hub in Villingen-Schwenningen (4) can serve rural areas.

3.1.8 Styria (AT22)

The scenario for the Styrian region is based on data shown in Figure 25. The total hydrogen demand for mobility is estimated to be 17.000 tons per year in 2040 with the highest demand in the region around the capital city of Graz. Pipelines were chosen as delivery method.



Route 1: Highway A9 Slovenian boarder to Graz and A2 going to Vienna – transit route with high traffic volume. Including the S7 - Turn off in the direction of Burgenland and on to Hungary(1a). The Trans Austria gaspipeline (TAG) runs virtually parallel to the route and is due to be rededicated by 2030 (part of the Hydrogen Backbone), which means that HRS can be supplied by pipeline.

Route 2: Highway A9 transit-route (from Graz going to Upper Austria; route for Austrian inland traffic). Turn off at Liezen direction to A10 (2a; Salzburg – Germany)

Route 3: S35-S6 connection between Graz and Lower Austria (going to Vienna) – important as on this route is a lot of heavy industry (steel, paper, etc.)

Route 4: section of A2 from Graz to Carinthia (going to Italy) – transit route with high traffic volume. TAG pipeline nearby – will be rededicated until 2030.

Route 5: S36 connection from St. Michael to A10 (Tauern Highway) minor importance for heavy duty transport, but for Austrian inland traffic.

Along the main corridors (Route 1, Route 3 and Route 4) a pipeline makes sense as until 2040 the main pipelines will be rededicated or hydrogen pipelines will exit. In other or more rural areas the concepts needs to be discussed. Furthermore, onsite production could be more favourable in some locations.

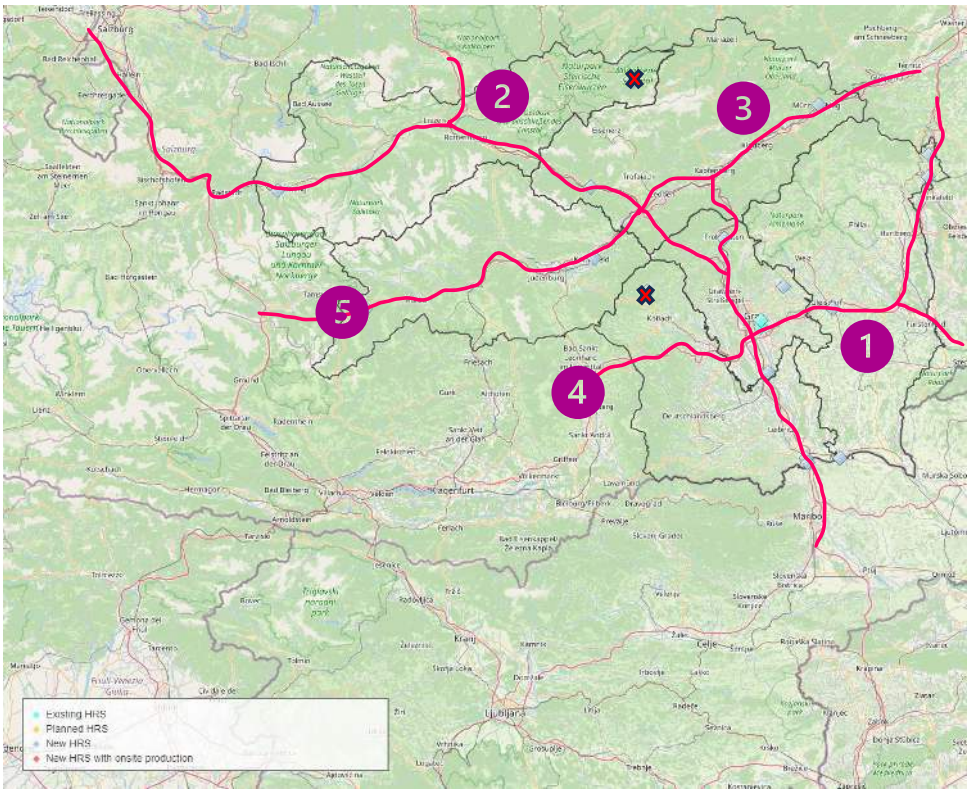


Figure 29: Locations of HRS and hydrogen pipelines suggested in the Styria region in comparison with the regional TEN-t network

Nine out of **16 proposed new HRSs** are on the TEN-T corridors.

