HI EAST 7 (Less-advanced)

Hydrogen Infrastructure in Croatia

Reasons for grouping [ENTSOG]

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

The group includes investments in Hungary (TRA-N-1066) and in Croatia (HYD-N-1307, HYD-N-1274 and HYD-N-1255).

Objective of the group [Promoter]

Objective of the group is to create H2 cross border transmission network that will enable transmission of H2 from the expected H2 production zones in the southern Croatia to the customer base in northern Croatia, Hungary and CEE. The project group will also contribute to the development of hydrogen economy in the involved countries. Increased interest in domestic hydrogen production and consumption in both countries is expected since the project group will enable access to hydrogen transmission system and allow export and import of hydrogen.

The long-term group objective is to create cross border regional H2 market

HYD-N-1255 **H2 repurposing interconnection HR-HU**
Comm. Year **2040**

TRA-N-1066 **Capacity increment HR>HU direction and later HU hydrogen corridor II HU/HR**

Comm. Year **2040**

HYD-N-1274 **H2 supply system Croatia – North**

Comm. Year **2045**

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

Comm. Year **2045**

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]
HYD-N-1255	Slobodnica - IP Dravaszerdahely	Repurposing	800	81	
TRA-N-1066	Városföld-Kozármisleny;	Repurposing	800	165,7	30
TRA-N-1066	Kozárm.-HU/HR border	Repurposing	800	36,2	
TRA-N-1066	Városföld-Adony	Repurposing	600 - 400	77,1	
TRA-N-1066	Adony-Százhalombatta	Repurposing	600 - 400	33	
HYD-N-1274	Donji Miholjac - Osijek	Repurposing	500	60	
HYD-N-1274	Kutina - Virovitica	Repurposing	500	80	
HYD-N-1274	Lučko - Zagreb istok	Repurposing	700	20	
HYD-N-1274	Ludbreg - Varaždin	Repurposing	300	20	
HYD-N-1274	Slobodnica - Kutina	Repurposing	600	107	
HYD-N-1274	Zabok - Ludbreg	Repurposing	500	67	
HYD-N-1274	Zagreb - Karlovac	Repurposing	700	33	
HYD-N-1274	Zagreb istok - Kutina	Repurposing	600	67	
HYD-N-1307	Bosiljevo - Split	Repurposing	500	297	
HYD-N-1307	Pula - Rijeka	Repurposing	500	90	
HYD-N-1307	Rijeka - Karlovac	Repurposing	500	100	
HYD-N-1307	Zadar - Benkovac	Repurposing	300	37	

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-1255	H2_IP_HR-HU	Plinacro Ltd	Transmission Hungary (HU Hydrogen)	Transmission Croatia (HR Hydrogen)	148	2040
HYD-N-1255	H2_IP_HR-HU	Plinacro Ltd	Transmission Croatia (HR Hydrogen)	Transmission Hungary (HU Hydrogen)	148	2040
TRA-N-1066	H2_IP_HR-SI	FGSZ Ltd.	Transmission Croatia (HR Hydrogen)	Transmission Hungary (HU Hydrogen)	128.4	2040
TRA-N-1066	H2_IP_HR-SI	FGSZ Ltd.	Transmission Hungary (HU Hydrogen)	Transmission Croatia (HR Hydrogen)	128.4	2040

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-1255	40	15%	0.5	15%
TRA-N-1066	323,7	30%	15	30%
HYD-N-1274	180	15%	1,8	15%
HYD-N-1307	200	15%	2	15%

Description of the cost and range [Promoter]

Croatia: 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 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.

For project HYD-N-1066

• Description of CAPEX: the cost and range based on pre-feasibility study. During the preparation of TYNDP project submission ACER unit cost was not available for hydrogen project. FGSZ applied ACER based HU NRA guideline unit cost for natural gas 2022 multiplied by 0,3.

• Description of OPEX: the most significant impact on operating cost is the energy consumption of compressor stations. OPEX is estimated for max. capacity and electricity price 2022Q4, because FGSZ planned electric driven compressor units.

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].

