Large-scale hydrogen transportation: challenges and perspectives

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FORSCHUNGSNETZWERKE
ENERGIE

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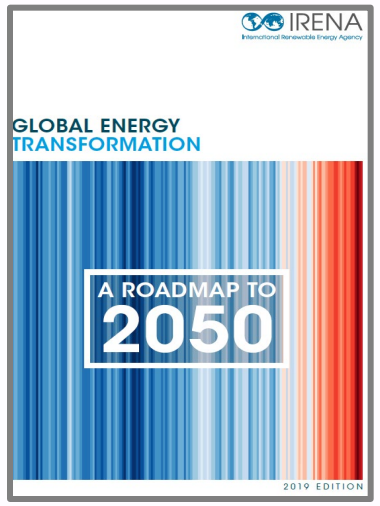
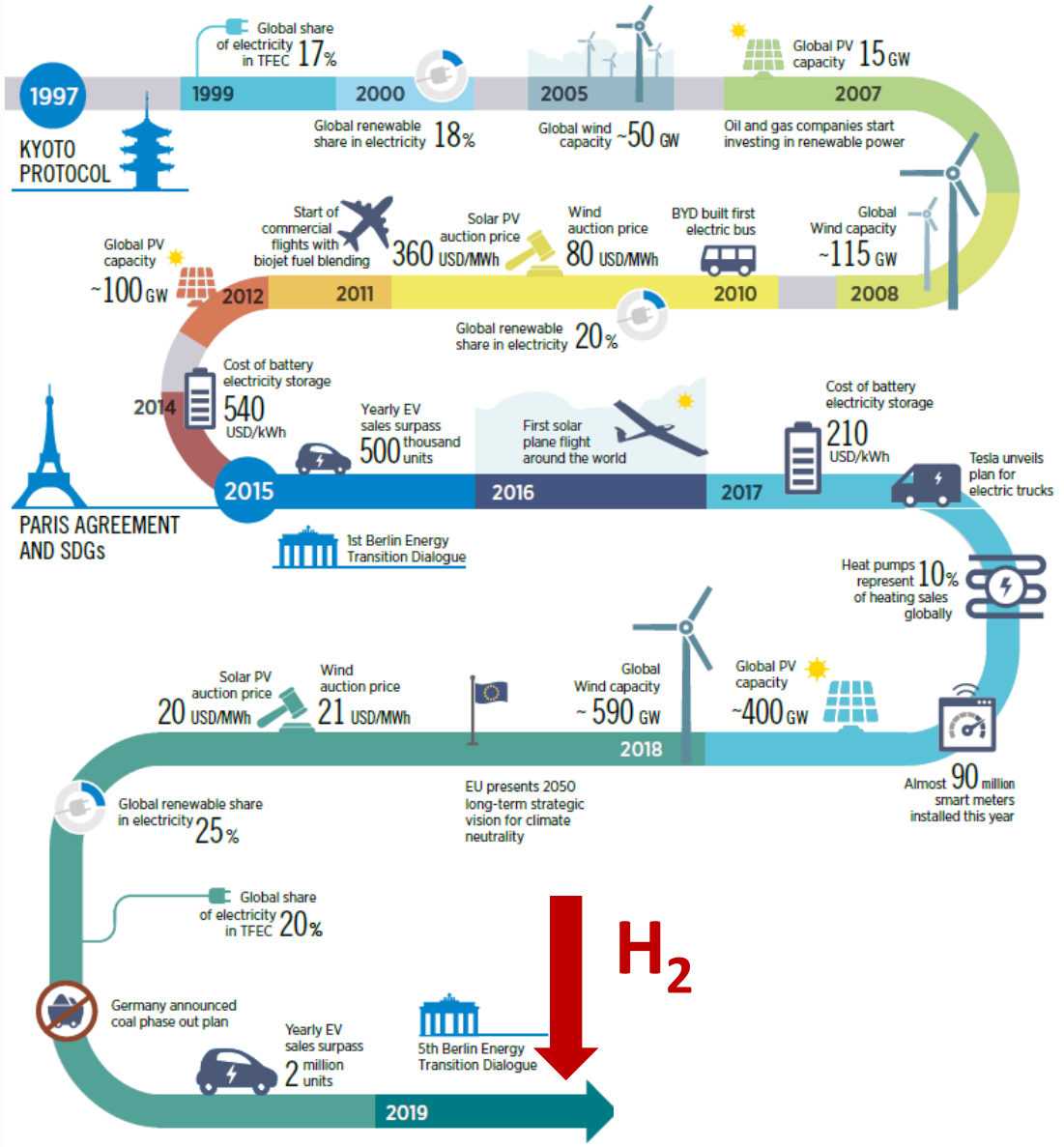
Energy transition: Roadmap to 2050



Sources: (IEA, 2018c); (IRENA, 2018f); (GWEC, 2015); (Reuters, 2007); (IRENA, 2018d); (INSIDEEVs, 2019b); (IEA-PVPS, 2018); (EV Volumes, 2019); (Solar Impulse, 2019); (IRENA, 2017c); (Electrek, 2017); (IEA, 2019); (GlobalData, 2018); (EC, 2018a); (GWEC, 2019); (CleanTechnica, 2018); (IATA, 2018); (BNEF, 2018).



KEY BENEFITS OF THE ENERGY TRANSFORMATION

- Lower renewable power costs
- Increase energy access
- Reduce emissions and air pollution
- Increase welfare and growth

