Long-distance transport of green hydrogen

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Source: Getty images

Transport options for hydrogen

Pipeline

- Repurposing of existing natural gas pipelines
- Construction of new hydrogen pipelines

Ship

- Liquid Hydrogen
- Liquid Organic Hydrogen Carrier (LOHC)
- Ammonia

Electricity

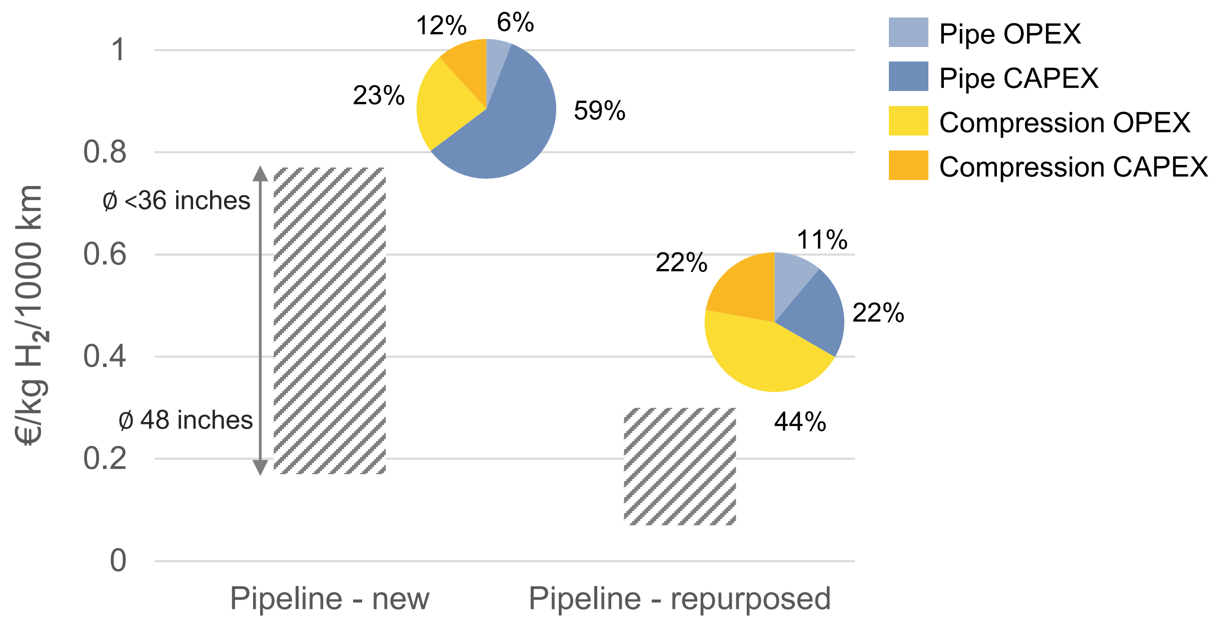
- Transmission lines

Truck

- Compressed gas containers, LOHC

Hydrogen transport costs via pipeline depend on compression and pipeline diameter

Costs of hydrogren pipeline [€/kgH_2/1,000km]



Source: European Hydrogen Backbone, Bloomberg New Energy Forum, Agora Energiewende, IEA

Key messages

- **Repurposed pipelines** are **significantly cheaper** than new hydrogen pipelines
- **Costs per kg hydrogen decrease with increasing pipeline diameter.** If possible, pipelines should be built with a **large diameter** in order to be able to transport increasing quantities of hydrogen in the future
- Pipeline transportation requires **large geologic storage** to ensure consistent pipeline utilization
- **Compression as a cost driver**
  - Compression costs initially low, since transported hydrogen volume is low
  - Utilization of 75% represents cost optimum, since compression costs increase exponentially at higher utilization rates
- **Geopolitical feasibility** of intercontinental pipelines must be examined

