BEMIP HYD 2 (Less Advanced)
Nordic Hydrogen Route – Bothnian Bay

Reasons for grouping [ENTSOG]

The project group aims at interconnecting future hydrogen infrastructure between Sweden and Finland through a new route around Gulf of Bothnia.

The project group includes both sides of the route (HYD-N-1171 in Sweden and HYD-N-1130 in Finland), as well as equipment (HYD-N-1350 in Sweden and HYD-N-1172 in Finland).

Objective of the group [Promoter]

The Nordic Hydrogen Route (NHR PRJ-G-260) is an initiative set-up by Gasgrid Finland Oy and Nordion Energi AB to kick-off and accelerate the creation of a regional and European hydrogen economy. The main goal of the NHR is to enable the collection, storage, and transmission of hydrogen in the Bothnia Bay region.

Nordic Hydrogen Route - Bothnian Bay is enabling significant deployment of H2 production based on new RES (mainly onshore wind and solar) in Finland and Sweden and advancing the decarbonisation of regional industrial emissions in both Finland and Sweden by providing a range of off-takers with access to a low carbon fuel and raw material supply. Hydrogen will be produced from local, wind powered production sites and from the electricity grid for the purpose of direct hydrogen and hydrogen derivatives supply to multiple end users in Sweden, Finland, and exports to other countries. By building cross-border hydrogen infrastructure in the Bothnian Bay an open hydrogen market will be enabled by 2028.

HYD-N-1136 **Nordic Hydrogen Route – Bothnian Bay – Finnish section**

Comm. Year **2028**

HYD-N-1172 **Nordic Hydrogen Route – Bothnian Bay – Finnish section – Equipment**

Comm. Year **2028**

HYD-N-1171 **Nordic Hydrogen Route - Bothnian Bay- Swedish section**

Comm. Year **2028**

HYD-N-1350 **Nordic Hydrogen Route - Bothnian Bay- Swedish section - Equipment**

Comm. Year **2028**

A. Project group technical information [Promoter/ ENTSOG]

Project technical information [Promoter]

TYNDP Project code	Section name	New / Repurposing	Nominal Diameter [mm]	Section Length [km]	Compressor power [MW]
HYD-N-1136	NHR – Finnish section pipeline	New	1200	478	260
HYD-N-1171	NHR – Swedish section pipeline	New	1200	786	260

Capacity increment [ENTSOG]

TYNDP Project code	Point name	Operator	From system	To system	Capacity increment [GWh/d]	Comm. year
HYD-N-1136	H2_IP_FI_SE	Gasgrid Finland Oy	Transmission Sweden (FI Hydrogen)	Transmission Finland (FI Hydrogen)	162	2028
HYD-N-1136	H2_IP_FI_SE	Gasgrid Finland Oy	Transmission Finland (FI Hydrogen)	Transmission Sweden (FI Hydrogen)	162	2028
HYD-N-1171	H2_IP_FI_SE	Nordion Energi AB	Transmission Finland (FI Hydrogen)	Transmission Sweden (FI Hydrogen)	162	2028
HYD-N-1171	H2_IP_FI_SE	Nordion Energi AB	Transmission Sweden (FI Hydrogen)	Transmission Finland (FI Hydrogen)	162	2028

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-1136	1652	40%	8,3	40%
HYD-N-1171	1652	40%	8,3	40%

Description of the cost and range [Promoter]

Pipeline CAPEX and OPEX are computed using the European Hydrogen Backbone (EHB) assumptions.

- Pipeline CAPEX of 2.8 M€/km – Source (EHB)
- Pipeline OPEX assumed as 0.5% of pipeline CAPEX

At this stage, the pipeline capital and operational costs are assumed to be equally shared between Gasgrid Finland and Nordion Energi. Meaning that the total NHR pipeline CAPEX is 3305 M€ and the total pipeline OPEX is 16.6 M€. Given the less advanced phase of NHR, the CAPEX and OPEX degree of cost variability is assumed to be 40%.

These numbers will be refined through the pre-feasibility assessment.

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].