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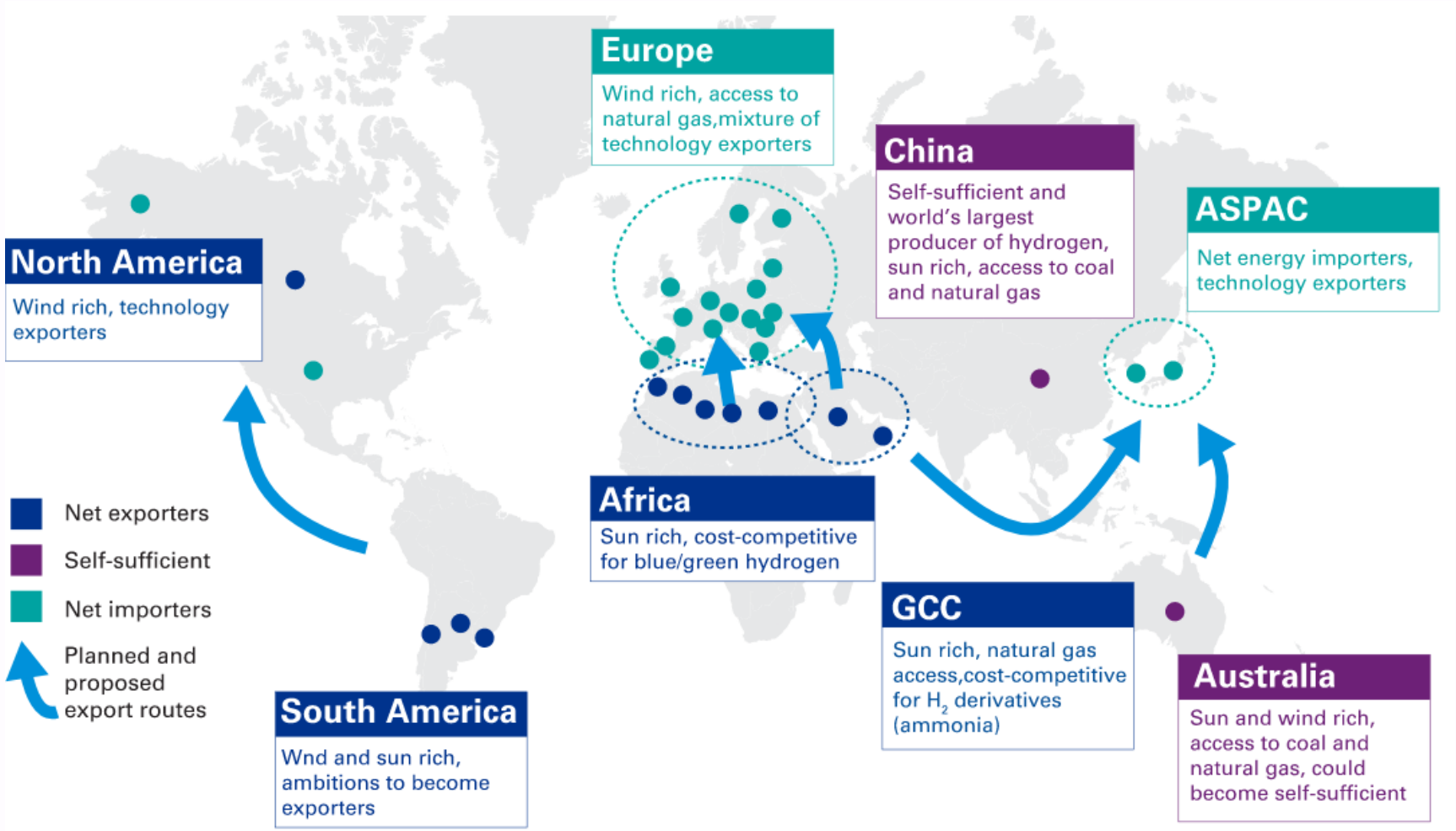
Global hot spots and corridors



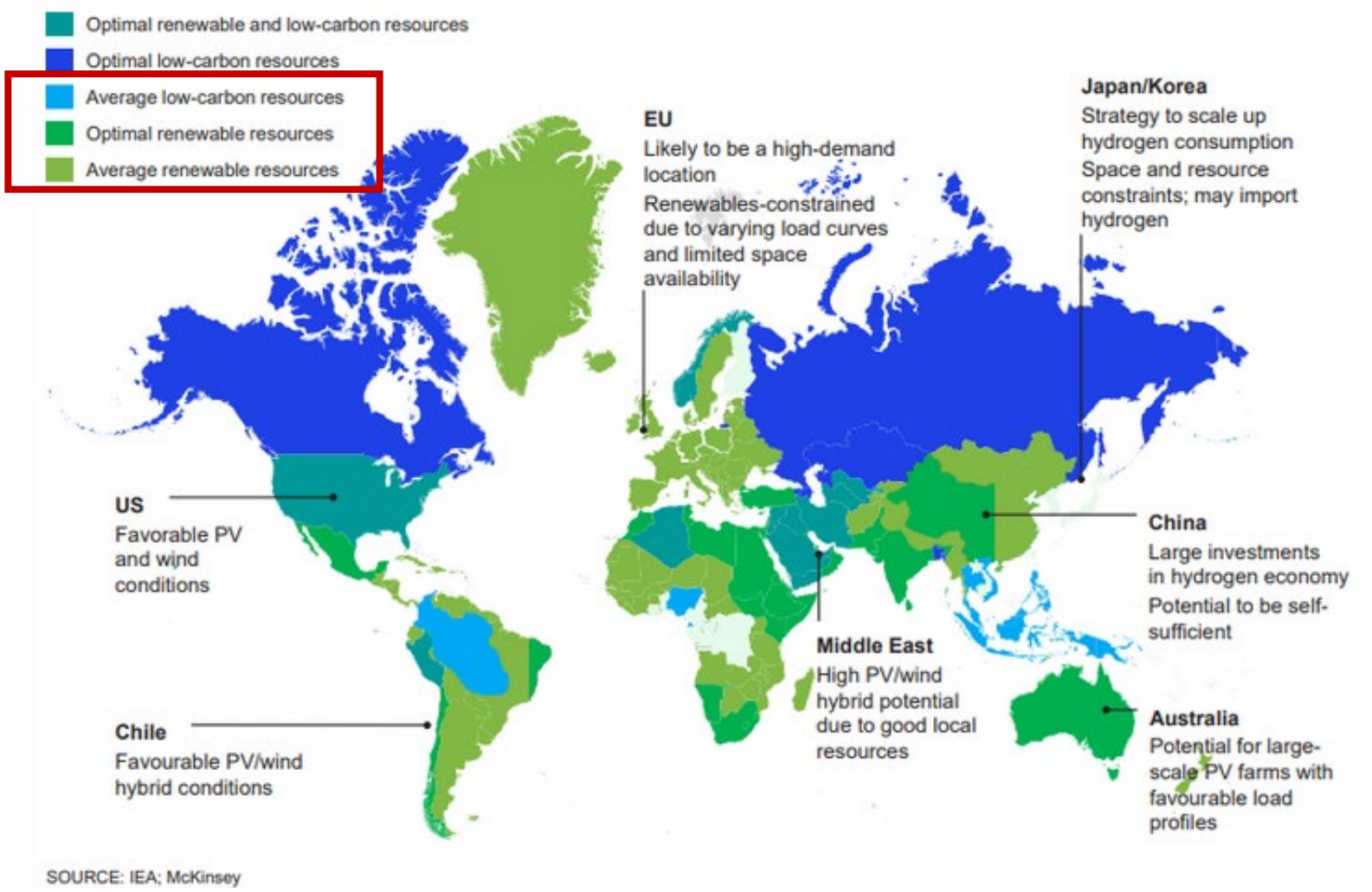
https://home.kpmg/xx/en/home/insights/2021/01/geographic-hydrogen-hotspots.html

