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European Hydrogen Backbone

How a dedicated infrastructure can pave the way to large-scale competitive hydrogen for the European market

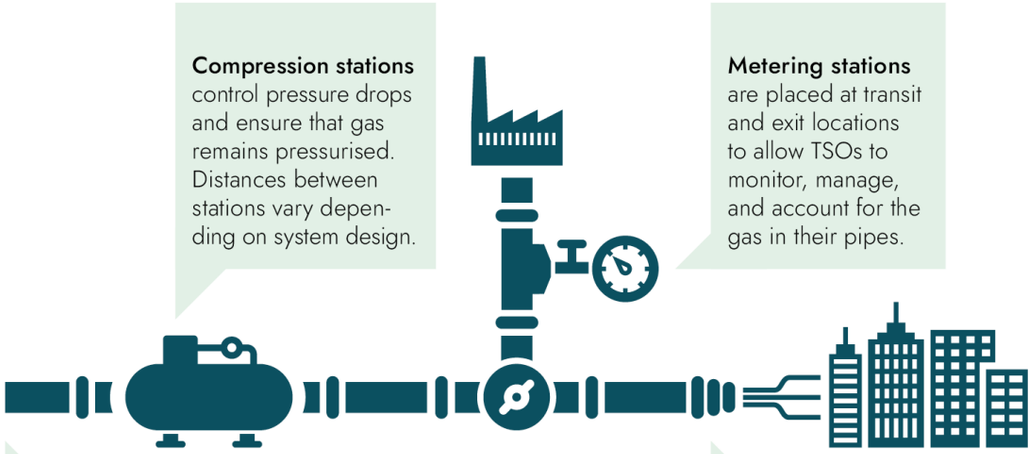
A Gas for Climate spin-off project

Madrid Forum – 14 Oct 2020

Hydrogen infrastructure

Hydrogen can efficiently be transported through pipelines that were built for natural gas

The EHB will have similar underlying principles as the existing gas grid



However some adaptations will be required

- The main elements of the conversion process include nitrogen purging, pipeline crack monitoring, and valve replacements (where needed)
- Adapt operational strategies to minimise hydrogen embrittlement risk
- Adapted or new compressors to provide higher compression capacities as well as a different approach to compression system design (sizing, power capacity, distance between compressors)
- Inner coating of an existing natural gas pipeline – though not technically required – might allow for higher pressures when switching to hydrogen[1]

