Interreg Co-funded by the European Union

Alpine Space

H2MA

H2MA

"Green Hydrogen Mobility for Alpine Region Transportation"

Common 'green H2 mobility routes' interconnecting current with upcoming/planned infrastructure across the Alpine space

Output 2.1

October, 2024

DOCUMENT CONTROL SHEET

Project reference	
Project title	Green Hydrogen Mobility for Alpine Region Transportation
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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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The H2MA project is co-funded by the European Union through the Interreg Alpine Space programme

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)
- PP7 Climate Partner Südbaden (DE) (formerly Upper Rhine Valley)
- PP8 4ward Energy Research GmbH in cooperation with Reiterer and Scherling GmbH (AT)
- 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

PP4 Lombardy Foundation for the Environment (IT)

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1. Single Region Routes overview

Under WP2 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.

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 the following maps new networks are represented visually by blue lines on the scenario map, linking hydrogen production sites (marked by red dots) with the strategically placed HRS (green dots) and already existing HRS (yellow dots).

1.1 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

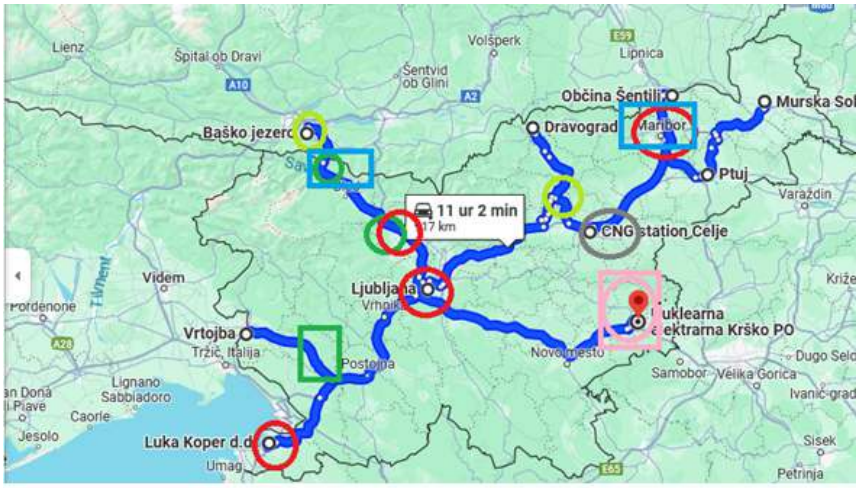
1.2 Vzhodna Slovenija (SI03; Eastern)

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.

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 1).



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

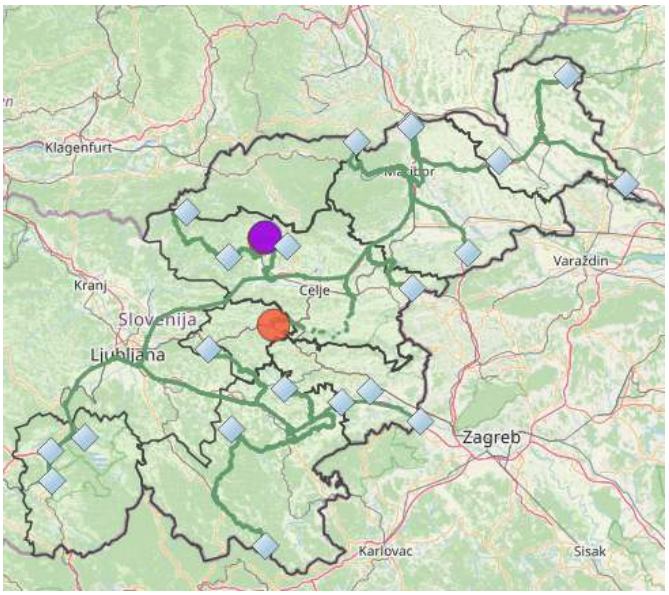


Figure 2: Locations of HRS and hydrogen pipelines suggested in the Vzhodna Slovenija region adjusted with input from LWG meetings

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.
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.

