HI EAST 6 A (Less-advanced)

H2 Interconnection Croatia - Slovenia with Hydrogen supply system in Croatia

Reasons for grouping [ENTSOG]

The project group aims at interconnecting future hydrogen infrastructure between Slovenia and Croatia.

The group includes investments in Slovenia (HYD-N-1237) and in Croatia (HYD-N-1307 and HYD-N-619).

Objective of the group [Promoter]

Project involves repurposing of existing natural gas main pipeline for use with hydrogen. Parallel natural gas counterparts of repurposed main pipeline will remain in function as natural gas pipelines. Repurposed pipeline will be connected with planned new hydrogen ready pipelines and together they will enable hydrogen transit between Slovenia and all neighboring countries. Objective of the group is to create H2 cross border transmission network that will enable transmission of gas from the expected H2 production zones in the southern Croatia to the customer base in Slovenia, northern Croatia and H2 transit across Slovenian territory to and from CE. The long-term group objective is to create cross border regional H2 market.

HYD-N-619 **H2 interconnection Croatia/Slovenia (Lučko-Zabok-Rogatec)**

Comm. Year **2040**

HYD-N-1237 **Croatia-Slovenia-Austria H2 corridor**

Comm. Year **2035**

HYD-N-1307 **H2 supply system Croatia – South**

Comm. Year **2040**

A. Project group technical information [Promoter/ ENTSOG]

Project technical information [Promoter]

Hydrogen Transmission

TYNDP Project code	Section name	New / Repurposing	Nominal Diameter [mm]	Section Length [km]	Compressor power [MW]	Maximum depth [m]
HYD-N-619	Lučko-Zabok-Rogatec H2 pipeline	New	700	69	NA	
HYD-N-1237	Upgrade of Murfeld/Ceršak interconnection	Repurposing	800	0.2		
HYD-N-1237	M1 retrofitting	Repurposing	500	58		
HYD-N-1237	CS Kidričevo, 2nd phase of upgrade	New			8	
HYD-N-1237	Upgrade of Rogatec interconnection	New	800	3.8		
HYD-N-1307	Bosiljevo - Split	Repurposing	500	297	NA	
HYD-N-1307	Pula - Rijeka	Repurposing	500	90	NA	
HYD-N-1307	Rijeka - Karlovac	Repurposing	500	100	NA	
HYD-N-1307	Zadar - Benkovac	Repurposing	300	37	NA	

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-619	H2_IP_HR-SI	Plinacro Ltd	Transmission Slovenia (SI Hydrogen)	Transmission Croatia (HR Hydrogen)	160	2040
HYD-N-619	H2_IP_HR-SI	Plinacro Ltd	Transmission Croatia (HR Hydrogen)	Transmission Slovenia (SI Hydrogen)	160	2040
HYD-N-1237	H2_IP_HR-SI	Plinovodi d.o.o.	Transmission Slovenia (SI Hydrogen)	Transmission Croatia (HR Hydrogen)	33	2035
HYD-N-1237	H2_IP_HR-SI	Plinovodi d.o.o.	Transmission Croatia (HR Hydrogen)	Transmission Slovenia (SI Hydrogen)	16	2035

B. Project Cost Information

During the TYNDP 2022 Project Data Collection, promoters were asked to indicate whether their costs were confidential or not. The following tables display the non-confidential costs provided by the promoters (as of December 2022, end of PCI project collection). The amounts provided can differ from the figures used by the project promoters in other contexts, where costs can be updated and/or evaluated using different methodologies or assumptions.

[ENTSOG]

TYNDP Project code	CAPEX [M€]	CAPEX range [%]	OPEX [M€]	OPEX range [%]
HYD-N-619	105	15%	0.21	15%
HYD-N-1237	144.5	30%	11.2	30%
HYD-N-1307	200	15%	2	15%

Description of the cost and range [Promoter]

Slovenia: During the period of preparing the project data collection for TYNDP 2022, the costs associated with HYD-N-1237 were in the process of being determined at the national level as part of the national development plan. Consequently, the costs for HYD-N-1237 were estimated based on the unit prices provided in the EHB study.

Croatia HYD-N-1307 and HYD-N-619: Project costs are based on the "Extending the European Hydrogen Backbone A EUROPEAN HYDROGEN INFRASTRUCTURE VISION COVERING 21 COUNTRIES, APRIL 2021" table "Overview of unit capital costs for different pipeline transport scenarios" on the page 17.
Project costs consider not only the pipeline repurposing costs but also the future compression capex costs, which are the result of a series of hydraulic simulations conducted by gas TSOs. The modelled scenarios cover a range of point-to-point pipeline transport cases with varying input parameters.