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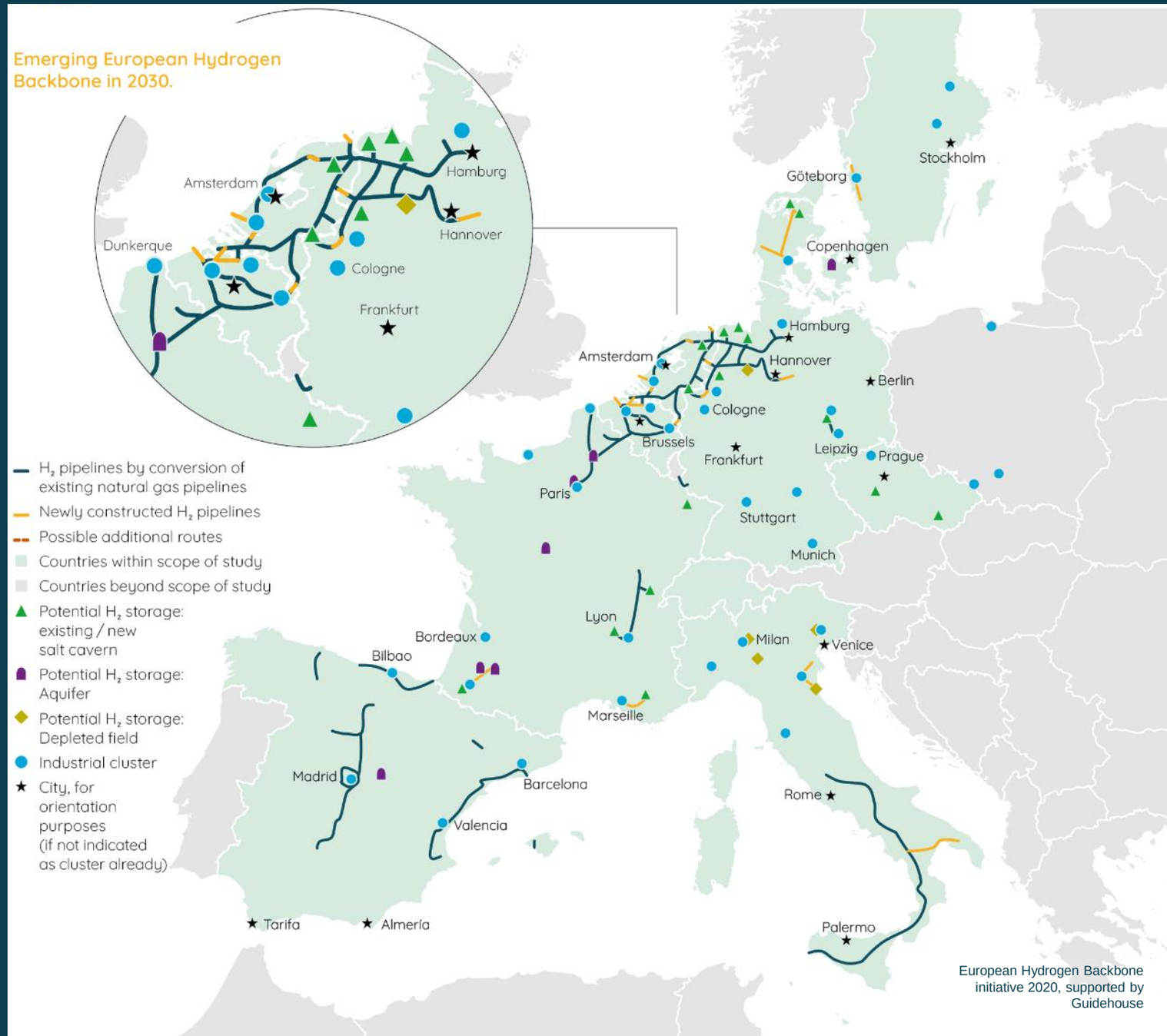
1. According to R&D results and exploratory analysis by TSOs, technical details regarding coating vary by region depending on the state of the existing natural gas network.

