NORDION ENERGI

The future role of large-scale hydrogen transport in Sweden/Nordics

MISTRA Electrification webinar May, 9th , 2023

Består av FALBYGDENS ENERGI SWEDEGAS WEUM

Agenda

- Intro Nordion Energi – today and our way forward
- The future role of hydrogen transmission in EU & Sweden
- Nordion Energi Hydrogen – vision/aims, example of projects
- Sector integrated electricity/hydrogen infrastructures for an optimized energy system
- Questions and Discussion

Short facts on our high pressure methane grid

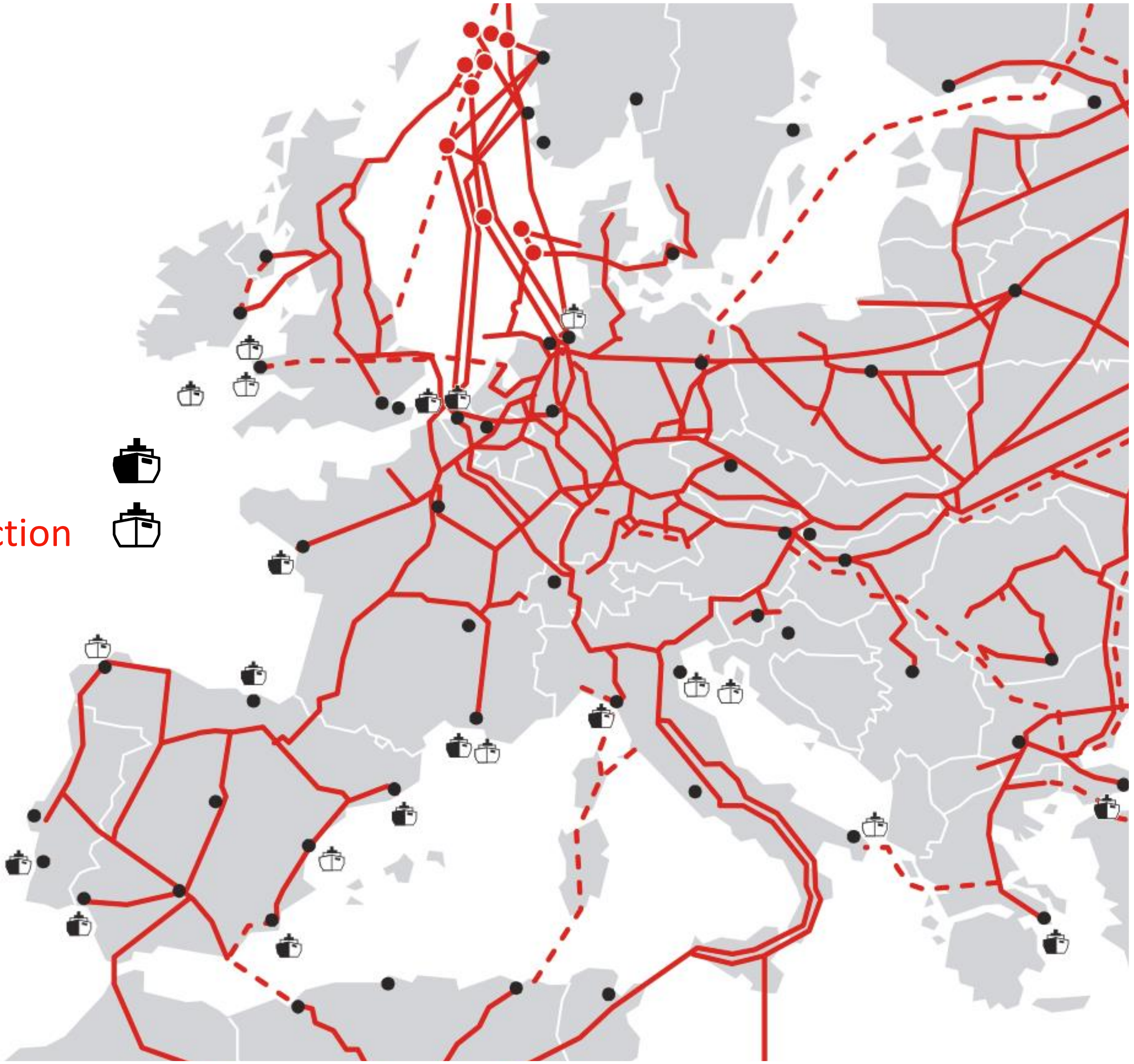
- From Dragör to Stenugnssund, ca 600 km
- All underground pipelines (≥ 1 m, 400-600 mm, steel)
- 50-80 bar
- Today ca 8 TWh of gas is transported, out of which 34 % biogas* (37 % if distribution grid is included)
- High security of supply (99, 999% incl. distribution network)
- Low transmission losses (< 0,01 % of total transferred gas volume)
- Existing co-location/intersection electricity/gas

* Traded biogas. To be noted that Nordion, being a TSO, is not allowed to participate in gas trading.

European methane gas grid

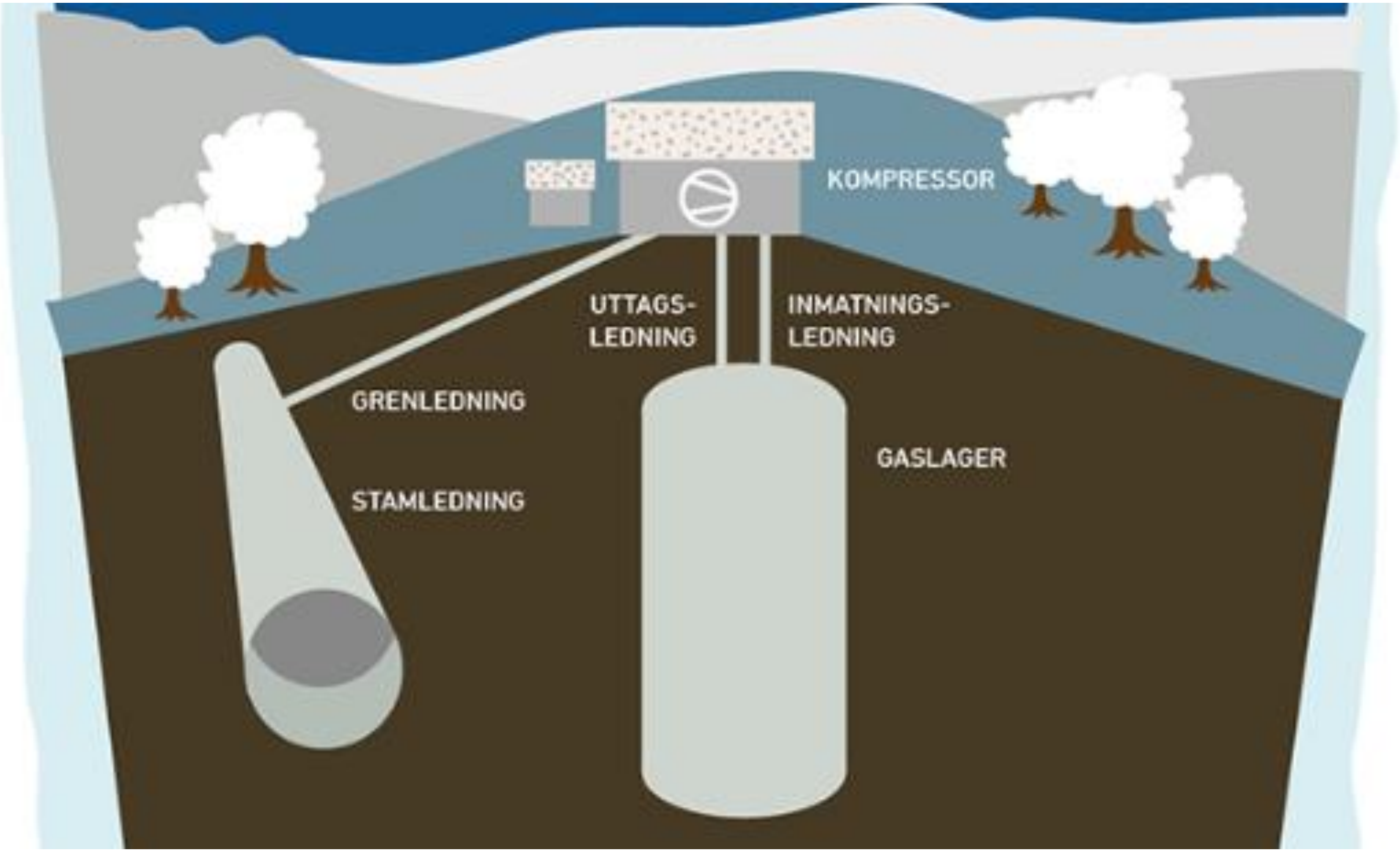
Existing

Planned or under construction



Gas storage Skallen – Securing access and reducing the risk for disturbance in security of supply