Hydrogen “rainbow”

MITSUBISHI HEAVY INDUSTRIES GROUP

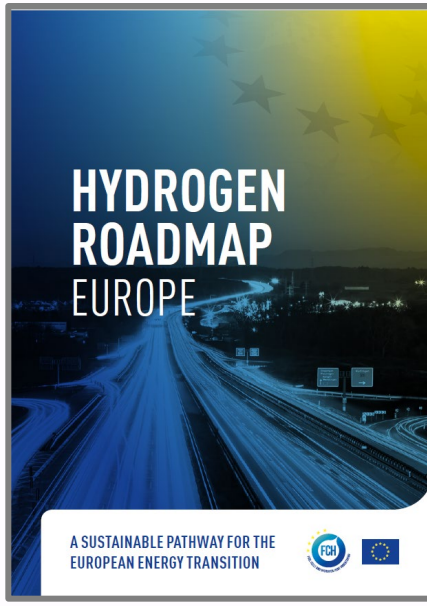
https://spectra.mhi.com/hydrogen-rainbow-the-colors-of-decarbonization

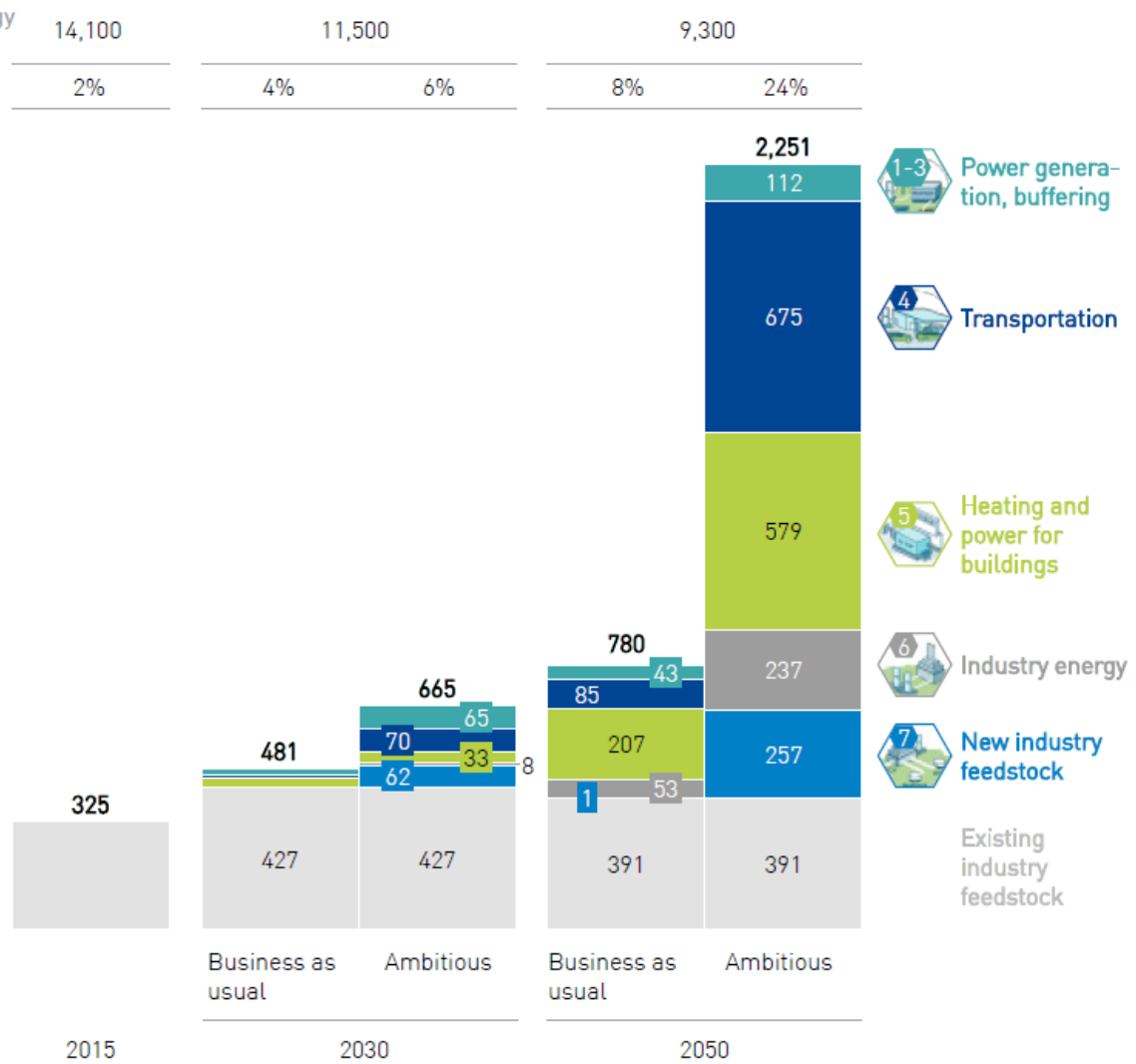
Low-carbon hydrogen



https://www.nsenergybusiness.com/features/renewable-hydrogen-infrastructure/

Hydrogen “Roadmap Europe”





