BEMIP HYD 4 (Less-Advanced)

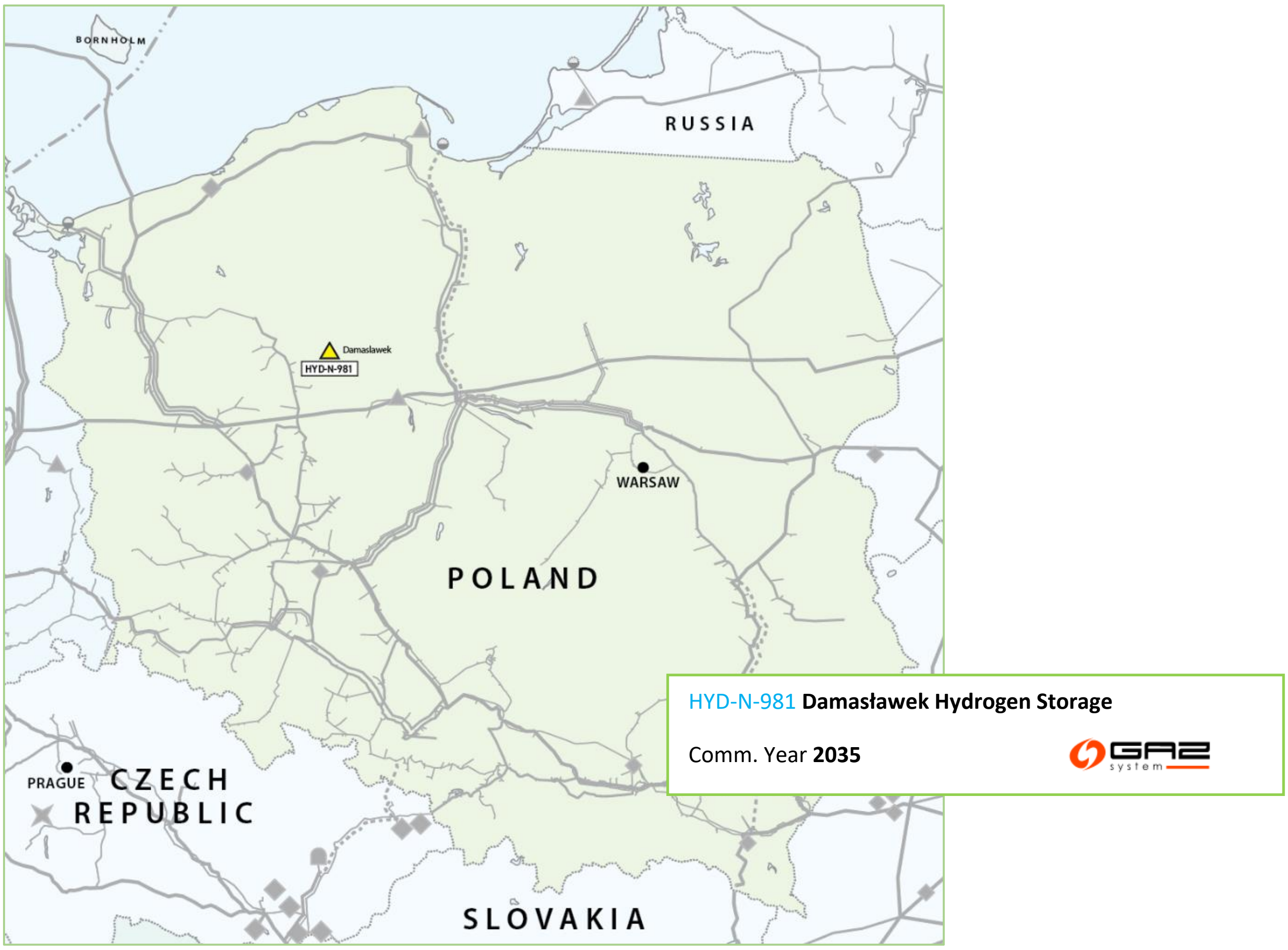
Hydrogen Storage in Poland

Reasons for grouping [ENTSOG]

The project group is a stand-alone underground storage in Poland. This project will enable storage of hydrogen in Poland by 2035 (HYD-N-981).

Objective of the group [Promoter]

Construction of underground storage facility for pure H2 (up to 36 caverns with the capacity of approx. 40 mcm each). The project is planned to be located in the Damasławek salt deposit and be connected to the Nordic-Baltic Hydrogen Corridor. Integral parts of the investment are the underground and aboveground infrastructure of the storage facility, leaching plant, brine, water and high-pressure pipelines for H2. The project foresees the construction of a tankless underground H2 storage facility that will offer the possibility to store renewable energy and thus support the operation of the Nordic-Baltic Hydrogen Corridor and in the Polish Hydrogen Backbone. The figures on capacity and WGV on page 2 reflect the first 2 caverns.