- 10 miljoner Nm^3 methane stored at 200 bar, 115 m underground
- Max. withdrawal capacity ca 0,9 miljoner Nm^3 /day



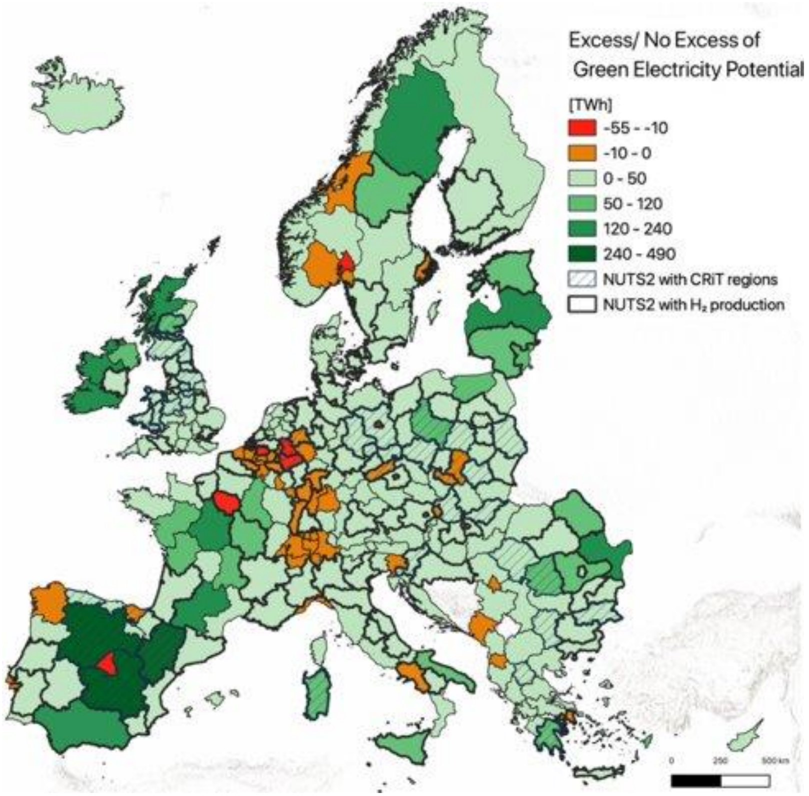
Powering a changing society - and making green energy accessible to all

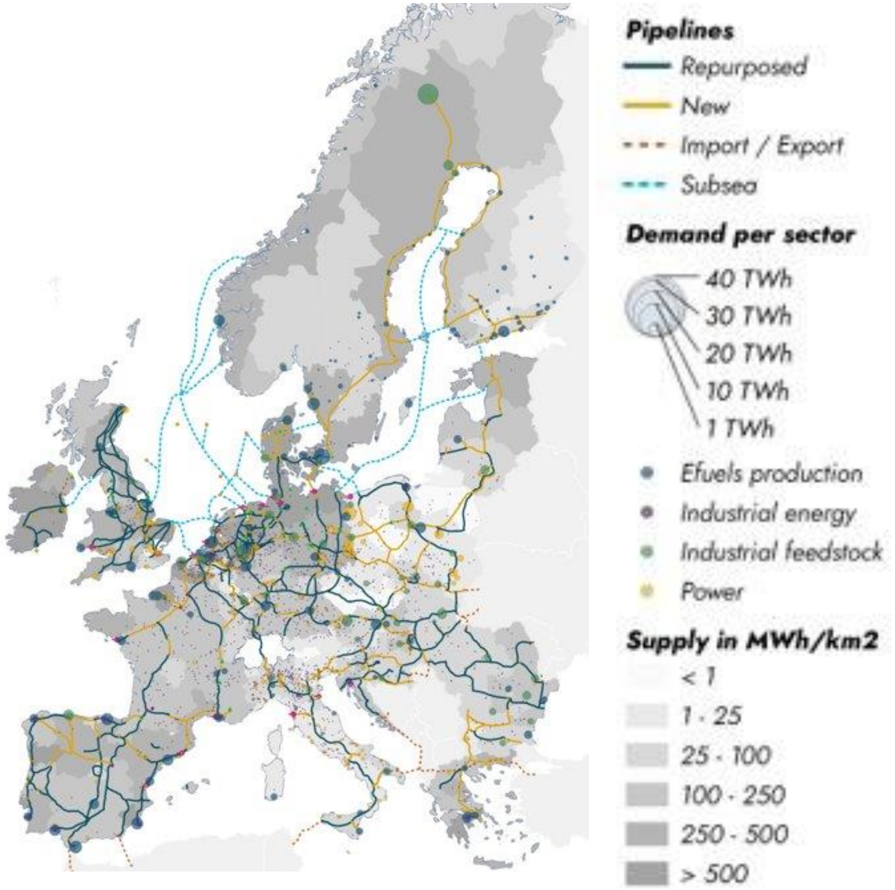
The future role of hydrogen transmission in EU & Sweden