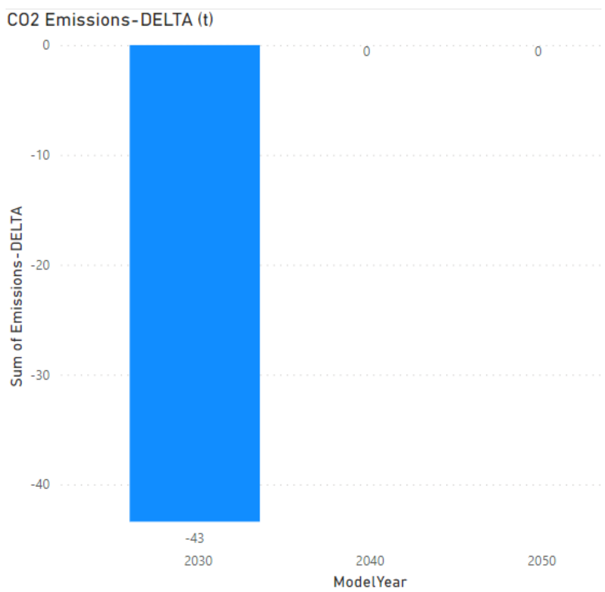
Distributed Energy

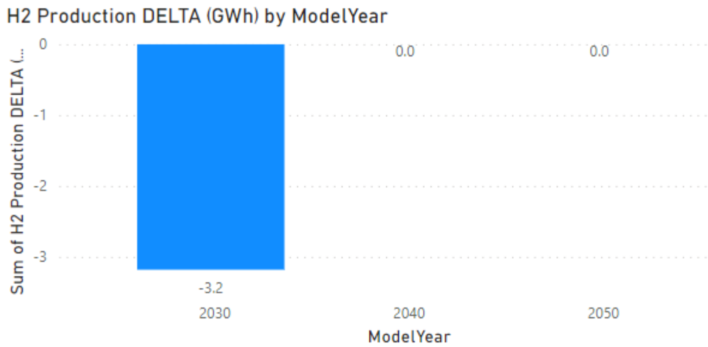
Sustainability:

In the reference case, which analyses yearly demand in two periods (average winter and average summer), the project group is not contributing to sustainability by reducing CO2 emissions. However, it is important to mention that the benefits of this project group could be limited by another group (BEMIP 8) included in the hydrogen reference network, located in the same geographical area connecting Sweden with Finland via an offshore route.

In case of no H2 supplies from North Africa, the project group will contribute to sustainability by reducing overall CO2 emissions by 43 t in 2030. This is explained as the project group will enable replacement of blue hydrogen supplies that are needed due to the lower availability of supplies and, therefore, will reduce natural gas imports, with different hydrogen supply sources.

North Africa H2 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

2030 DE- Benefits

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. Similar to the sustainability indicator, the benefits could be limited based on the composition of the hydrogen reference infrastructure level.

> 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):

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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.*

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

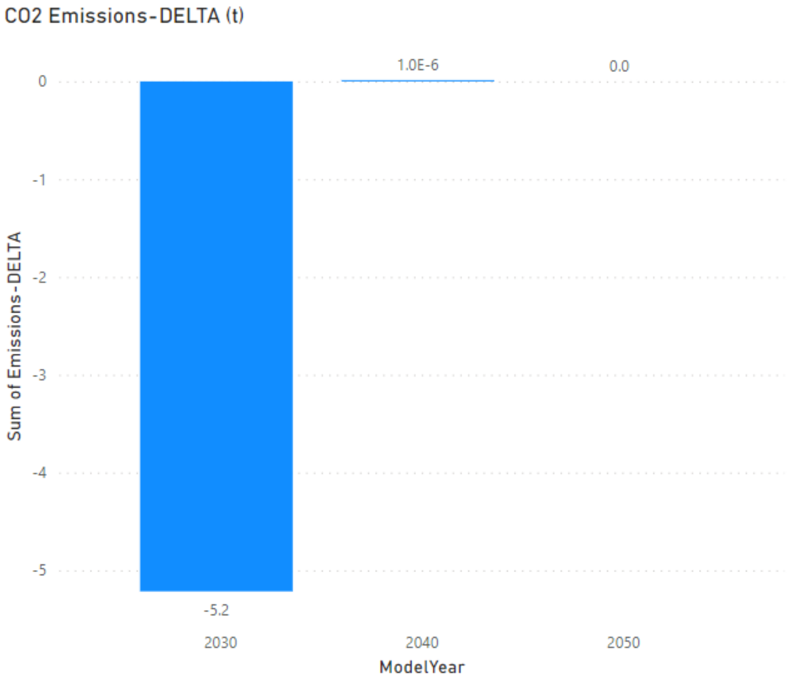
> Single largest capacity disruption (SLCD):