The two marked with **X** must be replaced as the location is inappropriate for heavy duty transport. For the others in rural areas and close to neighbouring regions and the neighbouring states specific planning is needed.

In addition, the location of some HRSs in the vicinity of the TEN-T network was also adjusted during the LWG to take local conditions into account. A comparison is shown in the following two figures.

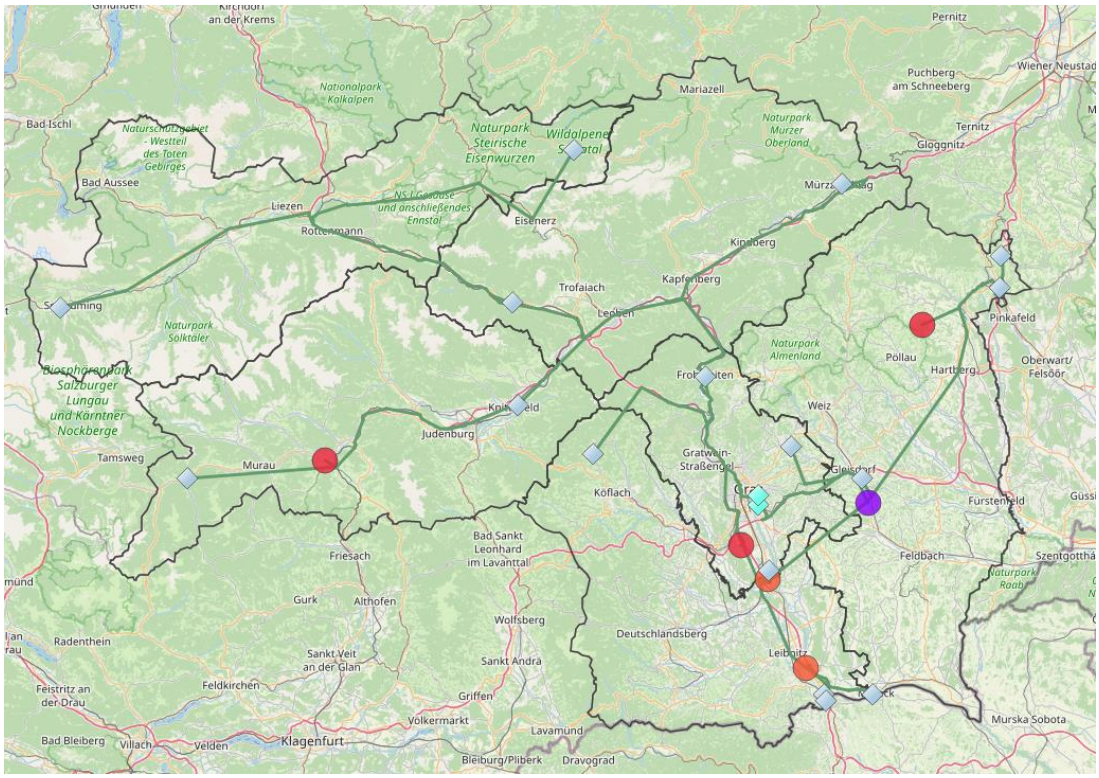


Figure 30: Locations of HRS suggested in the Styria region by the H2MA-Tool

In addition to the results of the H2MA tool the input of the LWG meetings was implemented for more detailed results. These are shown in Figure 31.

