HI WEST 24 B (Less-Advanced)

bp Wilhelmshaven Green Hydrogen Hub

Reasons for grouping [ENTSOG]

The project group is an ammonia terminal including a cracker in Wilhelmshaven, Germany (HYD-N- 1159).

This project will enable hydrogen imports to Germany.

Objective of the group [Promoter]

The HI West corridor will need to import significant volumes of green hydrogen to meet the expected demand. bp's project aims to facilitate the decarbonization of multiple demand centers across Northwest Europe as a notable input source for hydrogen from multiple international production locations.

A. Project group technical information [Promoter/ ENTSOG]

Project technical information [Promoter]

Hydrogen Terminal

The Wilhelmshaven Green Hydrogen Hub project aims to develop an ammonia import and cracking facility for importing ammonia and cracking to hydrogen in Wilhelmshaven. The cracked gaseous hydrogen will be exported via repurposed pipeline to future customers. The project aims to produce up to 130 ktpa of low carbon hydrogen from imported ammonia.

TYNDP Project code	Hydrogen carrier	H_2 Import capacity [GWh/d]	Injection capacity [GWh/d]	Storage capacity [m^3]
HYD-N-1159	Ammonia	15.1 (LHV[1] as ammonia import depending on technology selected)	13.0 (LHV)	TBC

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-1159	LH2_Tk_DE	BP Europa SE	Terminal Germany (LH2_Tk_DE)	Transmission Germany (DE Hydrogen)	54.8	2028

[1] LHV = lower heating value

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-1159	1797	–15%/+ 50%	124	–15%/+ 50%

CAPEX and OPEX costs have been estimated during the current engineering feasibility studies based on engineering norms and input from bp's engineering contractor and a key supplier for ammonia tankage. The current estimate at this feasibility study level of project definition gives a CAPEX range of –15%/+ 50% and preliminary OPEX range of -15%/+50%.

As bp's project has evolved since data were submitted for the first TYNDP/PCI Call (Dec 2022), the updated cost (as of 2023) are, additionally, presented below.

Project cost updated 2023

TYNDP Project code	CAPEX [M€]	CAPEX range [%]	OPEX [M€]	OPEX range [%]
HYD-N-1159	900 million USD (*0.92 = **824 M€**)	–15%/+ 50%	95 million USD/ year (*0.92 = **87 M€/ year**)	–15%/+ 50%

