HI WEST 22 (Less-Advanced)
H2 Storage in Harsefeld, Germany

Reasons for grouping [ENTSOG]

The project group is a stand-alone underground storage in Germany. This project will enable storage of hydrogen in Germany from 2030 (HYD-N-934).

Objective of the group [Promoter]

Storengy plans to construct an underground hydrogen storage close to the Harsefeld natural gas storage (Lower Saxony, close to Hamburg and Stade). The current project phase consists in the creation of a new salt cavern and construction of dedicated surface facilities to store 100% H_2. The planned Working Gas Volume of 205 GWh could be cycled several times in a year thanks to a highly-flexible plant design. The maximum storage volume and the injection/withdrawal capacities are subject to further investigations and may be adapted depending on market needs. As the Harsefeld salt dome potentially allows for the creation of several caverns, the option to leach a 2nd cavern and add up the necessary surface equipment is foreseen in a second phase. A third phase could be achieved by repurposing to H_2 the existing natural gas facilities. The storage would be connected to the H_2 network of Gasunie running from the Netherlands to Denmark via Hamburg where a H_2 distribution network is planned.

HYD-N-934 **SaltHy Harsefeld**

Comm. Year **2030**

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-934	17	17	205	500 000

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-934	H2_ST_DE	Storengy Deutschland GmbH	Transmission Germany (DE Hydrogen)	Storage Germany (DE Hydrogen)	17	2030
HYD-N-934	H2_ST_DE	Storengy Deutschland GmbH	Storage Germany (DE Hydrogen)	Transmission Germany (DE Hydrogen)	17	2030

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-934	81	30	3.7	30

Description of the cost and range [Promoter]

The project depends on negotiations especially for cavern creation , publishing CAPEX and OPEX information might jeopardize the negotiation with the third parties. Reference costs are results of inhouse studies for typical UHS projects, results for a given project may differ due to local specificities and ramp-up effects. Depending on the development of H_2 transportation network and market needs, project scope/timing and thus CAPEX could evolve.

The OPEX range provided is expressed in €2022 under the assumption of an integrated natural gas and hydrogen storage operator and covers one yearly cycle of the maximum Working Gas Volume. The main drivers for operating costs are storage utilization and operating (grid) pressure as well as electricity price (commodity, taxes and levies).