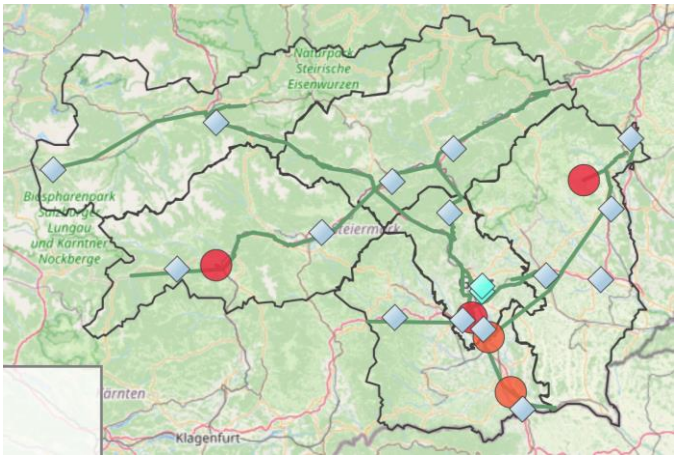


Figure 31: Locations of HRSs adjusted with input from LWG meetings

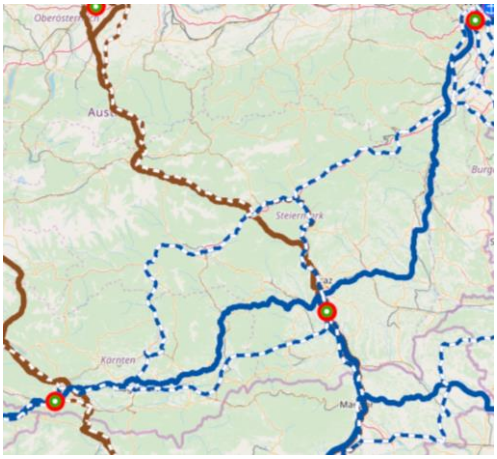


Figure 32: TEN-t network in the Styria region

For the green H2-routes the Baltic Adriatic corridor (blue) and the Western Balkan-Eastern Mediterranean corridor (brown) have been considered. These are important freight transit routes.

3.1.9 Vienna (AT13)

The main H2-route 1 follows the A21 motorway which is part of the TEN-T Baltic Adriatic, Rhine-Danube corridor. The H2-route 3 is an important west Austria connection starting from the city centre (urban logistics). H2-route 2 follows the highway that connects the Baltic Adriatic, Rhine-Danube corridor with the Vienna Airport.