C. Project Benefits [ENTSOG]

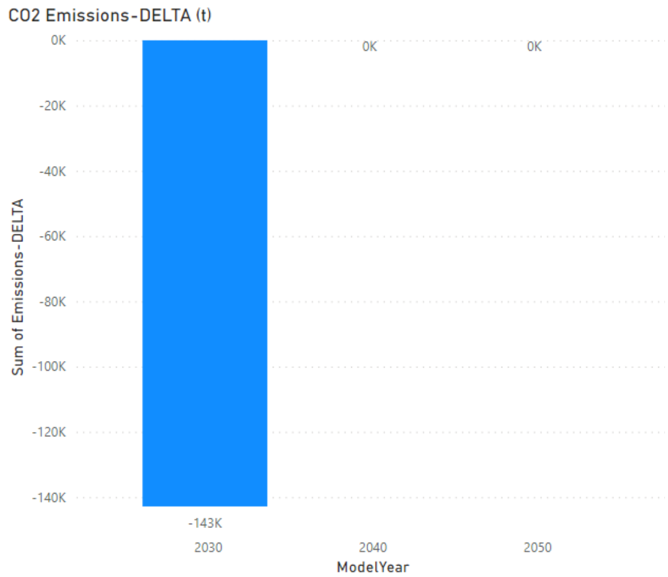
C.1 Summary of benefits

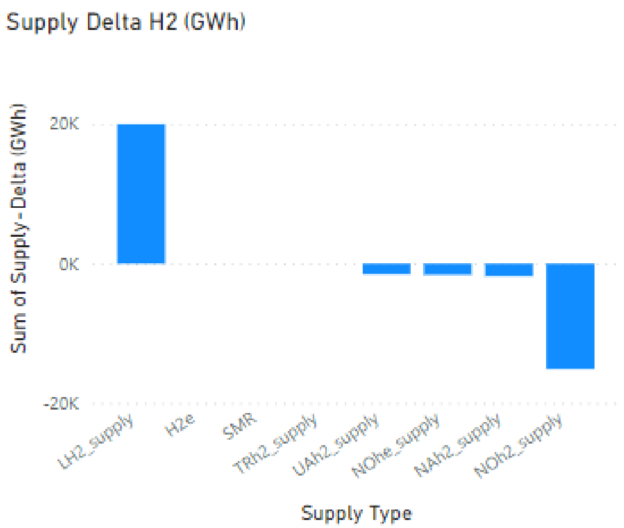
This section provides a summary analysis by ENTSOG of the main benefits stemming from the realisation of the overall group. More details on the indicators are available in Annex D of TYNDP 2022[2].

Distributed Energy

Sustainability benefits

Thanks to the project group, from 2030, the newly built terminal improves and diversifies hydrogen supply in Germany. 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 143 kt in 2030. This can be explained as in 2030 the project group will enable the replacement of blue hydrogen imports from Norway with green hydrogen liquid imports.





Sustainability benefits are increased under supply disruption cases, such as Norway, Ukraine, or North Africa Disruption for 2030 and 2040. For example, in case of Norway disruption the project group will reduce CO_2 emissions by 371 kt in 2030 and by 112 kt in 2040.

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

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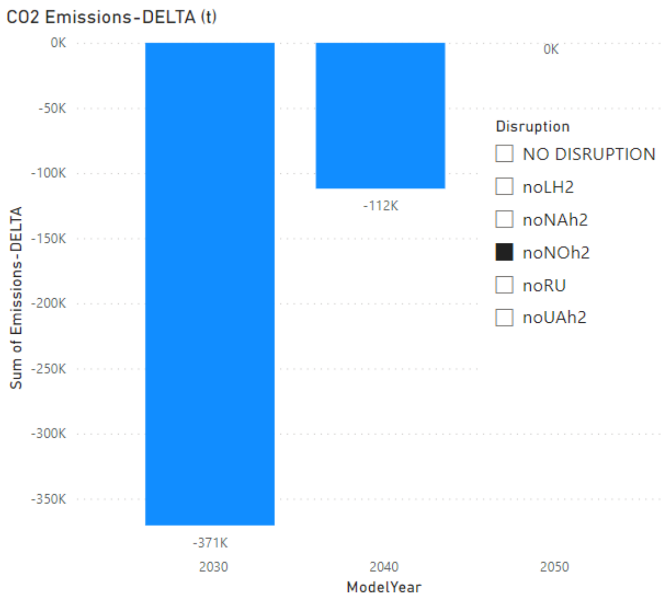
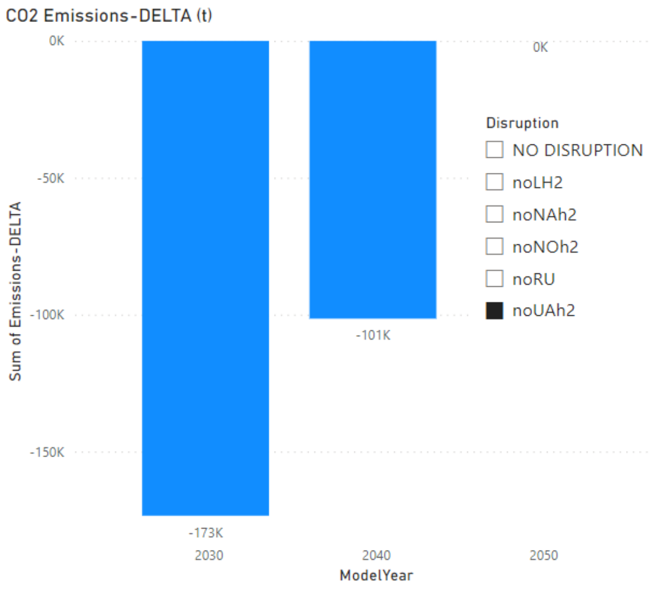
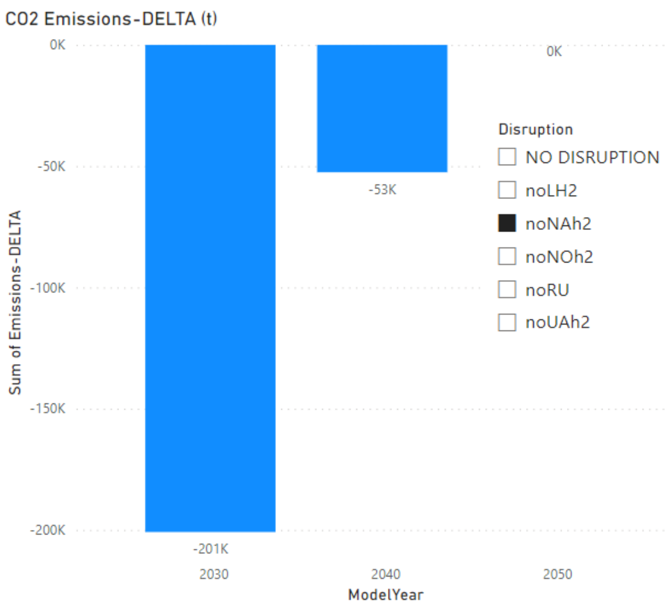
[2] https://www.entsog.eu/sites/default/files/2023-04/ENTSOG_TYNDP_2022_Annex_D_Methodology_230411.pdf