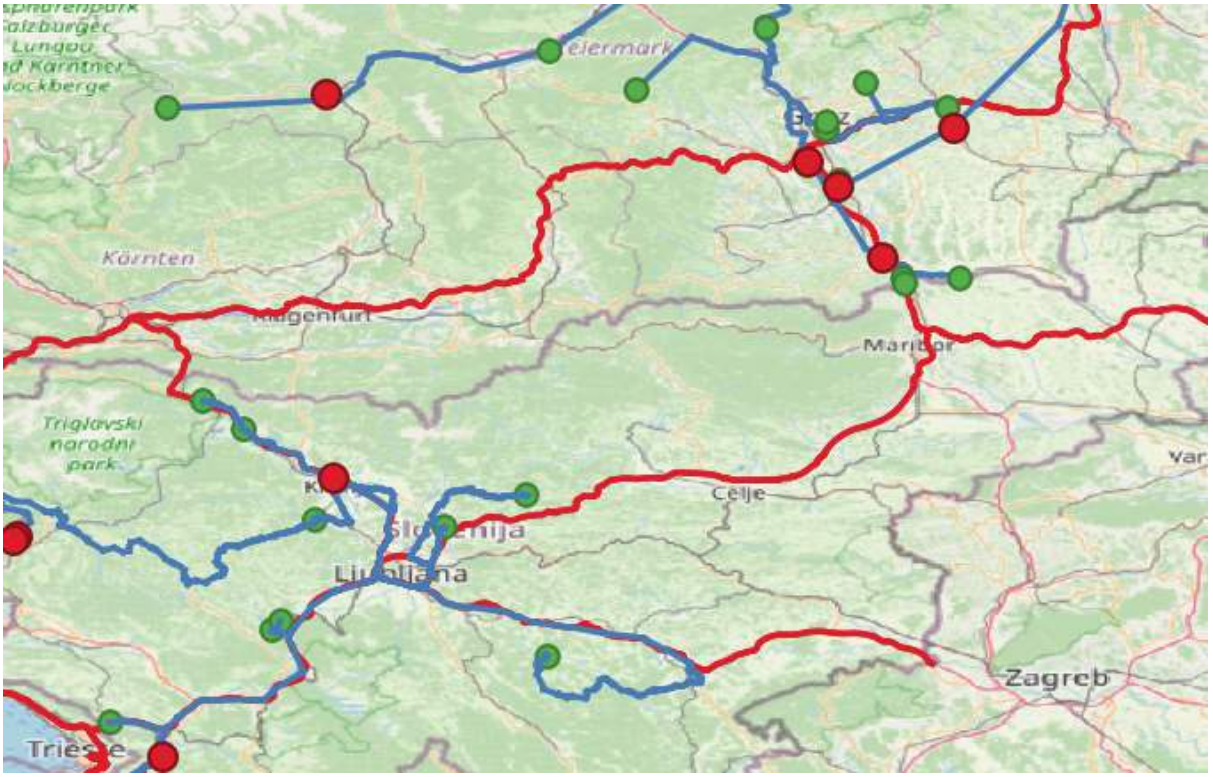


Figure 3. Locations of HRS and hydrogen pipelines suggested in the Zahodna Slovenija region. (Source: H2MA project, 2024)

1.3. Franche-Comté (FRC2)

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.

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.

