Extending the European Hydrogen Backbone grows to 40,000 km covering 21 countries

April 2021
Welcome & Introduction

Who we are

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Highlights of the new report

Dedicated hydrogen pipeline infrastructure is needed to help integrate large amounts of renewable energy and to create a liquid, cross-border market for renewable and low-carbon hydrogen.

European Hydrogen Backbone demonstrates a technically and economically plausible vision for such a dedicated hydrogen infrastructure.

Twelve European gas TSOs from eleven European countries have joined the European Hydrogen Backbone initiative and the 2040 backbone has almost doubled in length compared to last year’s report.

The European Hydrogen Backbone can be created at an affordable cost.

The report published today shows a vision for a 39,700 km hydrogen pipeline infrastructure almost 70% of which is based on repurposed existing natural gas pipelines.

In 21 countries by 2040.
Connecting industrial clusters to an emerging infrastructure in 2030

In addition to what was presented in the previous report:

- **In the UK**, four of the country’s five major industrial clusters could be connected through the phased repurposing of existing gas pipelines to form an initial hydrogen backbone.

- **In Finland**, first stretches emerge around industrial hydrogen valleys in the south and along the west coast, where large amounts of onshore wind will be deployed.

- **In Hungary**, a first industrial cluster can be connected, while an interconnection to Ukraine could also emerge.

- **In Italy**, a south-north connection already emerges, and alongside domestic production, imports from North Africa could be possible, by repurposing one of the five subsea pipelines.
Gradual creation of a dedicated hydrogen infrastructure

Growing network covers more countries and reaches large potential import regions of green hydrogen in 2035

In addition to what was presented in the previous report....

• **In central and eastern Europe**, a route from the east to the west of Europe could emerge, passing through the networks in **Slovakia** and the **Czech Republic**.

• Through **Spain and France**, a corridor towards Germany emerge

• **In Sweden, Finland and Estonia**, the network will support the increased need to balance the future decarbonised energy system.

• **In Central Europe**, the network of Slovenia, Hungary and Italy matures and interconnects with Austria, and southeast Europe

• In the **Baltic Sea**, green hydrogen is used to integrate and store large amounts of intermittent (offshore) wind energy
Gradual creation of a dedicated hydrogen infrastructure

Mature infrastructure stretching towards all directions by **2040**

In addition to what was presented in the previous report....

- **In the North Sea**, energy islands, offshore and coastal hydrogen production help integrate energy and complement the power grid

- **In Poland**, a matured backbone creates a highway connecting renewable production in the north with industry in the south

- **In Central and Eastern Europe**, multiple interconnections enhance security of supply and a liquid hydrogen market

- **In Austria**, the backbone now connects Slovakia with Germany, providing for an alternative east-west route

- **In Ireland and the UK**, the repurposed subsea interconnectors connect the mature UK network and Dublin with the EU mainland
Updated cost of an expanded European Hydrogen Backbone

The 2040 infrastructure has an estimated investment cost of €43-81 billion. Transporting hydrogen over 1000 km over an average stretch of the backbone cost €0.11-0.21 per kg. Capital costs per km of backbone are slightly lower compared to costs reported in the EHB 2020 report, while transport costs are slightly higher, because of three reasons:

1. The backbone has expanded in length and scope. The updated network covers a total distance of 39,700 km across 21 countries, compared to 23,000 km across 10 countries in the previous EHB report.

2. The relative share of repurposed and new pipelines has changed. The enlarged network includes 69% repurposed pipelines, while 75% of the previous shorter network consisted of repurposed pipelines.

3. A more granular assessment of pipeline diameters has been conducted. The updated investment costs differentiate between 48-, 36-, and 20-inch pipelines - with almost half of the total network consisting of medium-sized pipelines alongside shorter stretches of pipelines with a smaller diameter.

Key implications of updated analysis
- Reduced investment cost per km of network
- Increased operating cost per kg transported, due to pipeline scale effect
- Increased levelised cost per kg of hydrogen transported per km

Although marginally higher than last year’s estimate this confirms that the EHB is a cost-effective option for long-distance transport of hydrogen, taking into account estimated future production cost of €1.0-2.0 per kg of hydrogen.

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<th>Low</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>Total Capex</td>
<td>€ billion</td>
<td>43</td>
<td>56</td>
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<tr>
<td>Total Opex</td>
<td>€ billion/year</td>
<td>1.7</td>
<td>2.2</td>
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<tr>
<td>Levelised cost (69% repurposed)$^1$</td>
<td>€/kg/1,000km</td>
<td>0.11</td>
<td>0.16</td>
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$^1$ Levelised cost estimates assume 5,000 full load hours. Like in our 2020 report, these cost estimates are based on calculations for single stretches of hydrogen pipeline, but now with a weighted average of diameters. They do not incorporate a scenario-based optimisation simulation of a full-scale network as is commonly done for network development planning. Depending on circumstances, the costs for individual stretches can be lower or higher than the range indicated.
Highlighting 5 new regions on the European Hydrogen Backbone map

- Great Britain & Ireland
- Greece
- Poland, Czech Republic & Slovakia
- Hungary, Austria & Slovenia
- Finland, Sweden & Estonia
Ireland & Great Britain

Background

• National Grid: owns and operates the National Transmission System in Great Britain of 7,660 km
  • UK targets at least 5 GW hydrogen production capacity and 40 GW offshore wind by 2030, with four low carbon industrial clusters established.