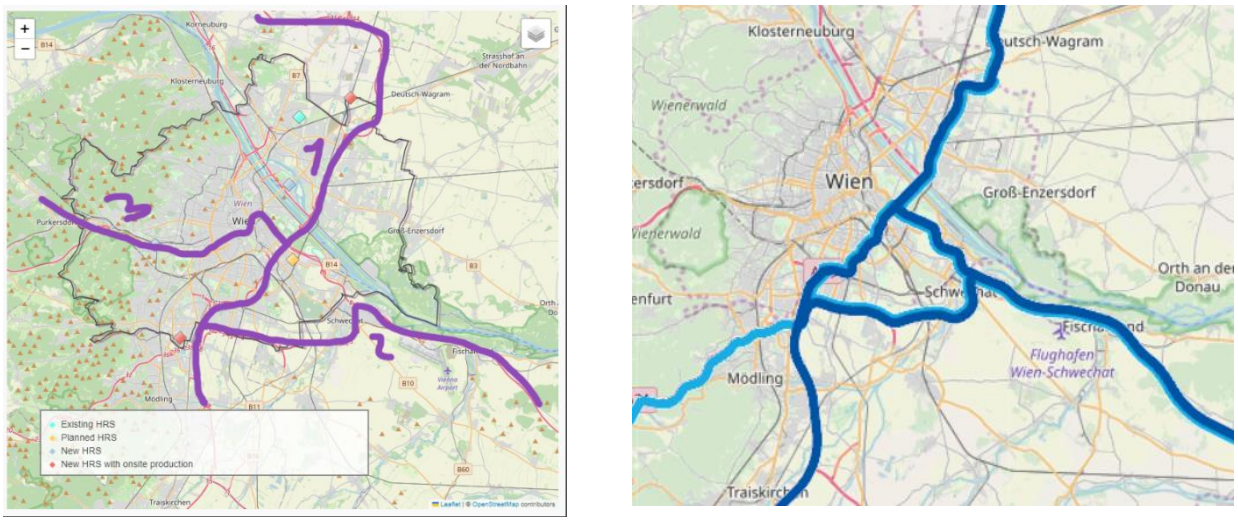


Figure 33: H2-routes compared to the TEN-t network in the Vienna area

The H2MA tool suggest a total of **4 new HRSs**. All of them are above 1 tons/day as requested from AFIR Reg. Of those, 2 are with onsite production. In addition, those with onsite prod. are near the TENT corridor. The western HRS is located on H2 route 3. One new HRS is located near to Danube the river potentially serving inland waterways connections. Actually, one HRS is missing near the Vienna Airport as important hub allowing to reach nearest regions and countries.

3.1.10 Stuttgart (DE11)

The scenario for the Stuttgart region is based on data shown in Figure 34. The total hydrogen demand for mobility is estimated to be 27.000 Tons per year with the highest demand in the Stuttgart area with 9 tons per day. Pipelines were chosen as delivery method.

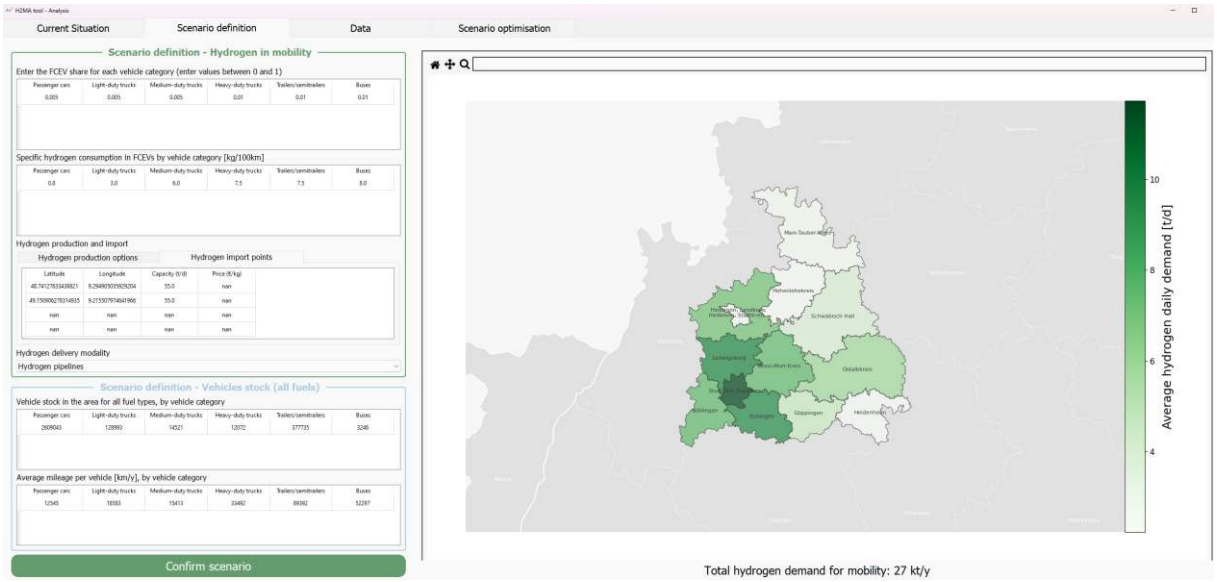


Figure 34: Scenario definition for Stuttgart region

Based on the input data the scenario was developed.