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

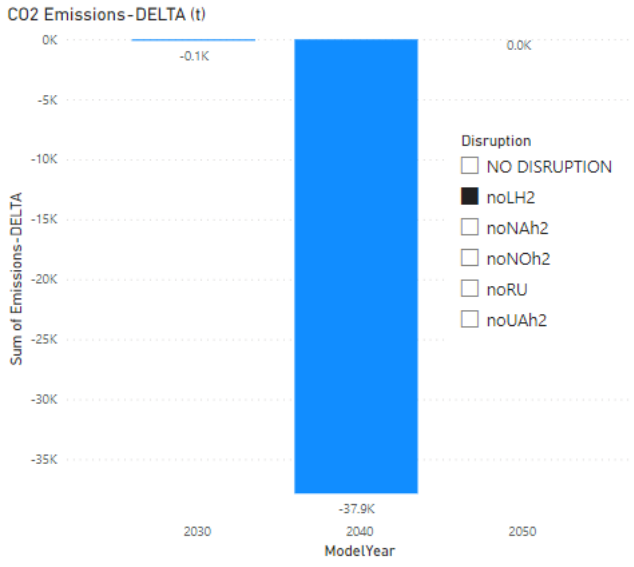
Distributed Energy

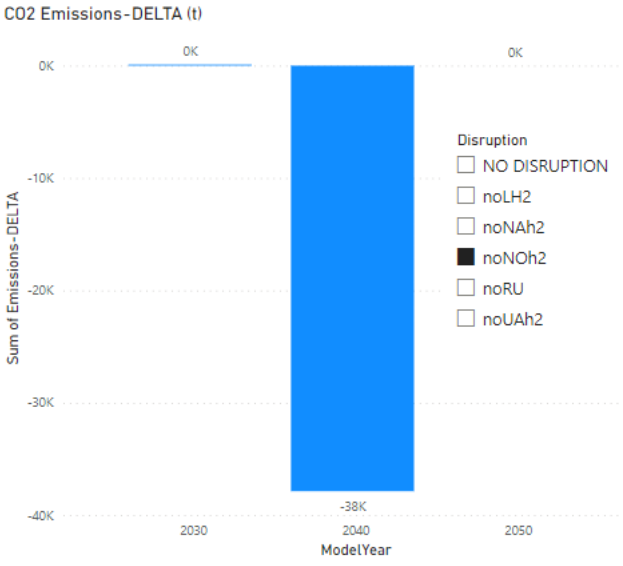
Sustainability

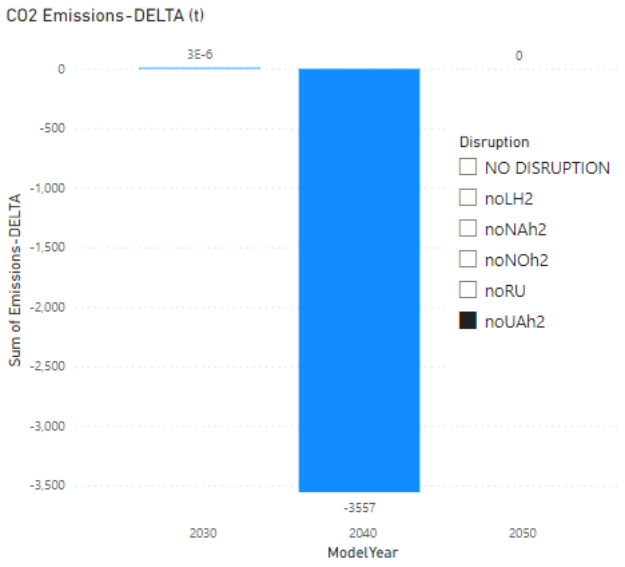
The project group contributes to sustainability by reducing hydrogen demand curtailment. With the implementation of the project group countries in the region can further cooperate avoiding demand curtailment. Indeed in the reference case, as all green hydrogen supply sources are already used at their maximum capacity, an increase in blue hydrogen (i.e. SMR) is needed to satisfy the hydrogen demand in 2040 and reduce demand curtailment.