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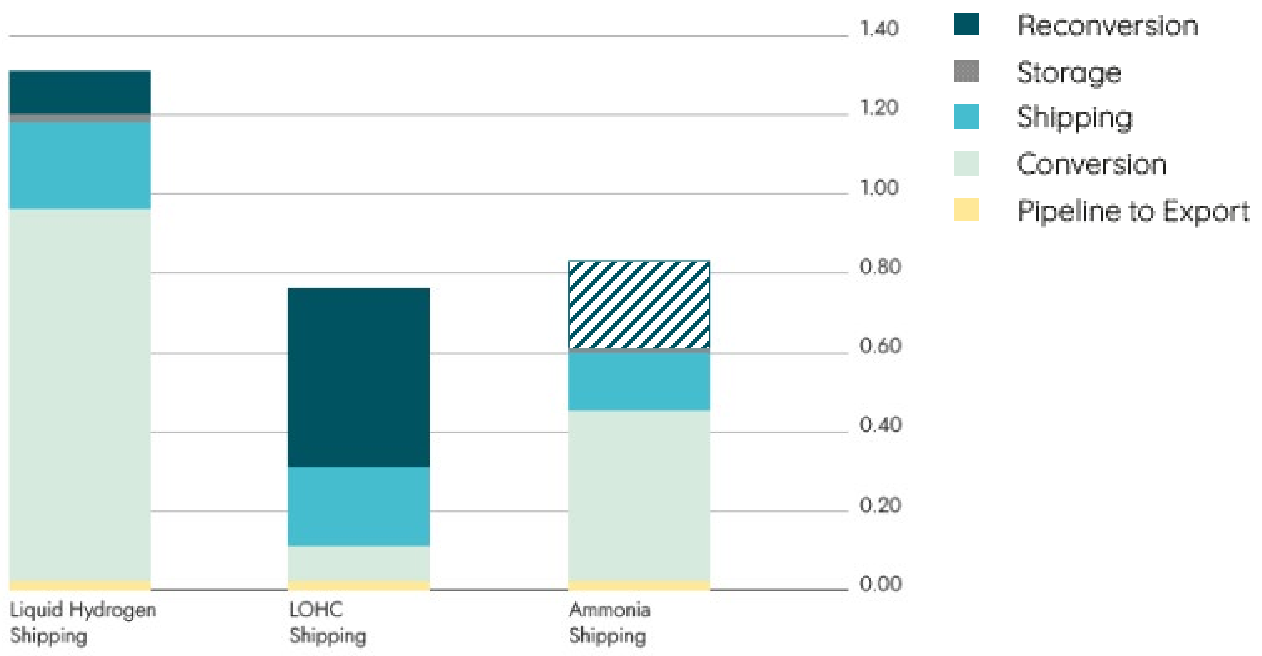
Shipping is particularly suitable for derivatives over long distances

Costs of different shipping options [€/kgH_2/10,000km]



Source: Guidehouse / European Hydrogen Backbone (2021)

Key messages

- All three options have **high fix costs** for conversion (60-80% of total transport costs for 10,000 km)
- Transport of **liquid hydrogen** via LNG-like tankers at -253°C requires strong cooling and compression, resulting in loss of about 1/3 of the energy. At the same time, the volumetric energy density increases by a factor of 10. A portion of the hydrogen boil-off can be used as fuel for the ship, however the remaining boil off is flared to the environment in order to limit the pressure build up inside the tank and prevent rupturing. Ships are not yet available.
- **LOHC** has low conversion costs, but typically consumes more fuel than the other two methods because it is heavier than ammonia and the carrier material must be shipped back unused.
- **Ammonia** is already traded internationally. As with shipping liquid hydrogen, ammonia can be used to fuel the ship. However, cracking (the reconversion) of ammonia back into nitrogen and hydrogen is relatively inefficient and has not yet been tested on an industrial scale.