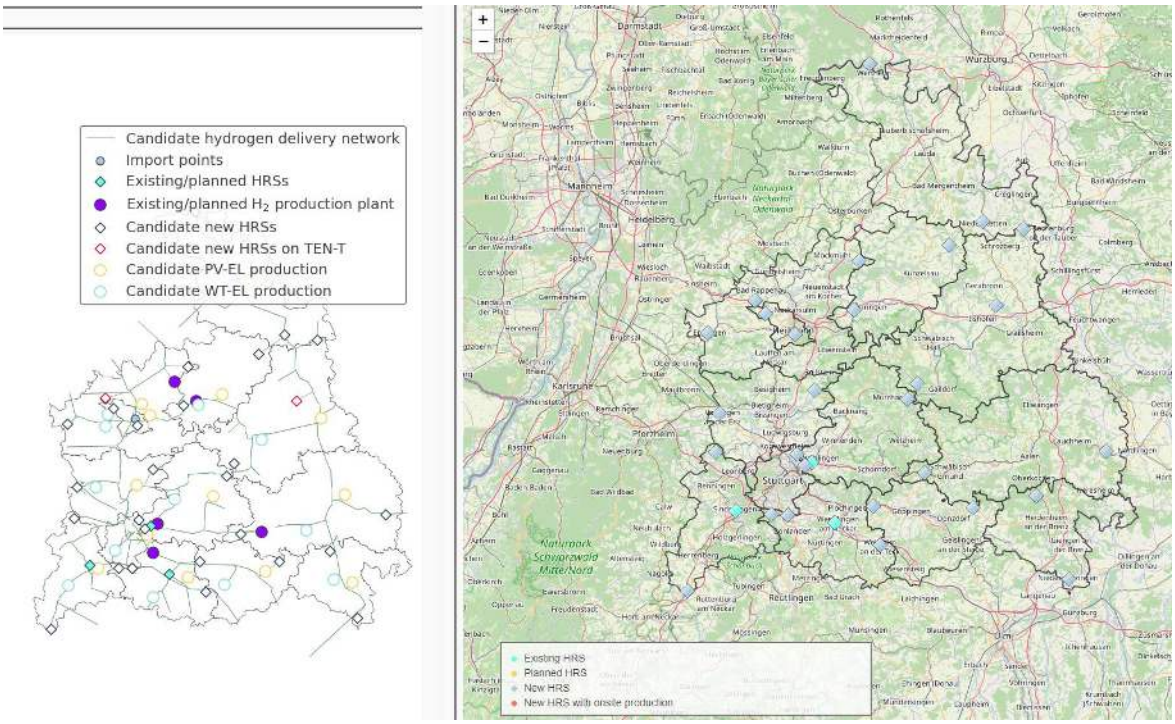


Figure 35: results of the H2MA tool for the Stuttgart region

Compared to the TEN-t network

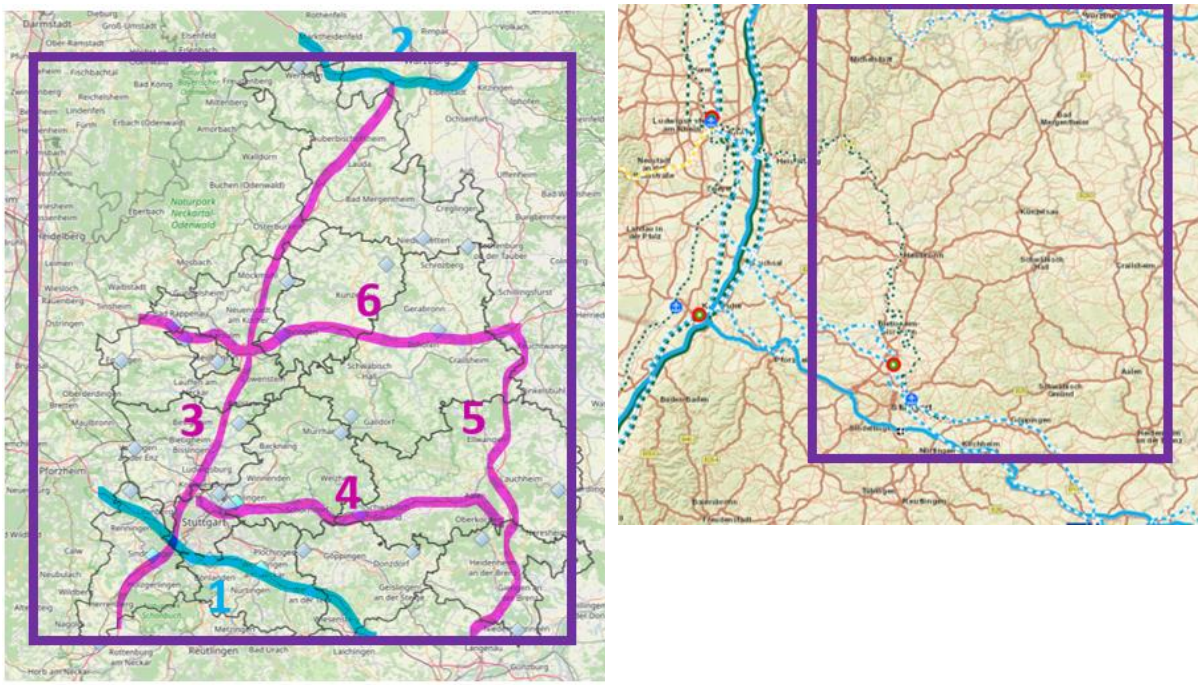


Figure 36: H2-routes compared to the TEN-t network in the Stuttgart area

The main H2-route 1 follows the highway A8, which is part of the Rhine-Danube corridor TEN-T corridor. The H2-route 2, at the northern border with the region, follows the highway A3. The H2-route 3, 4, 5 and 6 are other important connections, but are not part of any TEN-T corridor.

Pipelines were chosen as delivery method. The tool suggested more pipeline kilometres that experts think will reasonably and cost-effectively be built.

Along the main TEN-T corridor the pipeline makes sense, in more rural areas the concepts needs to be discussed.

This scenario was performed with a conservative estimate of 0.5% passenger cars and 1% of heavy vehicles. These estimates are a realistic outlook, however, as factors such as existing pipeline grid and minimum daily capacity of HRSs are not taken into account by the H2MA tool, the results of the scenario need to be discussed with care and additional planning is required. Furthermore, neither the demand of transit vehicles nor the industrial H2 considered by the H2MA tool and hence the results do not give a complete picture required for planning.

3.1.11 Summary

The data has been generated with the focus of the interconnection of existing and future hydrogen infrastructure. In the following summary the proposed new HRS for each region is compared to the number of suggested new HRS located on the TEN-T core network.

Region	new HRS	HRS in the immediate vicinity of the TEN-T core network	Total hydrogen demand for mobility [t/a]
Vzhodna Slovenija (SI03)	21	7	1.000
Zahodna Slovenija (SI04)	10	9	2.000
Lombardy (ITC4)	16	7	21.000
Alsace (FRF1)	7	3	12.000
Franche-Comté (FRC2)	5	3	
Piemonte (ITC1)	18	4	2.000
Freiburg (DE13)	26	16	18.000
Styria (AT22)	16	9	17.000
Vienna (AT13)	4	4	7.000
Stuttgart (DE11)	30	11	27.000
Overall	**153**	**73**	**107.000**

Approximately 50% of the HRS locations calculated with the H2MA tool are located in the immediate vicinity of the TEN-T core networks. Future planning should focus on these HRS.

3.1.12 Transalpine overview

As results different scenarios were identified and analyzed to plan and optimize a green hydrogen network, taking into account regional mobility needs and industrial hydrogen requirements.