Location Challenge

Transporting H_2 from centres with high renewable energy

To centres of high demand





Map source: European Hydrogen Backbone Maps | EHB European Hydrogen Backbone

European Hydrogen Backbone

European Hydrogen backbone maps show a vision for

53,000 km hydrogen pipeline infrastructure

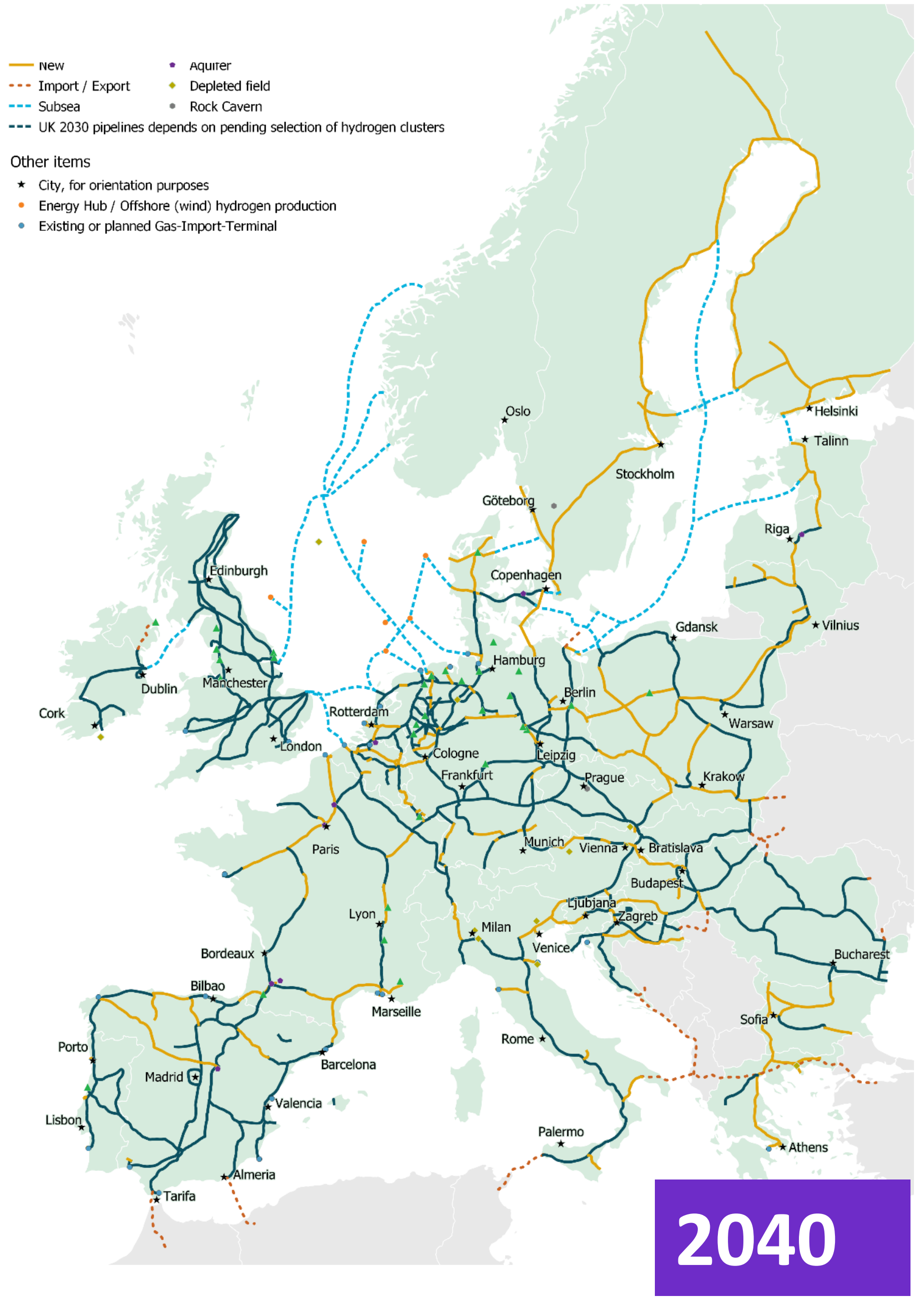
In **28** countries by 2040

60% of which is based on repurposed existing natural gas pipelines.

At an average cost of

€0.1-0.2 per kg per 1000 km (on-shore)

€0.2-0.3 per kg per 1000 km (off-shore)



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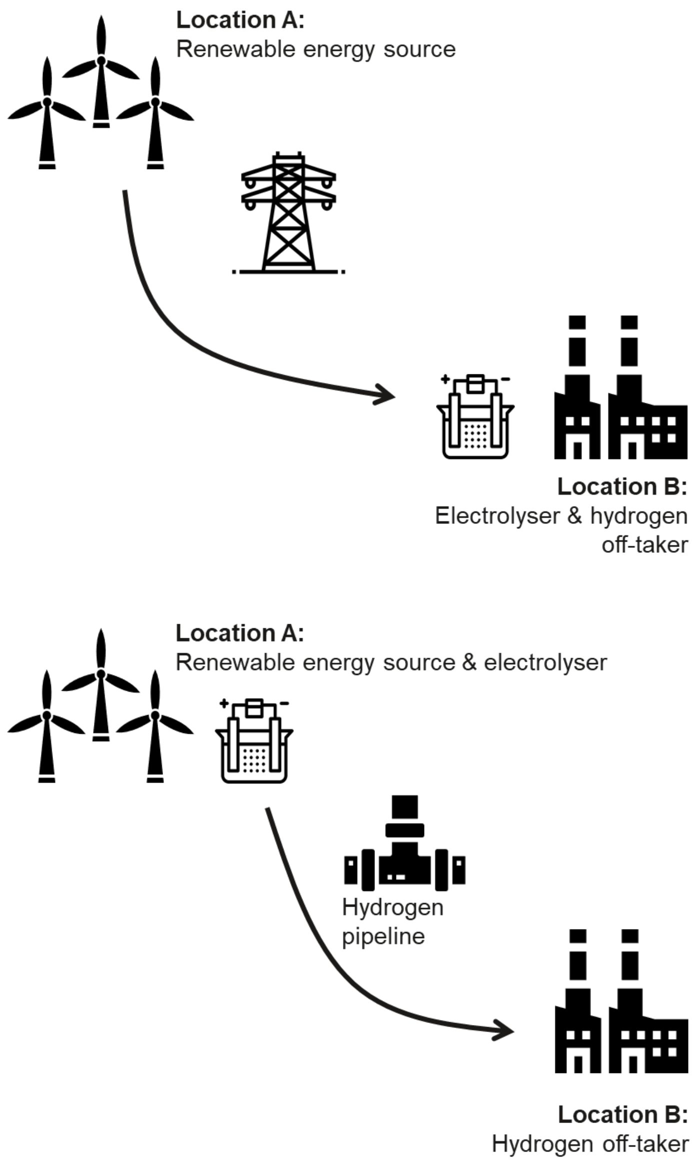
Electricity or H2 transmission?

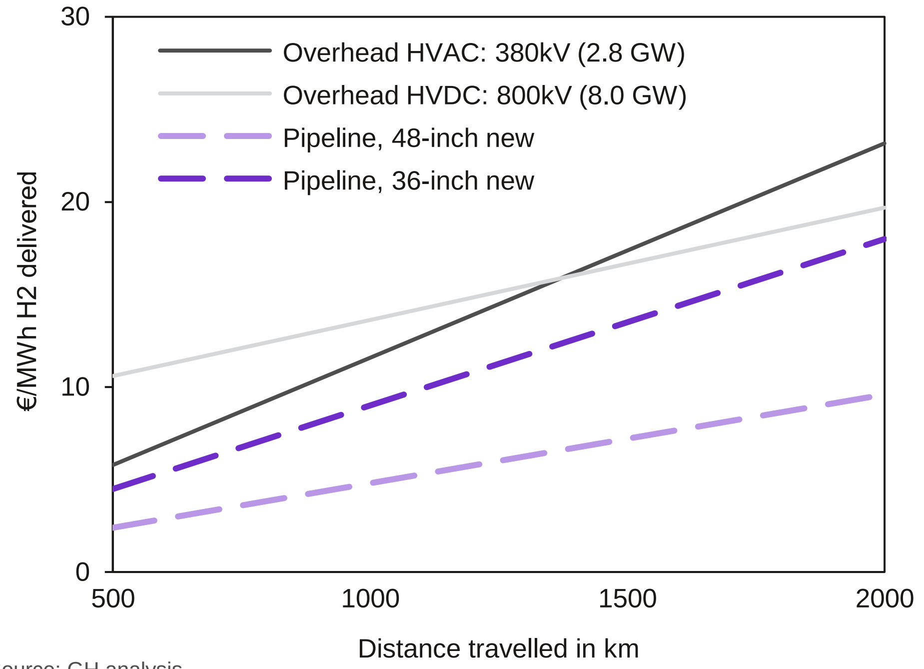
The optimal infrastructure investment depends on a range of factors including:

- Local cost and availability of electricity and hydrogen supply
- Distance to and hydrogen demand at end uses
- Required energy profile
- Interconnection costs
- Regional underground storage availability
- Terrain
- Public acceptance



Cost comparison electricity vs. hydrogen transmission – one example

Comparing transmission of energy via electricity powerline and hydrogen pipeline when hydrogen is the desired end product