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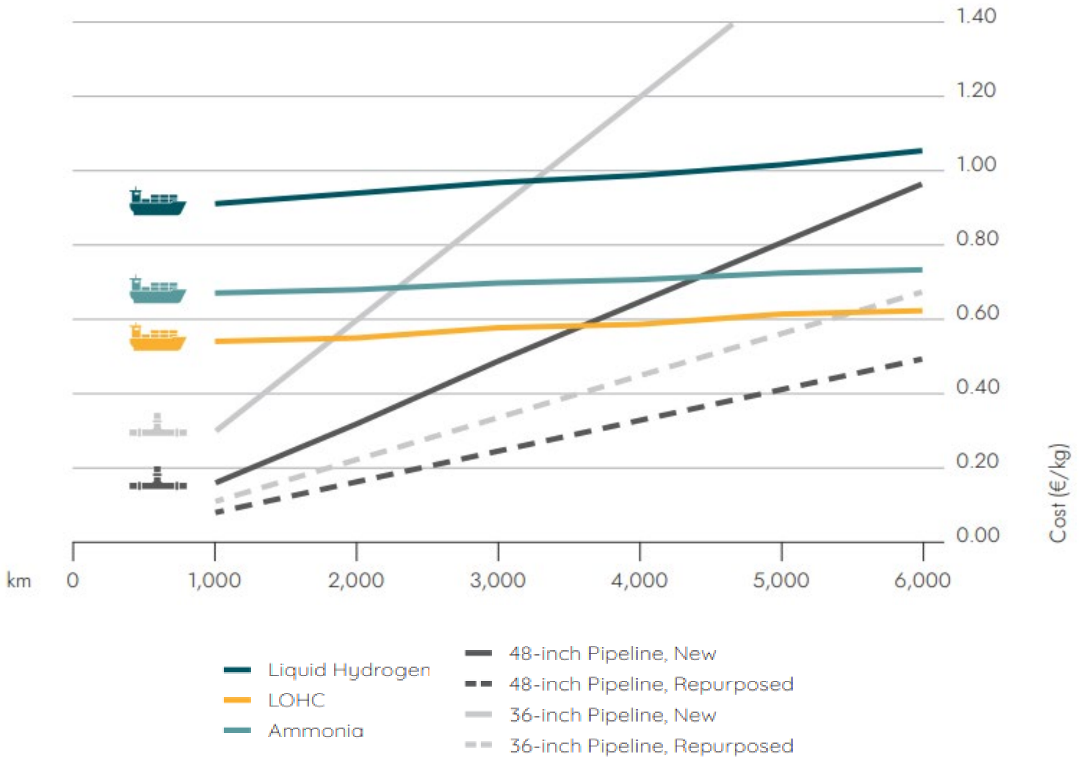
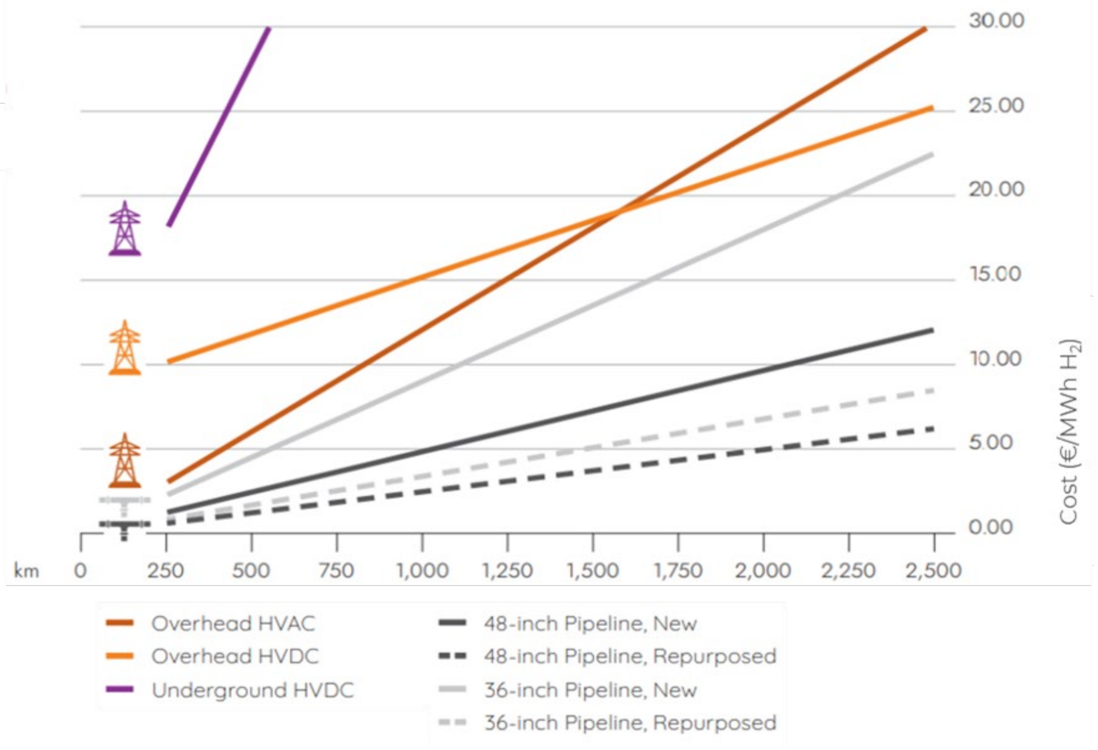
Pipelines offer advantages in terms of costs and volumes compared to ships and power lines

