HI WEST 24 A (Less-Advanced)
Green Wilhelmshaven Terminal

Reasons for grouping [ENTSOG]

The project group is an ammonia terminal including a cracker in Wilhelmshaven, Germany (HYD-N- 968).

This project will enable hydrogen imports to Europe.

Objective of the group [Promoter]

All businesses in Uniper's portfolio have two main missions: ensure supply security and propel the energy transition. Unipers plan to construct and operate a sustainable import terminal for green ammonia and the first large-scale ammonia into H_2 cracker to supply Germany and Europe with green H_2 via the future European H_2 pipeline system pays into this mission. The project will be located at the German North Sea coast in Wilhelmshaven, Germanys only deep water port. Against the background of the considerable difference between future European H_2 generation capacities and industry needs, the import of H_2-based energy carriers will be crucial for the success of an effective market ramp-up of an H_2 economy to meet the European ambitions regarding climate protection, SoS and leadership in H_2 technologies and contribute significantly to market liquidity and the development of trading hubs with market based H_2 pricing mechanisms.

HYD-N-968 **Green Wilhelmshaven Terminal/Storage/Cracker**

Comm. Year Terminal & Storage **2028**

Comm. Year Cracker **2030**

A. Project group technical information [Promoter/ ENTSOG]

Project technical information [Promoter]

Hydrogen Terminal

TYNDP Project code	Hydrogen carrier	H_2 Import capacity [GWh/d]	Injection capacity [GWh/d]	Storage capacity [m^3]
HYD-N-968	Ammonia	31.2	35.1 (max)	2 x 50,000 (NH_3)

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-968	LH2_Tk_DE	Uniper Hydrogen GmbH	Terminal Germany (LH2_Tk_DEE)	Transmission Germany (DE Hydrogen)	31.2	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-968	910	50%	66	50%

Description of the cost and range [Promoter]

The CAPEX of the import terminal mainly consist of the costs for the terminal (jetty and supra structure), the costs for the tank farm and the costs for the crackers to convert the ammonia into hydrogen. Even if parts of the existing LNG import terminal can continue to be used, the costs for a completely new infrastructure are deposited here. Large-scale cracker technology is not currently in use. Therefore the range is +/- 50%.

Opex costs consist of 50% costs for electrical energy and related taxes. Due to the existing uncertainties, especially in commodity prices, a range of +/-50% is assumed.

C. Project Benefits [ENTSOG]

C.1 Summary of benefits

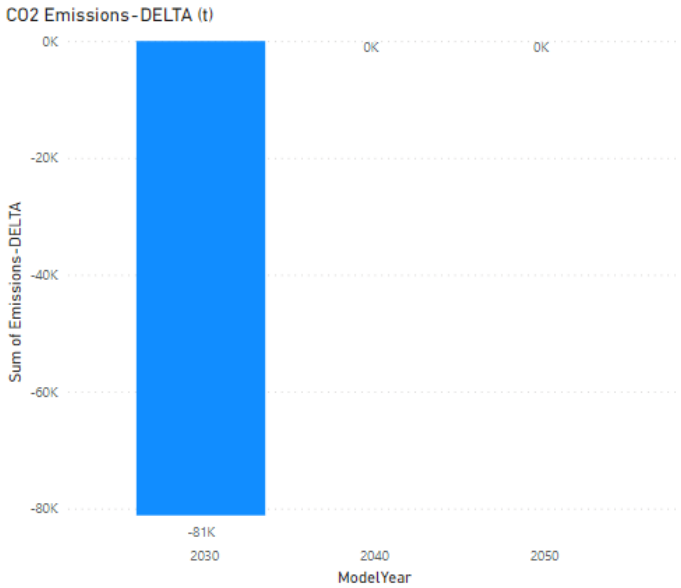
This section provides a summarised analysis by ENTSOG of the main benefits stemming from the realisation of the overall group. More details on the indicators are available in Annex D of TYNDP 2022[1].