Security of Supply:[3]

> Reference case:

In the reference case, the project is mitigating the risk of hydrogen demand curtailment for Germany by 1% in 2050. However, it is important to mention that the SoS benefits of this project group could be

[3] *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.*

limited due to a competing(s) project group(s) (such as WEST 24A, WEST 23) located in the same geographical area enabling, as well, liquid import supplies to flow to Germany.

2030 DE- Benefits

2040 DE- Benefits

2050 DE- Benefits

> 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 contributing to the mitigation of hydrogen demand curtailment risk for many European countries by 2% in 2030.

2030 DE- Benefits

2040 DE- Benefits

2050 DE- Benefits

> Disruption cases (S-1):

In case of supply disruption cases such as Norway, Ukraine or North Africa supply disruption the project improves mitigation of hydrogen demand curtailment risk in 2050. For example, under North Africa supply disruption in 2050 France, Germany, Netherlands, Denmark, Sweden, Finland, Estonia, Poland, Czech Republic and Slovenia can mitigate the risk of demand curtailment by 1%.

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

1 noNOh2 : Norway disruption

2 noUAh2 : Ukraine disruption

3 noNAh2 : North Africa disruption

> Single largest capacity disruption (SLCD):

In case of SLCD many European countries benefitting on small scale from this project group by mitigating the risk of demand curtailment from 2030 onwards. Thanks to the project group respective countries mitigate the risk of demand curtailment by 1-3%.

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

SLCD Benefits - 2030 - Distributed Energy

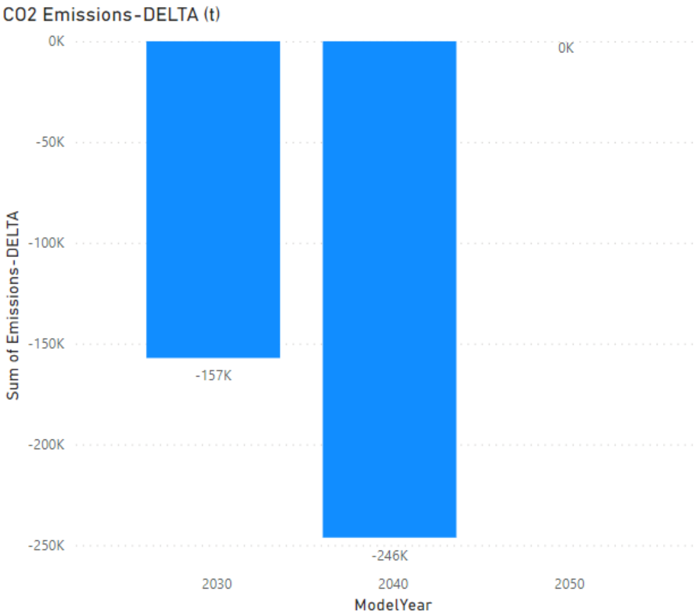
SLCD Benefits - 2040 - Distributed Energy