C. Project Benefits [ENTSOG]

C.1 Summary of benefits

This section provides a summarised analysis by ENTSOG of the main benefits stemming from the realisation of the overall group. More details on the indicators are available in Annex D of TYNDP 2022[1].

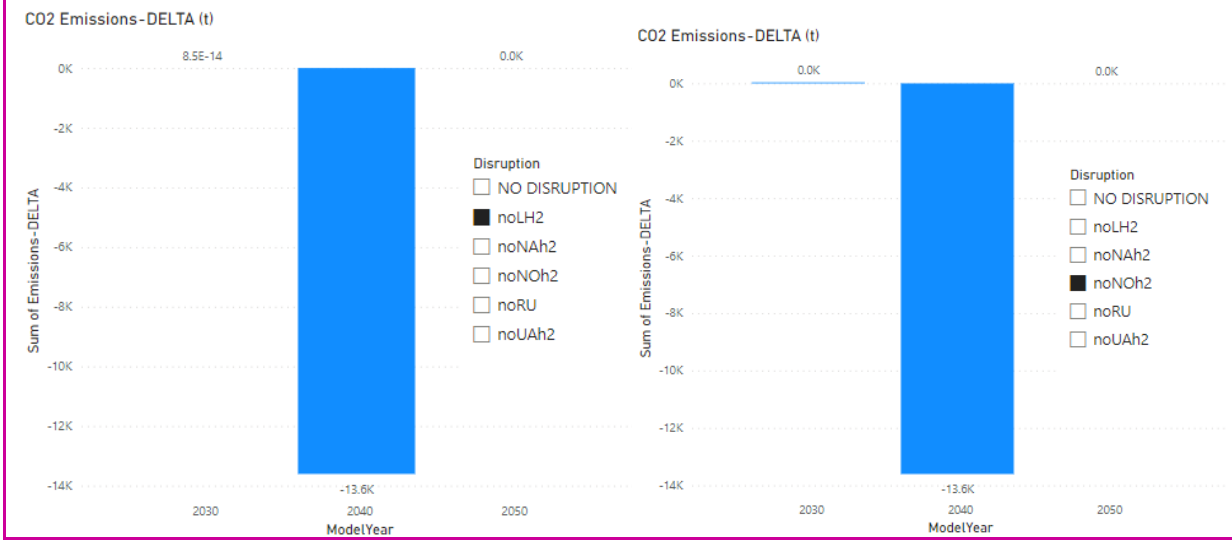
Distributed Energy

Sustainability

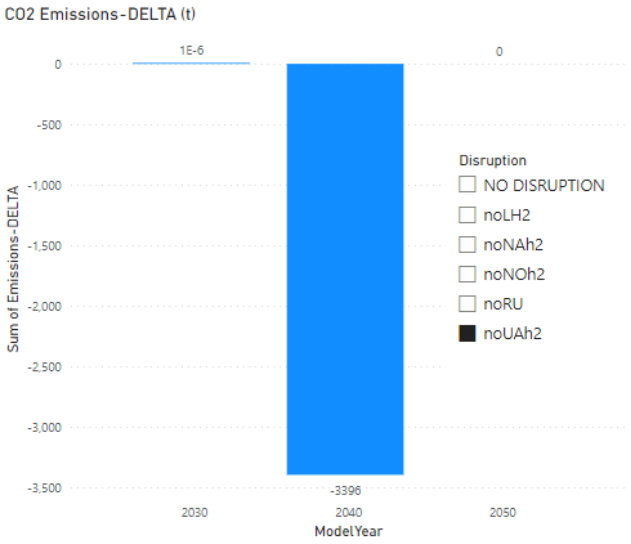
In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group contributes to sustainability by reducing hydrogen demand curtailment. With the implementation of the project group, countries in the region can further cooperate avoiding demand curtailment. However, as project groups is commissioning in 2040, benefits are lower due to other supplies routes to Slovenia and Croatia.