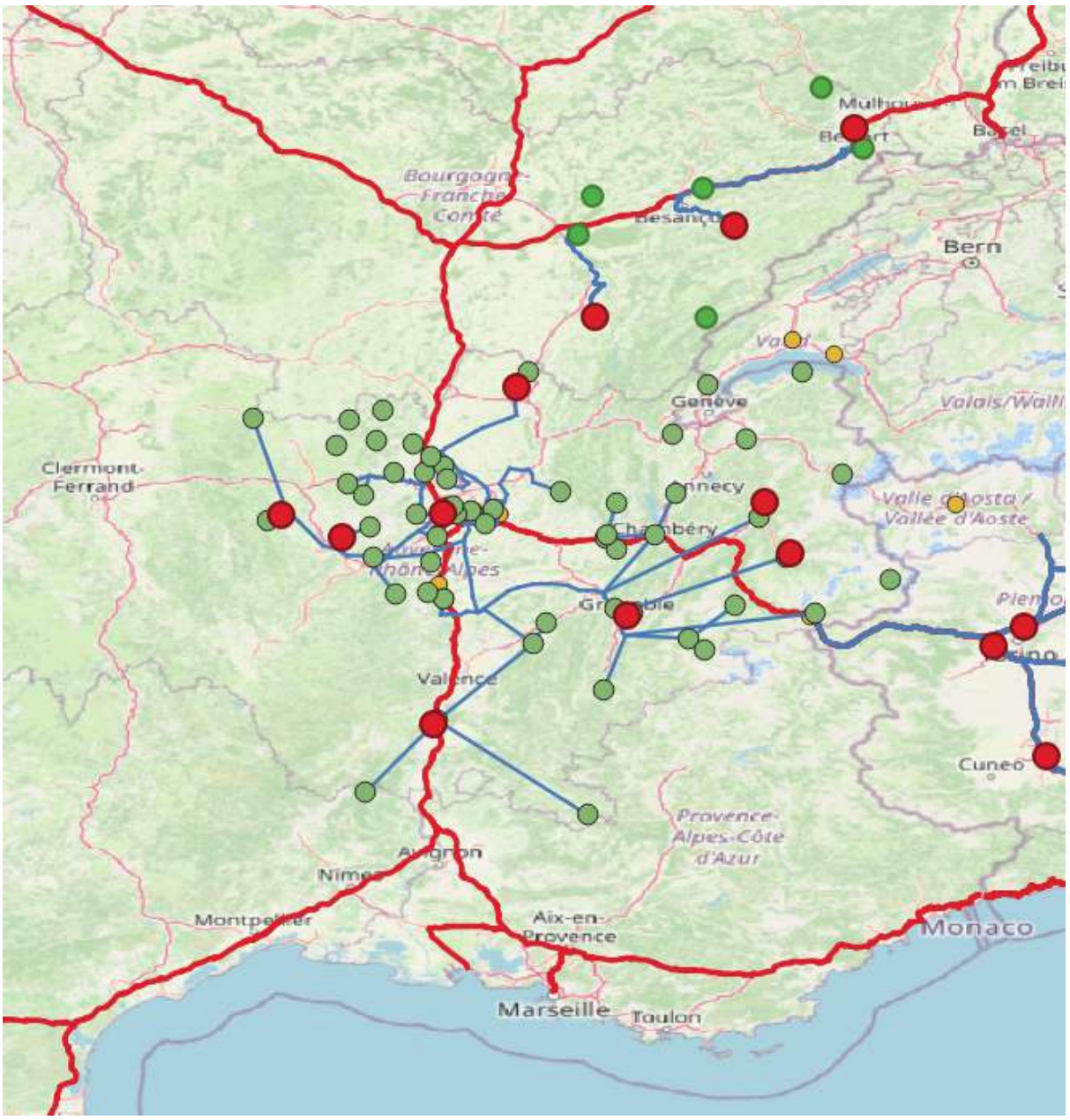


Figure 4. Locations of HRS and hydrogen pipelines suggested in theFranche-Comté (FRC2). (Source: H2MA project, 2024)

1.3. 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.

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.