In case of single largest capacity disruption (SLCD), the project group reduces the risk of demand curtailment in countries in many European countries (Baltic States and countries in central and western Europe) from 2040. In addition, from 2040, under single largest capacity disruption in Sweden, the project group helps to mitigate the risk of demand curtailment due to increase cooperation between Sweden and Finland with the rest of Europe.

Global Ambition

Sustainability benefits

In the reference case, the project group will contribute to sustainability in a small extent by reducing overall CO_2 emissions by 5.2 t in 2030. This is explained as the project group will enable a higher cooperation between countries and enable other green hydrogen supplies. However, also here it is important to mention that the benefits of this project group could be limited due to a competing project group (BEMIP 8), located in the same geological area connecting Sweden with Finland via an offshore route.



A similar trend for sustainability benefits is observed under north African H2 supply disruption cases in 2030.

In case of no H2 supply from Norway CO_2 emissions are reduced by 39 t in 2040. This can be explained as the project group will enable the replacement of blue hydrogen supplies under this con figuration and therefore will reduce natural gas imports.

Security of supply

> Reference case

2030 GA- Benefits 2040 GA- Benefits 2050 GA- Benefits

In reference case, the project group is not reducing the risk of demand curtailment in average summer and average winter. Following the same remark as in distributed energy, benefits are likely to limited here based on another project included in the reference hydrogen infrastructure level.

> 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.

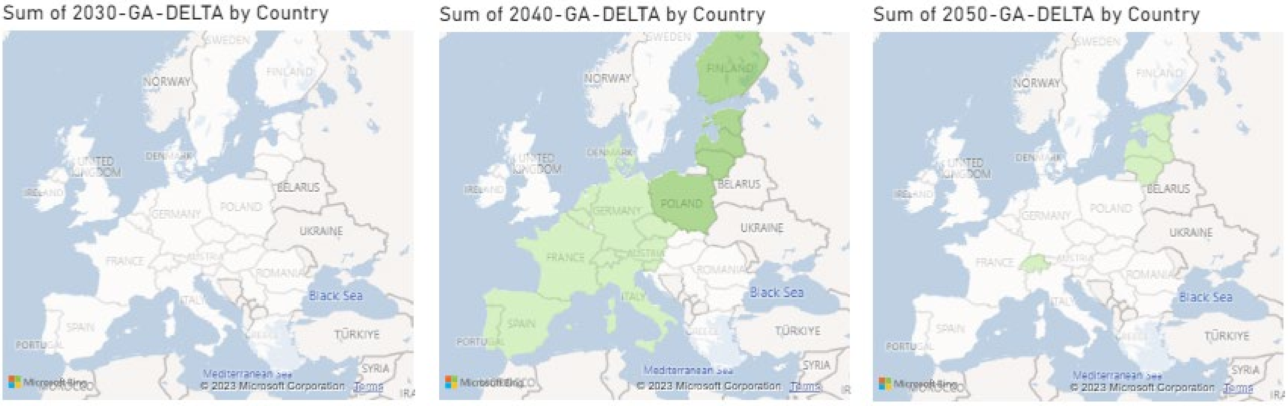
> Disruption cases (S-1)

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)

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

Sum of 2030-GA-DELTA by Country Sum of 2040-GA-DELTA by Country Sum of 2050-GA-DELTA by Country



In case of single largest capacity disruption (SLCD), the project group significantly reduces the risk of demand curtailment in Baltic states Finland, Estonia, Latvia, Lithuania and Poland in 2040. In addition, also in 2040 the project group will help to mitigate the risk of demand curtailment due to the increase cooperation between Sweden and Finland with central and west Europe. As Global ambition scenario considers higher hydrogen demand the contribution of the hydrogen supply enabled by the project group is lower than in Distributed Energy scenario in 2050.