C. Project Benefits [ENTSOG]

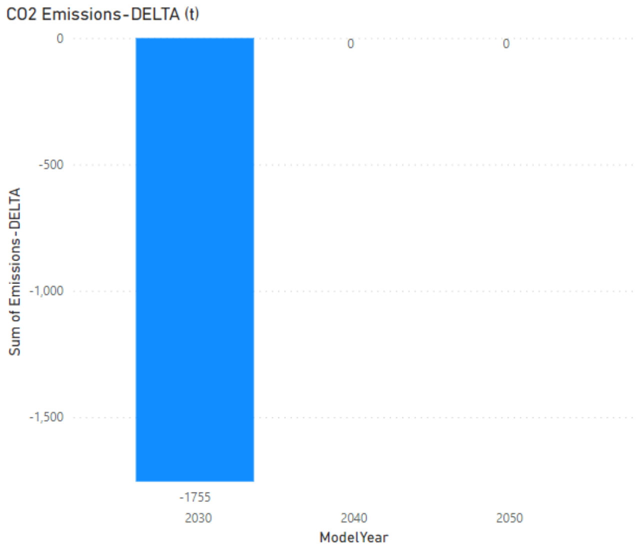
C.1 Summary of benefits

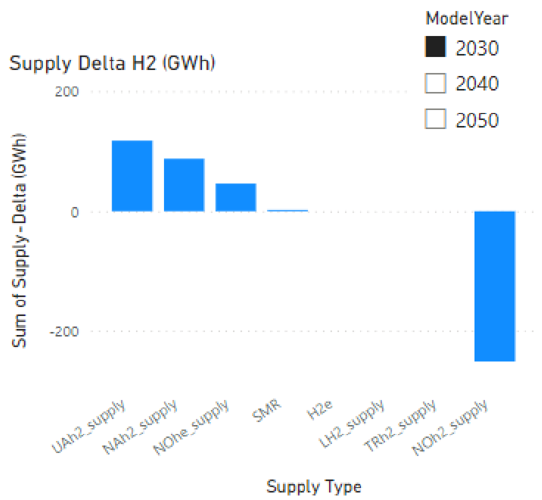
This section provides a summarised analysis by ENTSOG of the main benefits stemming from the realisation of the overall group. More details on the indicators are available in Annex D of TYNDP 2022[1].

Distributed Energy

Sustainability benefits

In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group will contribute to sustainability by reducing overall CO2 emissions by 1,8 kt in 2030. This can be explained as the project group will enable the replacement of blue hydrogen imports with green hydrogen supplies.