2030

Emerging regional networks

Connecting industrial clusters to an emerging 6,800 km infrastructure



European Hydrogen Backbone initiative 2020, supported by Guidehouse

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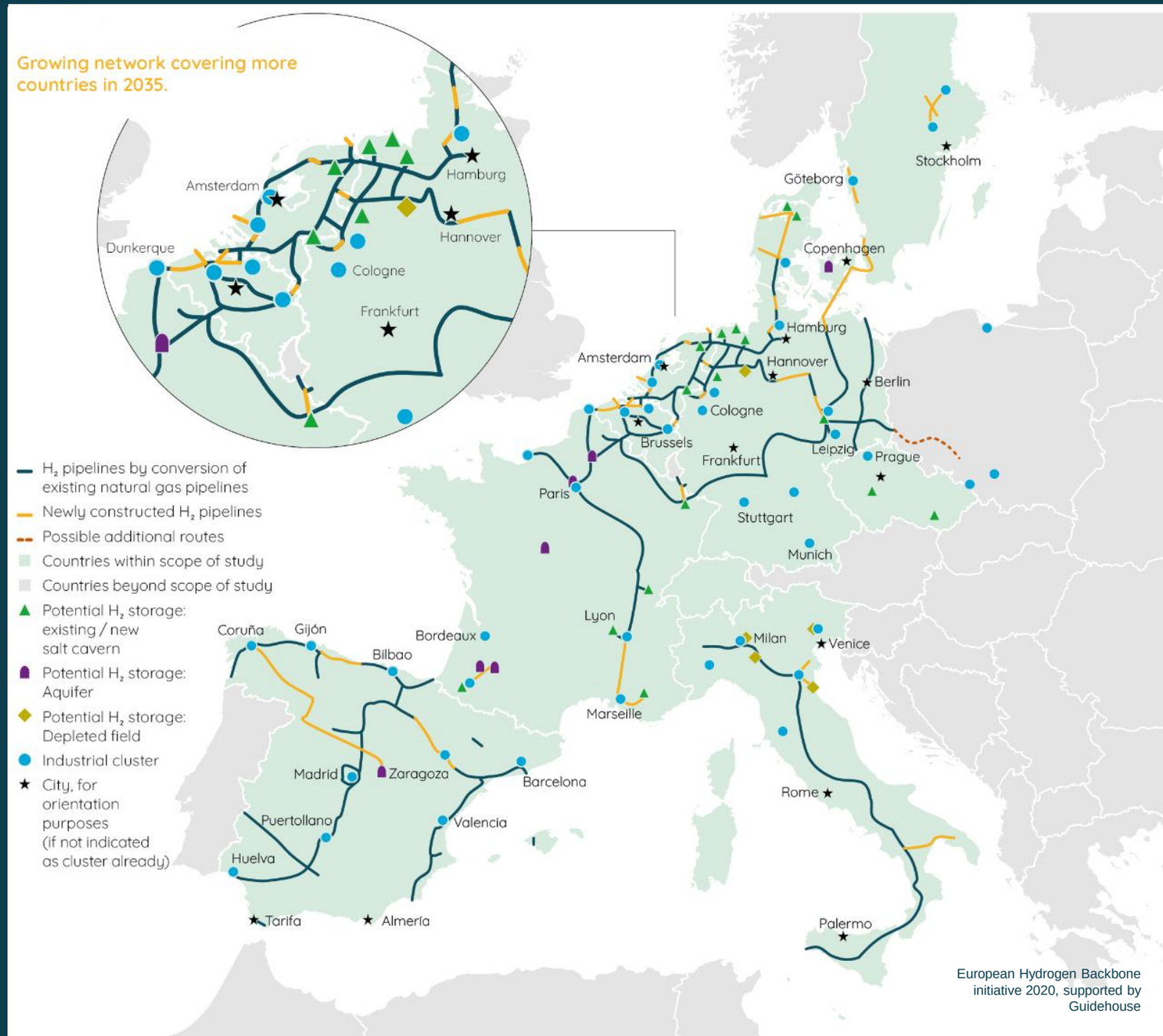
2035

Growing backbone

Expanding network covering more countries, linking sources and sinks across Europe



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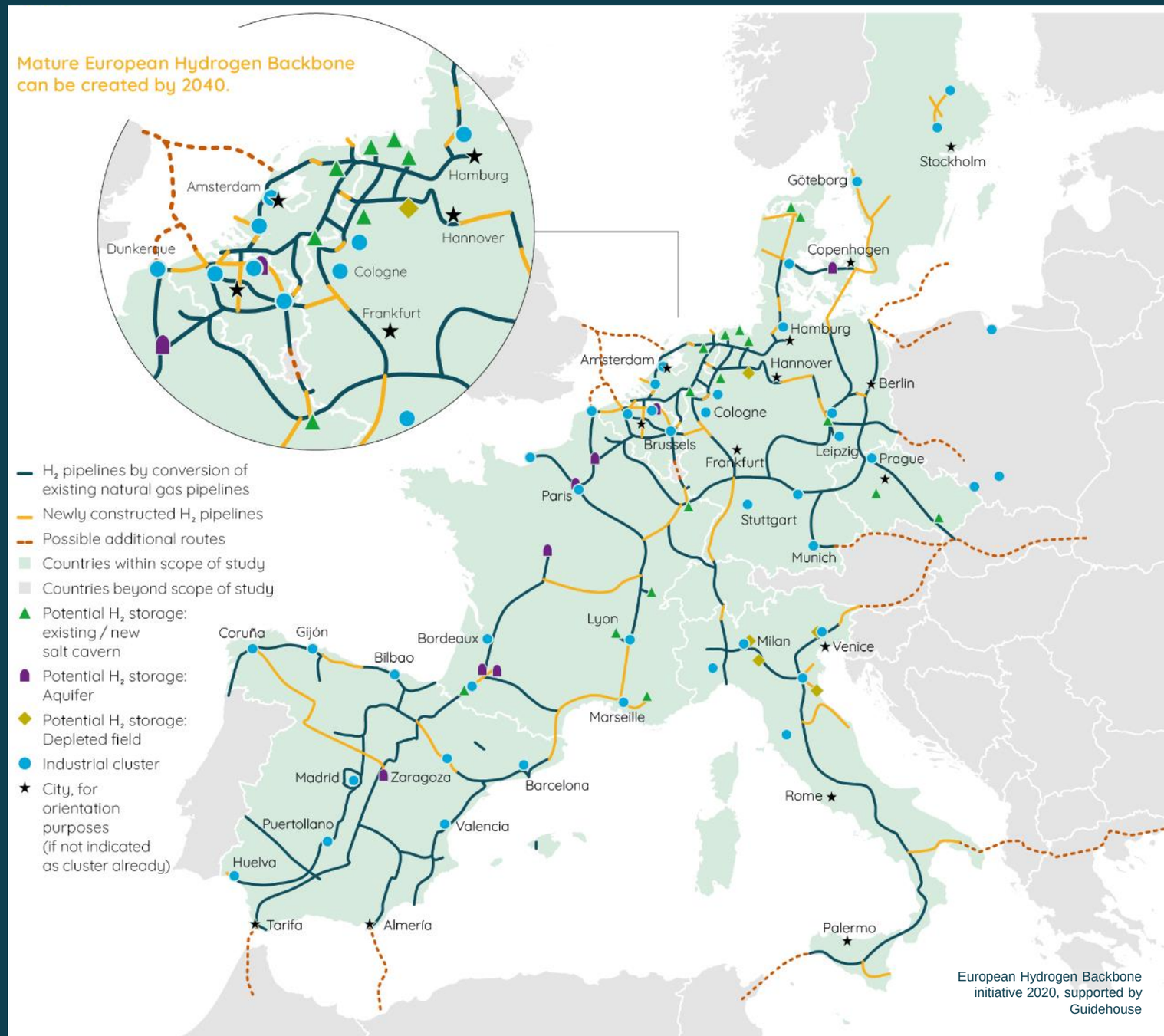
2040