C.2 Quantitative benefits [ENTSOG]

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

Sustainability

GROUP Number	ModelYear	Disruption	Scenario	Unit	Emission Delta	Emission Plus	Emission Minus
BEMIP HYD 2	2030	NO DISRUPTION	DE	tonne	0	538.677.299	538.677.299
BEMIP HYD 2	2030	NO DISRUPTION	GA	tonne	-5	592.910.448	592.910.454
BEMIP HYD 2	2030	noLH2	DE	tonne	0	540.175.890	540.175.890
BEMIP HYD 2	2030	noLH2	GA	tonne	0	594.817.481	594.817.481
BEMIP HYD 2	2030	noNAh2	DE	tonne	-43	539.785.356	539.785.399
BEMIP HYD 2	2030	noNAh2	GA	tonne	-2	594.141.433	594.141.436
BEMIP HYD 2	2030	noNOh2	DE	tonne	16	538.877.198	538.877.182
BEMIP HYD 2	2030	noNOh2	GA	tonne	0	593.310.994	593.310.994
BEMIP HYD 2	2030	noUAh2	DE	tonne	0	539.378.772	539.378.772
BEMIP HYD 2	2030	noUAh2	GA	tonne	0	593.627.618	593.627.618
BEMIP HYD 2	2040	NO DISRUPTION	DE	tonne	0	392.077.044	392.077.044
BEMIP HYD 2	2040	NO DISRUPTION	GA	tonne	0	396.523.252	396.523.252
BEMIP HYD 2	2040	noLH2	DE	tonne	0	392.213.883	392.213.883
BEMIP HYD 2	2040	noLH2	GA	tonne	0	397.455.197	397.455.197
BEMIP HYD 2	2040	noNAh2	DE	tonne	0	392.188.098	392.188.098
BEMIP HYD 2	2040	noNAh2	GA	tonne	0	397.301.977	397.301.977
BEMIP HYD 2	2040	noNOh2	DE	tonne	0	392.144.023	392.144.023
BEMIP HYD 2	2040	noNOh2	GA	tonne	-39	397.450.977	397.451.016
BEMIP HYD 2	2040	noUAh2	DE	tonne	0	392.399.183	392.399.183

BEMIP HYD 2	2040	noUAh2	GA	tonne	0	397.478.498	397.478.498
BEMIP HYD 2	2050	NO DISRUPTION	DE	tonne	0	232.557.735	232.557.735
BEMIP HYD 2	2050	NO DISRUPTION	GA	tonne	0	228.306.707	228.306.707
BEMIP HYD 2	2050	noLH2	DE	tonne	0	232.557.735	232.557.735
BEMIP HYD 2	2050	noLH2	GA	tonne	0	228.306.707	228.306.707
BEMIP HYD 2	2050	noNAh2	DE	tonne	0	232.557.735	232.557.735
BEMIP HYD 2	2050	noNAh2	GA	tonne	0	228.306.707	228.306.707
BEMIP HYD 2	2050	noNOh2	DE	tonne	0	232.557.735	232.557.735
BEMIP HYD 2	2050	noNOh2	GA	tonne	0	228.306.707	228.306.707
BEMIP HYD 2	2050	noRU	DE	tonne	0	232.557.735	232.557.735
BEMIP HYD 2	2050	noRU	GA	tonne	0	228.306.707	228.306.707
BEMIP HYD 2	2050	noUAh2	DE	tonne	0	232.557.735	232.557.735
BEMIP HYD 2	2050	noUAh2	GA	tonne	0	228.306.707	228.306.707

Security of Supply

Curtailment Rate (SLCD):