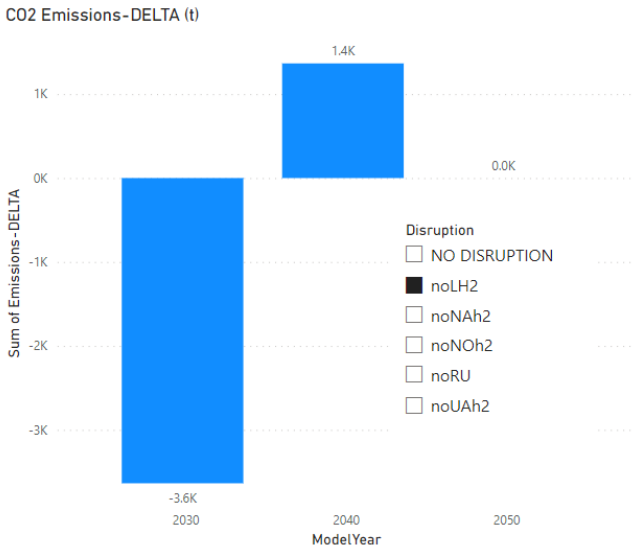


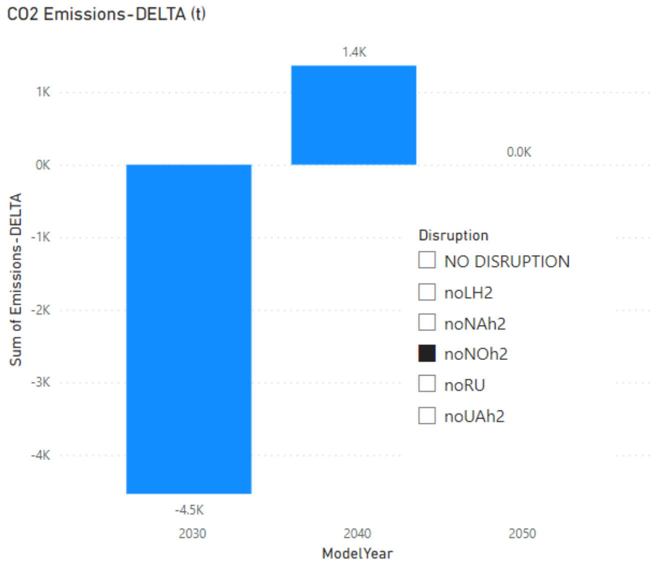


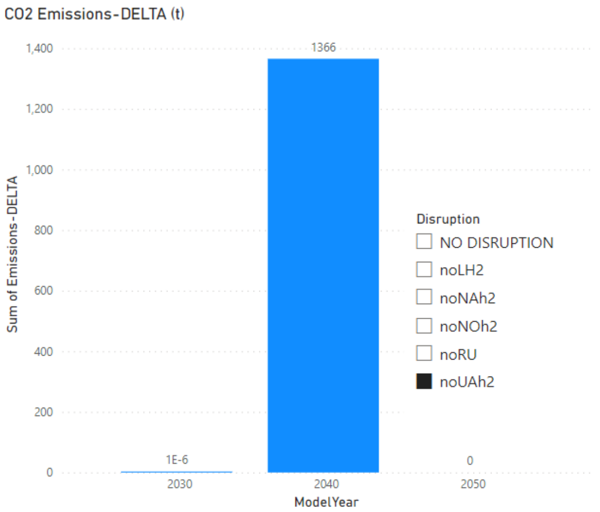
Similar trend is expected under yearly supply disruption in 2030. In addition, in 2040 triggered by the higher hydrogen demand and lower availability of supplies due to the disruption case, project group will increase overall CO2 emissions savings by increasing SMR production, and hence, reduce demand curtailment.

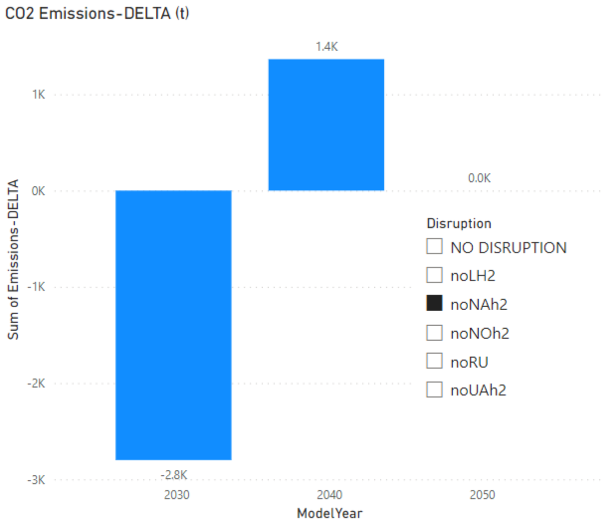
[1] TYNDP 2022 Annex D
https://www.entsog.eu/sites/default/files/2023-04/ENTSOG_TYNDP_2022_Annex_D_Methodology_230411.pdf

1. NoLH2: Liquid imports disruption/ 2. noNOh2: Norway disruption / 3. noUAh2: Ukraine disruption/ 4. noNAh2: North Africa disruption









Security of Supply:[2]

> Reference case:

No security of supply benefits observed under reference case (summer/winter average demand).

[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.*

2030 DE- Benefits

2040 DE- Benefits

2050 DE- Benefits

> Climatic stress cases:

Under climatic stress cases (peak day, 2-weeks and 2-weeks dunkelflaute), project group does not show additional SoS benefits.

> Disruption cases (S-1):

Under yearly disruption cases, project group does not show additional SoS benefits.

> Single largest capacity disruption (SLCD):

Project group slightly reduces the risk of demand curtailment under SLCD in Europe from 2030. Project group enables storage of supply allowing for further cooperation between Germany and its neighboring countries.

Benefits 100% - 20% 20% - 5% 5% - 0%

SLCD Benefits - 2030 - Distributed Energy

SLCD Benefits - 2040 - Distributed Energy

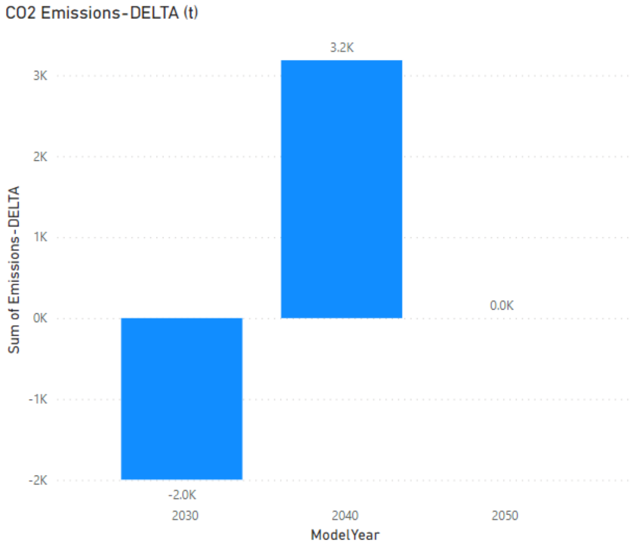
SLCD Benefits - 2050 - Distributed Energy

