HI WEST 32 C (Less-Advanced)

Amplifhy Rotterdam Ammonia Terminal

Reasons for grouping [ENTSOG]

The project group is a stand-alone ammonia terminal including a cracker in Rotterdam, Netherlands (HYD-N- 1127).

This project will enable hydrogen imports to Netherlands.

Objective of the group [Promoter]

To enable large scale hydrogen imports into the European backbone system in the form of cracked green ammonia, helping to decarbonize hard to abate industries in Europe as well as providing balancing services to the European hydrogen system in times of low renewables availability.

Amplifhy Rotterdam will be connected to other European countries (incl. Germany and Belgium) via the National H2 Backbone HYD-N-468 & Delta Rhine Corridor HYD-N-793.

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-1127	Ammonia	495	45	90.000

Description of hydrogen terminal [Promoter]

The ammonia import terminal will grow over time to facilitate the increasing flows of ammonia into Europe. The initial terminal will have excess capacity as a pre-investment for future growth.

The terminal figures above are for the 2030 size of the terminal. It is planned to increase in size after 2030.

Import capacity is based on the number of jetties at the terminal and the discharge flow rates from vessels into the terminal.

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-1127	LH2_Tk_DE	VTTI terminal support services	Terminal Netherlands (LH2_Tk_NL)	Transmission Netherlands (NL Hydrogen)	5	2026
HYD-N-1127	LH2_Tk_DE	VTTI terminal support services	Terminal Netherlands (LH2_Tk_NL)	Transmission Netherlands (NL Hydrogen)	2	2028
HYD-N-1127	LH2_Tk_DE	VTTI terminal support services	Terminal Netherlands (LH2_Tk_NL)	Transmission Netherlands (NL Hydrogen)	38	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-1127	642	+/- 30%	28	+/- 30%

Description of the cost and range [Promoter]

Capex is for the cracker and terminal size in 2028-2030, in line with PCI submission.

Scope and level of engineering detail is progressing as well as key material markets are changing vs the initial PCI submission date. Capex and opex figures are different per technology supplier, so final partner selection will also influence the final cost figures.

Therefore, cost estimate might change over time.

C. Project Benefits [ENTSOG]

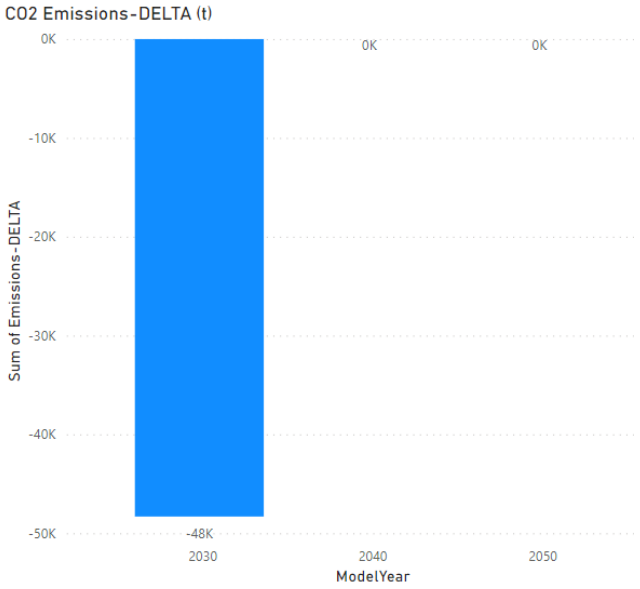
C.1 Summary of benefits

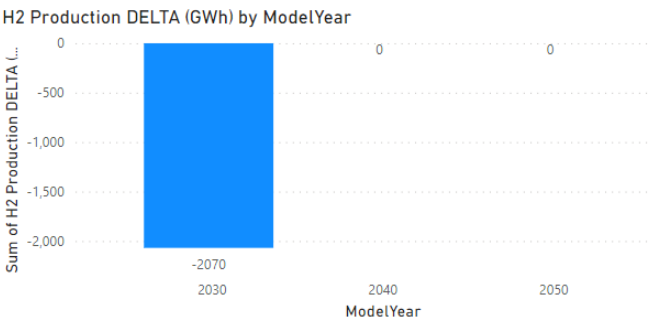
This section provides a summarised analysis by ENTSOG of the main benefits stemming from the realisation of the overall group. More details on the indicators are available in Annex D of TYNDP 2022[1].