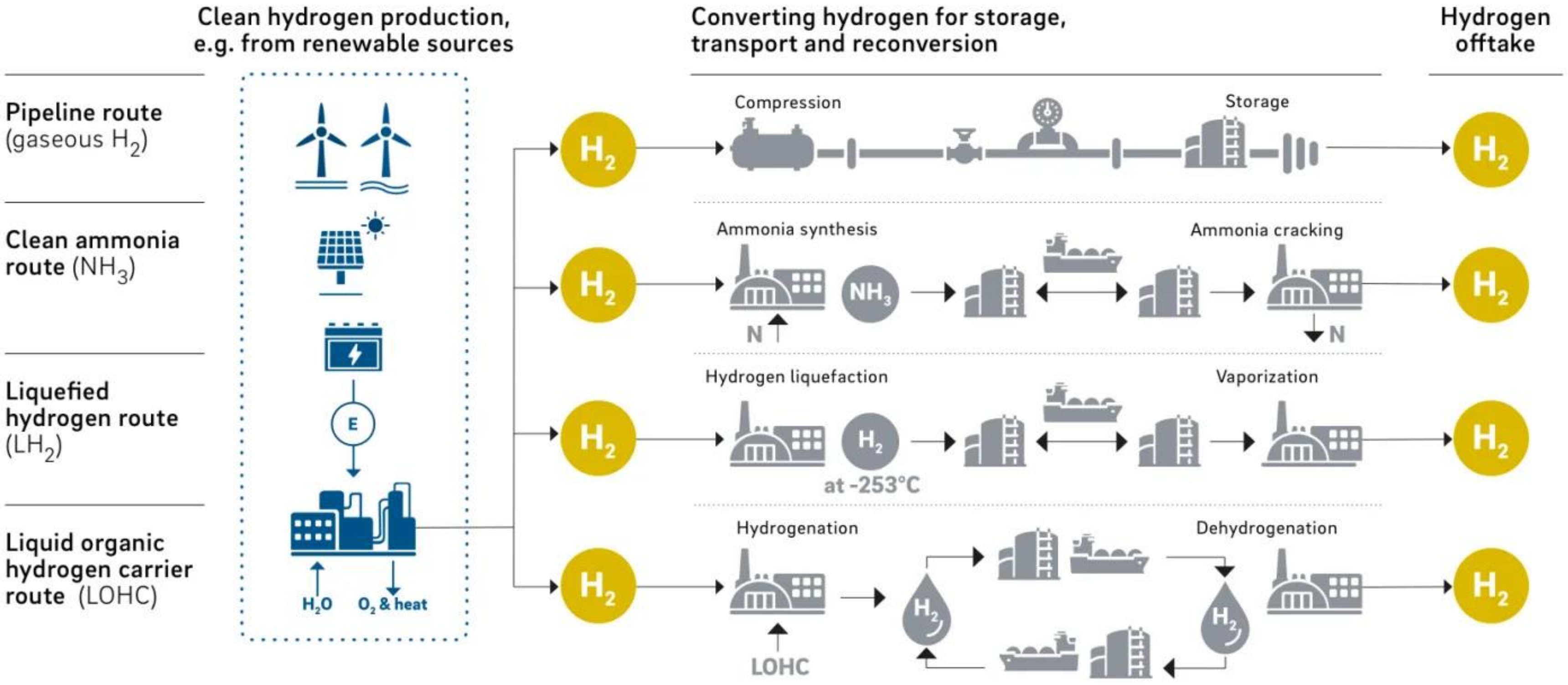


Source: GH analysis

Only considers overhead powerlines and does not consider branching or offtaking; asset utilisation is assumed to be 57% of for gas (5000 load hours) and 50% for electricity (4380 load hours), as per Energy Transitions Commission, Making the Hydrogen Economy Possible (2021); note that in Finland and Sweden powerlines are usually 200, 275 and 400 kV; note that 800 kV powerlines do not yet exist in Europe;

Leading carriers for large-scale hydrogen transportation

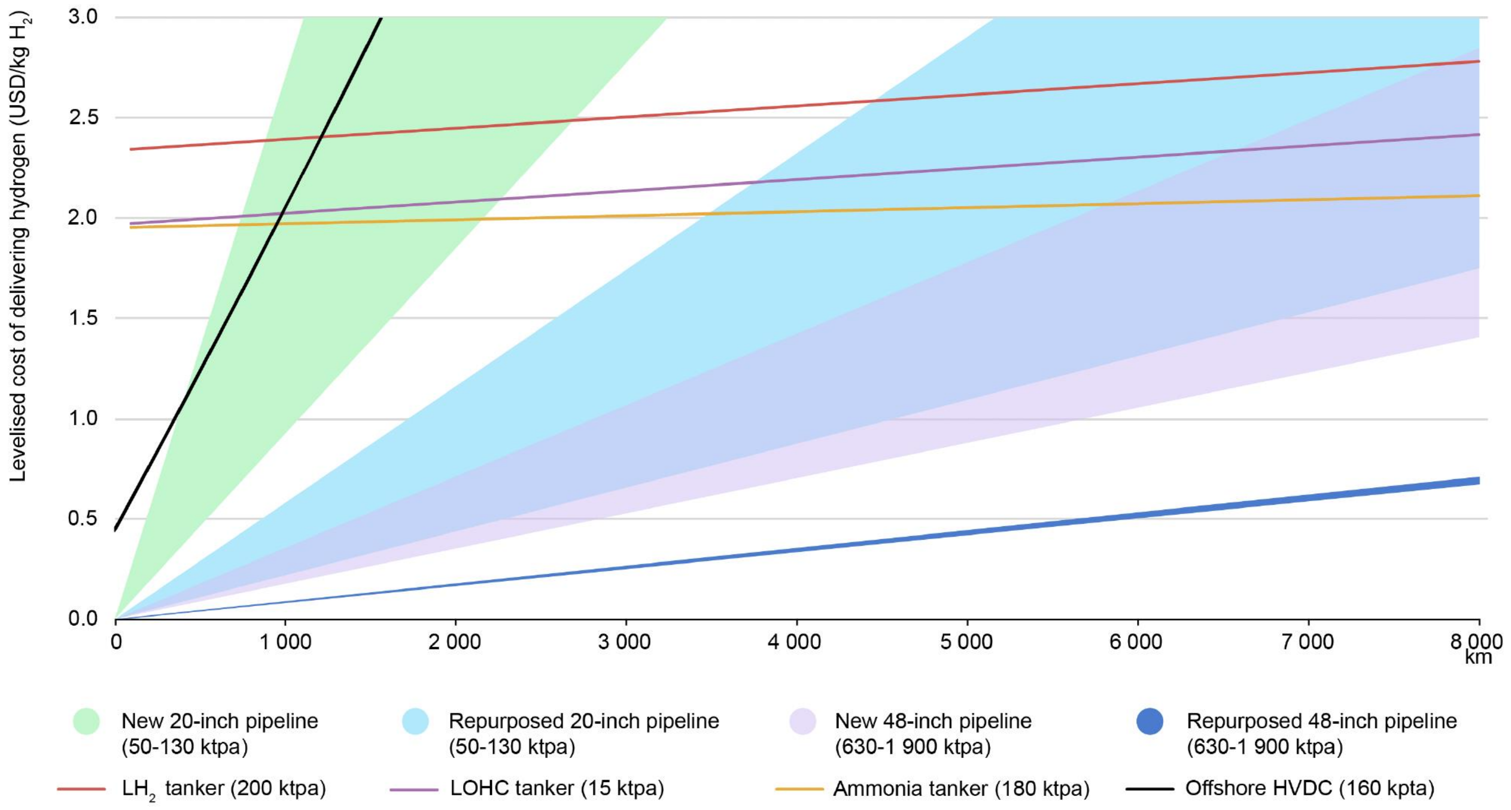
The most common hydrogen transportation routes



Source Roland Berger

Cost of hydrogen delivery for various transport distances

Levelised costs of delivering hydrogen by pipeline and by ship as LH_2, LOHC and ammonia carriers, and electricity transmission, 2030



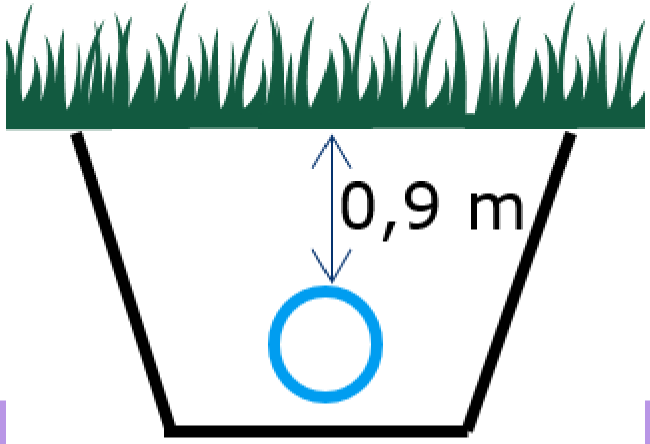
Notes: ktpa = kilotonnes per year; LH_2 = liquefied hydrogen; LOHC = liquid organic hydrogen carrier. Includes conversion, export terminal, shipping, import terminal and reconversion costs for each carrier system (LH_2, LOHC and ammonia). The import and export terminals include storage costs at the port. Pipelines refer to onshore transmission pipelines operating at ranges between 25% and 75% of their design capacity during 5 000 full load hours. Electricity transmission reflects the transmission of the electricity required to obtain 1 kg H_2 in an electrolyser with a 69% efficiency located at the distance represented by the x-axis.