Cost comparison ship vs. pipeline, €/kg H_2



Cost comparison power line vs. pipeline, €/MWh H_2



Source: Guidehouse / European Hydrogen Backbone (2021)

Storage option for hydrogen

Overground storage

- Compressed, liquified, solid, derivatives

Not ideal for mass storage due to inefficiencies, large space requirements, boil off. Costs exceed €1/kg H_2 (€30/MWh). Exceptions are derivatives.

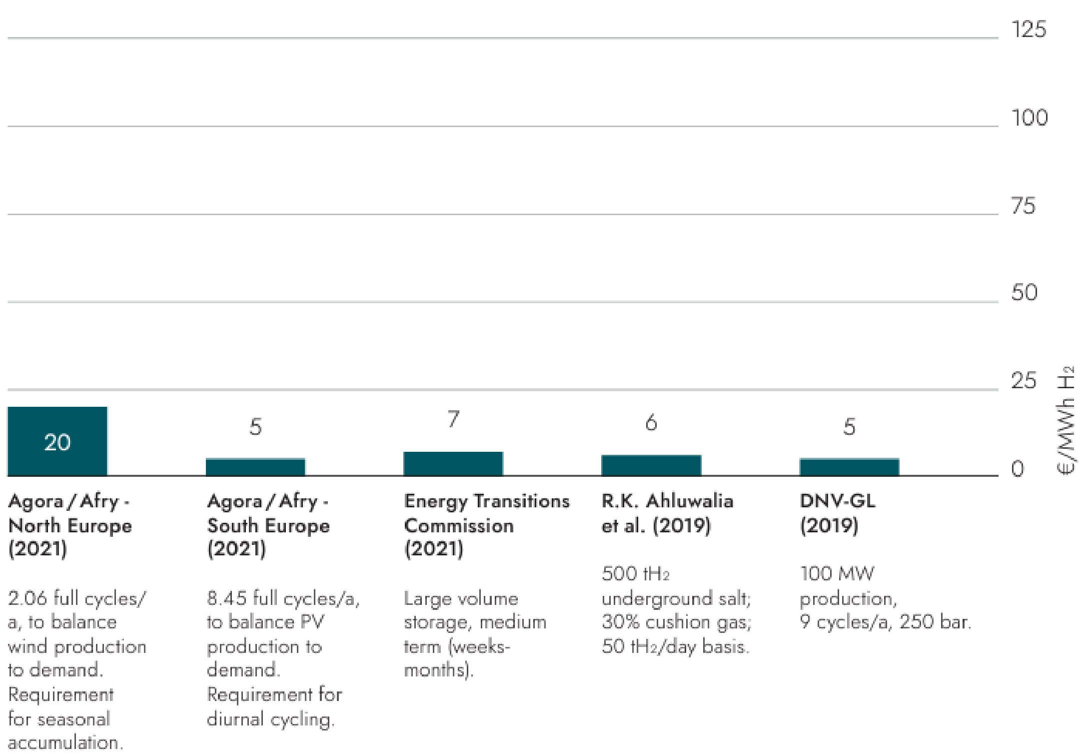
Underground (geologic) storage

- Salt caverns
- Aquifers
- Depleted gas fields

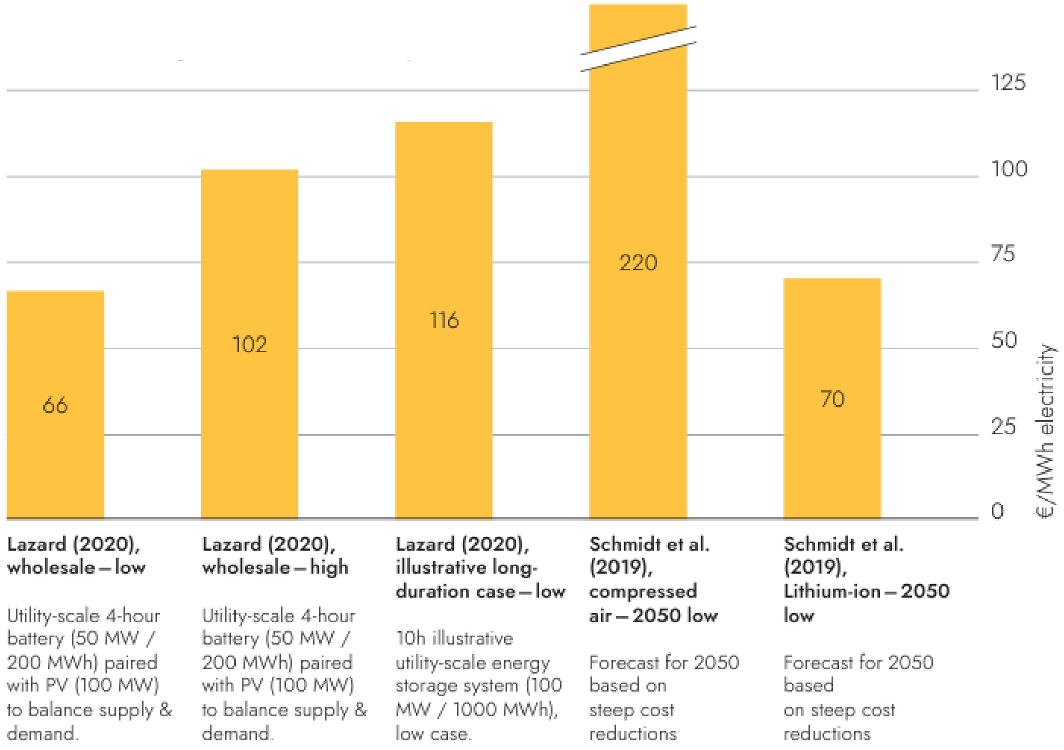
Gas is stored in large geologic structures underground at enormous volumes and for timescales as short as hours or as long as months.

Storage is increasingly needed in a decarbonised energy system – large scale hydrogen storage is cost-efficient

Levelized cost of H_2 storage in salt caverns, €/MWh H_2



Levelized cost of electricity storage using various technologies, €/MWh electricity



Sources: Agora: No regret Hydrogen (2021); Energy Transitions Commission: Making the Hydrogen Economy Possible (2021); R.K. Ahluwalia (2019); DNVGL: Hydrogen in the Electricity Value Chain (2019); Lazard LCOS Analysis (2020); Schmidt et al. (2019).

Summary

- To avoid conversion losses, energy should be transported, if possible, **in the form in which it is required on the demand side**.
- **Repurposed pipelines are most effective hydrogen transport alternative, especially large diameters (48 inches)**.
- **Ships are suitable for transport of derivatives** (ammonia, e-fuels) but less so for pure hydrogen, as high conversion losses have a negative impact on economic efficiency
- **Existing power lines** can be used for local generation. The construction of new (long-distance) power lines for hydrogen generation is at a disadvantage compared to pipelines in terms of costs and volumes.
- **Underground storage** is a cost-efficient way to store large volumes of energy/hydrogen for timescales as short as hours or as long as months

Kontakt

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