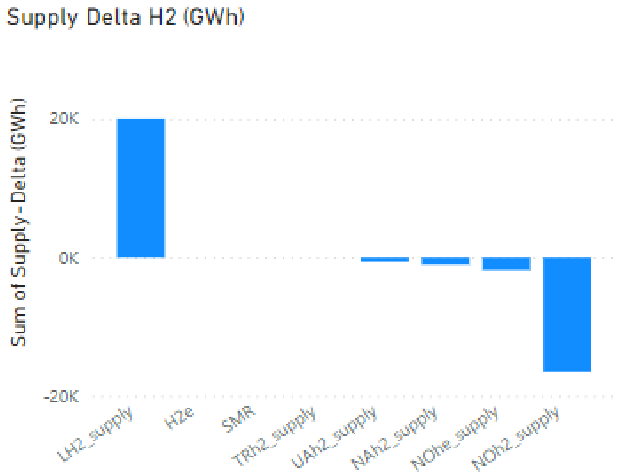
SLCD Benefits - 2050 - Distributed Energy

Global Ambition

Sustainability benefits

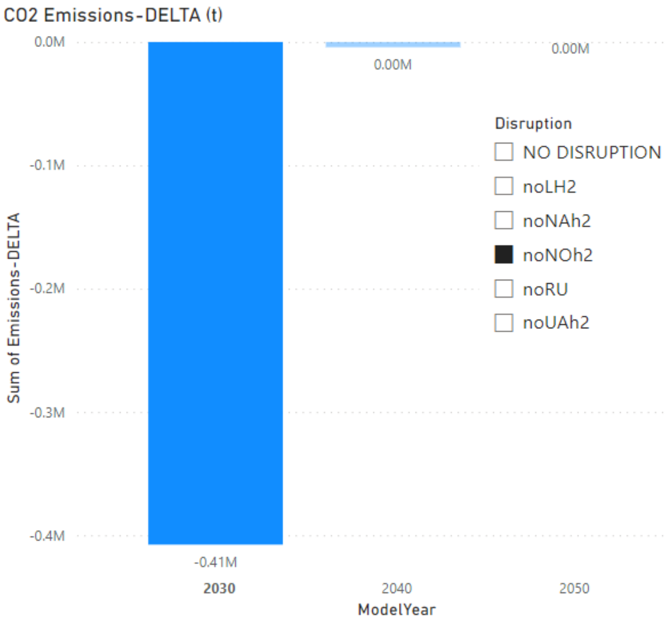
In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group will contribute to sustainability by reducing overall CO2 emissions by 157 kt in 2030 and by 246 kt in 2040. This can be explained as in 2030 the project group enables mainly the replacement of blue hydrogen imports from Norway and in 2040 the project replaces blue hydrogen locally produced n(I.e SMR).