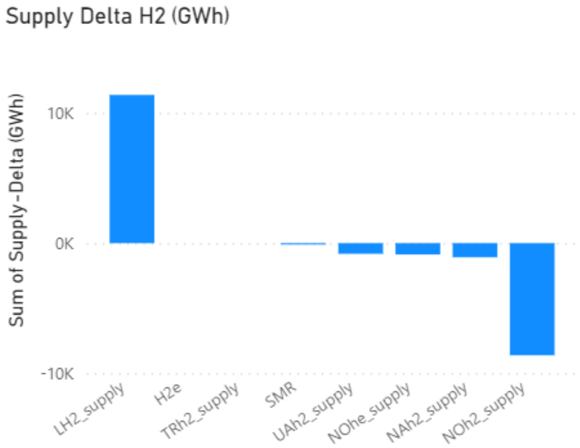
[1] https:/www.entsog.eu/sites/default/files/2023-04/ENTSOG_TYNDP_2022_Annex_D_Methodology_230411.pdf

Distributed Energy

Sustainability benefits

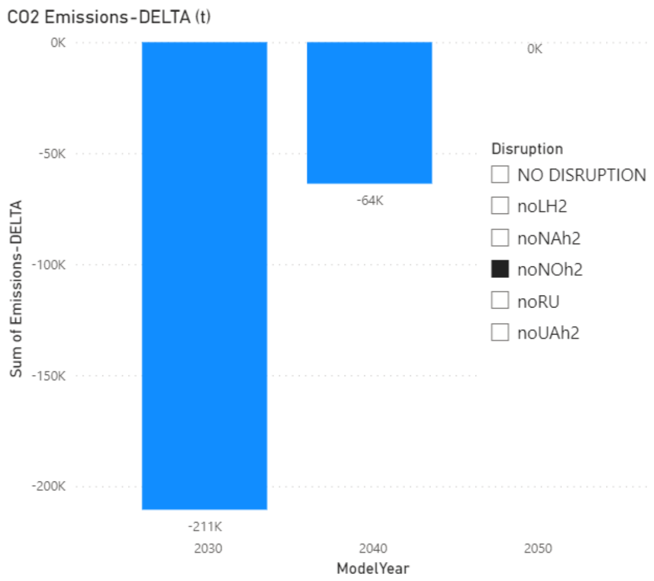
Thanks to the project group, from 2030, the newly built terminal improves and diversifies hydrogen supply in Germany. In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group will contribute to sustainability by reducing overall CO2 emissions by 81 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.