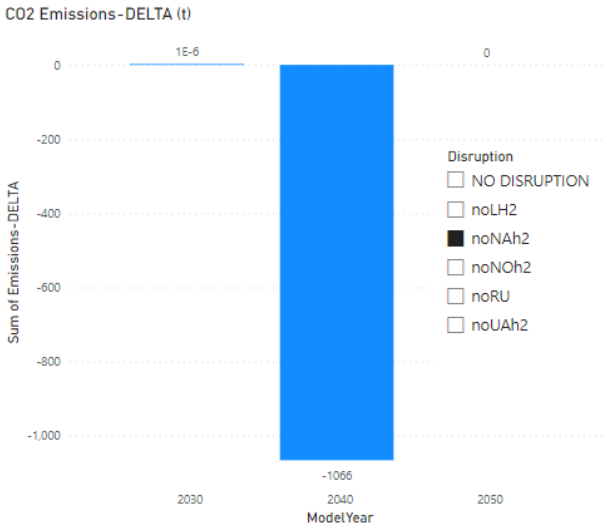
In case of disruptions, the project group will contribute to sustainability by reducing overall CO2 emissions up to 13,6kt kt in 2040 for Norwegian or LH2 disruptions.

1 noLH2 : LH2 disruption / 2 noNOh2 : Norway disruption / 3 noUAh2 : Ukraine disruption/ 4 noNAh2 : North Africa disruption



[1] https://www.entsog.eu/sites/default/files/2023-04/ENTSOG_TYNDP_2022_Annex_D_Methodology_230411.pdf





Security of Supply:[2]

> Reference case:

In the reference case, the project is contributing a little to further mitigation of hydrogen demand curtailment risk in average summer and average winter, lower than 1% which is not visible on the map.

> Climatic stress cases:

Under 2 -week and 2-week dunkelflaute climatic stress case, as well as under peak day climatic case the project group increases mitigation of risk of hydrogen demand curtailment in Poland, Latvia and Lithuania by 1% in 2040 and in Germany and Italy by 1% in 2050.

[2] *As for the hydrogen system there is no existing infrastructure level available yet, ENTSOG has identified a possible hydrogen network according to the information provided by promoters in their project submission for the TYNDP/PCI process (i.e., H2 Infrastructure level). Therefore, the System Assessment shows the results that could be reached (for different timestamps) under the hypothesis of a full commissioning of the H2 infrastructure projects that were submitted by project promoters but that are not yet in place. Therefore, even in configurations where no demand curtailment is identified (e.g., average winter in 2030) these results should not be read as an absence of H2 infrastructure needs for the given scenario. On the contrary, the full availability of the planned infrastructures composing the H2 infrastructure level is assumed to avoid the potential demand curtailment.*

> Disruption cases (S-1):

Similarly, under supply disruption cases, the project group mitigates in the same way as climatic stress demand curtailment risk in different countries by 1% depending on disruptions cases.

Maps for specifics disruptions: 1 noLH2 : LH2 disruption / 2 noNOh2 : Norway disruption / 3 noUAh2 : Ukraine disruption/ 4 noNAh2 : North Africa disruption