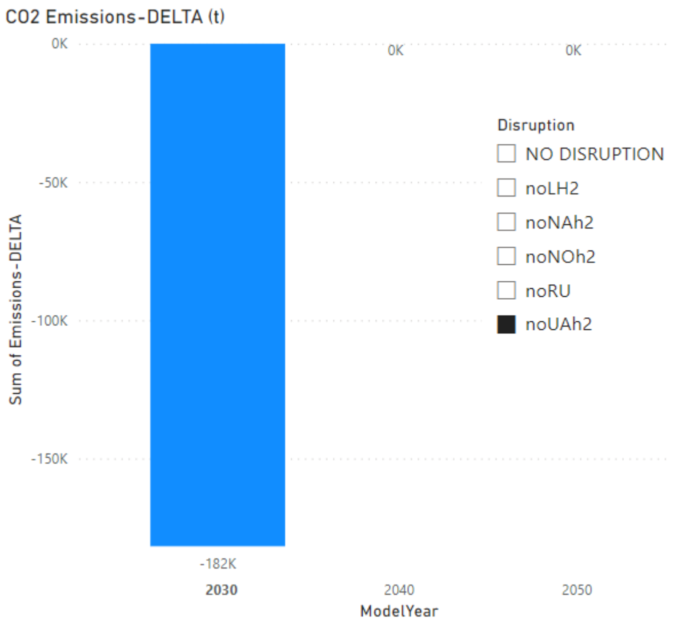


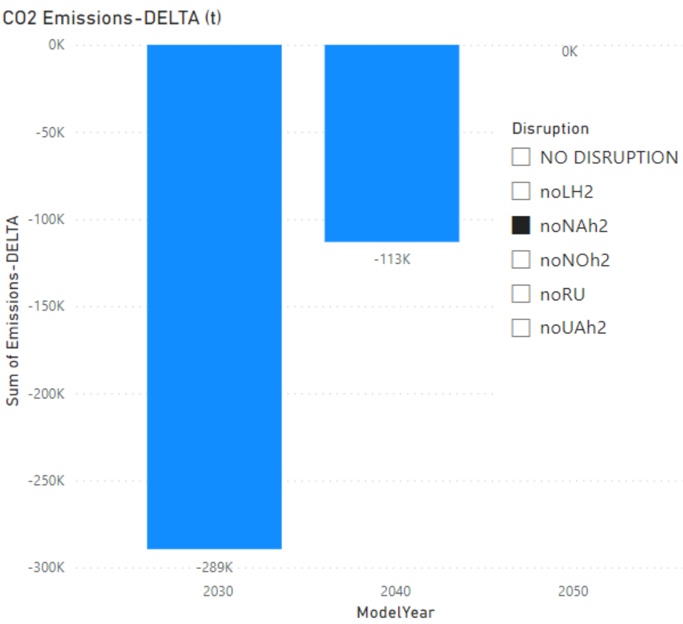


Sustainability benefits are increased under supply disruption cases, such as Norway, Ukraine, or North Africa Disruption for 2030. For example, in case of North Africa disruption the project group will reduce CO2 emissions by 289kt in 2030.

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







Security of supply benefits

> Reference case

In the reference case, the project helps to mitigate hydrogen demand curtailment risk in average summer and average winter in 2040 and 2050. In 2040 the project mitigates the risk of hydrogen demand curtailment by 1% for Italy, Germany, Belgium, Denmark and Latvia. In 2050 it mitigates the risk by 1% for Germany, Lithuania and Latvia. However, it is important to mention that the SoS benefits of this project group could be limited due to a competing(s) project group(s) (such as WEST 24A, WEST 23) located in the same geographical area enabling, as well, liquid import supplies to flow to Germany.

> 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 contributing to the mitigation of hydrogen demand curtailment risk for many European countries by 2-3% in 2030.

> Disruption cases (S-1)

Under supply disruption cases such as Norway, Ukraine or North Africa supply disruption the project improves mitigation of hydrogen demand curtailment risk in 2040 for many European countries by 1-2%. Additionally in case of Ukraine supply disruption the project mitigates the risk of demand curtailment for Germany, Sweden, Finland and Estonia by 1% in 2050.

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

1 noNOh2 : Norway disruption

2030 GA- Benefits

2040 GA- Benefits

2050 GA- Benefits

2 noUAh2 : Ukraine disruption

2030 GA- Benefits

2040 GA- Benefits

2050 GA- Benefits

3 noNAh2 : North Africa disruption

2030 GA- Benefits

2040 GA- Benefits

2050 GA- Benefits

> Single largest capacity disruption (SLCD):

In case of SLCD many European countries benefitting on small scale from this project group by mitigating the risk of demand curtailment from 2030 onwards. Thanks to the project group respective countries mitigate the risk of demand curtailment by 1-2%.