Source: IEA analysis based on data from Guidehouse (2021) and IAE (2016).

SOURCE: IEA 2022**Global Hydrogen Review 2022 URL:** https://www.iea.org/reports/global-hydrogen-review-2022 License: CC BY 4.0

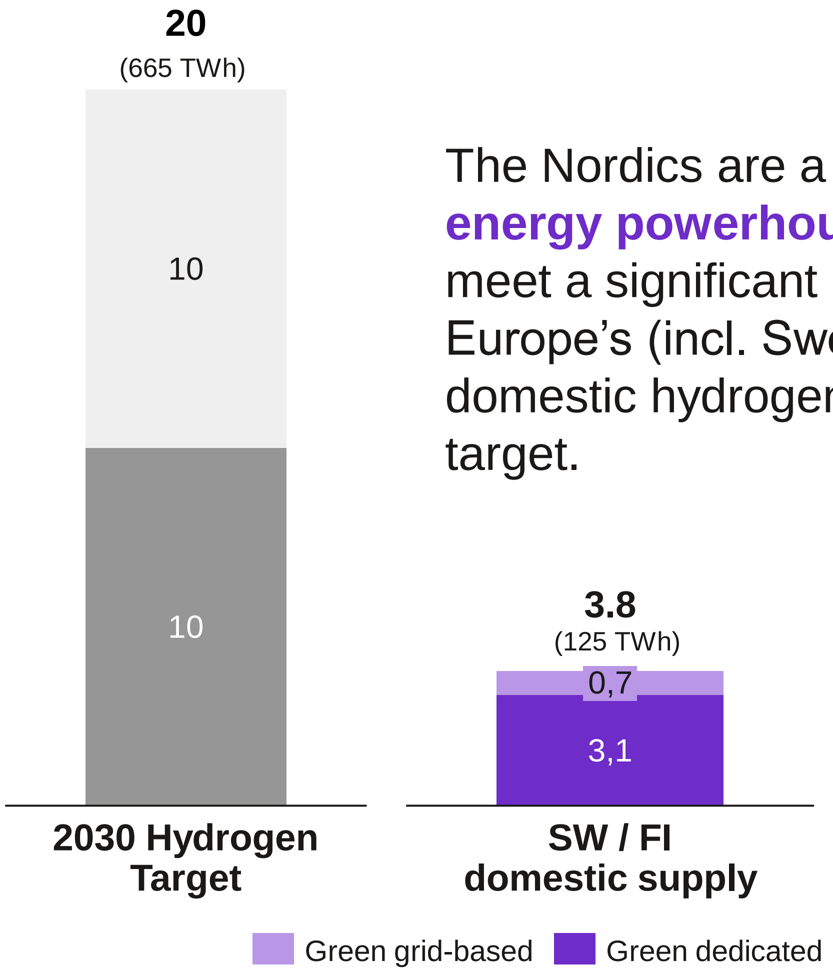
Hydrogen transmission – ”invisible” energy infrastructure with short-term storage

MSBFS 2009:7 (Methane)