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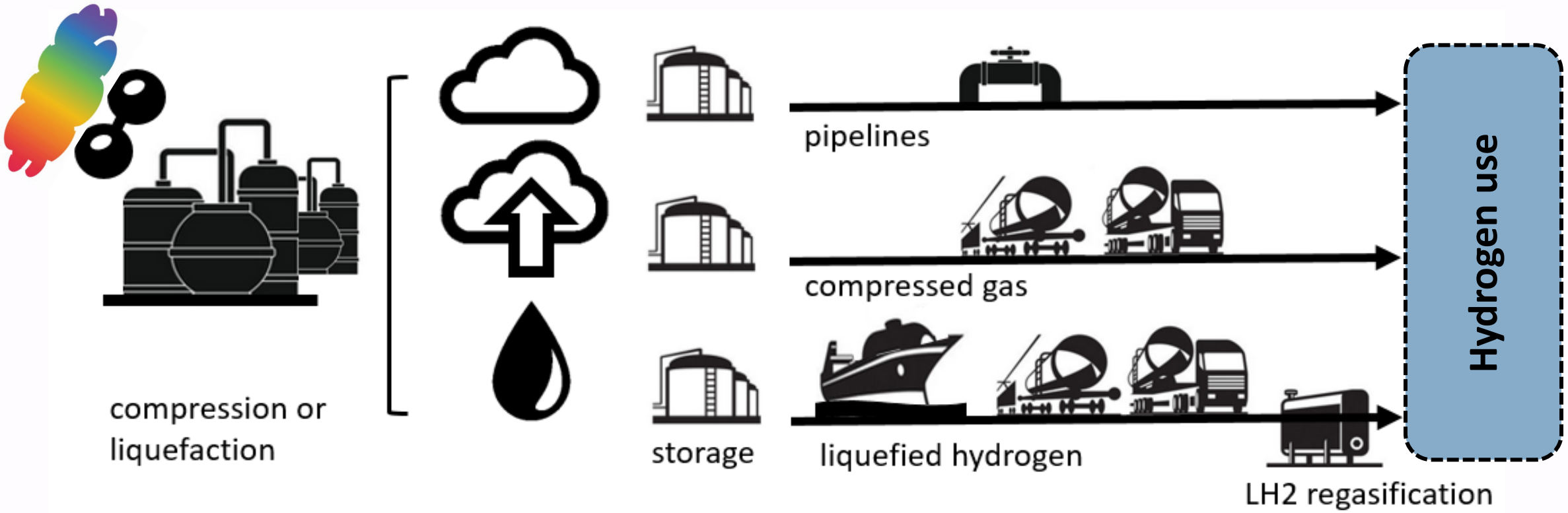
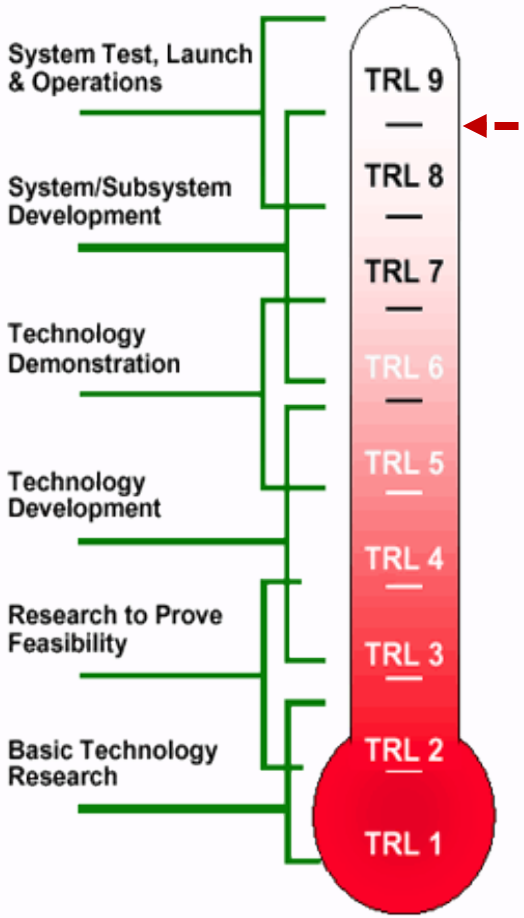
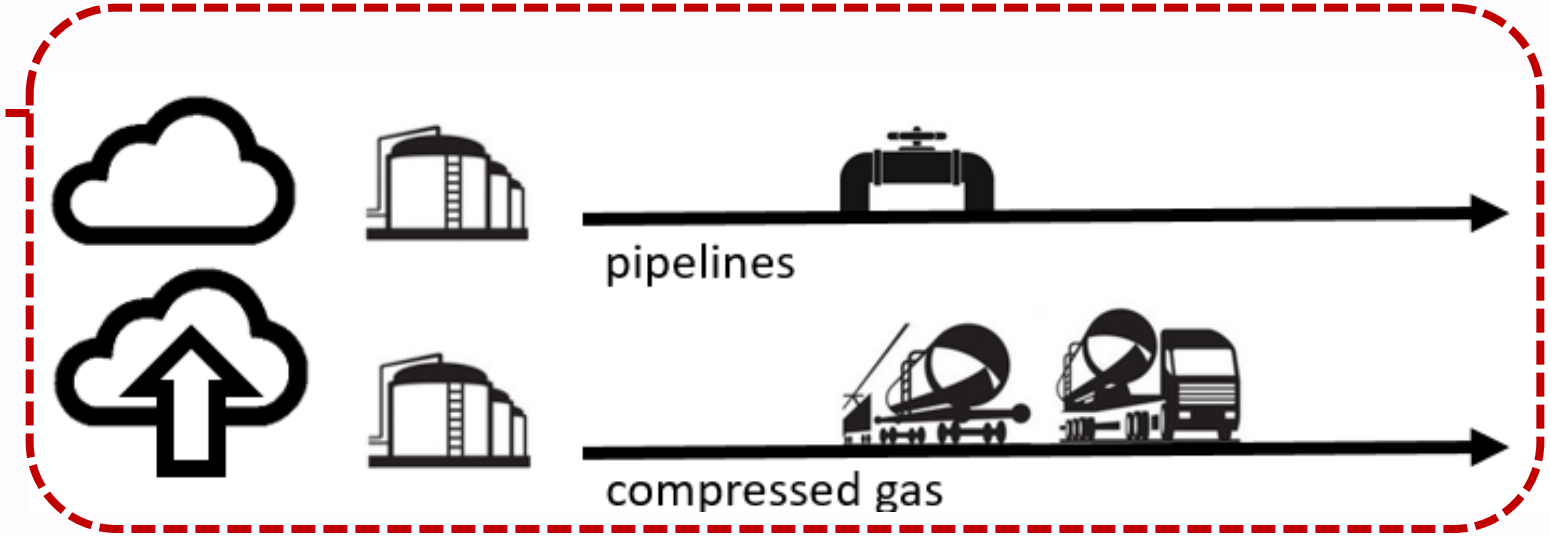
Hydrogen transportation