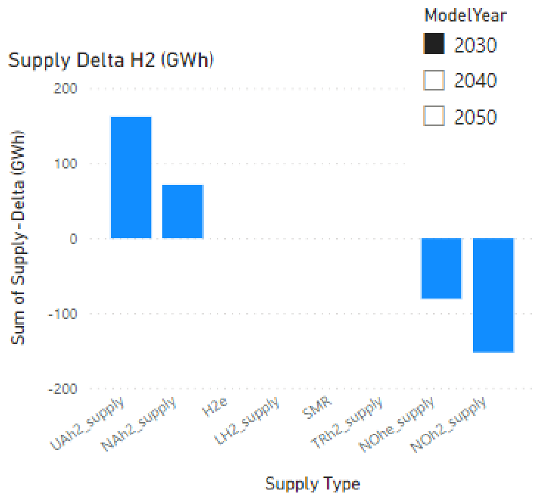
Global Ambition

Sustainability

In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group will contribute to sustainability by reducing overall CO2 emissions by 1,5 kt in 2030. This can be explained as the project group will enable the replacement of blue hydrogen imports with green hydrogen supplies, as project group enables also storage of green supplies.

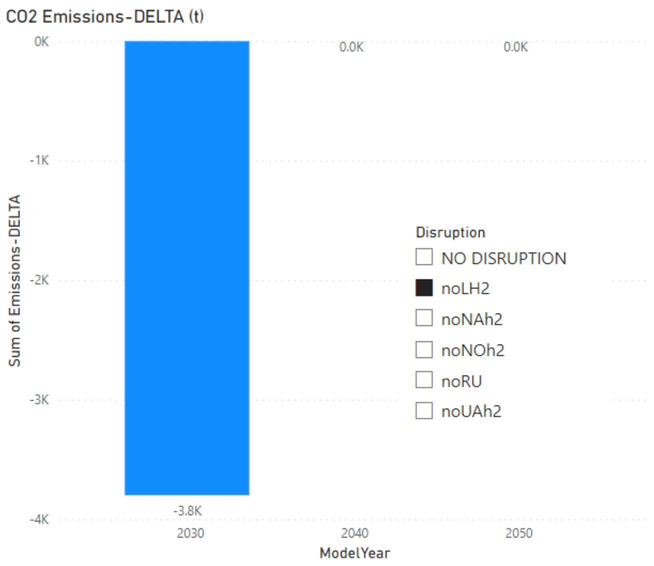
In addition, in 2040, triggered by the higher hydrogen demand, project group will increase overall CO2 emissions savings by increasing SMR production, and therefore, reduce demand curtailment.