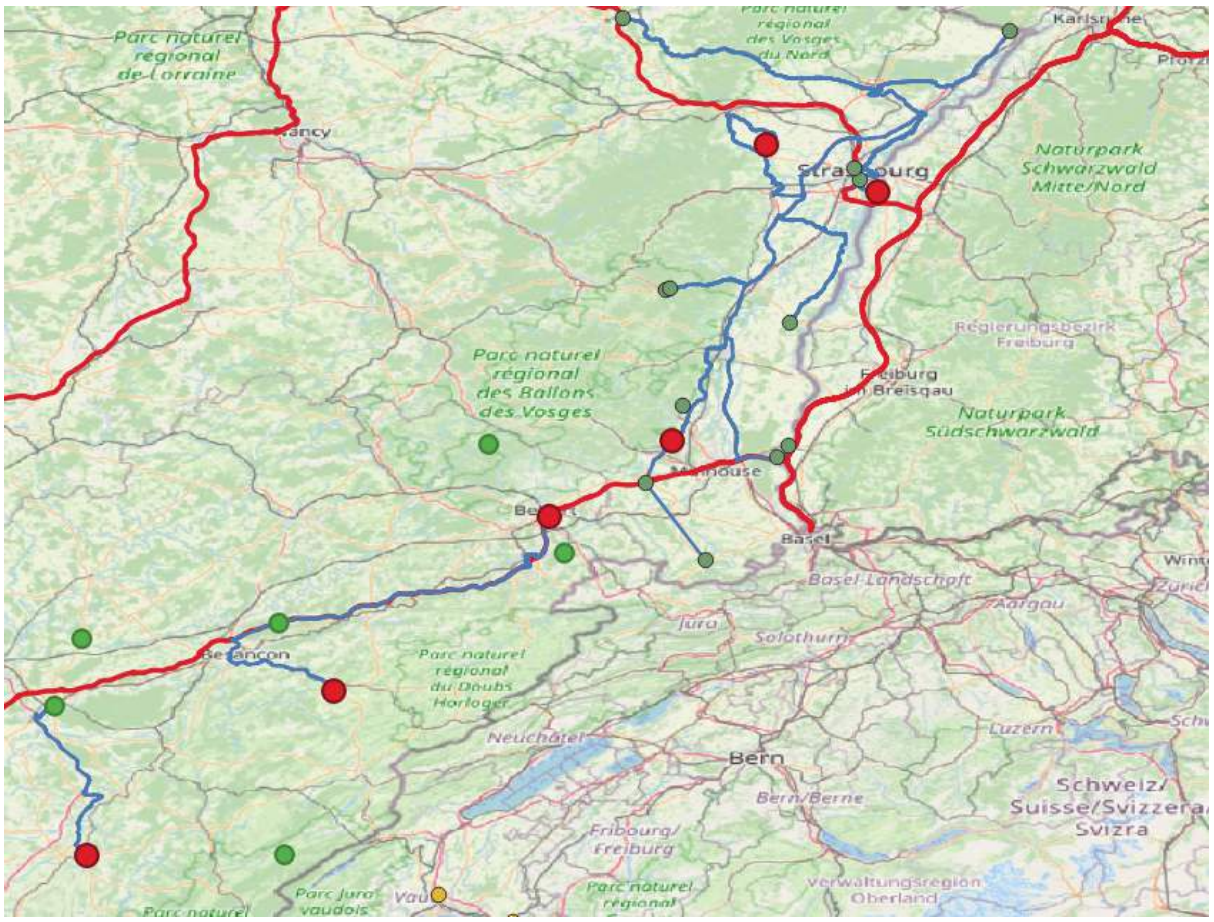


Figure 5. Locations of HRS and hydrogen pipelines suggested in the Alsace (FRF1) **(Source: H2MA project, 2024)**

1.4. Piemonte (ITC1)

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.

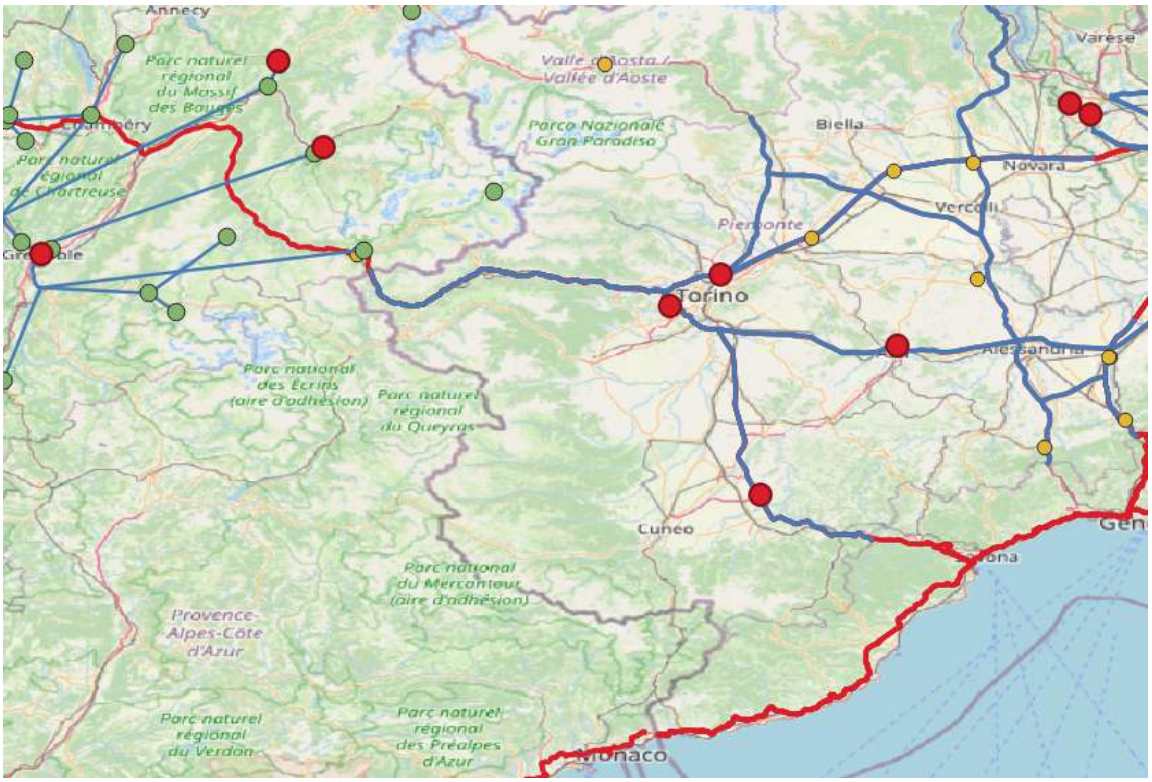


Figure 6. Locations of HRS and hydrogen pipelines suggested in Piemonte (ITC1)(Source: H2MA project, 2024)

1.5. Lombardy (ITC4)

The overall pattern of refueling stations (HRS) is more informative and accurate than the precise coordinates of each individual station