Technological readiness levels - 1



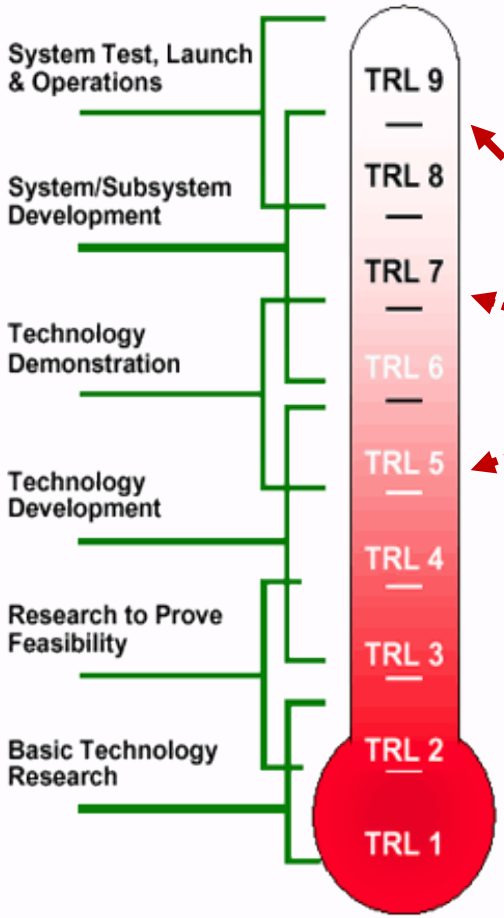


small, medium and large scale

The European Hydrogen Backbone initiative:
convert 26,000 km of current natural gas pipelines and build new 14,000 km of hydrogen pipelines to connect 21 countries in Europe by 2040

https://en.wikipedia.org/wiki/Technology_readiness_level

Technological readiness levels - 2

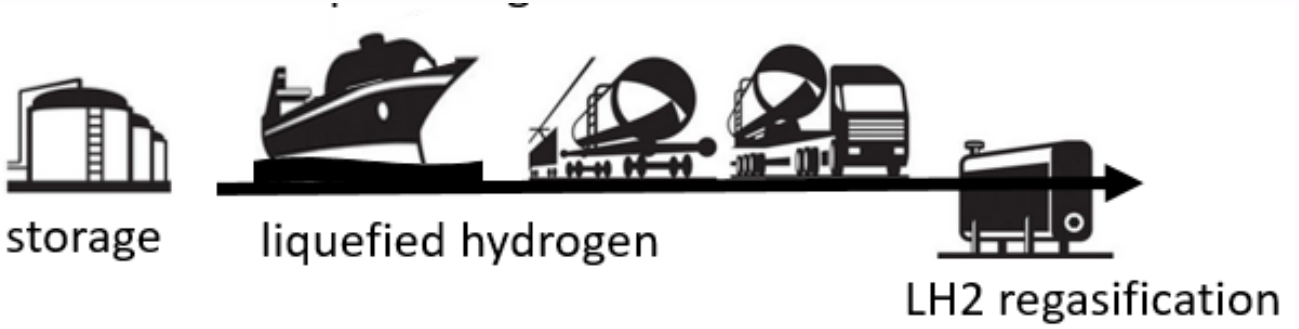


small scale

medium scale

large scale

The liquefaction energy use shall be decreased from 13.6 kWh/kg_{H2} to 6.0 kWh/kg_{H2} (in 2030)



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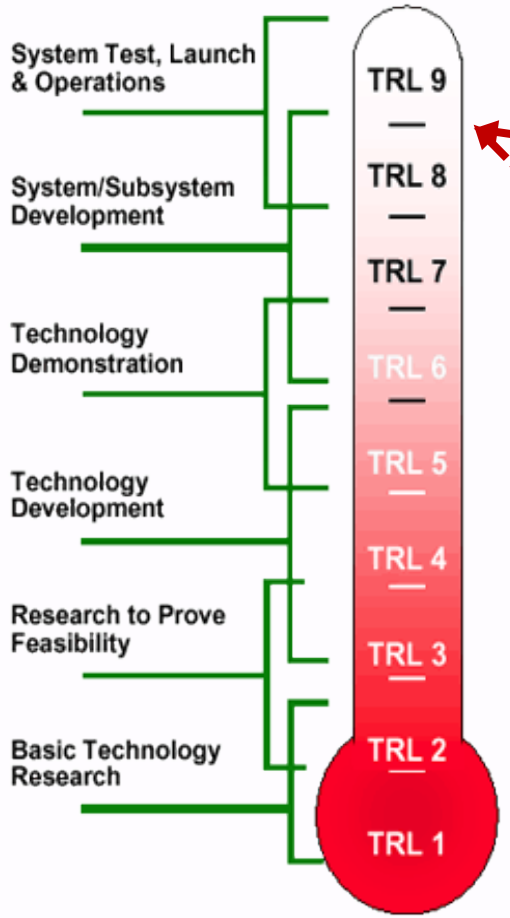
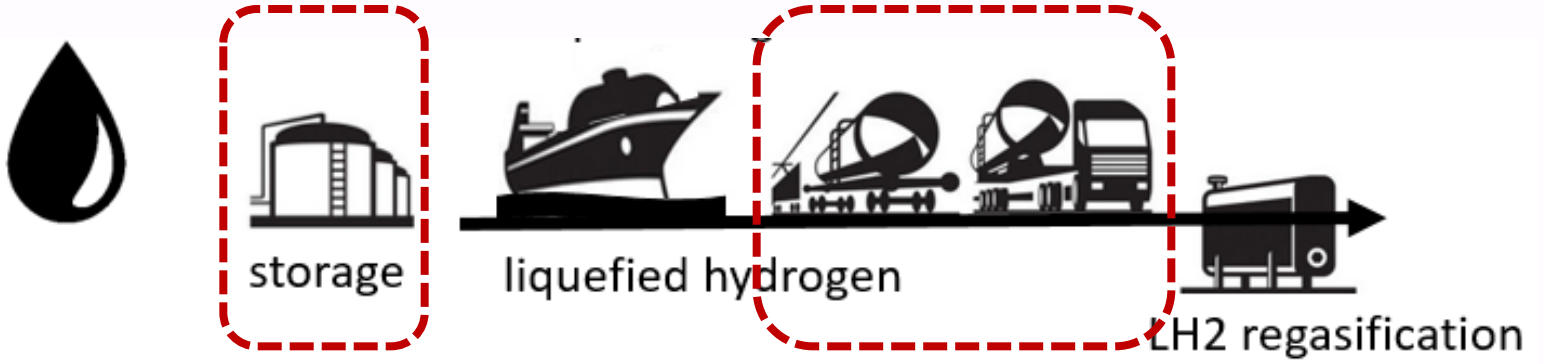
Technological readiness levels - 3