Country	2030-DE-DELTA	2030-GA-DELTA	2040-DE-DELTA	2040-GA-DELTA	2050-DE-DELTA	2050-GA-DELTA
Sweden	-31%	-20%	-5%	0%	-11%	0%
Belgium	0%	0%	-2%	-1%	-1%	0%
Czechia	0%	0%	-2%	-2%	-2%	0%
Estonia	-20%	-13%	-2%	-7%	-2%	-1%
Finland	-20%	-13%	-2%	-6%	-2%	-1%
Germany	0%	0%	-2%	-1%	-1%	0%
Latvia	-20%	-13%	-2%	-7%	-1%	-1%
Lithuania	-21%	-13%	-2%	-7%	-1%	-1%
Poland	-20%	-12%	-2%	-7%	-1%	0%
Portugal	0%	-1%	-2%	-1%	0%	0%
Slovenia	0%	0%	-2%	-1%	-1%	0%
Switzerland	0%	0%	-2%	-1%	-1%	-1%
France	0%	0%	-2%	-1%	-1%	0%
The Netherlands	0%	0%	-1%	-1%	-2%	0%
Austria	0%	0%	-1%	-1%	-2%	0%

Denmark	0%	0%	-1%	-1%	-1%	0%
Italy	0%	0%	-1%	-1%	-2%	0%
Spain	0%	0%	-1%	-1%	-1%	0%
Greece	0%	0%	0%	0%	0%	0%

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

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

DC	Slovakia	0%	0%	0%	0%	0%	0%
DC	Slovenia	0%	0%	0%	0%	0%	0%
DC	Spain	0%	0%	0%	0%	0%	0%
DC	Sweden	0%	0%	0%	0%	0%	0%
DC	Switzerland	0%	0%	0%	0%	-1%	0%
DC	The Netherlands	0%	0%	0%	0%	0%	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-1136	N/A	N/A	N/A
HYD-N-1171	N/A	N/A	N/A

Potential impact	Mitigation measures	Related costs included in project CAPEX and OPEX	Additional expected costs
HYD-N-1136	N/A	N/A	N/A
HYD-N-1171	N/A	N/A	N/A

Environmental Impact explained [Promoter]

NHR will be designed and built according to industry best practices, with safety and reliability as top priorities. Assessing the infrastructure carbon footprint is integral part of the design phase. NHR's negative impact on climate is significant during the construction phase; lower environmental impact is expected during operation. The emissions associated with the pipe production, equipment, transportation, and construction is estimated at 4 Mt CO2e. This carbon footprint estimation will be further reduced when local green steel is utilised in parts of the NHR pipeline network. Pipelines will be laid underground (minimizing visual impact) and according to the NHR Promoter's best practices; avoiding sensitive natural areas as far as possible and in cases where sensitive areas must be traversed, this will be done with the utmost care so that the footprint is minimized, and the affected land area restored to its original status. Where possible routing will follow existing stretches of roads and power lines to further reduce the environmental impact. NHR's focus on the upcoming activities is to further engage with local communities/municipalities to include their input in the design phase. The technical alternative to hydrogen infrastructure is electricity infrastructure, which in addition to being less energy efficient also has a significantly greater environmental impact.

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]