A. Project group technical information [Promoter/ ENTSOG]

Project technical information [Promoter]

Storage

TYNDP Project code	Maximum Injection rate [GWh/d]	Maximum Withdrawal rate [GWh/d]	Working gas volume [GWh]	Geometrical Volume [m3]
HYD-N-981	2	2	9,8	80000000

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-981	H2_ST_PL	GAZ-SYSTEM S.A.	Transmission Poland (PL Hydrogen)	Storage Poland (PL Hydrogen)	2	2035
HYD-N-981	H2_ST_PL	GAZ-SYSTEM S.A.	Storage Poland (PL Hydrogen)	Transmission Poland (PL Hydrogen)	2	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-981	345	50%	40	90%

Description of the cost and range [Promoter]

The figures reflect cost estimations covering the underground (i.e. the first 2 caverns) and aboveground infrastructure of the storage facility, leaching plant, brine, water and high-pressure pipelines for H2. CAPEX and OPEX figures were calculated based on preliminary coefficients.

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/202304/ENTSOG_TYNDP_2022_Annex_D_Methodology_230411.pdf

Distributed Energy

In 2035, the new storage in Poland allows hydrogen to be stored, during low demand period, for climatic stresses or international disruption.

Sustainability

The project group, will increase flexibility of hydrogen supplies, allowing for the replacement of blue hydrogen supplies, with green hydrogen supplies.

Security of Supply:[2]

> Reference case

2040 DE- Benefits

2050 DE- Benefits

In the reference case, the project is not contributing to further mitigation of hydrogen demand curtailment risk in average summer and average winter.

> 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 also not showing security of supply benefits.

> Disruption cases (S-1):

Similarly, under supply disruption cases, the project group is not further contributing to the mitigation of hydrogen demand curtailment rest.

> Single largest capacity disruption (SLCD):

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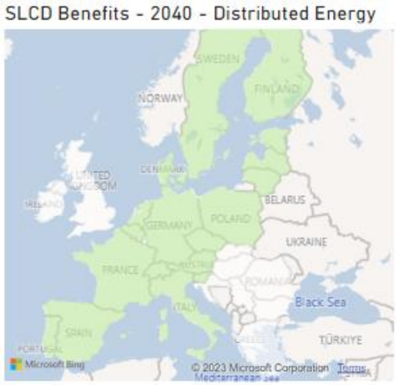
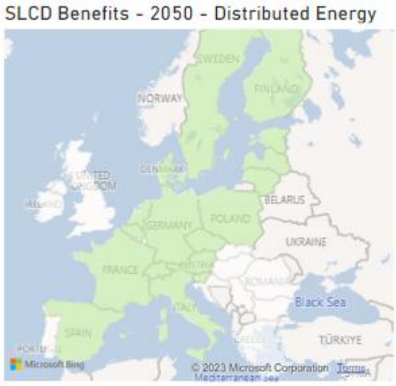
[2] *As for the hydrogen system there is no existing infrastructure level available yet, ENTSOG has identified a possible hydrogen network according to the information provided by promoters in their project submission for the TYNDP/PCI process (i.e., H2 Infrastructure level). Therefore, the System Assessment 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.*

In case of single largest capacity disruption (SLCD), the storage reduces a little (1-2%) the risk of demand curtailment in all European countries from 2040.





Global Ambition

Sustainability

The project group, will increase flexibility of hydrogen supplies, allowing for the replacement of blue hydrogen supplies, with green hydrogen supplies.

Security of supply benefits

> Reference case

In the reference case, the storage is not contributing to further mitigation of hydrogen demand curtailment risk in average summer and average winter.

> 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 also not showing security of supply benefits.

> Disruption cases (S-1)

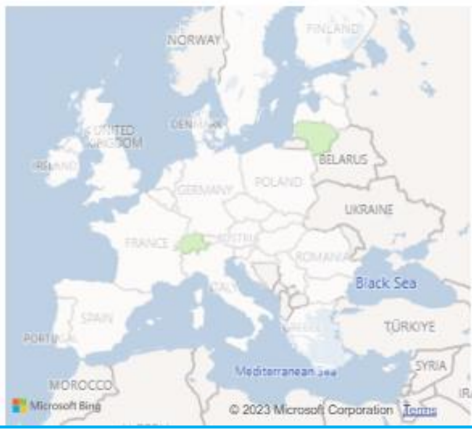
Similar to reference case and climatic stress cases the project is not further mitigating the demand curtailment risk in case of disruption cases.