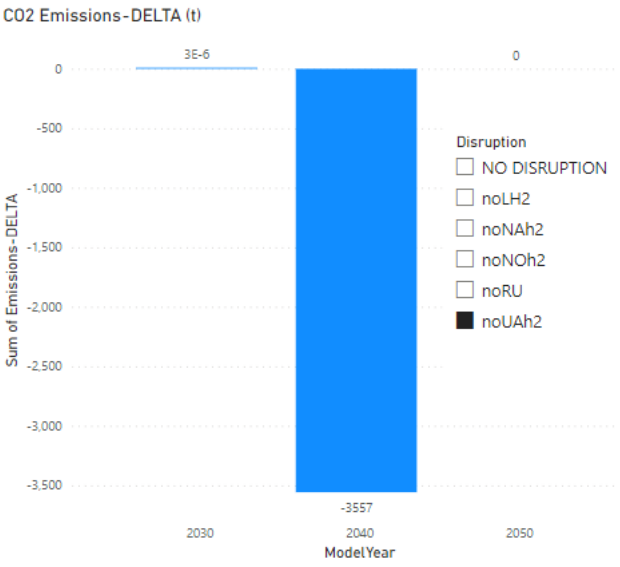
In case of disruptions, the project group will contribute to sustainability by reducing overall CO2 emissions up to 37,9kt kt in 2040 for Norwegian or LH2 disruptions.

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









Security of Supply:[2]

> Reference case:

In the reference case, the project mitigates the risk of hydrogen demand curtailment in Croatia by 3% in 2040 and 7% in 2050.

> 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 Croatia by 1-2% in 2040 and by 11% in 2050.

> Disruption cases (S-1):

[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.*

Under supply disruptions, the project group mitigates, mainly in Croatia, risk of demand curtailment in Croatia by 6-7% in 2040 and 11% in 2050. In other countries, in green, it mitigates by 1-2%.

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

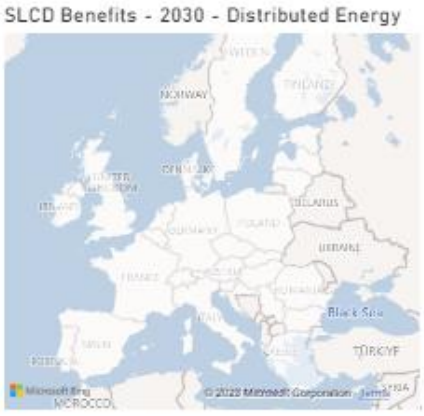
2 noNOh2 : Norway disruption

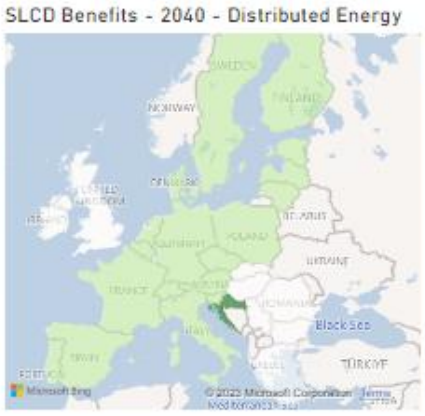
3 noUAh2 : Ukraine disruption

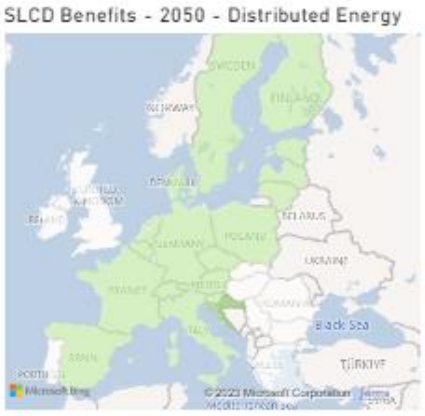
4 noNAh2 : North Africa disruption

> Single largest capacity disruption (SLCD):

From 2040, the projects group mitigates risk of demand curtailment in almost all European countries by 1-3%. However the projects group has more benefits, mitigating risk of demand curtailment in Croatia by 21% in 2040 and 19% in 2050.







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 Hungary 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 mitigates the risk of hydrogen demand curtailment in Croatia by 2% in 2040.

> Climatic stress cases

Under 2 -week and 2-week dunkelflaute climatic stress case, as well as under peak day climatic case the project group is not showing security of supply benefits.

> Disruption cases (S-1)

Under supply disruptions, the project group mitigates, mainly in Croatia, risk of demand curtailment in Croatia by 5 % in 2040. Under Ukrainian disruption, it mitigates risk in Slovakia, Hungary, Romania, Bulgaria and Greece by 3-4% from 2040.

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 7% in Croatia. In 2050, it mitigates in some European countries by 1%. However in Croatia is mitigates up to 11%.