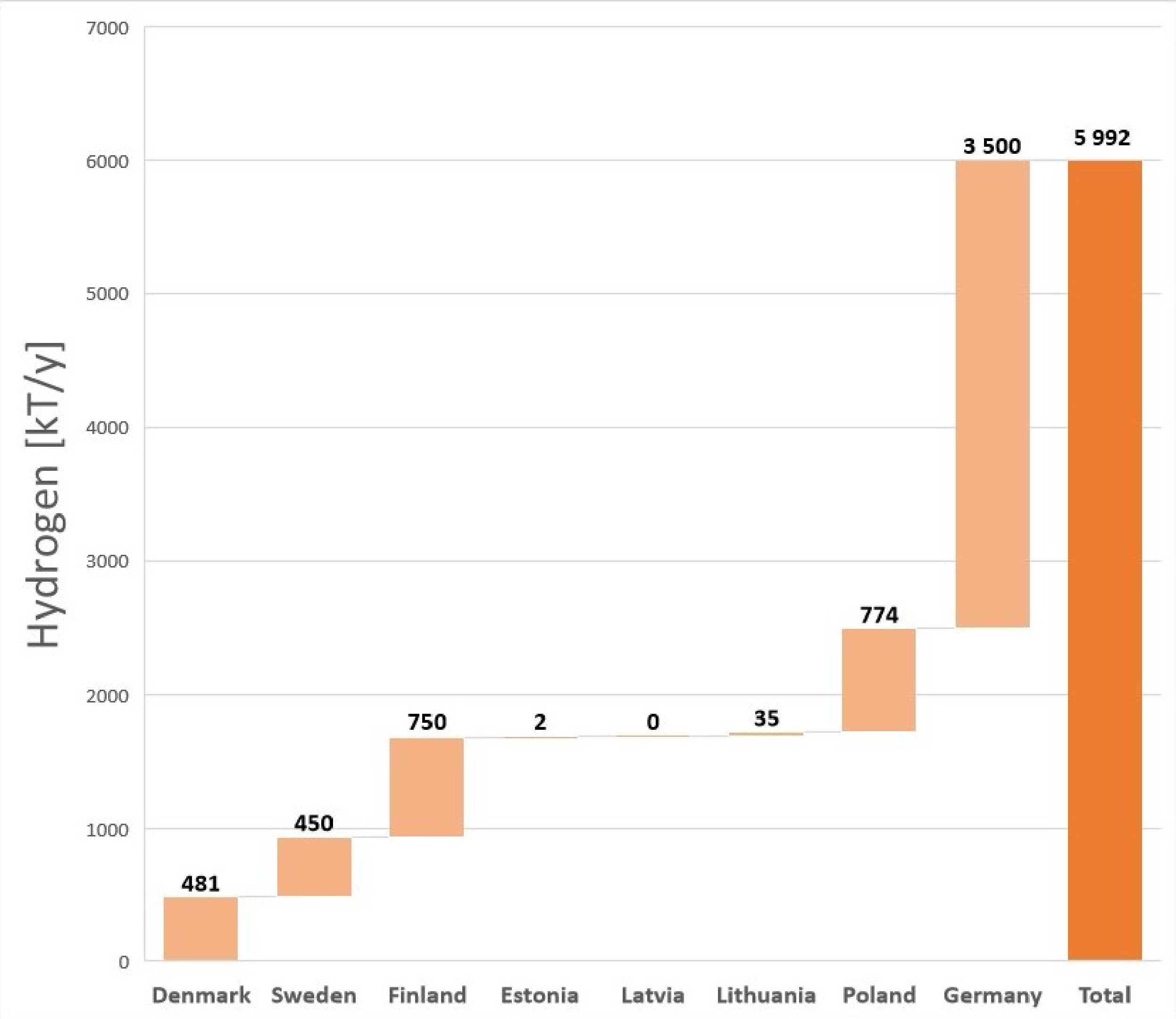
Infrastructure for hydrogen opens up future growth in the region. It helps existing industries to improve their sustainability, but it also enables new industries to develop and establish themselves in the future. The region has a unique position in terms of being able to produce renewable electricity in large quantities.

New industry is forming in the region. This will be replacing the CO2 emissions. This demand is not yet existing in the current CO2 emissions and Fossil-based production (steel, fuels). Indirect CO2 emission reduction in multiple sectors will be enabled by replacing fossil-based products with clean hydrogen based production (fertilizers, fuels etc.) which improves the sustainability.

The key aim of the Nordic Hydrogen Route project is to connect hydrogen produced with Bothnia Bay onshore wind to hydrogen users in the northern parts of Sweden and Finland.