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)

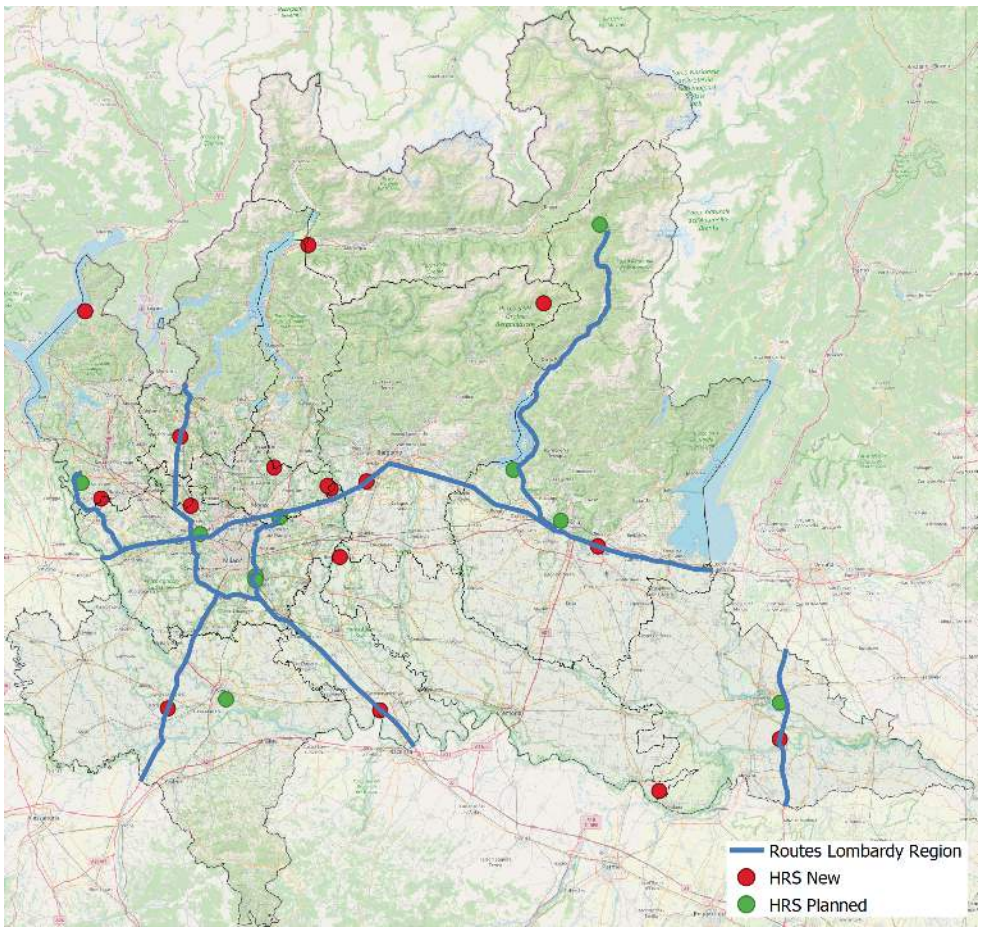


Figure 7. Locations of HRS and Routes suggested in Lombardy (ITC4)(Source: H2MA project, 2024)

1.6. Freiburg (DE13)

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.