• Gas Networks Ireland: Operates a network in Ireland and 2 subsea interconnectors connecting to Great Britain
  • Ireland plans 5 GW of offshore wind to be operational by 2030, with 30 GW of projects already in the pipeline

Great Britain: Up to 4 out of 5 industrial clusters could be connected forming the basis of the GB hydrogen backbone

Ireland: Hydrogen from offshore wind in Ireland is still developing with blending into the Irish gas grid.
Ireland & Great Britain

Regional perspective

- Low carbon hydrogen produced at scale in connected industrial clusters close to demand centres in GB
- Significant wind potential exists in the North Sea in Scotland and West and South Coasts of Ireland for scaled green hydrogen to emerge
- Diversity of supply and interconnections provides resilience
- Optionality provided at Moffat and Bacton for networked hydrogen or natural gas flows
- Project Cavendish at the Isle of Grain provides the potential to connect hydrogen supply and demand in the South East

Great Britain: All 5 industrial clusters could be connected. A converted pipeline to Bacton could enable future imports and exports of hydrogen across the interconnectors to Belgium and the Netherlands.

Ireland: a hydrogen network is expected to emerge around the hydrogen valley in Cork fed by imported and indigenous renewable hydrogen.
Great Britain: Further repurposed pipelines may start to emerge between 2035 and 2040. The interconnector from the UK (Bacton) to Belgium could be repurposed to transport hydrogen.

Ireland: One of the interconnectors to the UK could be converted and a connection to Dublin could already provide large gas-fired power plants and industry with hydrogen.
New countries on the maps

Greece

Background and Regional perspective

• Greece: DESFA operates a relatively new network of 1,456km
  • Suitable conditions for both wind and solar power would allow the complete phase out of coal-fired power plants by 2028 or earlier.
  • There are plans to increase installed capacity of Wind Power to 7 GW and Solar PV to almost 8 GW
  • A dedicated hydrogen pipeline will foster production projects which will supply the industrial clusters and the mobility sector.

2040

• Two main industrial clusters in Athens and Thessaloniki and the potential hydrogen cluster in West Macedonia would be connected
• Storage could be available in the form of an aquifer near the Island of Thasos
• The connection to Europe could either go through the TAP pipeline or via South East Europe.
New countries on the maps

**Poland, Czech Republic & Slovakia**

**Background**

- **Poland**: GAZ-SYSTEM operates a network of 11,000 km
  - H2 Strategy: 2 GW of installed electrolyser capacity (2030). Offshore wind capacity targets of 5.9GW (2030) & 11GW (2040)

- **Czech republic**: NET4GAS operates a network of ~4,000 km
  - The Czech Republic is currently developing its hydrogen strategy

- **Slovakia**: Eustream operates a main east-west 450 km network of 4 or 5 large pipelines (total length 2,230km)

**2035**

**Poland**: Network emerges in the north around of f-and onshore wind potential with storage possibility, interconnection to Germany in the east.

**Slovakia and Czech Republic**: By 2035 an import route from Ukraine to the EU could emerge, passing through large diameter fully repurposed pipelines in **Slovakia** and the **Czech Republic** into Germany.
New countries on the maps

Poland, Czech Republic & Slovakia

Regional perspective

- Hydrogen enables decarbonization of coal-based region
- Slovakia and Czechia serve a transit role from hydrogen from the south east/Ukraine, while Czechia also enhances north south transport route in the EU and Germany
- Hydrogen highway in Poland helps integrate (offshore) wind in the north with storage and transport, also enabling decarbonization of industry in the south

2040

Poland: Matured network, north-south highway, storage and interconnections to Ukraine, Denmark via Baltic Pipe and possibly to Baltic states via Lithuania.