> Single largest capacity disruption (SLCD)

In case of single largest capacity disruption (SLCD), the storage reduces a little (1-2%) the risk of demand curtailment in all European countries in 2040.

SLCD Benefits - 2040 - Global Ambition

SLCD Benefits - 2050 - Global Ambition



C.2 Quantitative benefits [ENTSOG]

The following tables display all the benefits quantified by ENTSOG through specific security of supply and sustainability indicators.

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	0	392.077.044	392.077.044
2040	NO DISRUPTION	GA	tonne	152	396.523.252	396.523.100
2040	noLH2	DE	tonne	65	392.213.883	392.213.818
2040	noLH2	GA	tonne	0	397.455.197	397.455.197
2040	noNAh2	DE	tonne	65	392.188.098	392.188.033
2040	noNAh2	GA	tonne	434	397.301.977	397.301.543
2040	noNOh2	DE	tonne	65	392.144.023	392.143.958
2040	noNOh2	GA	tonne	72	397.450.977	397.450.906
2040	noUAh2	DE	tonne	65	392.399.183	392.399.118
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
Belgium	-2%	-1%	-1%	0%
Czechia	-2%	-2%	-2%	0%
Estonia	-2%	-1%	-2%	0%
Finland	-2%	-1%	-2%	0%
Germany	-2%	-1%	-1%	0%
Latvia	-2%	-1%	-1%	0%
Lithuania	-2%	-1%	-1%	-1%
Poland	-2%	-1%	-1%	0%
Portugal	-2%	-1%	0%	0%
Slovenia	-2%	-1%	-1%	0%
Sweden	-2%	-1%	-2%	0%
Switzerland	-2%	-1%	-1%	-1%
France	-2%	-1%	-1%	0%
The Netherlands	-1%	-1%	-2%	0%
Austria	-1%	-1%	-2%	0%
Denmark	-1%	-1%	-1%	0%
Italy	-1%	-1%	-2%	0%
Spain	-1%	-1%	-1%	0%
Greece	-1%	0%	0%	0%
Bulgaria	0%	0%	0%	0%
Croatia	0%	-1%	0%	0%
Hungary	0%	0%	0%	0%
Romania	0%	0%	0%	0%
Slovakia	0%	0%	0%	-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	0%	0%	0%	0%
Average2W	Bulgaria	0%	-1%	0%	0%
Average2W	Croatia	0%	0%	0%	0%
Average2W	Cyprus	0%	0%	0%	0%
Average2W	Czechia	0%	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	0%	-1%	0%	0%
Average2W	Spain	0%	0%	0%	0%
Average2W	Sweden	0%	0%	0%	0%
Average2W	Switzerland	0%	0%	0%	0%
Average2W	The Netherlands	0%	-1%	0%	0%
Average2W	United Kingdom	0%	0%	0%	0%
Average2WDF	Austria	0%	0%	0%	0%
Average2WDF	Belgium	0%	0%	0%	0%
Average2WDF	Bulgaria	0%	0%	0%	0%
Average2WDF	Croatia	0%	0%	0%	0%
Average2WDF	Cyprus	0%	0%	0%	0%
Average2WDF	Czechia	0%	0%	0%	0%
Average2WDF	Denmark	0%	0%	0%	0%
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Average2WDF	Finland	0%	0%	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%
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Average2WDF	Romania	0%	0%	0%	0%
Average2WDF	Serbia	0%	0%	0%	0%
Average2WDF	Slovakia	0%	0%	0%	0%
Average2WDF	Slovenia	0%	0%	0%	0%
Average2WDF	Spain	0%	0%	0%	0%
Average2WDF	Sweden	0%	0%	0%	0%
Average2WDF	Switzerland	0%	0%	0%	0%
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	0%	0%	0%	0%
DC	Cyprus	0%	0%	0%	0%
DC	Czechia	0%	0%	0%	0%
DC	Denmark	0%	0%	0%	0%
DC	Estonia	0%	0%	0%	0%
DC	Finland	0%	0%	0%	0%
DC	France	0%	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	0%	0%	0%	0%
DC	Lithuania	0%	0%	0%	0%
DC	Luxembourg	0%	0%	0%	0%
DC	Malta	0%	0%	0%	0%
DC	Poland	0%	0%	0%	0%
DC	Portugal	0%	0%	0%	0%
DC	Romania	0%	0%	0%	0%
DC	Serbia	0%	0%	0%	0%
DC	Slovakia	0%	0%	0%	0%
DC	Slovenia	0%	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-981	Hydrogen storage in Damasławek Pipeline connecting the hydrogen grid Brine transmission infrastructure Industrial water transmission infrastructure	Hydrogen storage in Damasławek Pipeline connecting the hydrogen grid – DN1000, approx. 29 km Brine transmission infrastructure – DN500, approx. 63 km Industrial water transmission infrastructure – DN800, approx. 81 km & DN500, approx. 23 km	• Natura 2000 areas: ○ Middle Noteć Valley and Bydgoszcz Canal PLB300001 ○ Noteć Valley PLH300004 ○ ostoja Barcińsko-Gąsawska PLH040028 ○ Solniska Szubinskie PLH040030 • Surface water reservoirs • Natural habitats