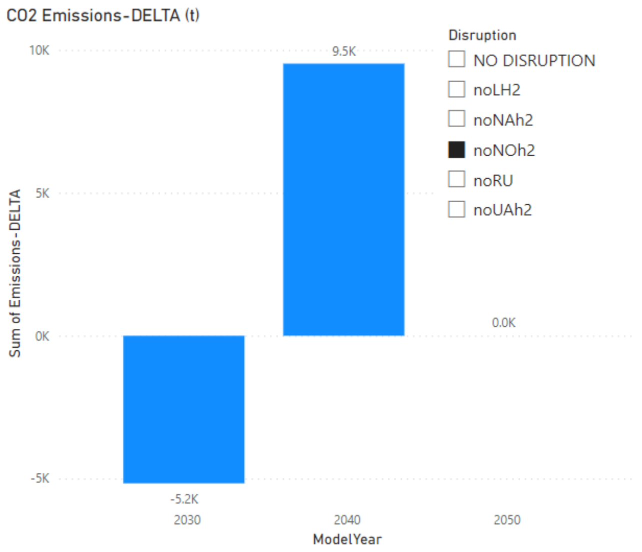


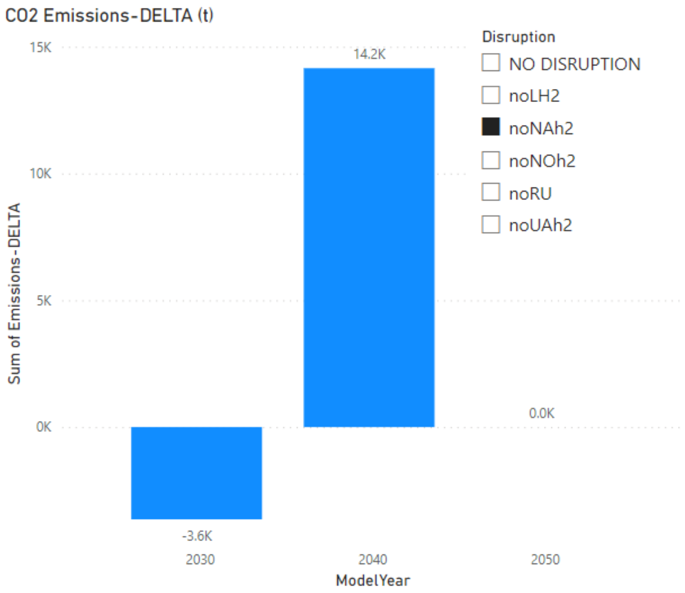


Similar trend is expected under yearly supply disruption cases in 2030 and 2040 for liquid imports, Norwegian and North African supply disruptions. No sustainability benefits observed under Ukrainian disruption case.

1. *NoLH2: Liquid imports disruption/ 2. noNOh2 : Norway disruption / 3. noNAh2 : North Africa disruption*







Security of supply benefits

> Reference case:

No security of supply benefits observed under reference case (summer/winter average demand).

> Climatic stress cases:

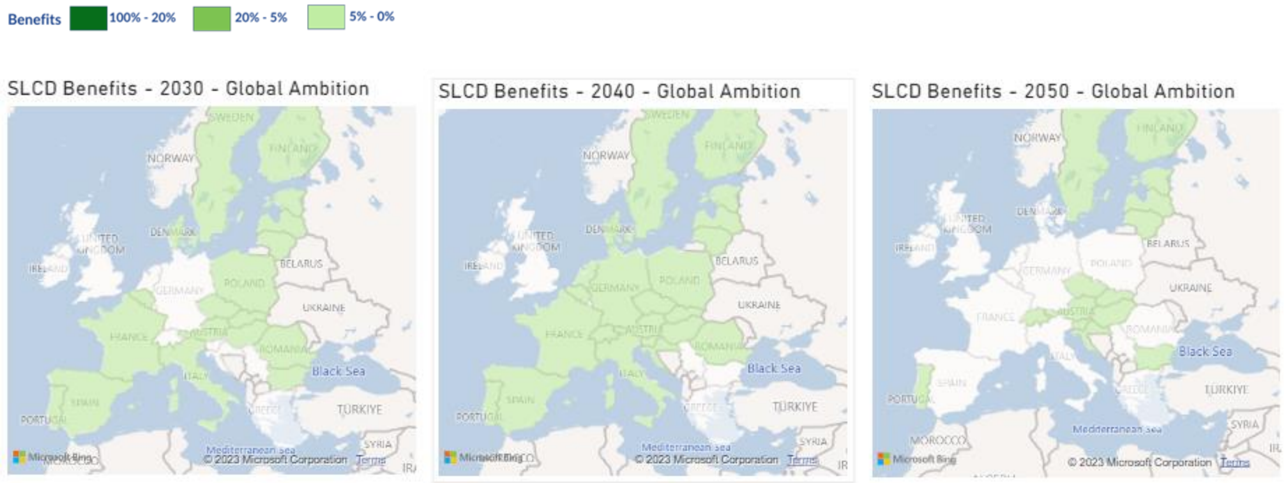
Under climatic stress cases (peak day, 2-weeks and 2-weeks dunkelflaute), project group does not show additional SoS benefits.