1 noLH2 : LH2 disruption

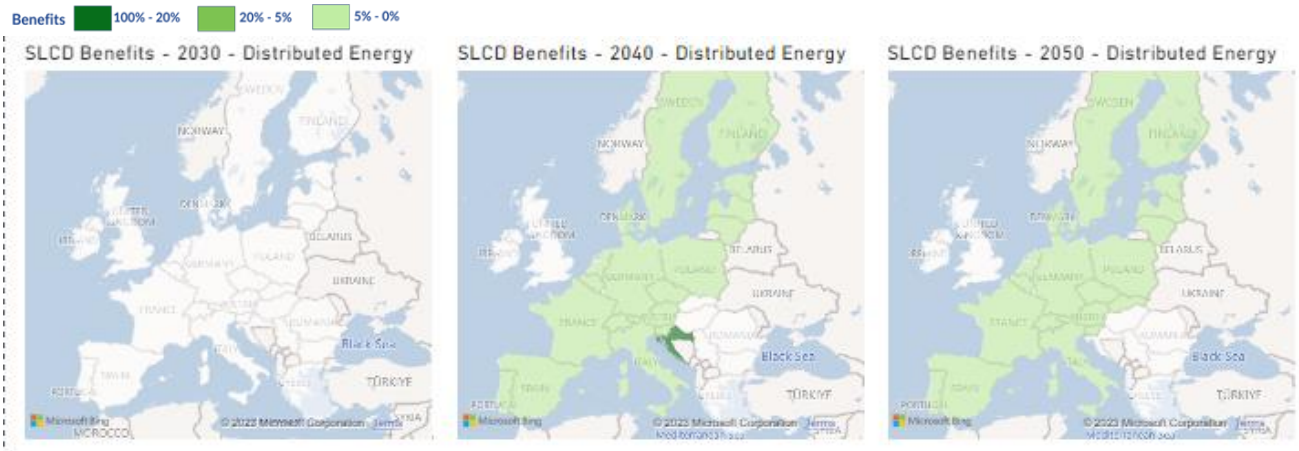
2 noNOh2 : Norway disruption

3 noUAh2 : Ukraine disruption

4 noNAh2 : North Africa disruption

> Single largest capacity disruption (SLCD):

From 2040, the projects group mitigates risk of demand curtailment in almost all European countries by 1-2%. However, the projects group has more benefits, mitigating risk of demand curtailment in Croatia by 21% in 2040.



Global Ambition

Sustainability

The project group contributes to sustainability by reducing hydrogen demand curtailment. With the implementation of the project group countries in the region can further cooperate avoiding demand curtailment. However, as project groups is commissioning in 2040, benefits are lower due to many other supplies routes to Slovenia and Croatia.

In disruptions cases, as all green hydrogen supply sources are already used at their maximum capacity, an increase in blue hydrogen (i.e. SMR) is needed to satisfy the hydrogen demand in 2040 and reduce demand curtailment.

Security of supply

> Reference case

In the reference case, the project is not contributing to further mitigation of hydrogen demand curtailment risk in average summer and average winter, except in Slovenia, where the project mitigates risk by 1%. It is important to mention that the security of supply benefits of this project group could be limited due the inclusion of competing/complementary projects in the infrastructure level that will increase flows from alternative routes to Slovenia and Croatia.

> Climatic stress cases

Similarly, to reference case the project group is not further contributing to the mitigation of hydrogen demand curtailment risk, except in Slovenia by 1% in 2040.

> Disruption cases (S-1)

Under supply disruption cases, the project is contributing to further mitigation of hydrogen demand curtailment risk in different countries by 1% depending on disruptions cases. More benefits under Ukrainian disruption are expected by 3%.

Maps for specifics disruptions: 1 noLH2 : LH2 disruption / 2 noNOh2 : Norway disruption / 3 noUAh2 : Ukraine disruption/ 4 noNAh2 : North Africa disruption

1 noLH2 : LH2 disruption

2 noNOh2 : Norway disruption

3 noUAh2 : Ukraine disruption

4 noNAh2 : North Africa disruption

> Single largest capacity disruption (SLCD)

In 2040, the projects group mitigates risk of demand curtailment in almost all European countries by 1-2% and up to 7% in Croatia.

C.2 Quantitative benefits [ENTSOG]

The following tables display all the benefits quantified by ENTSOG through specific indicators and stemming from the realisation of the considered project group.

CO2 Emissions:

ModelYear	Disruption	Scenario	Unit	Emission Delta	Emission Plus	Emission Minus
2030	NO DISRUPTION	DE	tonne	-6.505	538.677.299	538.683.804
2030	NO DISRUPTION	GA	tonne	-7.169	592.910.448	592.917.618
2030	noLH2	DE	tonne	-9.789	540.175.890	540.185.679
2030	noLH2	GA	tonne	-15.768	594.817.481	594.833.249
2030	noNAh2	DE	tonne	-8.765	539.785.356	539.794.122
2030	noNAh2	GA	tonne	-9.789	594.141.433	594.151.222
2030	noNOh2	DE	tonne	-16.875	538.877.198	538.894.072
2030	noNOh2	GA	tonne	-18.595	593.310.994	593.329.590
2030	noUAh2	DE	tonne	-7.810	539.378.772	539.386.582
2030	noUAh2	GA	tonne	-7.810	593.627.618	593.635.428
2040	NO DISRUPTION	DE	tonne	0	392.077.044	392.077.044
2040	NO DISRUPTION	GA	tonne	-13.544	396.523.252	396.536.796
2040	noLH2	DE	tonne	-5.107	392.213.883	392.218.990
2040	noLH2	GA	tonne	0	397.455.197	397.455.197
2040	noNAh2	DE	tonne	-1.721	392.188.098	392.189.818
2040	noNAh2	GA	tonne	0	397.301.977	397.301.977
2040	noNOh2	DE	tonne	-5.107	392.144.023	392.149.129
2040	noNOh2	GA	tonne	-1.721	397.450.977	397.452.698
2040	noUAh2	DE	tonne	-5.107	392.399.183	392.404.290
2040	noUAh2	GA	tonne	0	397.478.498	397.478.498
2050	NO DISRUPTION	DE	tonne	0	232.557.735	232.557.735
2050	NO DISRUPTION	GA	tonne	0	228.306.707	228.306.707
2050	noLH2	DE	tonne	0	232.557.735	232.557.735
2050	noLH2	GA	tonne	0	228.306.707	228.306.707
2050	noNAh2	DE	tonne	0	232.557.735	232.557.735
2050	noNAh2	GA	tonne	0	228.306.707	228.306.707
2050	noNOh2	DE	tonne	0	232.557.735	232.557.735
2050	noNOh2	GA	tonne	0	228.306.707	228.306.707
2050	noRU	DE	tonne	0	232.557.735	232.557.735
2050	noRU	GA	tonne	0	228.306.707	228.306.707
2050	noUAh2	DE	tonne	0	232.557.735	232.557.735
2050	noUAh2	GA	tonne	0	228.306.707	228.306.707