Potential impact	Mitigation measures	Related costs included in project CAPEX and OPEX	Additional expected costs
Any impact on the environment will occur at the construction stage as a result of: cutting shrubs and trees, drainage excavations, noise	In order to ensure adequate protection of environmentally sensitive areas, the following mitigation measures are planned to	N/A	N/A

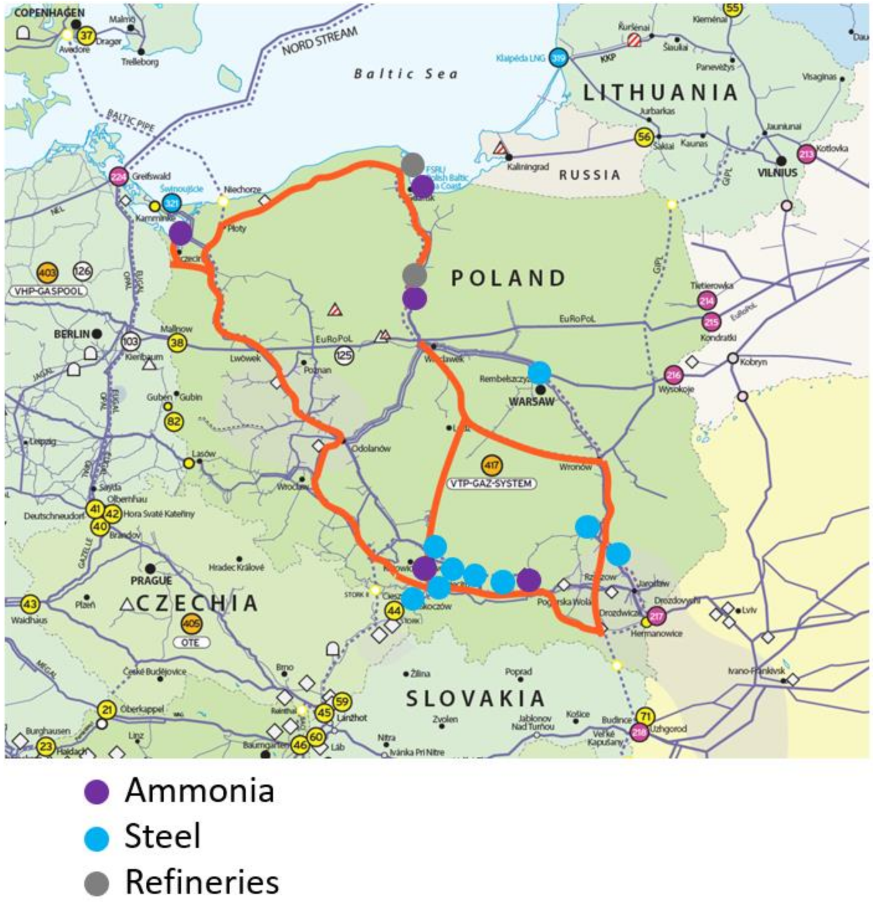
emissions, air pollution, sewage and waste. The range of impacts will be limited to the construction site. Following project commissioned the impact on the environment will only be possible in the event of a failure.	be implemented during the construction of the underground hydrogen storage together with the accompanying infrastructure: • narrowing the width of the construction site to a minimum in particularly valuable areas; • carrying out construction works outside the growing season; • crossing selected habitats (including river valleys, forests) with trenchless technology (eg HDD); • location of construction site facilities outside acoustically protected areas, at a distance of at least 100 m from reservoirs and watercourses; • habitat relocation and restoration to original site after construction; • installation of nesting boxes for habitats of protected bird species; • environmental supervision during construction.		

Environmental Impact explained [Promoter]

Poland is ranked in the third place in Europe in terms of hydrogen production that was at the level of approx. 1 million tonnes per year. The production was entirely allocated to cover domestic needs. Hydrogen is currently produced mostly for the purpose of fertiliser, chemical, petrochemical and coking plants. This is grey hydrogen produced mostly by using steam reforming and coal gasification.