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

SLCD Benefits - 2030 - Global Ambition

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 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	-142847,92	538677299	538820147
2030	noLH2	DE	tonne	-2,40	540175890,2	540175892,6
2030	noNAh2	DE	tonne	-200829,11	539785356,1	539986185,2
2030	noNOh2	DE	tonne	-370539,99	538877197,8	539247737,8
2030	noUAh2	DE	tonne	-173428,64	539378771,9	539552200,6
2030	NO DISRUPTION	GA	tonne	-157137,25	592910448,4	593067585,7
2030	noLH2	GA	tonne	0,00	594817481,2	594817481,2
2030	noNAh2	GA	tonne	-289494,90	594141433,2	594430928,1
2030	noNOh2	GA	tonne	-407609,83	593310994,3	593718604,1
2030	noUAh2	GA	tonne	-181706,58	593627617,9	593809324,5
2040	NO DISRUPTION	DE	tonne	0,00	392077044	392077044
2040	noLH2	DE	tonne	0,00	392213883,4	392213883,4
2040	noNAh2	DE	tonne	-52511,97	392188097,7	392240609,7
2040	noNOh2	DE	tonne	-111940,61	392144022,6	392255963,2
2040	noUAh2	DE	tonne	-101442,50	392399182,9	392500625,4
2040	NO DISRUPTION	GA	tonne	-246233,74	396523251,6	396769485,4
2040	noLH2	GA	tonne	0,00	397455196,7	397455196,7
2040	noNAh2	GA	tonne	-113157,36	397301976,6	397415134
2040	noNOh2	GA	tonne	-4219,61	397450977,1	397455196,7
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
Czechia	-3%	-2%	-3%	-2%	-3%	-1%
Estonia	-3%	-2%	-3%	-1%	-2%	-1%
Latvia	-3%	-2%	-3%	-1%	-2%	-1%
Lithuania	-3%	-2%	-3%	-1%	-2%	-1%
Poland	-2%	-2%	-3%	-1%	-2%	-1%
Portugal	-2%	-2%	-3%	-2%	-1%	-1%
Slovenia	0%	0%	-3%	-1%	-2%	-1%
France	-2%	-2%	-3%	-2%	-2%	-1%
Germany	-2%	-2%	-2%	-2%	-2%	-1%
Austria	-2%	-2%	-2%	-2%	-2%	-1%
Belgium	-2%	-2%	-2%	-2%	-2%	-1%
Denmark	-2%	-3%	-2%	-2%	-2%	-1%
Finland	-3%	-3%	-2%	-1%	-2%	-1%
Italy	-2%	-2%	-2%	-1%	-2%	-1%
Spain	-2%	-2%	-2%	-2%	-2%	-1%
Sweden	-2%	-3%	-2%	-1%	-2%	-1%
Switzerland	0%	0%	-2%	-1%	-1%	-1%
The Netherlands	0%	0%	-2%	-2%	-2%	-1%
Bulgaria	-2%	-2%	-1%	-1%	-1%	-1%
Croatia	0%	0%	-1%	-1%	-1%	-1%
Greece	-2%	-1%	-1%	-1%	0%	-1%
Hungary	-2%	-2%	-1%	-1%	-1%	-1%
Romania	-2%	-2%	-1%	-1%	0%	-1%
Slovakia	-2%	-2%	-1%	-1%	-1%	-1%

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	-3%	-2%	-1%	-1%	-1%	-1%
Average2W	Belgium	-2%	-2%	-1%	-1%	-1%	0%
Average2W	Bulgaria	0%	-2%	-1%	-1%	0%	0%
Average2W	Croatia	0%	0%	-1%	-1%	0%	-1%
Average2W	Cyprus	0%	0%	0%	0%	0%	0%
Average2W	Czechia	-3%	-2%	-1%	-1%	-1%	-1%
Average2W	Denmark	-2%	-2%	-1%	-1%	-1%	-1%
Average2W	Estonia	-2%	-2%	0%	-1%	-1%	-1%
Average2W	Finland	-2%	-2%	-1%	-1%	-1%	-1%
Average2W	France	-2%	-3%	-1%	-1%	-1%	-1%
Average2W	Germany	-2%	-2%	-1%	0%	0%	0%
Average2W	Greece	0%	-2%	-1%	-1%	0%	0%
Average2W	Hungary	0%	-3%	-1%	-1%	0%	-1%
Average2W	Ireland	0%	0%	0%	0%	0%	0%
Average2W	Italy	-3%	0%	-1%	-1%	0%	0%
Average2W	Latvia	-2%	-2%	-1%	-1%	-1%	-1%