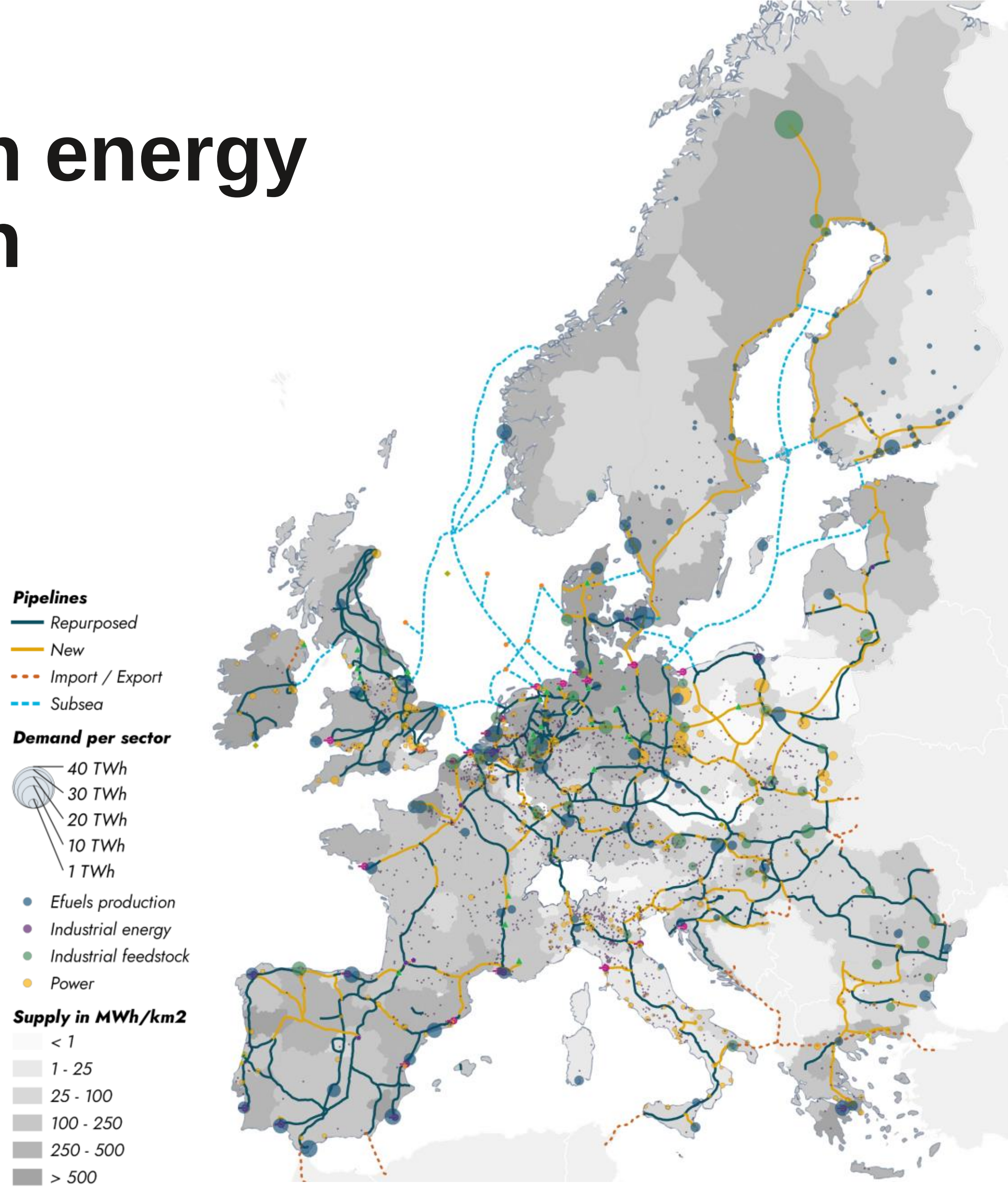


Nordion Energi Hydrogen AB – vision/aims, example of projects

Supporting the Swedish & European energy independence and climate transition

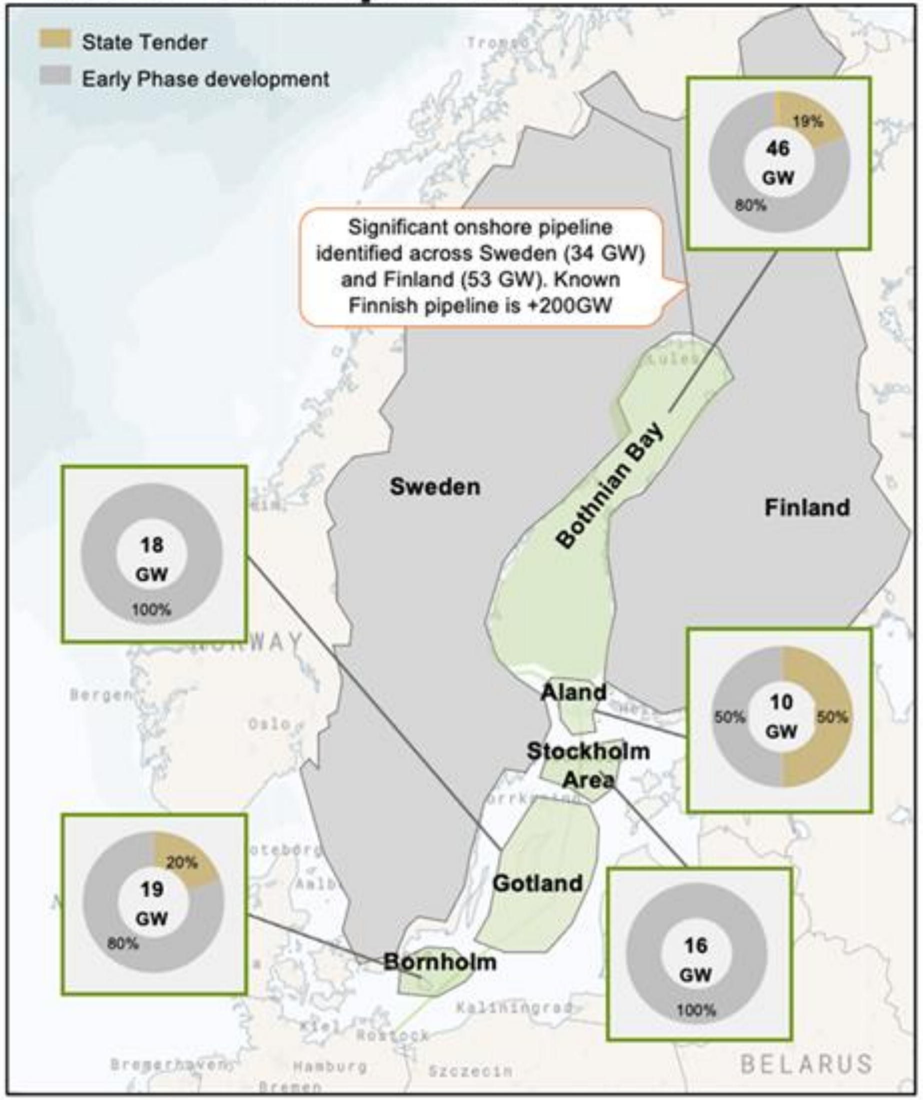


The Nordics are a **renewable energy powerhouse** that can meet a significant amount of Europe's (incl. Sweden´s) domestic hydrogen production target.



Map source: European Hydrogen Backbone Maps | EHB European Hydrogen Backbone

>100GW Of Offshore Wind In Early Phase Development



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Nordic Hydrogen Route

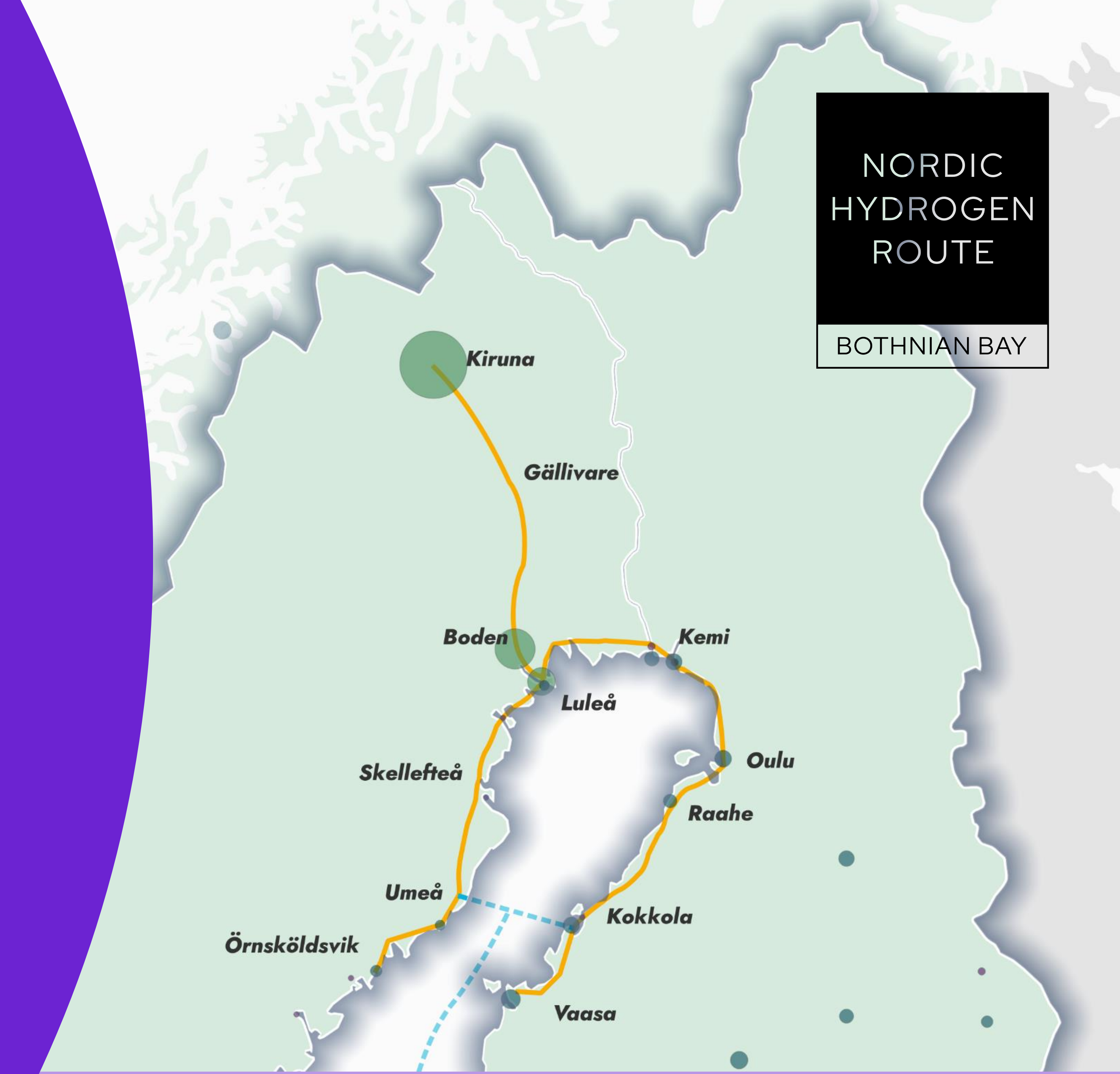
1 000 km
dedicated hydrogen pipelines

3B EUR / 30B SEK
hydrogen market until the year 2050

>20 MtCO_2e / year
reduced emissions by the year 2050

Nordic energy security
is strengthened by replacing fossil fuels with new, clean energy carriers