Czech Republic: No changes

Slovakia: Interconnection to Poland provides security of supply and decarbonisation possibilities in currently coal-based region
Hungary, Austria & Slovenia

Background

- Hungary: FGSZ operates a 5,900 km network
  - Hungary has set a carbon neutrality target for 2050 and targets 6 GW of Solar PV to be installed by 2030
- Austria: two TSOs, TAG and Gas Connect Austria, operate over 1,700 km
  - Austria has a target to produce 100% electricity from renewable sources (by 2030) and a carbon neutrality target by 2040
- Slovenia: Plinovodi operates a network of 1,174 km
  - Slovenia has an indicative target to have 10% of renewable gases until 2030

2030

Hungary: Emerging network using repurposed freed up pipelines, already interconnection to Ukraine possible, blending possibilities
Austria: De-/Blending as a potential first step
Slovenia: De-/Blending as a potential first step
Hungary, Austria & Slovenia

Regional perspective

• Reshaped regional gas market, decommissioning of coal-fired power plants
• Substantial growth in renewable electricity production
• First step: blending and deblending hydrogen into/from the existing infrastructure
• Gradual repurposing of parallel pipelines and the regional interconnections
• Emerging regional backbone by 2035

2035

Hungary: Already matured network with interconnections to Slovakia, Austria, Slovenia and possible more with Southeast Europe
Austria: TAG’s pipeline repurposed to transport hydrogen in both directions, interconnections to Italy. GCA’s network with possibility for bidirectional hydrogen transport from/to Slovenia and Hungary
Slovenia: Regional backbone emerges with interconnections to Austria, Italy, Hungary and possibly Croatia
Hungary, Austria & Slovenia

Regional perspective

• Mostly repurposed mature and interconnected regional network
• Bidirectional hydrogen transportation possibilities, emerging regional hydrogen transit role
• Connecting two important hydrogen regions: Italy / North Africa and Ukraine
• Essential integrated network to connect the energy systems of Northwest Europe and Southeast Europe

2040

Hungary: Already matured network with interconnections to Slovakia, Austria, Slovenia and Southeast Europe, hydrogen transit.

Austria: Bidirectional hydrogen transportation possibilities at all interconnection points would be in place. Austria’s grid would be ready to serve as a hydrogen hub in the region.

Slovenia: no changes
New countries on the maps

Finland, Sweden & Estonia

**Background**

- **Finland:** Gasgrid Finland operates a 1,300 km network in the south
  - Finland has set a 2035 carbon neutrality target.
- **Sweden:** Nordion Energi operates a small network in the south
  - Sweden has set a 2045 carbon neutrality target, large renewable potential but dislocated from demand
- **Estonia:** Elering operates a network of 977 km
  - Estonia has significant offshore (7GW) wind potential, but relatively low electricity demand
- The region has excellent conditions for onshore and offshore wind, while also water and land availability. Heat from hydrogen production potentially to be used in district heating

**2030**

**Finland:** Hydrogen network could develop near the first hydrogen valleys with potentially significant use in heavy industry

**Sweden:** The Swedish backbone emerges on the coastal region in the south-west of the country with an interconnection to the Danish grid
New countries on the maps

Finland, Sweden & Estonia

Regional perspective

- In the Nordics and Baltics a significant new hydrogen infrastructure is proposed
  - Network potentially enabling more extensive utilization of clean energy sources
  - Hydrogen used, together with electricity infrastructure, to transport large amounts of energy from north to south to demand locations – Hydrogen could eventually also be exported into the rest of Europe
  - The development would benefit from excellent onshore wind conditions along the coast of the Gulf of Bothnia, and from the Baltic sea offshore wind potential.

2035

Finland: Carbon neutral Finland, north south connection emerges, export of hydrogen could be possible

Sweden: North south connection transporting large amounts of energy from remote locations to demand centers

Estonia: Network emerges to integrate and possibly export the oversupply of energy from offshore wind, considering Estonia’s 7 GW of the total 93 GW Baltic sea wind potential. Offshore wind potential exceeds energy demand in Baltics.
New countries on the maps

Finland, Sweden & Estonia

Regional perspective

- In the Nordics and Baltics a significant new hydrogen infrastructure is proposed
  - Network potentially enabling more extensive utilization of clean energy sources and providing important connections between hydrogen and energy production and demand
  - Hydrogen from the Nordics could eventually also be exported into the rest of Europe
  - The development would benefit from excellent onshore wind conditions along the coast of the Gulf of Bothnia, and from the Baltic sea offshore wind potential.

2040

Finland: The hydrogen network could possibly develop further, and possible second north south connection might be developed

Sweden: Two interconnections with Denmark provide security of supply access to storage and the German market

Estonia: Second route to rest of (eastern) Europe emerges through Baltic states into Poland
What’s next?

- We’re working on an updated, region-specific analysis of expected hydrogen supply and demand.
- We’re engaging with many stakeholders throughout the value chain: renewable energy producers, industrial energy users, equipment suppliers, DSOs.
- Expect new results on 7 June!
- Co-ordinating our efforts with GIE and ENTSOG.
- And looking forward to engage with you!
For more information

Download the report and updated maps [here](#)

For more information contact the EHB member organisations or send an email to: [gasforclimate@guidehouse.com](mailto:gasforclimate@guidehouse.com)