Distributed Energy

Sustainability benefits

Thanks to the project group, from 2026, the newly built terminal improves and diversifies hydrogen supply in the Netherlands. 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 48 kt in 2030. This can be explained as in 2030 the project group will enable the replacement of blue hydrogen locally produced (i.e SMR) with green hydrogen imports in form of ammonia.

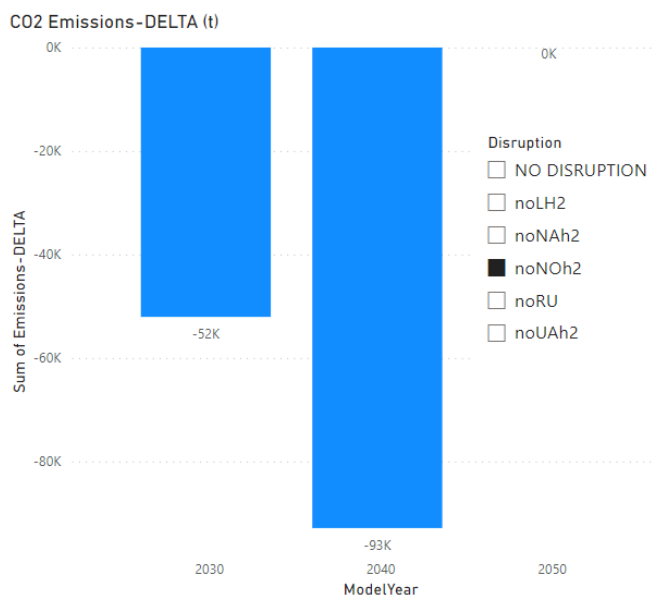


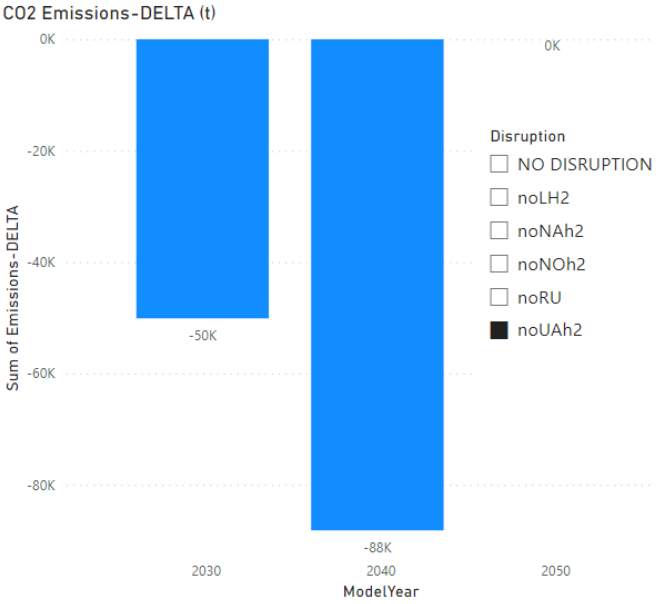


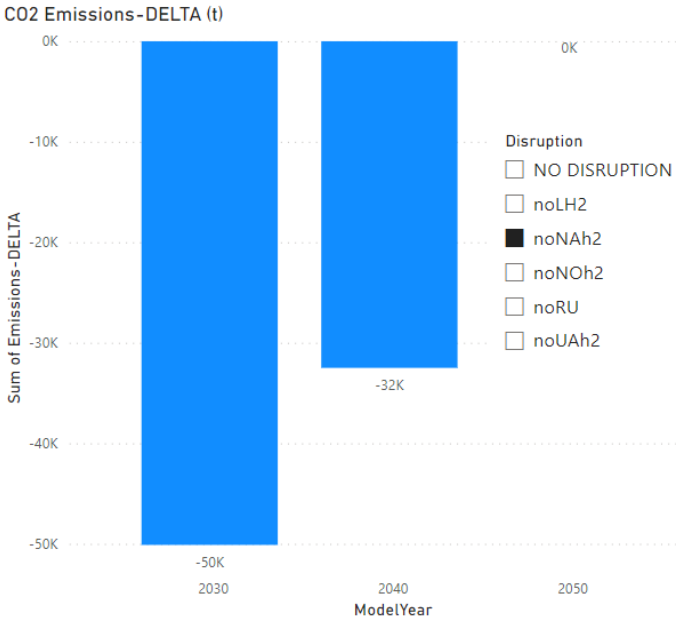
Sustainability benefits are increased under supply disruption cases, such as Norway, Ukraine, or North Africa Disruption for 2030 and 2040. For example, in case of Norway disruption the project group will reduce CO_2 emissions by 52 kt in 2030 and by 93 kt in 2040.