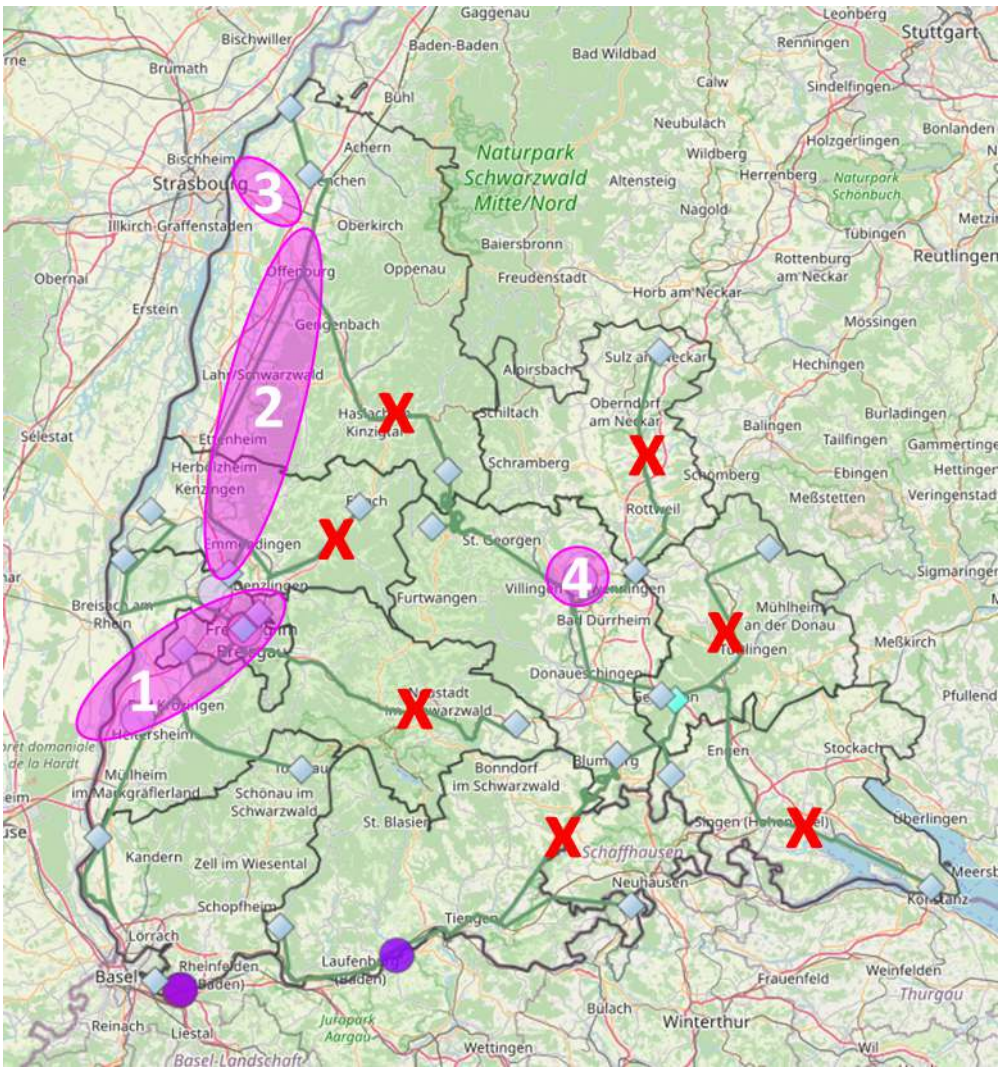


Figure 9: H2-Hubs with pipelines and HRS along the TEN-T corridor in the Freiburg region; Pipelines in the Black Forrest Mountains due to geographical issues unlikely to realise

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.

Figure 10. Locations of HRS and hydrogen pipelines suggested in Freiburg (DE13) (Source: H2MA project, 2024)