> Disruption cases (S-1):

Under yearly disruption cases, project group does not show additional SoS benefits.

> Single largest capacity disruption (SLCD):

Project group slightly reduces the risk of demand curtailment under SLCD in Europe mainly in 2030 and 2040. Project group enables storage of supply allowing for further cooperation between Germany and its neighbouring countries.



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	Emissions-DELTA	Emissions-PLUS	Emissions-MINUS
2030	NO DISRUPTION	DE	tonne	-1754,66	538677299	538679053,7
2030	noLH2	DE	tonne	-3636,14	540175890,2	540179526,4
2030	noNAh2	DE	tonne	-2799,44	539785356,1	539788155,5
2030	noNOh2	DE	tonne	-4535,68	538877197,8	538881733,5
2030	noUAh2	DE	tonne	0,00	539378771,9	539378771,9
2030	NO DISRUPTION	GA	tonne	-1996,11	592910448,4	592912444,6
2030	noLH2	GA	tonne	-3799,25	594817481,2	594821280,4
2030	noNAh2	GA	tonne	-3638,55	594141433,2	594145071,7
2030	noNOh2	GA	tonne	-5164,51	593310994,3	593316158,8
2030	noUAh2	GA	tonne	0,00	593627617,9	593627617,9
2040	NO DISRUPTION	DE	tonne	0,00	392077044	392077044
2040	noLH2	DE	tonne	1365,51	392213883,4	392212517,9
2040	noNAh2	DE	tonne	1365,51	392188097,7	392186732,2
2040	noNOh2	DE	tonne	1365,51	392144022,6	392142657,1
2040	noUAh2	DE	tonne	1365,51	392399182,9	392397817,4
2040	NO DISRUPTION	GA	tonne	3186,19	396523251,6	396520065,4
2040	noLH2	GA	tonne	0,00	397455196,7	397455196,7
2040	noNAh2	GA	tonne	14155,11	397301976,6	397287821,5
2040	noNOh2	GA	tonne	9523,42	397450977,1	397441453,7
2040	noUAh2	GA	tonne	0,00	397478498,3	397478498,3
2050	NO DISRUPTION	DE	tonne	0,00	232557734,8	232557734,8
2050	noLH2	DE	tonne	0,00	232557734,8	232557734,8
2050	noNAh2	DE	tonne	0,00	232557734,8	232557734,8
2050	noNOh2	DE	tonne	0,00	232557734,8	232557734,8
2050	noRU	DE	tonne	0,00	232557734,8	232557734,8
2050	noUAh2	DE	tonne	0,00	232557734,8	232557734,8
2050	NO DISRUPTION	GA	tonne	0,00	228306706,5	228306706,5
2050	noLH2	GA	tonne	0,00	228306706,5	228306706,5
2050	noNAh2	GA	tonne	0,00	228306706,5	228306706,5
2050	noNOh2	GA	tonne	0,00	228306706,5	228306706,5
2050	noRU	GA	tonne	0,00	228306706,5	228306706,5

2050	noUAh2	GA	tonne	0,00	228306706,5	228306706,5

Curtailment Rate (SLCD):

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

Curtailment Rate (Climatic Stress):