small scale
medium scale
large scale

small scale
medium scale



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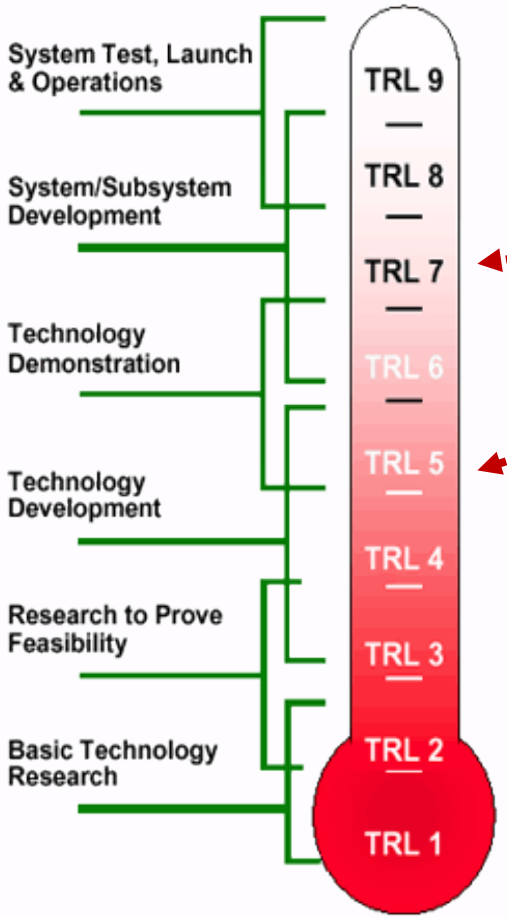
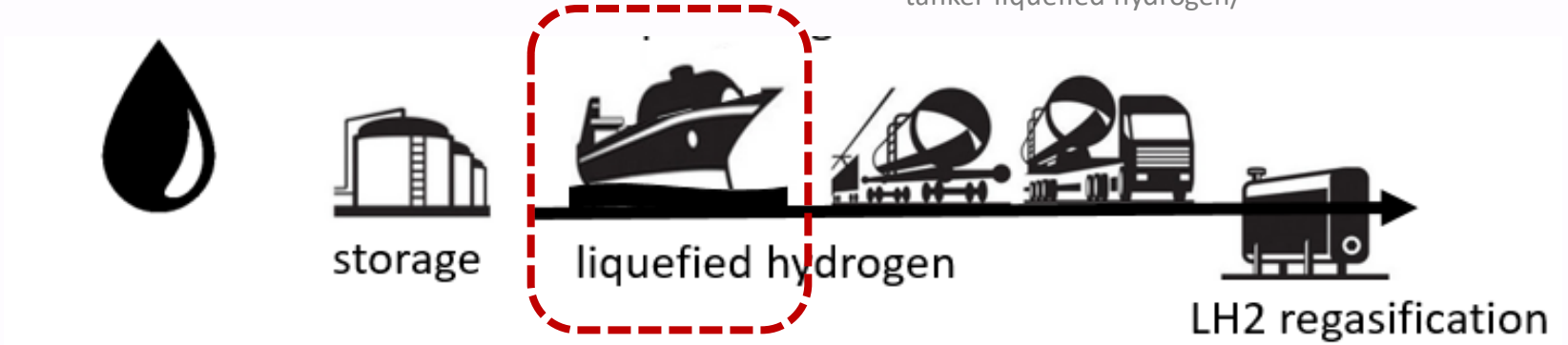
Technological readiness levels - 4



large scale

https://hydrogen-central.com/kawasaki-heavy-tanker-liquefied-hydrogen/



https://en.wikipedia.org/wiki/Technology_readiness_level

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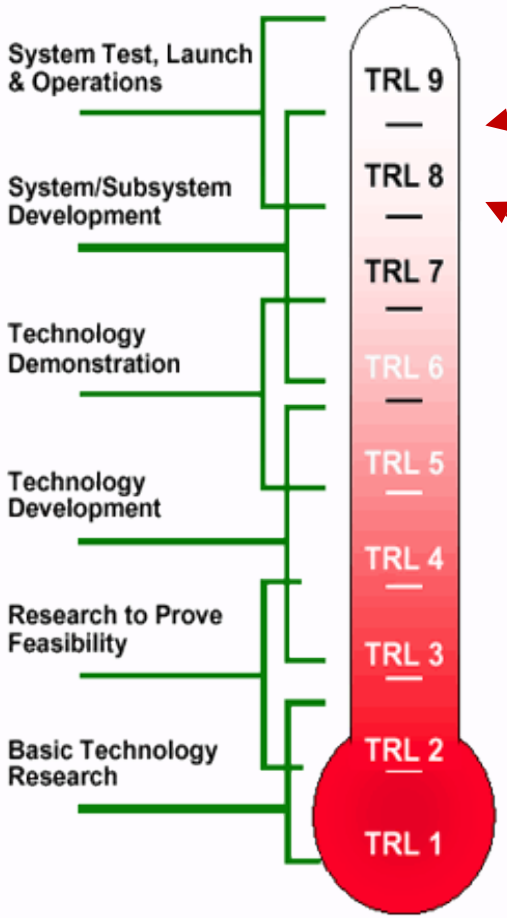
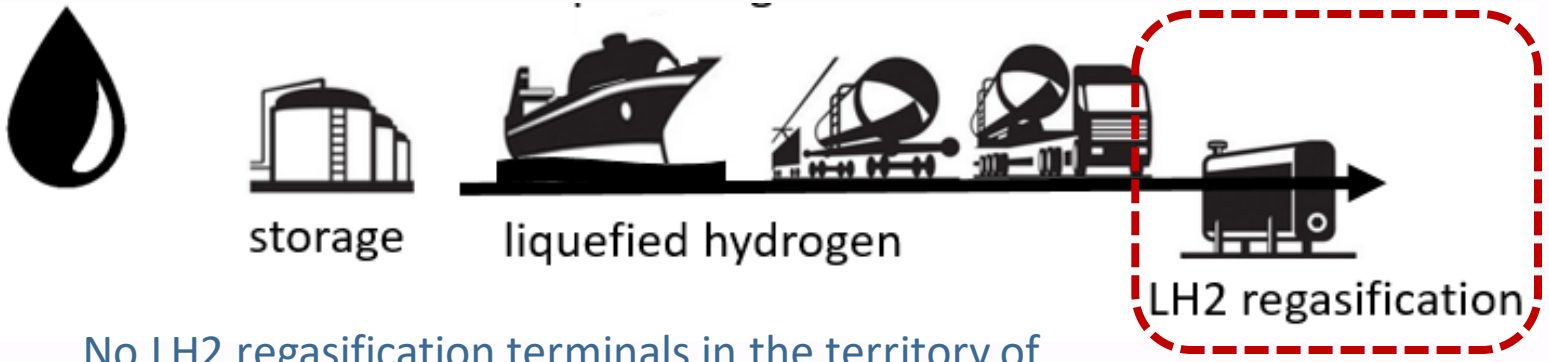
Technological readiness levels - 5



https://en.wikipedia.org/wiki/Technology_readiness_level

Small-scale (atmospheric vaporizers of H2 fueling stations), the specific energy consumption 1.7 kWh/kg_{H2}