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	0	538.677.299	538.677.299
2030	NO DISRUPTION	GA	tonne	-5	592.910.448	592.910.454
2030	noLH2	DE	tonne	-117	540.175.890	540.176.008
2030	noLH2	GA	tonne	-52	594.817.481	594.817.533
2030	noNAh2	DE	tonne	-2	539.785.356	539.785.359
2030	noNAh2	GA	tonne	-78	594.141.433	594.141.512
2030	noNOh2	DE	tonne	16	538.877.198	538.877.182
2030	noNOh2	GA	tonne	0	593.310.994	593.310.994
2030	noUAh2	DE	tonne	0	539.378.772	539.378.772
2030	noUAh2	GA	tonne	0	593.627.618	593.627.618
2040	NO DISRUPTION	DE	tonne	7.738	392.077.044	392.069.306
2040	NO DISRUPTION	GA	tonne	0	396.523.252	396.523.252
2040	noLH2	DE	tonne	-37.864	392.213.883	392.251.747
2040	noLH2	GA	tonne	42.955	397.455.197	397.412.242
2040	noNAh2	DE	tonne	-10.997	392.188.098	392.199.095
2040	noNAh2	GA	tonne	16.235	397.301.977	397.285.742
2040	noNOh2	DE	tonne	-37.864	392.144.023	392.181.887
2040	noNOh2	GA	tonne	38.736	397.450.977	397.412.242
2040	noUAh2	DE	tonne	-3.557	392.399.183	392.402.740
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	2040-DE-DELTA	2040-GA-DELTA	2050-DE-DELTA	2050-GA-DELTA
Croatia	-21%	-7%	-19%	-11%
Slovenia	-3%	-1%	-1%	-1%
France	-2%	-1%	-1%	0%
Austria	-2%	-1%	-2%	-1%
Belgium	-2%	-1%	-1%	0%
Czechia	-2%	-2%	-2%	-1%
Denmark	-2%	-1%	-1%	0%
Estonia	-2%	-1%	-2%	-1%
Finland	-2%	-1%	-2%	0%
Germany	-2%	-2%	-1%	0%
Italy	-2%	-1%	-2%	0%
Latvia	-2%	-1%	-1%	-1%
Lithuania	-2%	-1%	-1%	-1%
Poland	-2%	-1%	-1%	0%
Portugal	-2%	-1%	0%	-1%
Sweden	-2%	-1%	-2%	0%
Switzerland	-2%	-1%	-1%	-1%
The Netherlands	-2%	-1%	-2%	0%
Spain	-1%	-1%	-1%	-1%

Curtailment Rate (Climatic Stress):

SimulationPeriod	Country	2040-DE-DELTA	2040-GA-DELTA	2050-DE-DELTA	2050-GA-DELTA
Average2W	Austria	0%	0%	0%	0%
Average2W	Belgium	-1%	0%	0%	0%
Average2W	Bulgaria	0%	0%	0%	0%
Average2W	Croatia	-1%	-1%	-11%	0%
Average2W	Cyprus	0%	0%	0%	0%
Average2W	Czechia	-1%	0%	0%	0%
Average2W	Denmark	0%	-1%	0%	0%
Average2W	Estonia	0%	0%	0%	0%
Average2W	Finland	0%	0%	0%	0%
Average2W	France	0%	0%	0%	0%
Average2W	Germany	0%	0%	0%	0%
Average2W	Greece	0%	0%	0%	0%
Average2W	Hungary	0%	0%	0%	0%
Average2W	Ireland	0%	0%	0%	0%
Average2W	Italy	0%	0%	0%	0%