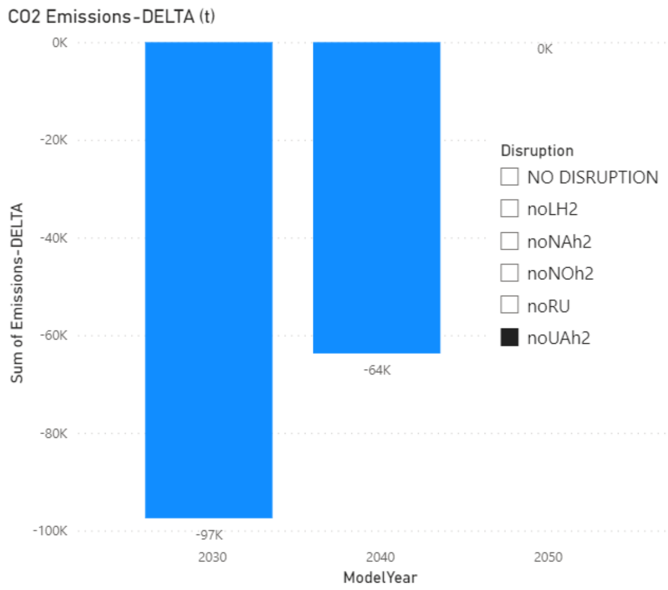


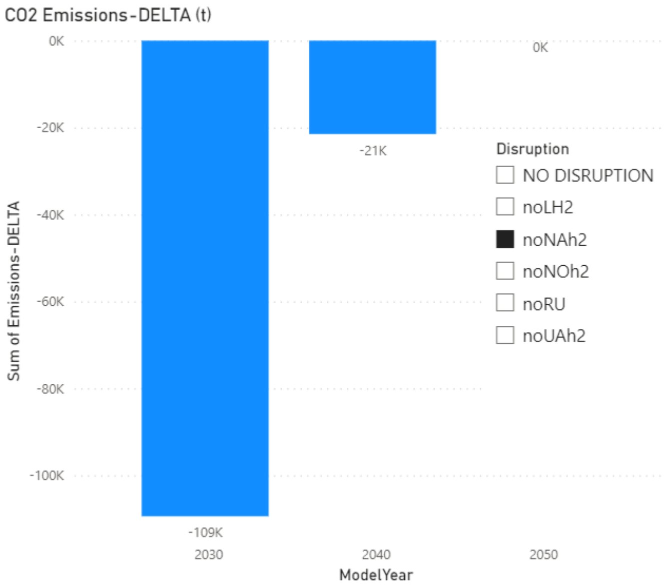


Sustainability benefits are increased under supply disruption cases, such as Norway, Ukraine, or North Africa Disruption for 2030 and 2040. For example, in case of Norway disruption the project group will reduce CO2 emissions by 211 kt in 2030 and by 64 kt in 2040.

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







Security of Supply:[2]

> Reference case:

In the reference case, the project is not further mitigating hydrogen demand curtailment risk in average summer and average winter for European countries.

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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.*

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 in Germany, Austria, Slovakia and Italy by 1% 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, similar as in the reference case, is not further mitigating the risk of hydrogen demand curtailment in Europe.

> 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

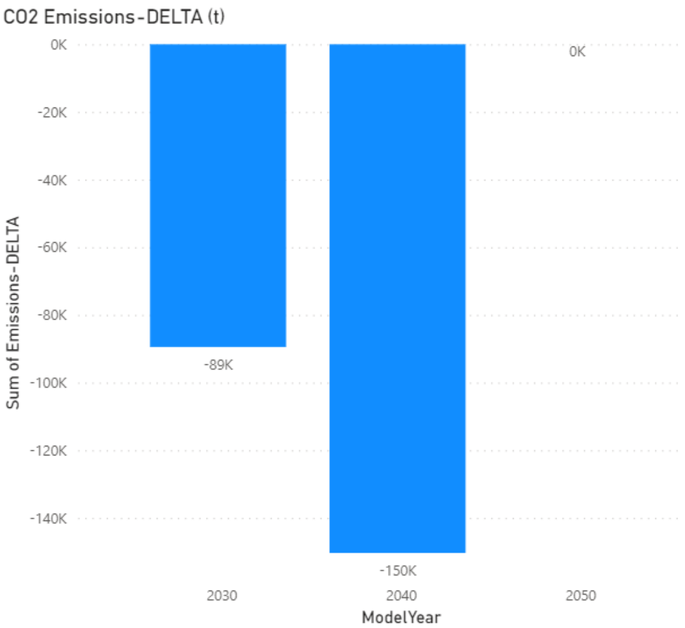
SLCD Benefits - 2040 - Distributed Energy

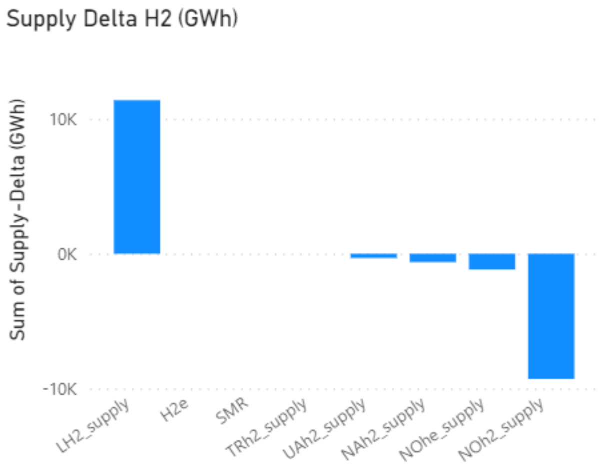
SLCD Benefits - 2050 - Distributed Energy