Curtailment Rate (SLCD):

Country	2030-DE-DELTA	2030-GA-DELTA	2040-DE-DELTA	2040-GA-DELTA	2050-DE-DELTA	2050-GA-DELTA
Croatia	0%	0%	-21%	-7%	0%	-11%
Austria	0%	0%	-2%	-1%	-2%	-1%
Belgium	0%	0%	-2%	-1%	-1%	0%
Czechia	0%	0%	-2%	-2%	-2%	-1%
Estonia	0%	0%	-2%	-1%	-2%	-1%
Finland	0%	0%	-2%	-1%	-2%	0%
Germany	0%	0%	-2%	-2%	-1%	0%
Latvia	0%	0%	-2%	-1%	-1%	-1%
Lithuania	0%	0%	-2%	-1%	-1%	-1%
Poland	0%	0%	-2%	-1%	-1%	0%
Portugal	0%	-1%	-2%	-1%	-1%	-1%
Slovenia	0%	0%	-2%	-1%	-2%	-1%
Sweden	0%	0%	-2%	-1%	-2%	0%
Switzerland	0%	0%	-2%	-1%	-1%	-1%
The Netherlands	0%	0%	-2%	-1%	-2%	0%
France	0%	0%	-2%	-1%	-2%	0%
Italy	0%	0%	-2%	-1%	-2%	0%
Denmark	0%	0%	-1%	-1%	-1%	0%
Spain	0%	0%	-1%	-1%	-2%	0%
Slovakia	0%	0%	0%	0%	-1%	0%

Curtailment Rate (Climatic Stress)

SimulationPeriod	Country	2030-DE-DELTA	2030-GA-DELTA	2040-DE-DELTA	2040-GA-DELTA	2050-DE-DELTA	2050-GA-DELTA
Average2W	Austria	0%	0%	0%	0%	-1%	0%
Average2W	Belgium	0%	0%	0%	0%	0%	0%
Average2W	Bulgaria	0%	0%	0%	0%	0%	0%
Average2W	Croatia	0%	0%	0%	0%	0%	0%
Average2W	Cyprus	0%	0%	0%	0%	0%	0%
Average2W	Czechia	0%	0%	0%	0%	-1%	0%
Average2W	Denmark	0%	0%	0%	-1%	0%	0%
Average2W	Estonia	0%	0%	0%	0%	0%	0%
Average2W	Finland	0%	0%	0%	0%	-1%	0%
Average2W	France	0%	0%	0%	0%	0%	0%
Average2W	Germany	0%	0%	0%	0%	0%	0%
Average2W	Greece	0%	0%	0%	0%	0%	0%
Average2W	Hungary	0%	0%	0%	0%	0%	0%
Average2W	Ireland	0%	0%	0%	0%	0%	0%
Average2W	Italy	0%	0%	0%	0%	0%	0%