A European hydrogen highway

A pan-EU backbone stretching into all directions, with a length of almost 23,000 km



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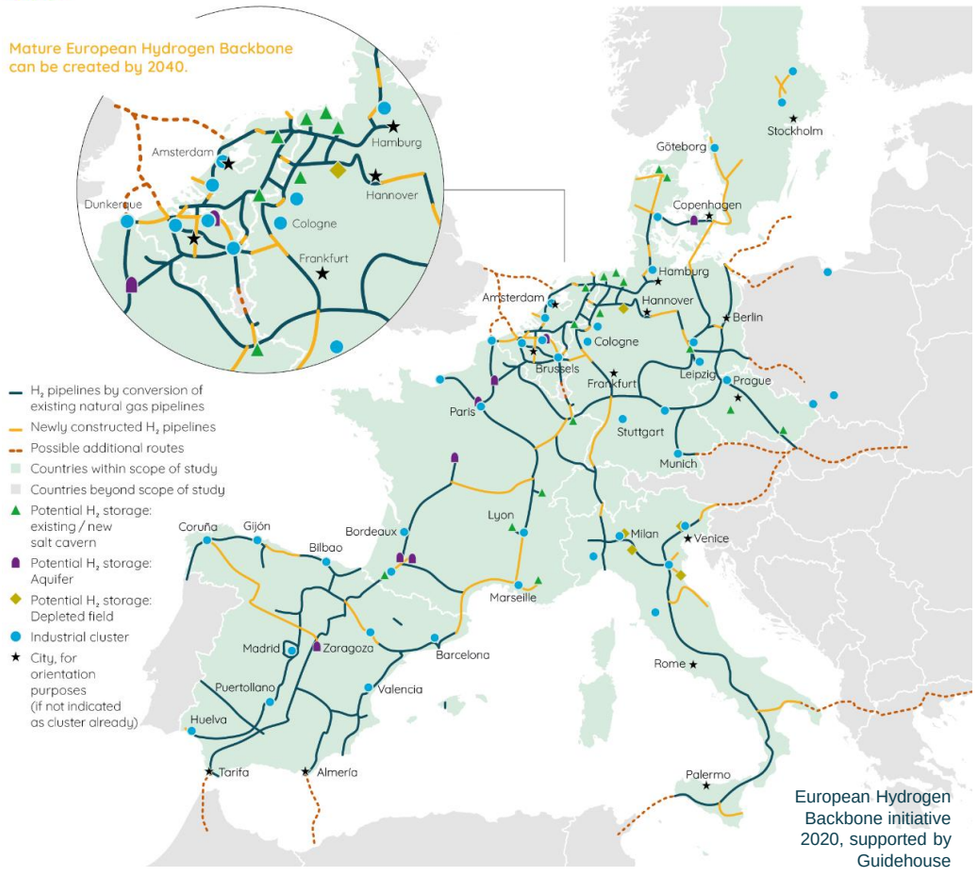
2040 A European hydrogen highway