Global Ambition

Sustainability benefits

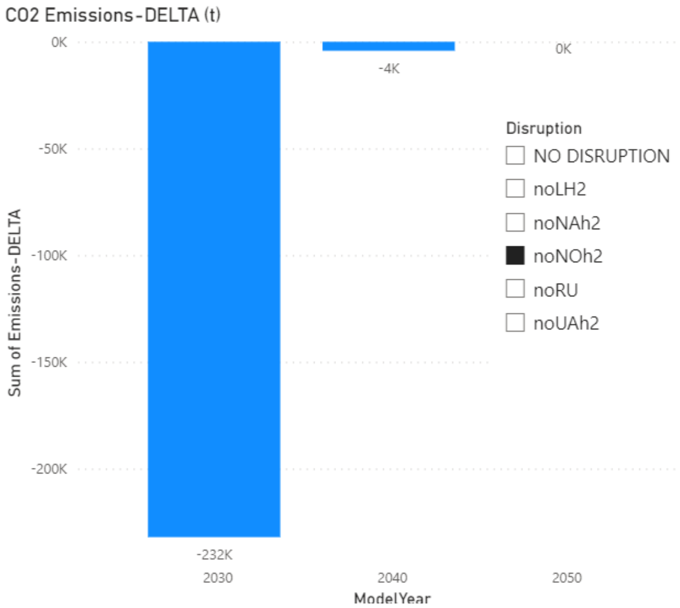
In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group will contribute to sustainability by reducing overall CO2 emissions by 89 kt in 2030 and by 150 kt in 2040. This can be explained as in 2030 the project group enables mainly the replacement of blue hydrogen imports from Norway and in 2040 the project replaces blue hydrogen locally produced (I.e SMR).

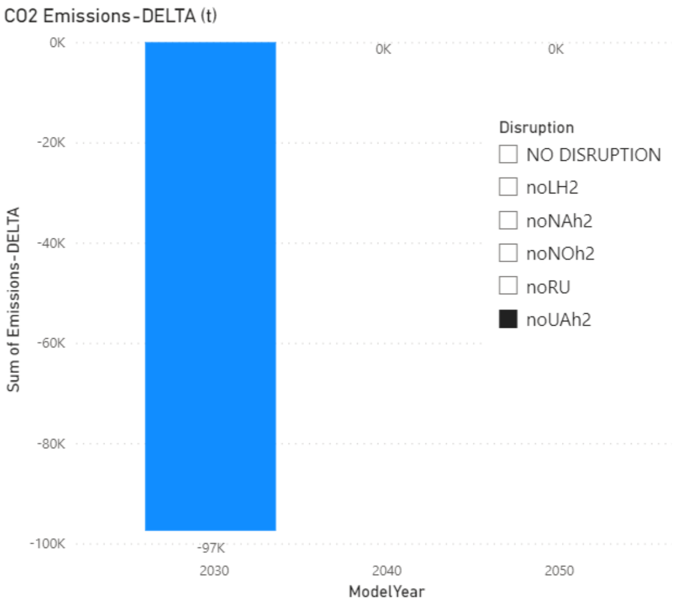


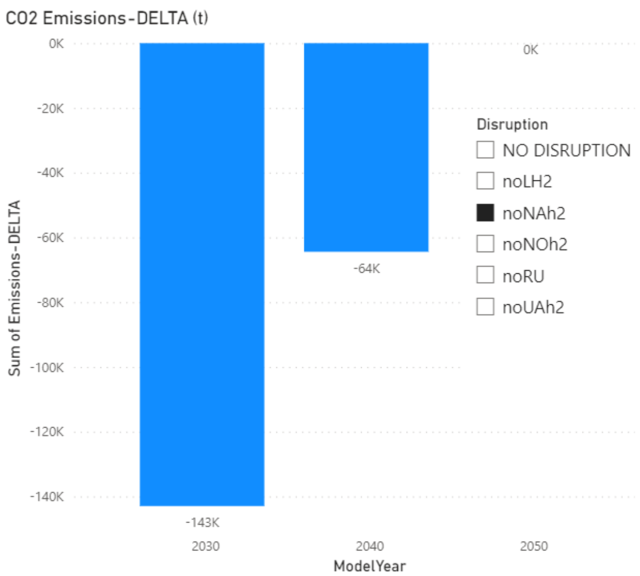


Sustainability benefits are increased under supply disruption cases, such as Norway, Ukraine, or North Africa Disruption for 2030. For example, in case of North Africa disruption the project group will reduce CO2 emissions by 143kt in 2030.

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 does not further mitigate hydrogen demand curtailment risk in average summer and average winter for European countries.