Average2W	Lithuania	-2%	-2%	-1%	-1%	-1%	-1%
Average2W	Luxembourg	0%	0%	0%	0%	0%	0%
Average2W	Malta	0%	0%	0%	0%	0%	0%
Average2W	Poland	-2%	-2%	-1%	-1%	-1%	-1%
Average2W	Portugal	-2%	-2%	-1%	-1%	0%	-1%
Average2W	Romania	0%	-2%	-1%	-1%	0%	-1%
Average2W	Serbia	0%	0%	0%	0%	0%	0%
Average2W	Slovakia	-3%	-2%	-1%	-1%	0%	0%
Average2W	Slovenia	0%	0%	-1%	-1%	-1%	-1%
Average2W	Spain	-2%	-2%	-1%	-1%	-1%	-1%
Average2W	Sweden	-2%	-3%	-1%	-1%	-1%	-1%
Average2W	Switzerland	0%	0%	-1%	-1%	-1%	0%
Average2W	The Netherlands	0%	0%	-1%	-1%	-1%	0%
Average2W	United Kingdom	0%	0%	0%	0%	0%	0%
Average2WDF	Austria	-2%	-2%	-1%	-1%	-1%	-1%
Average2WDF	Belgium	-2%	-2%	0%	-1%	-1%	0%
Average2WDF	Bulgaria	0%	-2%	-1%	-1%	0%	0%
Average2WDF	Croatia	0%	0%	-1%	-1%	0%	-1%
Average2WDF	Cyprus	0%	0%	0%	0%	0%	0%
Average2WDF	Czechia	-2%	-2%	-1%	-1%	-1%	-1%
Average2WDF	Denmark	-2%	-2%	-1%	-1%	-1%	-1%
Average2WDF	Estonia	-2%	-2%	-1%	0%	-1%	-1%
Average2WDF	Finland	-2%	-2%	-1%	-1%	-1%	0%
Average2WDF	France	-2%	-3%	-1%	-1%	-1%	-1%
Average2WDF	Germany	-2%	-2%	-1%	-1%	0%	-1%
Average2WDF	Greece	0%	-2%	-1%	-1%	0%	0%
Average2WDF	Hungary	0%	-3%	-1%	-1%	0%	-1%
Average2WDF	Ireland	0%	0%	0%	0%	0%	0%
Average2WDF	Italy	-3%	0%	-1%	0%	0%	0%
Average2WDF	Latvia	-2%	-2%	-1%	0%	-1%	-1%
Average2WDF	Lithuania	-2%	-2%	-1%	0%	-1%	-1%
Average2WDF	Luxembourg	0%	0%	0%	0%	0%	0%
Average2WDF	Malta	0%	0%	0%	0%	0%	0%
Average2WDF	Poland	-2%	-2%	-1%	0%	-1%	-1%
Average2WDF	Portugal	-2%	-2%	-1%	-1%	0%	0%
Average2WDF	Romania	0%	-2%	-1%	-1%	0%	-1%
Average2WDF	Serbia	0%	0%	0%	0%	0%	0%
Average2WDF	Slovakia	-3%	-2%	-1%	-1%	0%	-1%
Average2WDF	Slovenia	0%	0%	-1%	-1%	-1%	-1%
Average2WDF	Spain	-2%	-2%	-1%	-1%	-1%	0%
Average2WDF	Sweden	-2%	-3%	-1%	-1%	-1%	0%
Average2WDF	Switzerland	0%	0%	-1%	0%	-1%	-1%
Average2WDF	The Netherlands	0%	0%	-1%	-1%	-1%	0%
Average2WDF	United Kingdom	0%	0%	0%	0%	0%	0%
DC	Austria	-2%	-2%	0%	-1%	-1%	-1%