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

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







Security of Supply:[2]

> Reference case:

[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 the reference case, the project is mitigating the risk of hydrogen demand curtailment for Belgium and the Netherlands by 1% in 2050. 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 32 D, WEST 40) located in the same geographical area enabling, as well, liquid import supplies to flow to the Netherlands.

> 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 the Netherlands by 2% in 2030.

> Disruption cases (S-1):

In case of North Africa hydrogen supply disruption, the project mitigates the risk of demand curtailment for France and Slovenia by 1% in 2050. Under Norway and Ukraine supply disruption the project is not further mitigating the risk of hydrogen demand curtailment in Europe.

noNAh2 : North Africa disruption

2030 DE- Benefits

2040 DE- Benefits

2050 DE- Benefits

> Single largest capacity disruption (SLCD):

In case of SLCD many European countries benefitting from this project group by mitigating the risk of demand curtailment from 2030 onwards. The Netherlands are benefitting in all three timestamps including the mitigating of demand supply risk by 1% in 2030, by 8% in 2040 and by 4% in 2050. Other countries benefitting from this project can mitigate the risk of demand curtailment by 1-3% in 2040 and 2050.

SLCD Benefits - 2030 - Distributed Energy

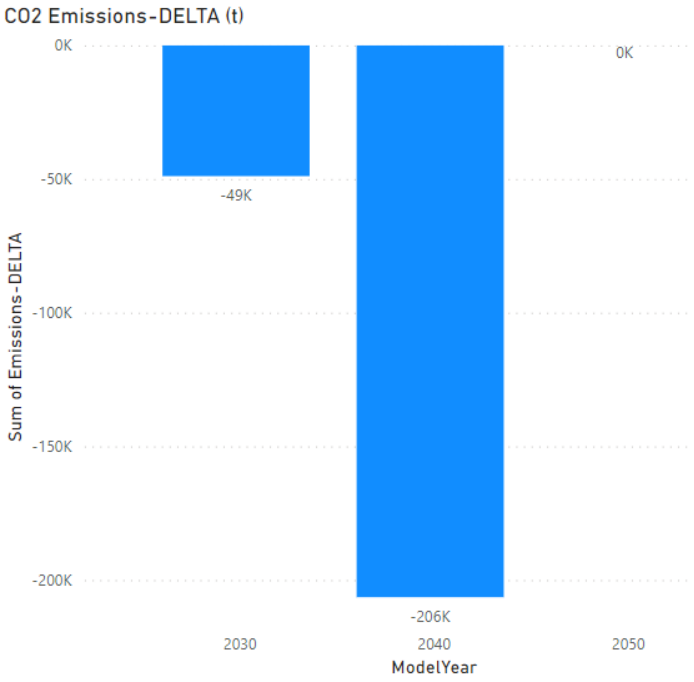
SLCD Benefits - 2040 - Distributed Energy

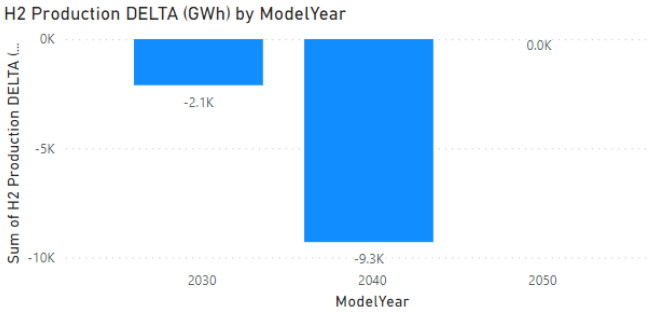
SLCD Benefits - 2050 - Distributed Energy