> 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 h2 demand curtailment risk in France, Germany, Denmark, Sweden, Finland and Romania by 1-2% in 2030.

> Disruption cases (S-1)

In case of supply disruption cases such as Norway, Ukraine or North Africa supply disruption the project, similar as in the reference case, is not further mitigating the risk of hydrogen demand curtailment.

> 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	-81183,46	538677299	538758482,5
2030	noLH2	DE	tonne	-2,40	540175890,2	540175892,6
2030	noNAh2	DE	tonne	-109393,02	539785356,1	539894749,1
2030	noNOh2	DE	tonne	-210578,70	538877197,8	539087776,5
2030	noUAh2	DE	tonne	-97473,56	539378771,9	539476245,5
2030	NO DISRUPTION	GA	tonne	-89462,92	592910448,4	592999911,4
2030	noLH2	GA	tonne	0,00	594817481,2	594817481,2
2030	noNAh2	GA	tonne	-142953,73	594141433,2	594284386,9
2030	noNOh2	GA	tonne	-232069,83	593310994,3	593543064,1
2030	noUAh2	GA	tonne	-97473,56	593627617,9	593725091,5
2040	NO DISRUPTION	DE	tonne	0,00	392077044	392077044
2040	noLH2	DE	tonne	0,00	392213883,4	392213883,4
2040	noNAh2	DE	tonne	-21475,12	392188097,7	392209572,8
2040	noNOh2	DE	tonne	-63732,61	392144022,6	392207755,2
2040	noUAh2	DE	tonne	-63732,61	392399182,9	392462915,5
2040	NO DISRUPTION	GA	tonne	-150341,74	396523251,6	396673593,4
2040	noLH2	GA	tonne	0,00	397455196,7	397455196,7
2040	noNAh2	GA	tonne	-64425,36	397301976,6	397366402
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
France	-2%	-1%	-3%	-1%	-2%	-1%
Austria	-1%	-1%	-2%	-1%	-2%	-1%
Belgium	-2%	-2%	-2%	-1%	-1%	-1%
Czechia	-2%	-1%	-2%	-2%	-3%	-1%
Denmark	-2%	-2%	-2%	-1%	-2%	-1%
Estonia	-2%	-2%	-2%	-1%	-2%	-1%
Finland	-2%	-2%	-2%	-1%	-2%	-1%
Germany	-1%	-1%	-2%	-2%	-1%	-1%
Italy	-1%	-1%	-2%	-1%	-2%	-1%
Latvia	-2%	-2%	-2%	-1%	-2%	-1%
Lithuania	-2%	-2%	-2%	-1%	-2%	-1%
Poland	-1%	-1%	-2%	-1%	-2%	-1%
Portugal	-2%	-1%	-2%	-1%	-1%	-1%
Slovenia	0%	0%	-2%	-1%	-2%	-1%
Sweden	-2%	-2%	-2%	-1%	-2%	-1%
Switzerland	0%	0%	-2%	-1%	-1%	-1%
The Netherlands	0%	0%	-2%	-2%	-2%	-1%
Spain	-2%	-1%	-2%	-1%	-2%	-1%
Bulgaria	-1%	-1%	-1%	0%	0%	-1%
Croatia	0%	0%	-1%	-1%	0%	-1%
Greece	-1%	-1%	-1%	-1%	0%	-1%
Hungary	-1%	-1%	-1%	-1%	0%	-1%
Romania	-1%	-1%	-1%	-1%	0%	-1%
Slovakia	-1%	-1%	-1%	-1%	-1%	-1%

Curtailment Rate (Climatic Stress):