Average2W	Latvia	0%	0%	0%	0%	0%	0%
Average2W	Lithuania	0%	0%	0%	0%	0%	0%
Average2W	Luxembourg	0%	0%	0%	0%	0%	0%
Average2W	Malta	0%	0%	0%	0%	0%	0%
Average2W	Poland	0%	0%	0%	0%	0%	0%
Average2W	Portugal	0%	0%	0%	0%	0%	0%
Average2W	Romania	0%	0%	0%	0%	0%	0%
Average2W	Serbia	0%	0%	0%	0%	0%	0%
Average2W	Slovakia	0%	0%	0%	0%	0%	0%
Average2W	Slovenia	0%	0%	-1%	-1%	-1%	0%
Average2W	Spain	0%	0%	0%	0%	0%	0%
Average2W	Sweden	0%	0%	0%	0%	-1%	0%
Average2W	Switzerland	0%	0%	0%	0%	0%	0%
Average2W	The Netherlands	0%	0%	0%	-1%	0%	0%
Average2W	United Kingdom	0%	0%	0%	0%	0%	0%
Average2WDF	Austria	0%	0%	0%	0%	-1%	0%
Average2WDF	Belgium	0%	0%	0%	0%	0%	0%
Average2WDF	Bulgaria	0%	0%	0%	0%	0%	0%
Average2WDF	Croatia	0%	0%	0%	0%	0%	0%
Average2WDF	Cyprus	0%	0%	0%	0%	0%	0%
Average2WDF	Czechia	0%	0%	0%	0%	-1%	0%
Average2WDF	Denmark	0%	0%	0%	0%	0%	0%
Average2WDF	Estonia	0%	0%	0%	0%	0%	0%
Average2WDF	Finland	0%	0%	0%	0%	-1%	0%
Average2WDF	France	0%	0%	0%	0%	0%	0%
Average2WDF	Germany	0%	0%	0%	0%	0%	0%
Average2WDF	Greece	0%	0%	0%	0%	0%	0%
Average2WDF	Hungary	0%	0%	0%	0%	0%	0%
Average2WDF	Ireland	0%	0%	0%	0%	0%	0%
Average2WDF	Italy	0%	0%	0%	0%	0%	0%
Average2WDF	Latvia	0%	0%	0%	0%	0%	0%
Average2WDF	Lithuania	0%	0%	0%	0%	0%	0%
Average2WDF	Luxembourg	0%	0%	0%	0%	0%	0%
Average2WDF	Malta	0%	0%	0%	0%	0%	0%
Average2WDF	Poland	0%	0%	0%	0%	0%	0%
Average2WDF	Portugal	0%	0%	0%	0%	0%	0%
Average2WDF	Romania	0%	0%	0%	0%	0%	0%
Average2WDF	Serbia	0%	0%	0%	0%	0%	0%
Average2WDF	Slovakia	0%	0%	0%	0%	0%	0%
Average2WDF	Slovenia	0%	0%	-1%	-1%	-1%	0%
Average2WDF	Spain	0%	0%	0%	0%	0%	0%
Average2WDF	Sweden	0%	0%	0%	0%	-1%	0%
Average2WDF	Switzerland	0%	0%	0%	0%	0%	0%
Average2WDF	The Netherlands	0%	0%	0%	0%	0%	0%

Average2WDF	United Kingdom	0%	0%	0%	0%	0%	0%
DC	Austria	0%	0%	0%	0%	0%	0%
DC	Belgium	0%	0%	0%	0%	0%	0%
DC	Bulgaria	0%	0%	0%	0%	0%	0%
DC	Croatia	0%	0%	0%	0%	0%	0%
DC	Cyprus	0%	0%	0%	0%	0%	0%
DC	Czechia	0%	0%	0%	0%	0%	0%
DC	Denmark	0%	0%	0%	0%	0%	0%
DC	Estonia	0%	0%	0%	0%	0%	0%
DC	Finland	0%	0%	0%	0%	0%	0%
DC	France	0%	0%	-1%	0%	0%	0%
DC	Germany	0%	0%	0%	0%	0%	0%
DC	Greece	0%	0%	0%	0%	0%	0%
DC	Hungary	0%	0%	0%	0%	0%	0%
DC	Ireland	0%	0%	0%	0%	0%	0%
DC	Italy	0%	0%	0%	0%	-1%	0%
DC	Latvia	0%	0%	0%	0%	0%	0%
DC	Lithuania	0%	0%	0%	0%	0%	0%
DC	Luxembourg	0%	0%	0%	0%	0%	0%
DC	Malta	0%	0%	0%	0%	0%	0%
DC	Poland	0%	0%	0%	0%	0%	0%
DC	Portugal	0%	0%	-1%	0%	0%	0%
DC	Romania	0%	0%	0%	0%	0%	0%
DC	Serbia	0%	0%	0%	0%	0%	0%
DC	Slovakia	0%	0%	0%	0%	0%	0%
DC	Slovenia	0%	0%	-1%	0%	0%	0%
DC	Spain	0%	0%	0%	0%	0%	0%
DC	Sweden	0%	0%	0%	0%	0%	0%
DC	Switzerland	0%	0%	0%	0%	-1%	0%
DC	The Netherlands	0%	0%	0%	0%	-1%	0%
DC	United Kingdom	0%	0%	0%	0%	0%	0%