The following graphic shows an overview of all scenarios of the different regions. The distribution network is shown as blue lines, production sites as red dots and refueling stations as green dots. Within the scenarios, it was calculated that a total number of **153**

HRS is needed in the 10 regions for the estimated hydrogen demand in the mobility sector (mostly heavy duty transport). A number of **73 HRS** are located directly in the immediate vicinity of the TEN-T core networks. Within the regions an optimized hydrogen distribution network was generated to connect the hydrogen production sites and the HRS. Overall the hydrogen demand for all focused regions is expected to surpass **100.000 tons of hydrogen per year** to provide the mobility sector.

When looking at the visual representation of the overall result, it becomes clear that it was possible to achieve results for the individual regions that can be used as a basis for more detailed planning, but the interaction between the regions under consideration was not taken into account. In a future step, the H2MA tool should therefore be expanded to link the individual regions with each other.

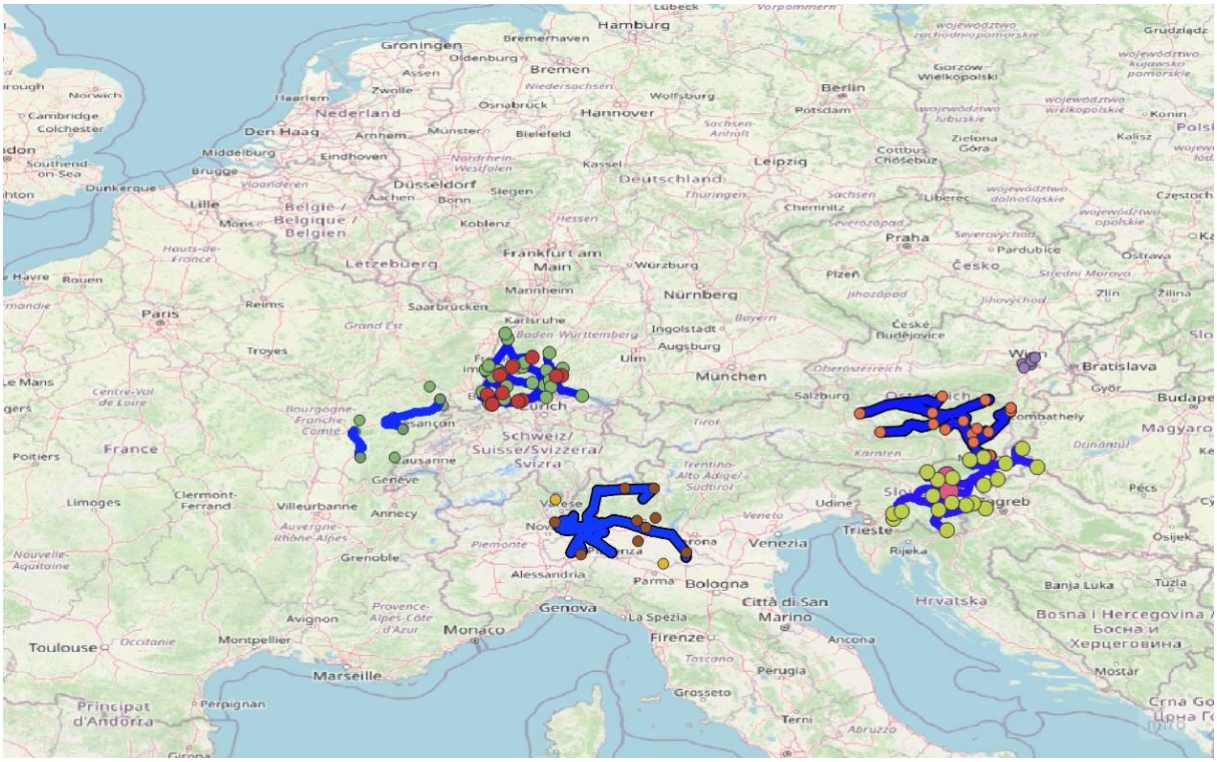


Figure 37: Overview of all scenarios of the 10 regions