25,000 new jobs
to the year 2030, and 46,000 to the year 2040



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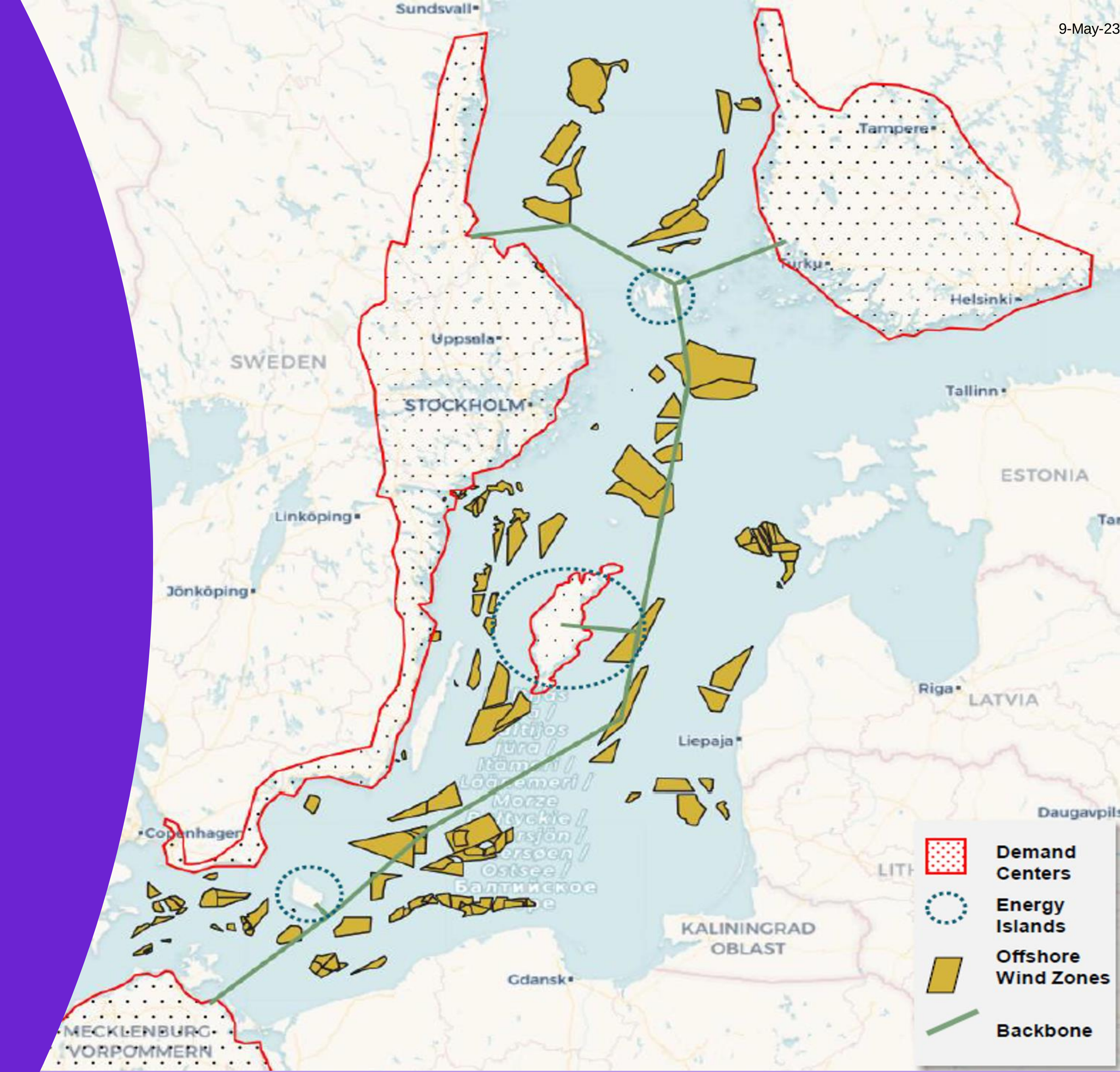
Baltic Sea Hydrogen Collector

2 x 1 250 km
dedicated offshore hydrogen pipelines

16B EUR / 165B SEK
of investments required

66B EUR / 720B SEK
investments in wind power and electrolysis enabled

33,000+ jobs
created during construction phase



Extensive Collective Impact

Driving **decarbonization**, supporting regional **economic development**, enabling **Europe’s independent energy** future.

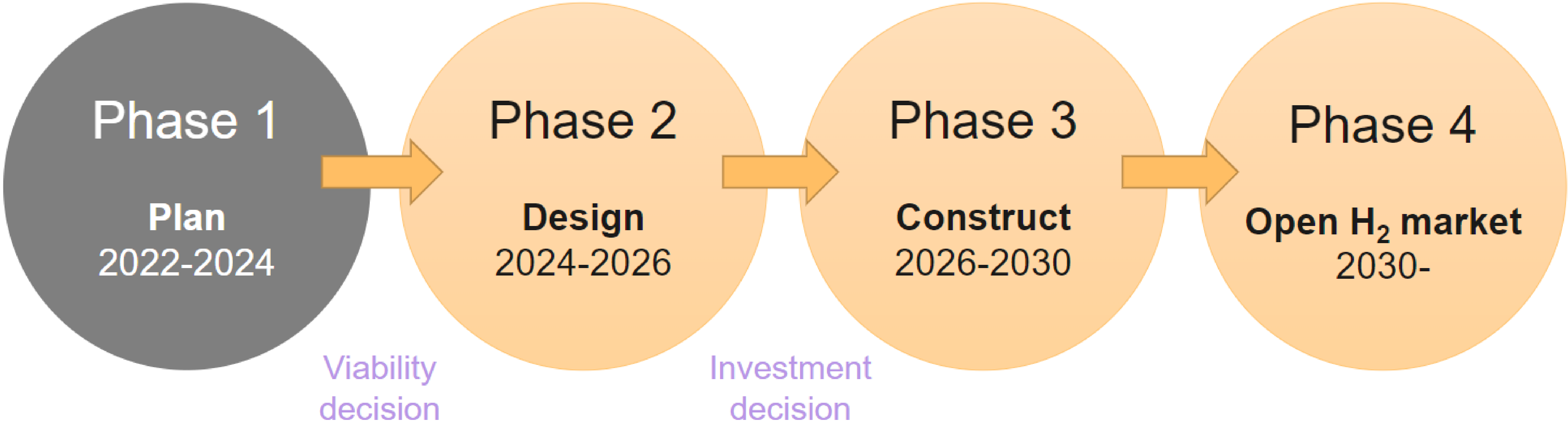
>3000 km
of dedicated onshore & offshore H2 pipelines

20B EUR / 225B SEK
of investments required

103B EUR / 1,160B SEK
investments in wind power and electrolysis enabled

58,000+ jobs
created during construction phase

Supporting creation of H_2 value chains

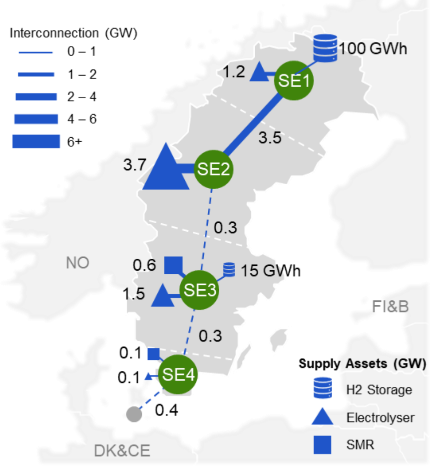


Sector integrated electricity/hydrogen infrastructures for an optimized energy system

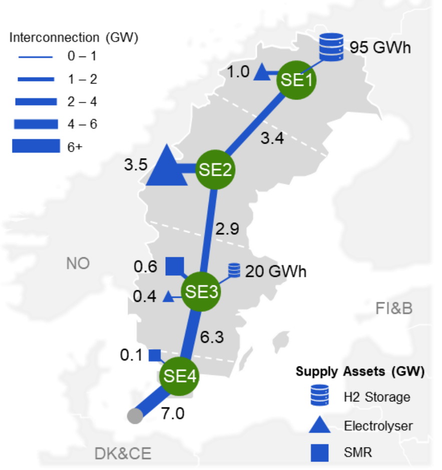
Analysis Results Energiforsk report 2021:788