Medium scale (three reported cases in the UK), the specific energy consumption 0.01 kWh/kWh_{H2} (2016), 0.002-0.005 kWh/kWh_{H2} (2019)



No LH2 regasification terminals in the territory of the EU. Germany has announced the conversion of the planned LNG terminal in the harbor of Wilhelmshaven (North Sea) to a hydrogen hub

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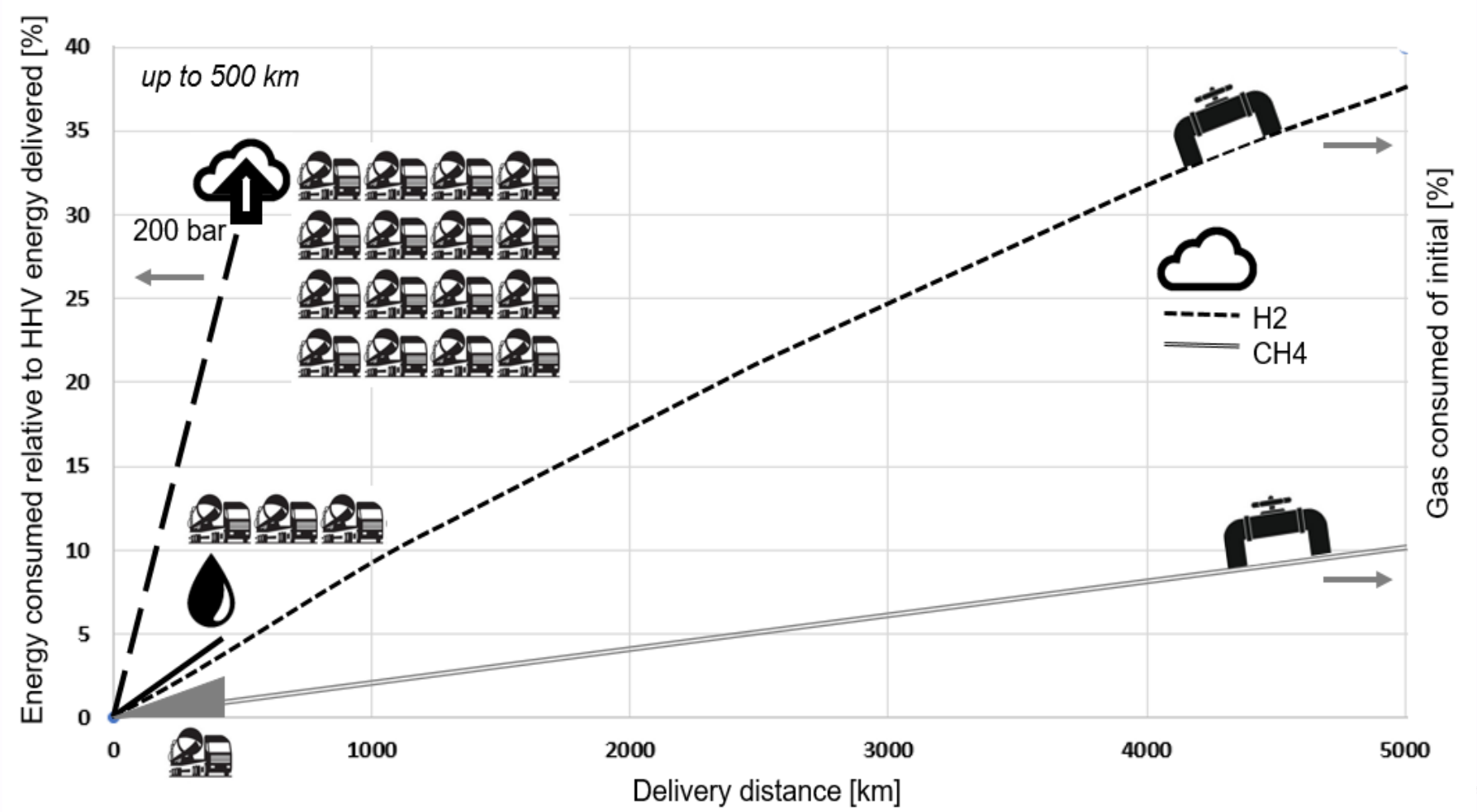
One-way transportation - 1