1.7. Stuttgart (DE11)

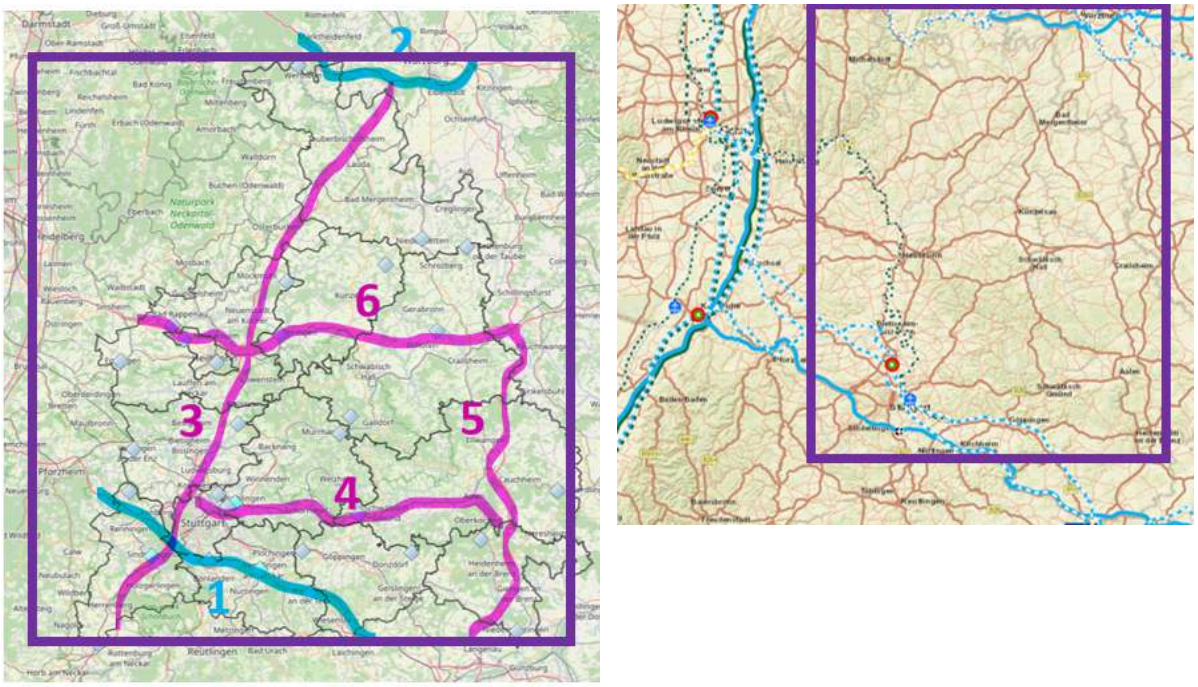


Figure 11: H2-routes compared to the TEN-t network in the Stuttgart area

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.

1.8. Styria (AT22)

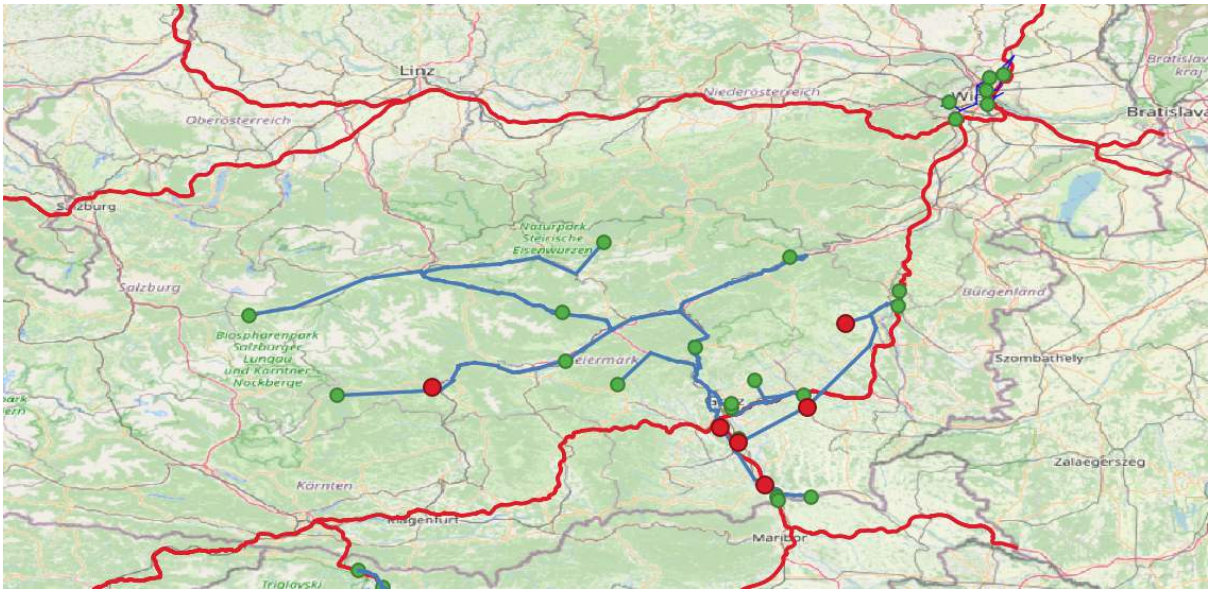


Figure 12: Locations of HRS suggested in the Styria region by the H2MA-Tool

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

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.

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.

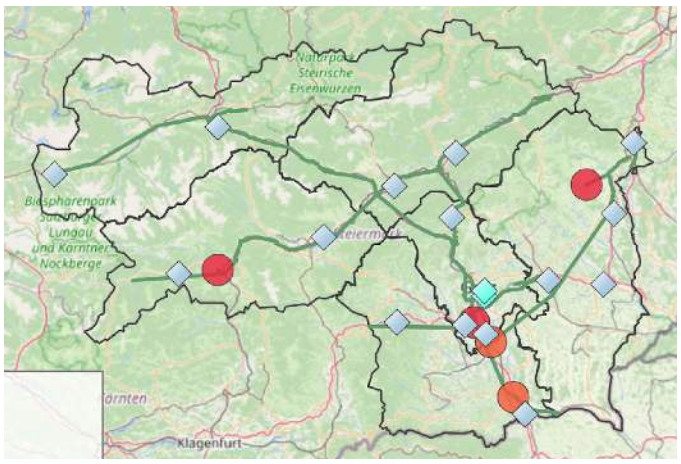


Figure 13: Locations of HRSs adjusted with input from LWG meetings

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.

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.