Global Ambition

Sustainability benefits

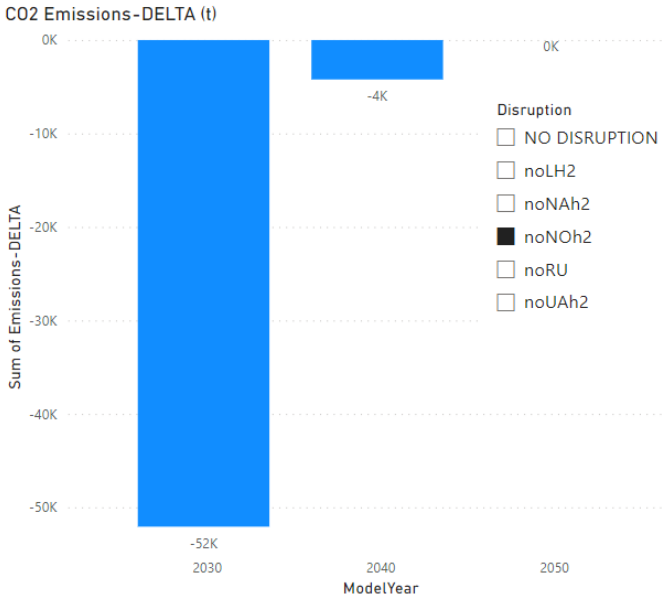
In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group will contribute to sustainability by reducing overall CO2 emissions by 49 kt in 2030 and by 206 kt in 2040. This can be explained as in 2030 the project group enables mainly the replacement of blue hydrogen locally produced n (I.e SMR) with green hydrogen imports in form of ammonia.