A pan-EU backbone stretching into all directions, with a length of almost 23,000 km



Important developments and corridors

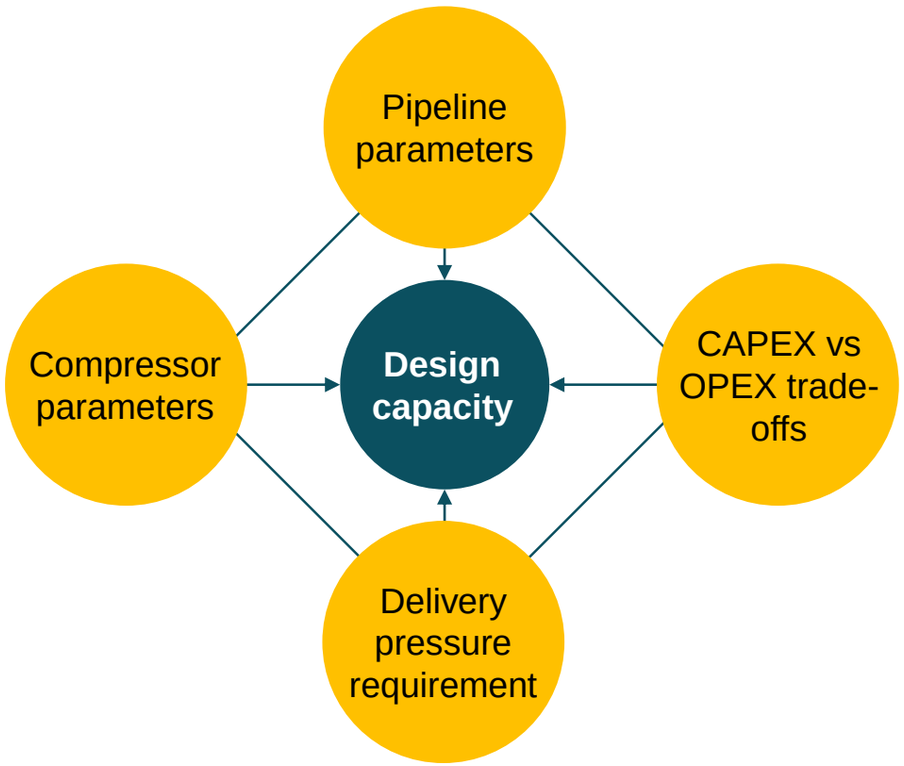
1. A core, pan-EU hydrogen infrastructure of almost 23,000 km, with large corridors connecting most of Western Europe with valuable extensions into Central and Eastern Europe.
2. The backbone will consist of 75% retrofitted pipelines, with diameters ranging from 24-48 inch, providing 3-13 GW_{LHV} transport capacity per pipeline. Combined with a fit-for-purpose compression system, the backbone should be able to meet currently expected annual hydrogen flows in Europe by 2040.[1]
3. The EHB enables connection to global hydrogen flows, including North Africa, the North Sea (UK and Norway), possibly Ukraine and Russia
4. The 2040 backbone can be considered as a critical milestone, but not a final product. It represents a foundational network upon which further developments can be built beyond 2040