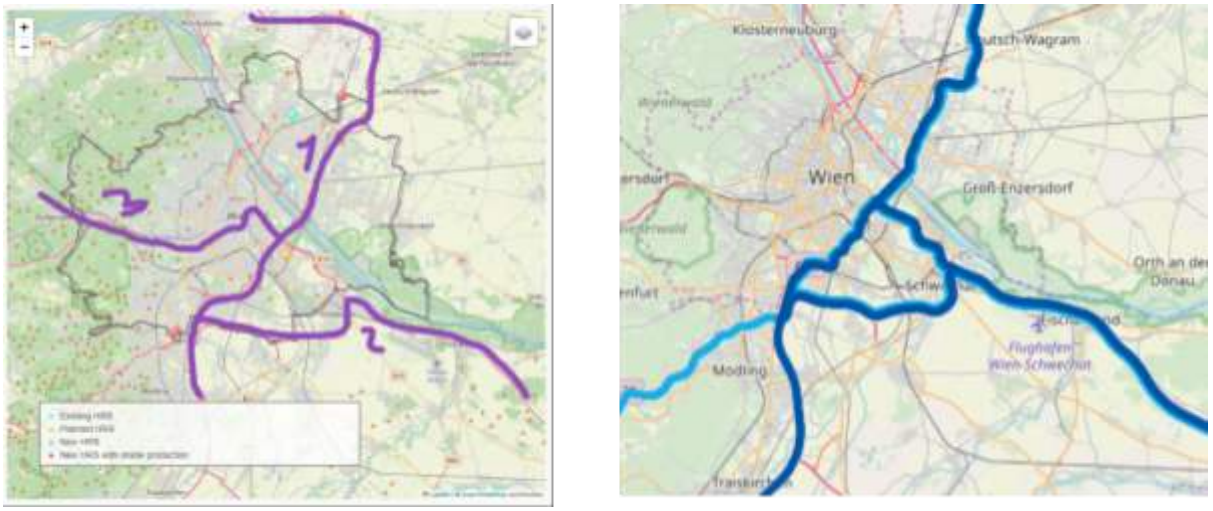


Figure 14: H2-routes compared to the TEN-t network in the Vienna area

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.

Figure 15: H2-routes compared to the TEN-t network in the Vienna area

2. Transalpine overview

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.
ANNEX I renders the integration of all the routes indicated *as most viable* into a unique map of the alpine space done with the software QGIS.

The alternative scenarios have been defined primarily in relation to the different degree of penetration of hydrogen in the different categories of vehicles; in particular, 6 scenarios were created: 3 scenarios in 2030 and 3 in 2050, with low, medium or high hydrogen penetration. The tables below show the degree of penetration of hydrogen in different scenarios.

Table 1 - Different degree of penetration of H2 considered in the scenarios evaluated with the H2MA tool

Scenario 2030

	% FCEVs on regional stock			
Scenario	**Passenger**	**LDVs**	**HDVs**	**Buses**

	Cars [%]	[%]	[%]	[%]
LOW penetration	0.0%	0.0%	0.5%	0.5%
MEDIUM penetration	0.5%	0.5%	1.7%	2.0%
HIGH penetration	1.0%	1.0%	4.0%	5.0%

Scenario 2050

	% FCEVs on regional stock			
Scenario	**Passenger**	**LDVs**	**HDVs**	**Buses**
	Cars [%]	**[%]**	**[%]**	**[%]**
LOW penetration	10%	10%	40%	15%
MEDIUM penetration	15%	20%	65%	25%
HIGH penetration	20%	50%	85%	35%

LDVs = Light-Duty Vehicles, HDVs = Heavy-Duty Vehicles, FCEVs = Fuel Cell Electric Vehicles

The maps of the simulation of the alternative scenarios *Alpine Space 2030_medium and Alpine Space 2050_low* done with the support of the H2MA runned for the overall alpine space in the region considered, are reported respectively in Figure 23 and Figure 24.On the map routes, are represented visually by blue lines on the scenario map, linking hydrogen production sites (marked by red dots) with the strategically placed HRS (green dots).

The maps of the simulation of the alternative scenarios *Alpine Space 2030_medium and Alpine Space 2050_low* done with the support of the H2MA runned for the overall alpine space in the region considered, are reported in ANNEX II respectively in Figure II1 and Figure II3.On the map routes, are represented visually by blue lines on the scenario map, linking hydrogen production sites (marked by red dots) with the strategically placed HRS (green dots).

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ANNEX I - H2MA MASTERPLAN Most Probable Scenario

ANNEX II - H2MA MASTERPLAN Alternative Scenarios

Figure II1 - Alpine Space 2030_medium

ANNEX II - H2MA MASTERPLAN Alternative Scenarios

Figure II2 - Alpine Space 2050_low