D. Environmental Impact [Promoter]

Any gas infrastructure has an impact on its surroundings. This impact is of particular relevance when crossing some environmentally sensitive areas. Mitigation measures are taken by the promoters to reduce this impact and comply with the EU and National regulations.

TYNDP Code	Type of infrastructure	Surface of impact	Environmentally sensitive area
HYD-N-619	H2 transmission pipeline	DN 700 (28”), length 69 km	NO

Potential impact	Mitigation measures	Related costs included in project CAPEX and OPEX	Additional expected costs
HYD-N-619 During construction period the potential impacts on the environment are likely for: air quality, noise, geomorphology, habitats, cultural heritage	For the project HYD-N-619, EIA procedures have been carried out and Decisions on acceptability have been issued by the Croatian line Ministry. The Ministry Decisions on acceptability includes prescribed relevant environmental protection measures for reducing the potential impacts to the lowest level. EIA procedures were carried out in accordance with Croatian national legislation that is aligned with EU requirements.	Included in project CAPEX	Not expected

Environmental Impact explained [Promoter]

Slovenia: Environmental impact assessments for the projects have not indicated any substantial and irreversible impacts on the environment. In order to ensure that environmental assessments are correct, environmental monitoring is carried out before, during and after the repurposing and construction of the infrastructure.

Croatia: Major influences of the project HYD-N-619 on the economic and environmental dimensions are to be considered during the construction period (disturbance, traffic disturbance where secondary roads are cut, and impacts due to the dust, noise, transport machinery, and other machineries). The impacts on the environment are likely to appear in the following areas: air quality, noise, geomorphology, habitats, flora and fauna, cultural heritage, occupational health, waste and accidents. The proposed Environmental mitigation measures include measures prescribed by national law and other regulations, protection measures in accidental situations, plans and technical solutions for environmental protection as well as other protective measures. Mitigation measures for reducing the possible impacts to the lowest possible level are proposed in the EIA procedures.

E. Other benefits [Promoter]

Missing benefits are all benefits of a project which may be not captured by ENTSOG analysis.

As a necessary condition a missing benefit cannot have discrepancies with the benefits already covered by the assessment run by ENTSOG and this condition needs to be proved and justified.

Description of Other benefits [Promoter]

Repurposing of the Slovenian part of the existing infrastructure will be completed by 2029 and will allow to transport hydrogen on the local national level. The repurposed part of the infrastructure will connect potential hydrogen producers with various natural gas consumers, which will be able to choose between natural gas and hydrogen. It will encourage hydrogen producers to invest in hydrogen production Infrastructure, and existing natural gas consumers to switch to domestically produced hydrogen. In Slovenia, project will be beneficial for development of hydrogen value chain even before the whole corridor will be operational in 2035.

Additionally, the planned pipelines will be part of a new hydrogen transmission system with the aim of taking on the role of an indispensable link in the transport of hydrogen from Eastern Europe, the Balkans and the Southern and Eastern Mediterranean countries to the final users of hydrogen in Croatia, Slovenia and to the growing regional and European hydrogen market as foreseen by the Hydrogen Strategy of the Republic of Croatia until 2050.

Pipelines will be able to transmit significant volumes of renewable H2 to Slovenia, Austria and other CE countries. Based on the results of the comprehensive study the Potential of production of hydrogen, biomethane and geological storage of CO2 for decarbonization of the gas transmission system, in which it is anticipated that, depending on the degree of implementation of the potential of the sun and wind, Croatia will be able to provide up to about 3,000 kt of green hydrogen for export to neighboring countries.

F. Useful links [Promoter]

Useful links:

https://www.plinovodi.si/sl/prenosni-sistem/razvoj-projektov-za-prenos-vodika/

https://www.plinacro.hr/