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

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

Belgium	0%	0%	0%	0%	0%	0%
Bulgaria	0%	0%	-1%	0%	0%	0%
Croatia	0%	0%	-1%	0%	0%	0%
Cyprus	0%	0%	0%	0%	0%	0%
Czechia	0%	0%	0%	0%	0%	0%
Denmark	0%	0%	0%	0%	0%	0%
Estonia	0%	-1%	0%	0%	0%	0%
Finland	0%	0%	0%	0%	0%	0%
France	0%	0%	-1%	0%	0%	0%
Germany	-1%	0%	0%	0%	0%	0%
Greece	0%	0%	-1%	0%	0%	0%
Hungary	0%	0%	-1%	0%	0%	0%
Ireland	0%	0%	0%	0%	0%	0%
Italy	0%	-1%	0%	0%	-1%	0%
Latvia	0%	-1%	0%	0%	0%	-1%
Lithuania	0%	-1%	0%	0%	0%	0%
Luxembourg	0%	0%	0%	0%	0%	0%
Malta	0%	0%	0%	0%	0%	0%
Poland	0%	-1%	0%	0%	0%	0%
Portugal	0%	0%	-1%	0%	0%	0%
Romania	0%	0%	-1%	0%	0%	0%
Serbia	0%	0%	0%	0%	0%	0%
Slovakia	0%	-1%	-1%	0%	0%	0%
Slovenia	0%	0%	-1%	0%	0%	-1%
Spain	0%	-1%	0%	0%	0%	0%
Sweden	0%	0%	0%	0%	0%	0%
Switzerland	0%	0%	0%	0%	-1%	0%
The Netherlands	0%	0%	0%	0%	0%	0%
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-934	H2 underground storage	Will be reduced to minimum and assessed during planning phase	No direct impact on environmentally sensitive area

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

Environmental Impact explained [Promoter]

Impact on nature (e.g. due to construction of well pad and surface facility on land previously used for agricultural purposes) will be reduced to the strict minimum, assessed during planning phase and would be compensated by appropriate measures. The impact during cavern creation would be limited thanks to the planned industrial utilization of the brine produced. Thanks to high environmental and safety standards a potential negative impact of the project on climate change should be limited. A specific attention will be put on gas leaks and gas hazard, two areas where Storengy is at the highest industry standards. Apart from the construction phase, only a minimal increase in traffic is to be expected compared to the previous traffic volume of the neighboring Harsefeld Underground Gas Storage (which is anyway not a major emission source). The mid and long term environmental benefits of the project (reduction of greenhouse gas emissions in industry and higher integration of renewable electricity) will outweigh the short term environmental and climate impact incurred during the construction phase.

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]

In addition to the benefits identified in this project fiche, the SaltHy project would provide significant flexibility services to the European energy system. These benefits will notably take the form of a reduced curtailment of renewable sources as well as generation cost savings in electricity markets. Independent evaluations were conducted by Artelys performing a multi-energy system modelling to compute hourly optimal operations of the European electricity and hydrogen system based on the latest ENTSOs' "Distributed Energy" scenario (matching REPowerEU ambitions).

They show that the development of the SaltHy project could help decrease renewable curtailment by 10.3 gigawatt-hours while saving 31.9 million euros in operation costs over the year 2030.

According to this same assessment, the implementation of the SaltHy project could also result in the integration of 2 additional kilotons of renewable hydrogen in the system each year which would allow to reduce GHG emissions by 237 kt $CO_{2\ eq}$ per year as well as emission of other pollutants (328 t per year). Artelys results also show that the project could be useful in concentrating the consumption of local electrolysers within hours of low-carbon power generation. Twenty-six additional kilotons of low-carbon hydrogen could therefore be produced each year within hours where thermal power generation resources do not contribute to the German electricity supply, which serves both security of supply and low-carbon hydrogen integration purposes.

Finally, according to ENTSOs' "Distributed Energy" scenario, industry and transportation uses respectively represent 67 and 9% of German H2 needs by 2030, which suggests direct opportunities for the decarbonation of hard-to-abate sectors through the integration of low-carbon and renewable hydrogen.

F. Useful links [Promoter]

Useful links:

https://www.storengy.de/en