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

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

DC	Croatia	0%	0%	-1%	0%	0%	0%
DC	Cyprus	0%	0%	0%	0%	0%	0%
DC	Czechia	-1%	0%	0%	0%	-1%	0%
DC	Denmark	-1%	-1%	0%	0%	0%	0%
DC	Estonia	0%	-1%	-1%	0%	-1%	0%
DC	Finland	0%	-1%	0%	0%	0%	0%
DC	France	-1%	0%	-1%	0%	0%	0%
DC	Germany	-1%	-1%	0%	-1%	0%	0%
DC	Greece	0%	-1%	-1%	0%	0%	0%
DC	Hungary	0%	-1%	-1%	0%	0%	0%
DC	Ireland	0%	0%	0%	0%	0%	0%
DC	Italy	-1%	-1%	0%	0%	-1%	0%
DC	Latvia	0%	-1%	-1%	0%	0%	-1%
DC	Lithuania	-1%	-1%	-1%	0%	0%	0%
DC	Luxembourg	0%	0%	0%	0%	0%	0%
DC	Malta	0%	0%	0%	0%	0%	0%
DC	Poland	-1%	-1%	-1%	0%	0%	0%
DC	Portugal	-1%	0%	-1%	0%	0%	0%
DC	Romania	0%	-1%	-1%	0%	0%	-1%
DC	Serbia	0%	0%	0%	0%	0%	0%
DC	Slovakia	-1%	-1%	-1%	0%	0%	0%
DC	Slovenia	0%	0%	-1%	0%	0%	-1%
DC	Spain	-1%	-1%	0%	0%	0%	-1%
DC	Sweden	0%	-1%	0%	0%	-1%	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-968	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]

The Green Wilhelmshaven Terminal project advances the decarbonisation of industry and energy supply. The environmental effects and greenhouse gas reduction potentials achieved by the project are mainly based on the provision of green hydrogen for the future hydrogen infrastructure. By providing green hydrogen from NH3 cracking as part of the project, annual CO2 reductions of around 2mt/a can be achieved (compared to the use of grey hydrogen).

There will be no major negative impacts on climate change from the ammonia import terminal. In fact, Uniper aims at decarbonizing the entire value chain as much as possible. This would include shipping vessels using green fuels and running all terminal facilities with renewable energies. Especially the crackers would be fired with either green ammonia or electricity from renewable sources.

Even though NH_3 is a toxic gas, the processes for handling NH_3 have been proven over a very long time. As a company with a long term experience in handling hazardous materials such as NH_3, Uniper will comply with the highest level of safety.

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]

TYNDP 2022 PS-CBA assessment is based on TYNDP 2022 Scenario Report assumptions for hydrogen demand and supply published in April 2022.

From our point of view this assessment method massively underestimates the contribution of a hydrogen import terminal to provide sufficient volumes of green hydrogen for Europe to decarbonize the European economy. In line with the EU Hydrogen Strategy and REPowerEU plan to produce 10 million tonnes of renewable hydrogen by 2030 and to import 10 million tonnes by 2030, the import of green hydrogen should be given a priority int the assessment.

With the possibility of bringing green energy to the centres of consumption in Europe via the carrier medium ammonia, new energy partnerships can emerge. The terminal offers the possibility of developing a globally diversified supply portfolio and thus avoiding dependencies like those in natural gas from the very beginning. The non-discriminatory access makes the terminal a central point for bringing together buyers and sellers of green energy and thus a nucleus for the establishment of a liquid trading hydrogen market.

The project supports to satisfy the growing green H_2 demand in various sectors and facilitates the RES. The project contributes to a more elastic H_2 supply curve and by this to lower and less volatile H_2 prices.

Due to weather-independent (no wind & solar / Dunkelflaute) injection of green H_2, pipeline infrastructure can be operated without pressure fluctuations. This prevents material failure. It reduces the overall storage demand resulting from fluctuating domestic hydrogen production on one hand and the constant demand in industry on the other.

The project inherently connects the energy carriers NH_3 and H_2. NH_3 can be transported independent from pipelines and used directly as NH_3 whereas H_2 will be transported by pipelines and may be used for other purposes. Market participant might develop smart solutions to cross commodity solutions. Users of the terminal & cracker are enabled to optimize their H_2 supply: e.g. by increasing cracker H_2 supply while simultaneously reducing electricity demand for H_2 supply from electrolysers (and vice versa).

F. Useful links [Promoter]

Useful links:

https://www.greenwilhelmshaven.de/en

https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en

https://www.bmwk.de/Navigation/EN/hydrogen/national-hydrogen-strategy.html

https://www.h2-global.de/

https://www.wasserstoff-leitprojekte.de//home

https://www.eex.com/en/services/hydrogen

https://alsi.gie.eu/