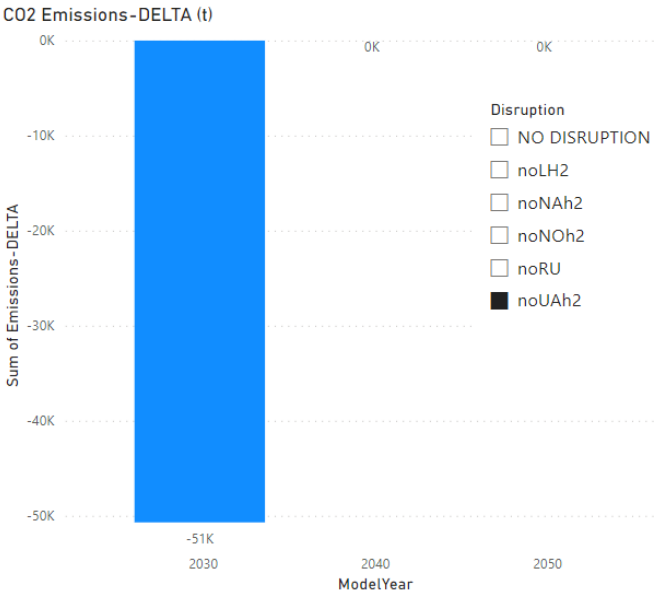


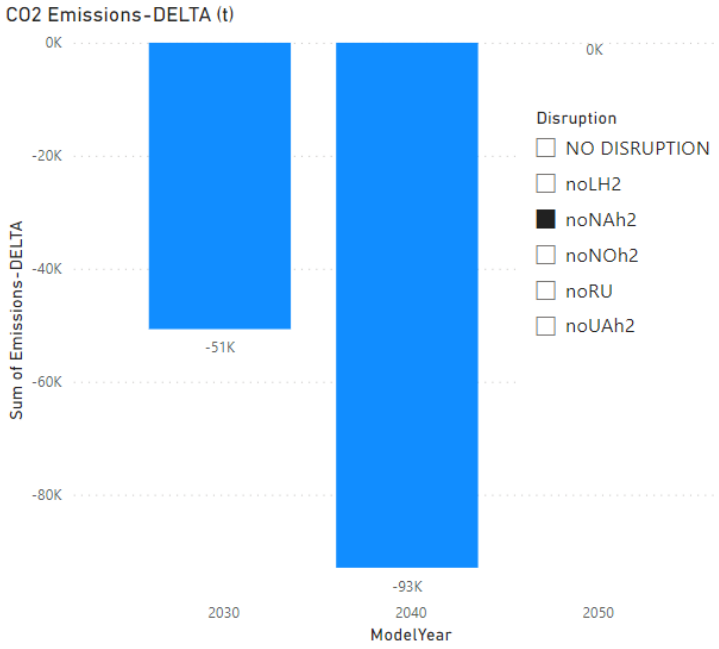


Sustainability benefits are slightly increased under supply disruption cases, such as Norway, Ukraine, or North Africa Disruption for 2030. For example, in case of Ukraine disruption the project group will reduce CO2 emissions by 51 kt in 2030.

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 for Netherlands and Belgium by 1% in 2050. 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 32 D, WEST 40) located in the same geographical area enabling, as well, liquid import supplies to flow to the Netherlands.

> Climatic stress cases

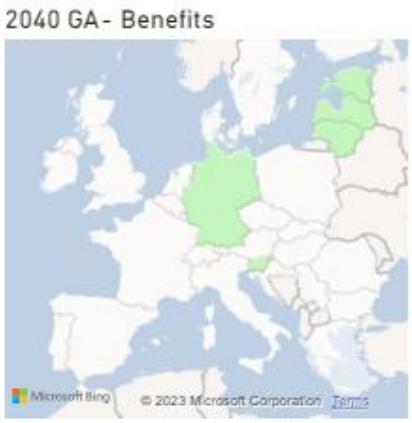
Under 2 -week and 2-week dunkelflaute climatic stress case, as well as under peak day climatic case the project group is contributing to the mitigation of hydrogen demand curtailment risk for the Netherlands by 1% in 2030.

> 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 several countries 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. Thanks to the project group respective countries mitigate the risk of demand curtailment by 1-2%.

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	-48310,86	538677299	538725609,9
2030	noLH2	DE	tonne	0,00	540175890,2	540175890,2
2030	noNAh2	DE	tonne	-50108,32	539785356,1	539835464,4
2030	noNOh2	DE	tonne	-52050,93	538877197,8	538929248,8
2030	noUAh2	DE	tonne	-50108,32	539378771,9	539428880,2
2030	NO DISRUPTION	GA	tonne	-48893,87	592910448,4	592959342,3
2030	noLH2	GA	tonne	0,00	594817481,2	594817481,2
2030	noNAh2	GA	tonne	-50690,09	594141433,2	594192123,2
2030	noNOh2	GA	tonne	-52066,95	593310994,3	593363061,2
2030	noUAh2	GA	tonne	-50690,09	593627617,9	593678308
2040	NO DISRUPTION	DE	tonne	0,00	392077044	392077044
2040	noLH2	DE	tonne	0,00	392213883,4	392213883,4
2040	noNAh2	DE	tonne	-32493,40	392188097,7	392220591,1
2040	noNOh2	DE	tonne	-92862,40	392144022,6	392236885
2040	noUAh2	DE	tonne	-88169,31	392399182,9	392487352,2
2040	NO DISRUPTION	GA	tonne	-206414,19	396523251,6	396729665,8
2040	noLH2	GA	tonne	0,00	397455196,7	397455196,7
2040	noNAh2	GA	tonne	-92921,19	397301976,6	397394897,8
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
The Netherlands	-1%	-1%	-8%	-4%	-4%	-2%
Czechia	0%	0%	-3%	-2%	-3%	-1%
Estonia	0%	0%	-3%	-1%	-2%	-1%
Latvia	0%	0%	-3%	-1%	-2%	-1%
Lithuania	0%	0%	-3%	-1%	-2%	-1%
Poland	0%	0%	-3%	-1%	-2%	-1%
Portugal	0%	0%	-3%	-1%	-1%	-1%
Slovenia	0%	0%	-3%	-1%	-2%	-1%
France	0%	0%	-3%	-1%	-2%	-1%
Germany	0%	0%	-2%	-2%	-1%	-1%
Austria	0%	0%	-2%	-1%	-2%	-1%
Belgium	0%	0%	-2%	-2%	-2%	-1%
Denmark	0%	0%	-2%	-2%	-2%	-1%
Finland	0%	0%	-2%	-1%	-2%	-1%
Italy	0%	0%	-2%	-1%	-2%	-1%
Spain	0%	0%	-2%	-2%	-2%	-1%
Sweden	0%	0%	-2%	-1%	-2%	-1%
Switzerland	0%	0%	-2%	-1%	-1%	-1%
Bulgaria	0%	0%	-1%	-1%	-1%	-1%
Croatia	0%	0%	-1%	-1%	-1%	-1%
Greece	0%	0%	-1%	-1%	0%	-1%
Hungary	0%	0%	-1%	-1%	-1%	-1%
Romania	0%	0%	-1%	-1%	0%	-1%
Slovakia	0%	0%	-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	0%	0%	-1%	-1%	-1%	-1%
Average2W	Belgium	0%	0%	-1%	-1%	0%	0%
Average2W	Bulgaria	0%	0%	-1%	-1%	0%	0%
Average2W	Croatia	0%	0%	-1%	-1%	0%	-1%
Average2W	Cyprus	0%	0%	0%	0%	0%	0%
Average2W	Czechia	0%	0%	-1%	-1%	-1%	-1%
Average2W	Denmark	0%	0%	-1%	-1%	-1%	-1%
Average2W	Estonia	0%	0%	0%	-1%	-1%	-1%
Average2W	Finland	0%	0%	-1%	0%	-1%	-1%
Average2W	France	0%	0%	-1%	-1%	-1%	-1%
Average2W	Germany	0%	0%	0%	0%	0%	0%
Average2W	Greece	0%	0%	-1%	0%	0%	0%
Average2W	Hungary	0%	0%	-1%	-1%	0%	-1%
Average2W	Ireland	0%	0%	0%	0%	0%	0%
Average2W	Italy	0%	0%	-1%	0%	0%	0%
Average2W	Latvia	0%	0%	0%	-1%	0%	-1%