DC	Belgium	-2%	-2%	-1%	0%	0%	0%
DC	Bulgaria	0%	-2%	-1%	0%	0%	0%
DC	Croatia	0%	0%	-1%	0%	0%	-1%
DC	Cyprus	0%	0%	0%	0%	0%	0%
DC	Czechia	-2%	-1%	0%	0%	-1%	-1%
DC	Denmark	-2%	-2%	0%	-1%	-1%	0%
DC	Estonia	-1%	-2%	-1%	0%	-1%	-1%
DC	Finland	-1%	-2%	0%	0%	-1%	0%
DC	France	-2%	-1%	-1%	0%	-1%	0%
DC	Germany	-2%	-1%	-1%	-1%	0%	0%
DC	Greece	0%	-1%	-1%	0%	0%	0%
DC	Hungary	0%	-1%	-1%	0%	0%	-1%
DC	Ireland	0%	0%	0%	0%	0%	0%
DC	Italy	-1%	-1%	0%	0%	-1%	0%
DC	Latvia	-1%	-2%	-1%	0%	0%	-1%
DC	Lithuania	-1%	-2%	-1%	0%	0%	0%
DC	Luxembourg	0%	0%	0%	0%	0%	0%
DC	Malta	0%	0%	0%	0%	0%	0%
DC	Poland	-1%	-2%	-1%	0%	-1%	0%
DC	Portugal	-2%	-1%	-1%	0%	0%	0%
DC	Romania	0%	-2%	-1%	0%	0%	-1%
DC	Serbia	0%	0%	0%	0%	0%	0%
DC	Slovakia	-2%	-2%	-1%	0%	0%	0%
DC	Slovenia	0%	0%	-1%	0%	-1%	-1%
DC	Spain	-2%	-2%	0%	-1%	-1%	-1%
DC	Sweden	-1%	-2%	-1%	0%	-1%	0%
DC	Switzerland	0%	0%	0%	0%	-1%	0%
DC	The Netherlands	0%	0%	0%	-1%	-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-1159	Ammonia Cracker and Storage	To be defined	NA – within an existing operational oil terminal

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

Environmental Impact explained [Promoter]

The planned ammonia import, storage and cracker plant will be located within an existing operational oil terminal in an industrial area. This facility footprint will, therefore, not be located within an environmentally sensitive area. The project is in the feasibility phase. As the project develops, bp will manage conformance with its own internal requirements and compliance with applicable local and federal environmental regulations, including in relation to identifying potentially sensitive receptors, assessing and minimising potential impacts from routine operations. bp will apply good industry practice and strive to contribute to the delivery of its sustainability aims, including those in relation to biodiversity.

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]

Resilience and security of supply through diversification of technologies and supply sources. Should Europe rely solely on imports via pipelines, the future hydrogen system could be vulnerable to supply security shocks , being at risk in the event of a pipeline failure (see parallels to Nord Stream I and II). Import terminals can obtain hydrogen from a multitude of international production sites with a variety of different and competitive characteristics which would vary over time.

Through the provision of ammonia storage at site, stable and consistent hydrogen supplies can be maintained into a hydrogen pipeline system, which could compensate for seasonal fluctuations from other sources of production and mitigate pipeline curtailment. Due to their inherent scalability, ammonia crackers could also provide short-term capacity in case of bottlenecks in other sources of supply.

Strengthening competition and market ramp-up: Hydrogen from ammonia cracking could be competitive in the long term due to economies of scale obtained from an increasing number of competitive international supply sources becoming available over time.

The main anticipated suppliers of green ammonia are located outside the EU and are, therefore, not linked to European electricity prices. The potential for lower renewable electricity prices in export countries e.g., Mauritania or Australia, combined with the scalability of supply would likely offset the cost of shipping over significant distances.

The diversification of supply sources through ammonia transport via ship, strengthens competition through introducing diversified supply sources, reducing the vulnerability of European industry to major price spikes in case of local or regional electricity price and volume curtailment.

Investment in a ship-based import terminal would aid the ramp-up of hydrogen supplies into European industrial clusters. These facilities can be developed in tandem with the expansion of domestic hydrogen pipeline infrastructure so that both elements are fully established by the time long-distance (trans-continental) pipeline-based imports are added. Thus, having a multitude of import options helps facilitate a smooth development of the European hydrogen economy.

F. Useful links [Promoter]

Useful links:

Project website: Wilhelmshaven green hydrogen hub | bp in Deutschland
(scroll down for english version)