On top of the current hydrogen consumers there is also a large industrial base in Poland that may be decarbonised using hydrogen. This concerns sectors that are considered as hard-to-abate including steel, ammonia, chemical, industries requiring high temperatures, maritime and heavy transport and district heating systems.

The map on the right-hand side illustrates the location of key hard-to-abate sectors in Poland.



The Polish section of the Baltic Sea with shallow water and very good wind conditions and inland Poland (especially the Northern part) with very good wind conditions and good insolation provides adequate conditions to generate renewable hydrogen. Based on market signals renewable hydrogen generation in Poland may increase up to approx. 62 GWh/d, thus reaching the level of the current natural gas production injected to the transmission system in Poland. Hydrogen production is expected to further rise and exceed 100 GWh/d by mid-2030 and reach the level of approx. 172 GWh/d in the perspective of 2040.

The ramp-up of hydrogen market based on variable renewable sources requires hydrogen storage facilities to balance variable supplies of hydrogen with the need to ensure stable supplies towards hydrogen off-takers. In this context the Hydrogen Storage in Damasławek will be connected to the Polish section of the Nordic-Baltic Hydrogen Corridor and in the Polish Hydrogen Backbone and it will thus support safe operations of both projects. This will allow the Polish and Central European hydrogen market players to get access to hydrogen generated in the Baltic Sea region that has the renewable potential of more than 200 GW enabling production of 470 TWh (15 590 kT/y) of renewable hydrogen.

Against this background, the Hydrogen Storage in Damasławek will create an opportunity for hydrogen consumers to balance their supply and demand for hydrogen and thus deliver required volumes of hydrogen industries present in Poland. As a result, the Hydrogen Storage in Damasławek will support:

- decarbonisation of Polish industries – existing and perspective consumers of hydrogen (fertilizers and chemicals, petrochemical, steel, heavy duty transport, e-fuels, high temperature heat)
- unlocking the full potential of renewable hydrogen generation in Poland and the Baltic Sea region.

The specificity of the hydrogen infrastructure is that it must ensure stable (continuous) supplies to customers, while dependent on variable production, so the hydrogen infrastructure needs to be designed to accumulate the commodity during unfavourable weather conditions (i.e. dunkelflaute conditions) and be capable of transporting large volumes of hydrogen during production peaks (e.g. windy conditions). The shape of the Hydrogen Storage in Damasławek meets this requirement by making full use of the storage potential of hydrogen that is particularly beneficial for power grids as it allows for renewable energy to be kept not only in large quantities, but also for long periods of time. In such perspective the Hydrogen Storage in Damasławek will help to improve the flexibility of energy systems on a regional level (Germany, Poland, the Nordic and Baltic regions) by balancing out supply and demand when there is either too much or not enough power being generated, contributing to energy efficiency improvement throughout the BEMIP region and at the EU level (as shown by the ENTSOG analyses results).

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]

SoS:

- The project creates an opportunity for hydrogen consumers to balance their supply and demand for hydrogen coming from various directions. Central location of the project that will support the storage of onshore and offshore domestic producers, Finnish/Baltic Sea hydrogen and hydrogen available on the German market). This will mitigate the SoS concerns from the start of an emerging market.
- The project will support the ramp-up of the hydrogen market based on variable renewable sources available in the EU by unlocking the potential for intra-EU production of hydrogen. This is extremally important under the current geopolitical situation, i.e. the Russian war in Ukraine and the use of energy supplies by Russia as a measure of coercion, while the EU energy independence is in the spotlight of the EU energy policy (e.g. goals set by REPowerEU).

Market Integration:

- The project is expected to be a part of the future pan-European hydrogen network and particularly aims at unlocking the potential for production and use of hydrogen in the BEMIP region by enabling the transport of hydrogen to supply consumption points and industrial clusters especially in Poland, but also in Germany. The project will make a key contribution to spreading out the penetration of hydrogen in the industrial sector and integrating multiple and competitive hydrogen suppliers with consumers, what in consequence will positively affect the development of the integrated, liquid, secure and competitive hydrogen market.

Competition:

- The Hydrogen Storage in Damasławek will allow the access to multiple supply sources covering onshore and offshore domestic producers, Finnish/Baltic Sea hydrogen and hydrogen available on the German market

F. Useful links [Promoter]

Useful links: https://www.gaz-system.pl/en/for-media/press-releases/2023/april/03-04-2023-market-screening-procedure-for-hydrogen-ammonia-and-biomethane-projects-extended-deadline-for-questionnaire-submission-.html