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

DC	Belgium	0%	0%	0%	0%	0%	0%
DC	Bulgaria	0%	0%	-1%	0%	0%	0%
DC	Croatia	0%	0%	-1%	0%	0%	0%
DC	Cyprus	0%	0%	0%	0%	0%	0%
DC	Czechia	0%	0%	0%	0%	-1%	-1%
DC	Denmark	0%	0%	0%	0%	0%	0%
DC	Estonia	0%	0%	-1%	0%	-1%	0%
DC	Finland	0%	0%	0%	0%	-1%	0%
DC	France	0%	0%	-1%	0%	0%	0%
DC	Germany	0%	0%	-1%	-1%	0%	0%
DC	Greece	0%	0%	-1%	0%	0%	0%
DC	Hungary	0%	0%	-1%	0%	0%	0%
DC	Ireland	0%	0%	0%	0%	0%	0%
DC	Italy	0%	0%	0%	0%	-1%	0%
DC	Latvia	0%	0%	-1%	0%	0%	-1%
DC	Lithuania	0%	0%	-1%	0%	0%	0%
DC	Luxembourg	0%	0%	0%	0%	0%	0%
DC	Malta	0%	0%	0%	0%	0%	0%
DC	Poland	0%	0%	-1%	0%	0%	0%
DC	Portugal	0%	0%	-1%	0%	0%	0%
DC	Romania	0%	0%	-1%	0%	0%	-1%
DC	Serbia	0%	0%	0%	0%	0%	0%
DC	Slovakia	0%	0%	-1%	0%	0%	0%
DC	Slovenia	0%	0%	-1%	0%	0%	-1%
DC	Spain	0%	0%	0%	0%	-1%	-1%
DC	Sweden	0%	0%	0%	0%	-1%	0%
DC	Switzerland	0%	0%	0%	0%	-1%	0%
DC	The Netherlands	-1%	-1%	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-1127	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 project is close to Natura 2000 areas in the Rotterdam area. NOx emissions during construction and operation will remain within the legislative boundaries set in the host country. Furthermore, project Amplifhy has the ambition to minimize emissions of any kind within the boundaries of economic feasibility by selecting specific low or zero emission technologies.

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]

F. Useful links [Promoter]

Useful links:

VTTI - Hydrogen will play a crucial role in the future energy mix.

VTTI, Essent and E.ON to jointly develop green ammonia cracker project in Rotterdam - VTTI