Across all scenarios and sensitivities, the development of hydrogen infrastructure remains a constant

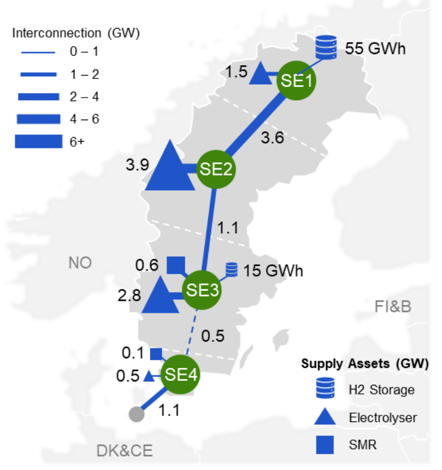
Limited Role for Gas



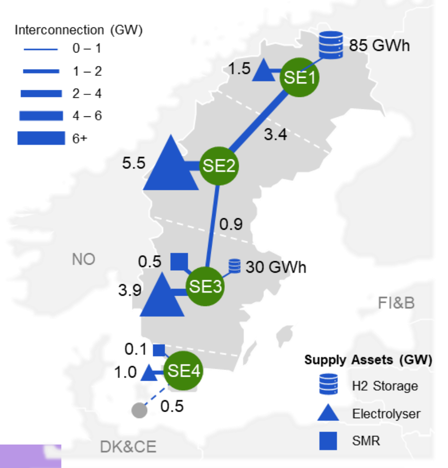
Sensitivity 1: Low H_2 Import Costs



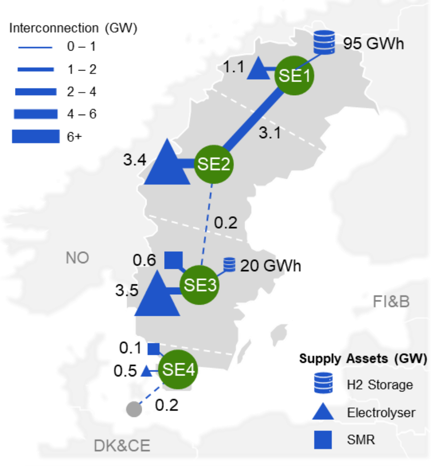
Sensitivity 2: Low H_2 Infra. Costs



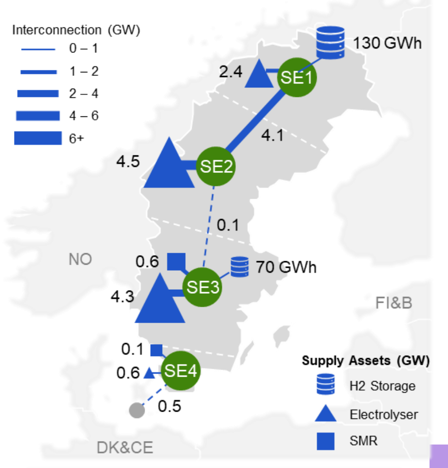
Sensitivity 3: Low Electrolyser Costs



Sensitivity 4: Extended Nuclear Life



Sensitivity 5: High Elec & H_2 Demand



Integrated energy system analysis - Nordic Hydrogen Route

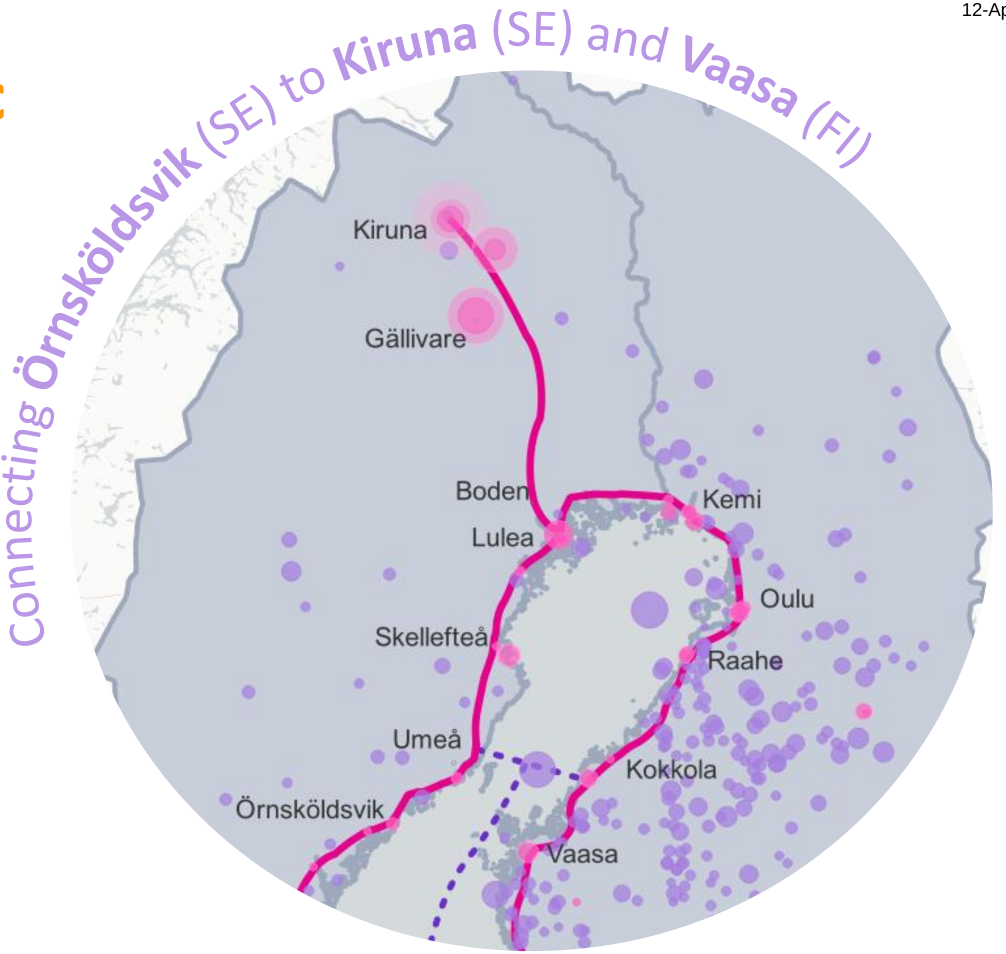
Key task

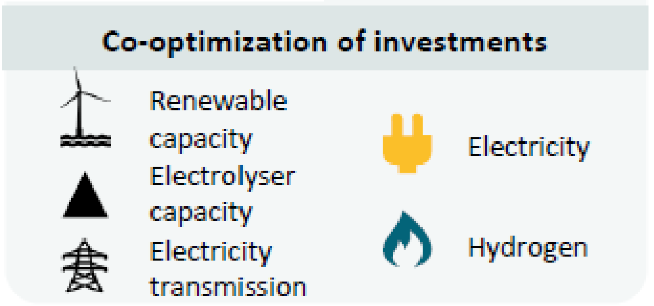
To investigate and quantify the benefits of a cost minimized integrated cross-boarder El/H2 system in the Bothnia Bay region

Example of key outputs

- Timeline for investments (2030, 2040, 2050) including production of renewable energy, electrolysis, storage and energy transmission grids (H2/El)
- CAPEX for investments (renewable electricity capacity, electrolysis, electricity and H2 transmission..)
- OPEX
- System operation (electricity and hydrogen flows, system balancing..)
- Levelized cost of hydrogen (LCOH)

The outputs serve as a basis for co-planning & energy system optimization





How is/can hydrogen transmission, as a complementary infrastructure, be integrated in the work of the MISTRA Electrification program?

Questions and discussion

Thank you!

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