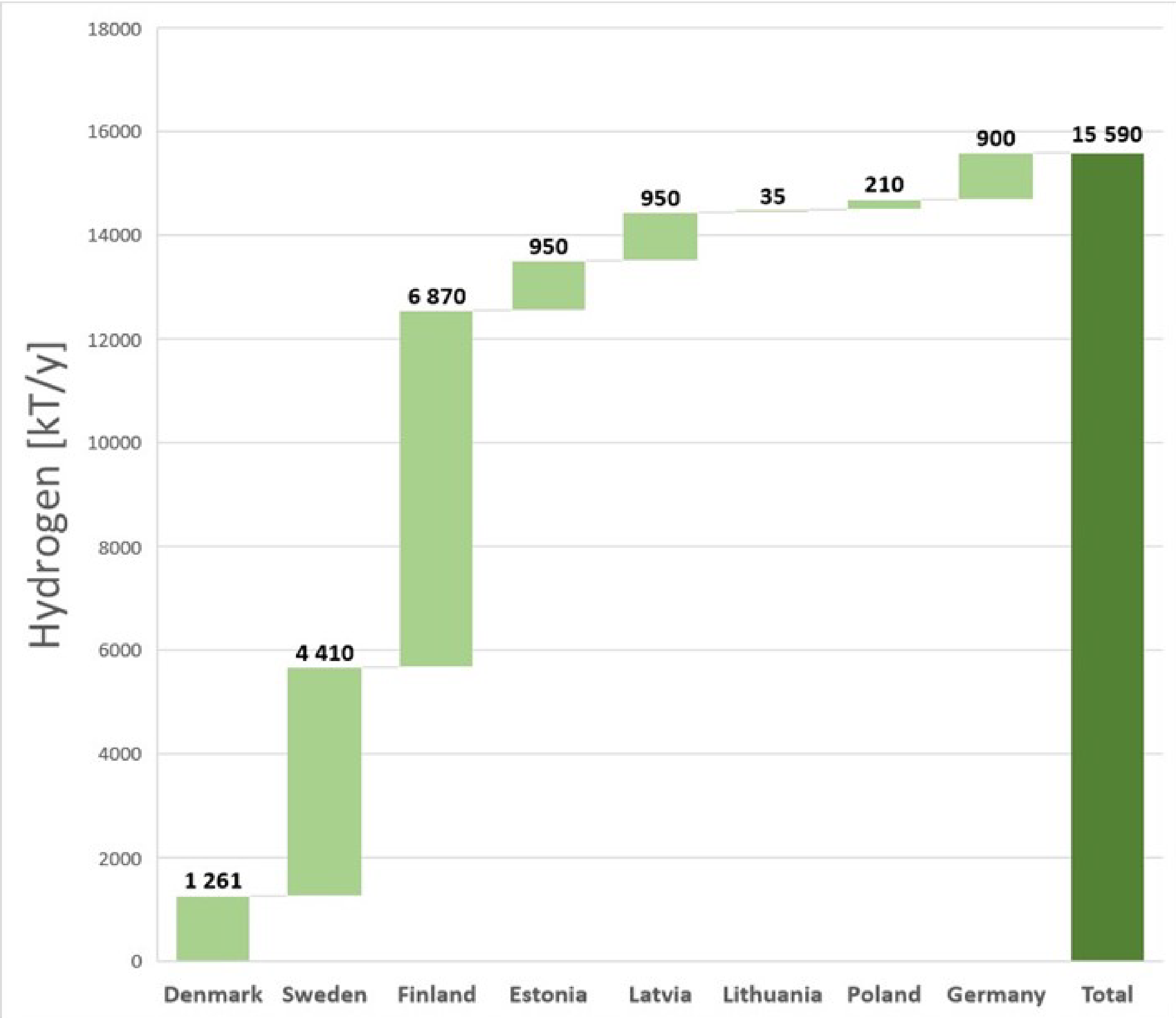
Hydrogen Demand and Supply potential around the Baltic Sea region can be seen from the pictures below.

Hydrogen demand around the Baltic Sea region[1] by 2030 (kt/year)



(1) For Poland the current demand based on the Member State data provided during the March 2023 is assumed to be decarbonized by 2030.
For other countries the Member State data for 2030 demand is used (provided during the March 2023).

Projected hydrogen production potential(2) (kt/year)



(2) For Denmark, Sweden, Finland and Estonia hydrogen production potential is based on the onshore and offshore wind potentials shown on the map.
For Lithuania, Poland and Germany the potential is based on the Member State data for 2030 provided during the March 2023.

F. Useful links [Promoter]

Useful links:

https://nordichydrogenroute.com/