Average2W	Latvia	0%	0%	0%	0%
Average2W	Lithuania	0%	0%	0%	0%
Average2W	Luxembourg	0%	0%	0%	0%
Average2W	Malta	0%	0%	0%	0%
Average2W	Poland	0%	0%	0%	0%
Average2W	Portugal	0%	0%	0%	0%
Average2W	Romania	0%	0%	0%	0%
Average2W	Serbia	0%	0%	0%	0%
Average2W	Slovakia	0%	0%	0%	0%
Average2W	Slovenia	-1%	-1%	0%	0%
Average2W	Spain	0%	0%	0%	0%
Average2W	Sweden	0%	0%	0%	0%
Average2W	Switzerland	-1%	0%	0%	0%
Average2W	The Netherlands	0%	-1%	0%	0%
Average2W	United Kingdom	0%	0%	0%	0%
Average2WDF	Austria	-1%	0%	0%	0%
Average2WDF	Belgium	0%	0%	0%	0%
Average2WDF	Bulgaria	0%	0%	0%	0%
Average2WDF	Croatia	-1%	-1%	-10%	0%
Average2WDF	Cyprus	0%	0%	0%	0%
Average2WDF	Czechia	0%	0%	0%	0%
Average2WDF	Denmark	0%	0%	0%	0%
Average2WDF	Estonia	0%	0%	0%	0%
Average2WDF	Finland	0%	-1%	0%	0%
Average2WDF	France	0%	0%	0%	0%
Average2WDF	Germany	0%	0%	0%	0%
Average2WDF	Greece	0%	0%	0%	0%
Average2WDF	Hungary	0%	0%	0%	0%
Average2WDF	Ireland	0%	0%	0%	0%
Average2WDF	Italy	0%	0%	0%	0%
Average2WDF	Latvia	0%	0%	0%	0%
Average2WDF	Lithuania	0%	0%	0%	0%
Average2WDF	Luxembourg	0%	0%	0%	0%
Average2WDF	Malta	0%	0%	0%	0%
Average2WDF	Poland	0%	0%	0%	0%
Average2WDF	Portugal	0%	0%	0%	0%
Average2WDF	Romania	0%	0%	0%	0%
Average2WDF	Serbia	0%	0%	0%	0%
Average2WDF	Slovakia	0%	0%	0%	0%
Average2WDF	Slovenia	-1%	-1%	0%	0%
Average2WDF	Spain	0%	-1%	0%	0%
Average2WDF	Sweden	0%	0%	0%	0%
Average2WDF	Switzerland	-1%	0%	0%	-1%
Average2WDF	The Netherlands	0%	0%	0%	0%
Average2WDF	United Kingdom	0%	0%	0%	0%
DC	Austria	0%	0%	0%	0%
DC	Belgium	0%	0%	0%	0%
DC	Bulgaria	0%	0%	0%	0%
DC	Croatia	-2%	-1%	-8%	0%

DC	Cyprus	0%	0%	0%	0%
DC	Czechia	0%	0%	0%	0%
DC	Denmark	0%	0%	0%	0%
DC	Estonia	-1%	0%	0%	0%
DC	Finland	0%	0%	0%	0%
DC	France	-1%	0%	0%	0%
DC	Germany	0%	0%	0%	0%
DC	Greece	0%	0%	0%	0%
DC	Hungary	0%	0%	0%	0%
DC	Ireland	0%	0%	0%	0%
DC	Italy	0%	0%	0%	0%
DC	Latvia	-1%	0%	0%	0%
DC	Lithuania	-1%	0%	0%	0%
DC	Luxembourg	0%	0%	0%	0%
DC	Malta	0%	0%	0%	0%
DC	Poland	-1%	0%	0%	0%
DC	Portugal	-1%	0%	0%	0%
DC	Romania	0%	0%	0%	0%
DC	Serbia	0%	0%	0%	0%
DC	Slovakia	0%	0%	0%	0%
DC	Slovenia	-1%	0%	0%	0%
DC	Spain	0%	0%	0%	0%
DC	Sweden	0%	0%	0%	0%
DC	Switzerland	0%	0%	-1%	0%
DC	The Netherlands	0%	0%	0%	0%
DC	United Kingdom	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-1255	n.a	n.a	n.a
TRA-N-1066	n.a	n.a	n.a
HYD-N-1274	n.a	n.a	n.a
HYD-N-1307	n.a	n.a	n.a

Potential impact	Mitigation measures	Related costs included in project CAPEX and OPEX	Additional expected costs

Environmental Impact explained [Promoter]

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.

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]

Pipelines will be able to transmit significant volumes of renewable H2 to Croatia, Hungary, and other CE and CEE 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.

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 and to the growing regional and European hydrogen market as foreseen by the Hydrogen Strategy of the Republic of Croatia until 2050.

For project HYD-N-1066

Along the pipeline route hydrogen producers will have the possibility to establish electrolyzers and hydrogen entry points.

The project group will help development of hydrogen economy in South and Central Hungary.

The project create connection with the Hungarian Hydrogen backbone system, especially RO/HU/SK hydrogen corridor.

F. Useful links [Promoter]

Useful links:

https://www.plinacro.hr/

HU/HR hydrogen corridor (page 21): FGSZ Földgázszállító Alcím dia 1