1. Preliminary estimation, the actual capacity of the meshed grid requires more detailed analysis

The EHB can be created at an affordable cost

Network optimisation to lower costs and save compression energy

Gas network design is a multi-faceted optimisation challenge



‘Maximising’ flow capacity is not the optimal solution

- Previous analyses recommended operating hydrogen pipelines at up to 80% of the capacity it has when transporting natural gas, or approximately 17 GW for 48-inch and 9 GW for 36-inch pipelines.
- However, to “maximise” the value of retrofitted natural gas pipelines, exploratory analyses by gas TSOs shows that it is more attractive to operate hydrogen pipelines at less than their maximum capacity, e.g. 13 GW and 7 GW for 48- and 36-inch pipelines.
- At 13 GW_{LHV}, initial analysis suggests that compression needs are 190-330 MW_e per 1000 km; which translates to 1.5-2.3% of the transported hydrogen’s energy content consumed for compression purposes per 1000 km transported
- Total investment cost of the envisaged 2040 EHB is expected to be between **€27 to €64 billion**. This translates to a levelized cost of **0.09-0.17 €/kg/1000km**[1]; compared to a previous estimate of **0.23 €/kg/1000km**.
- The opportunity to repurpose existing pipelines means that the EHB benefits from a gradual ramp-up of investment need – limited compression requirements in the early years will lead to modest start-up costs – enabling the creation of a **“first-mover”, facilitating backbone.**

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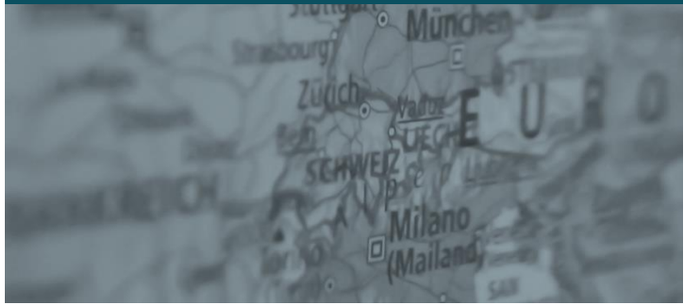
The European Hydrogen Backbone

A dedicated infrastructure can pave the way to large-scale competitive hydrogen for the European market

A hydrogen network can emerge from the mid-2020s onwards to an initial **6,800 km** pipeline network by 2030.

By 2040, a hydrogen network of **23,000 km** is foreseen, 75% of which will consist of converted natural gas pipelines, connected by 25% of new pipeline stretches.

A pan-EU hydrogen backbone



The backbone has an estimated cost of **€27 to €64 billion**, which is relatively limited in the overall context of the European energy transition.

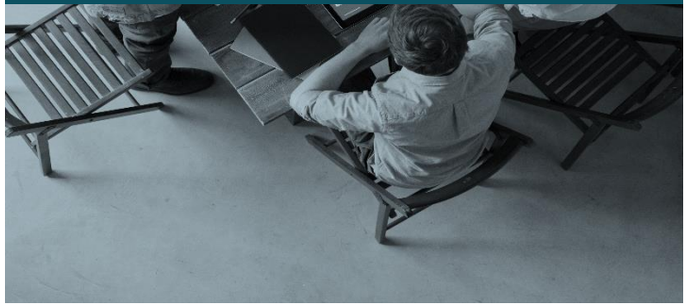
The levelised cost is estimated to be between **€0.09-0.17 per kg per 1000 km**, allowing hydrogen to be transported cost-efficiently over long distances across Europe.

At affordable cost

The group of gas infrastructure companies is convinced that the hydrogen backbone will eventually cover **the entire EU**.

The group **invites** other European gas infrastructure companies to join in the thinking to further develop the backbone plan.

An open initiative



The European Hydrogen Backbone

How EU policies can help

- With the European Hydrogen Backbone, gas infrastructure companies are ready to facilitate the scale-up of hydrogen supply and demand, thus contributing to enable the European Commission's Hydrogen strategy.

- The Gas for Climate consortium **supports an increased focus on sustainability and projects that are compatible with a net zero emission future in future TYNDPs and future PCI lists**.

- Gas for Climate calls on the Commission to ensure that dedicated hydrogen projects, including pipeline and storage infrastructure, can be part of future PCI lists including investments in new compressor stations, new pipelines, and new storages.
- A speedy implementation of the first legs of the EHB through repurposing of existing gas pipelines – in connection with hydrogen demand and supply developments - requires a fast update of regulatory frameworks to put TSOs in a position to play their role and allow for the assets and expertise to be utilized

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