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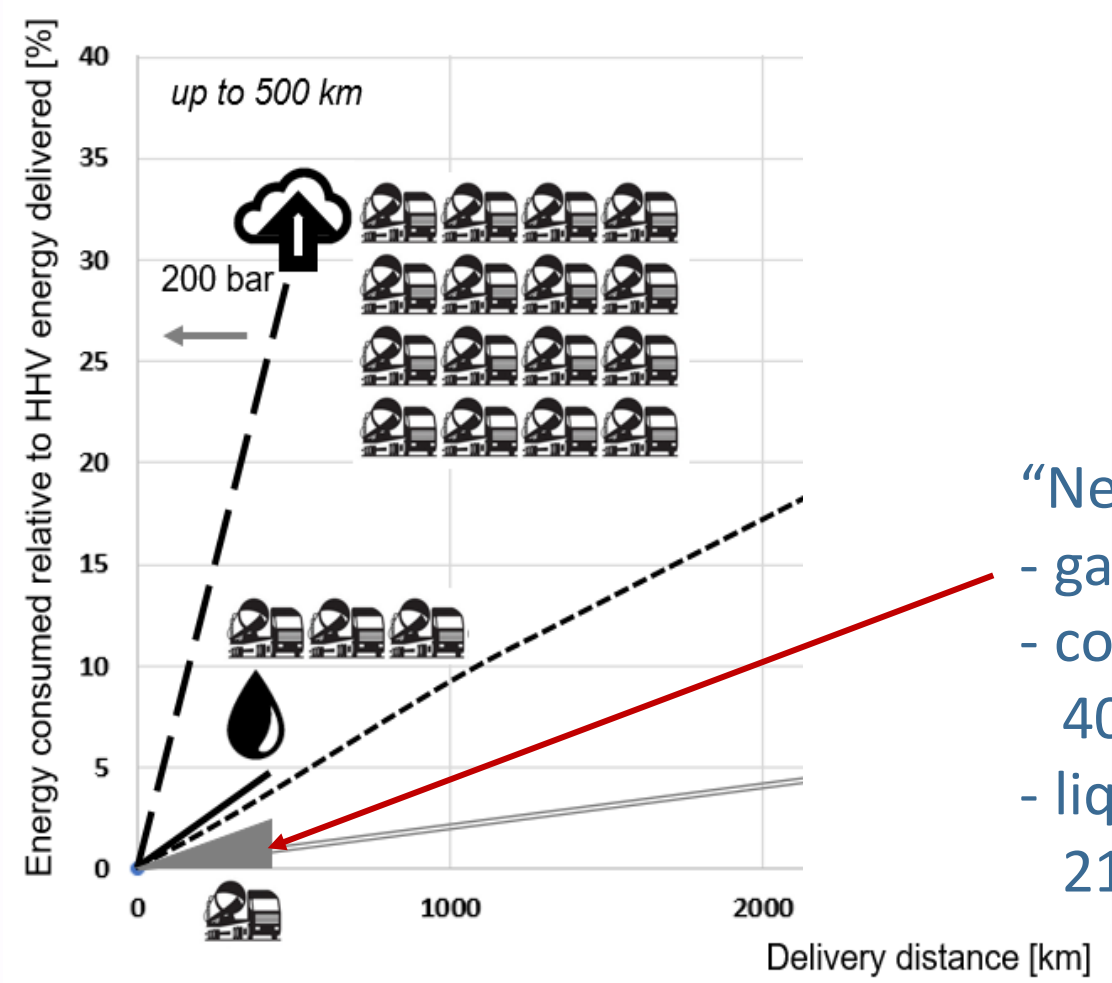
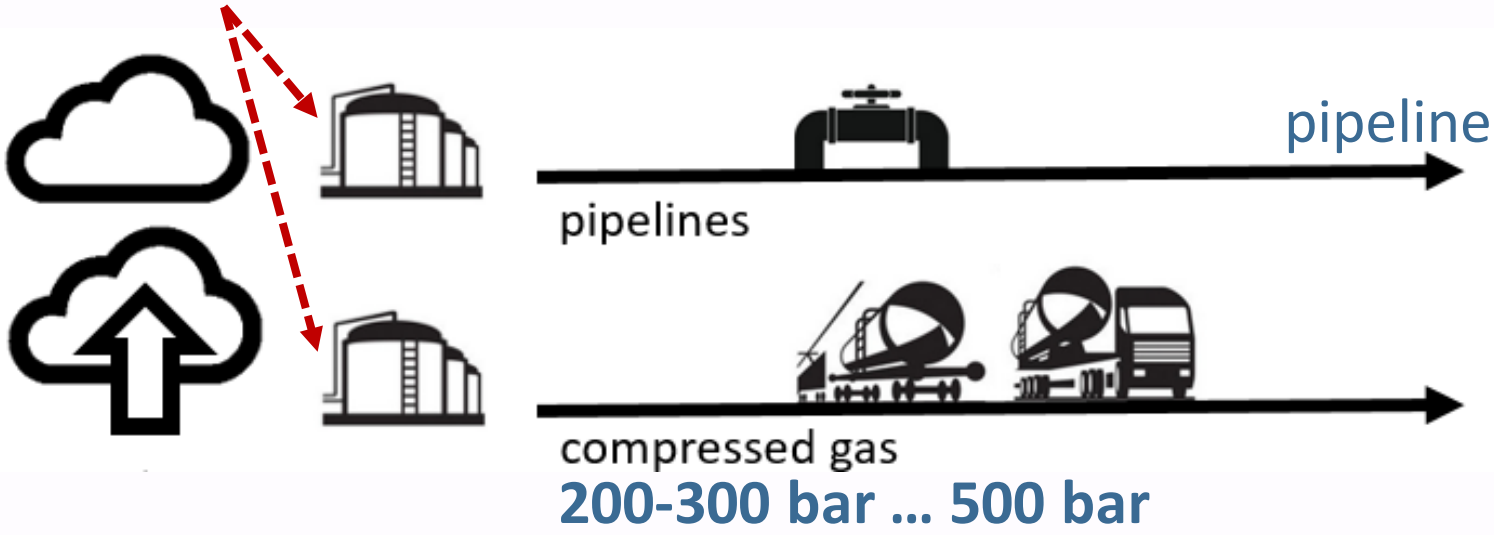
One-way transportation - 2



"Netto" delivery weight:
- gasoline (methanol, propane) 65%
- compressed hydrogen under 200 bar
  400 kg → 1%
- liquefied hydrogen under 1 bar
  2100 kg → 7%

Hydrogen losses - 1

1% of the stored gas



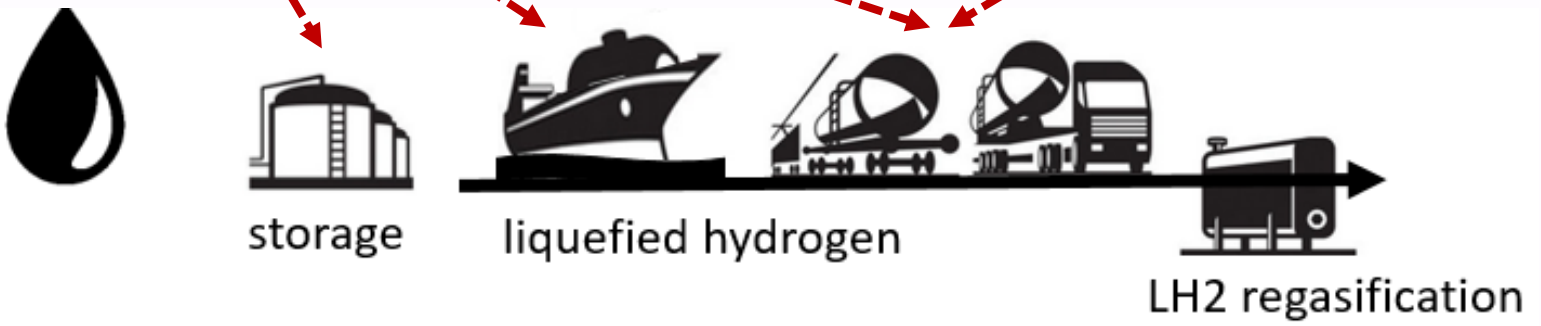
pipelines – 0.5% per 100 km

0.5% in compressed gas cylinders and gas tubes

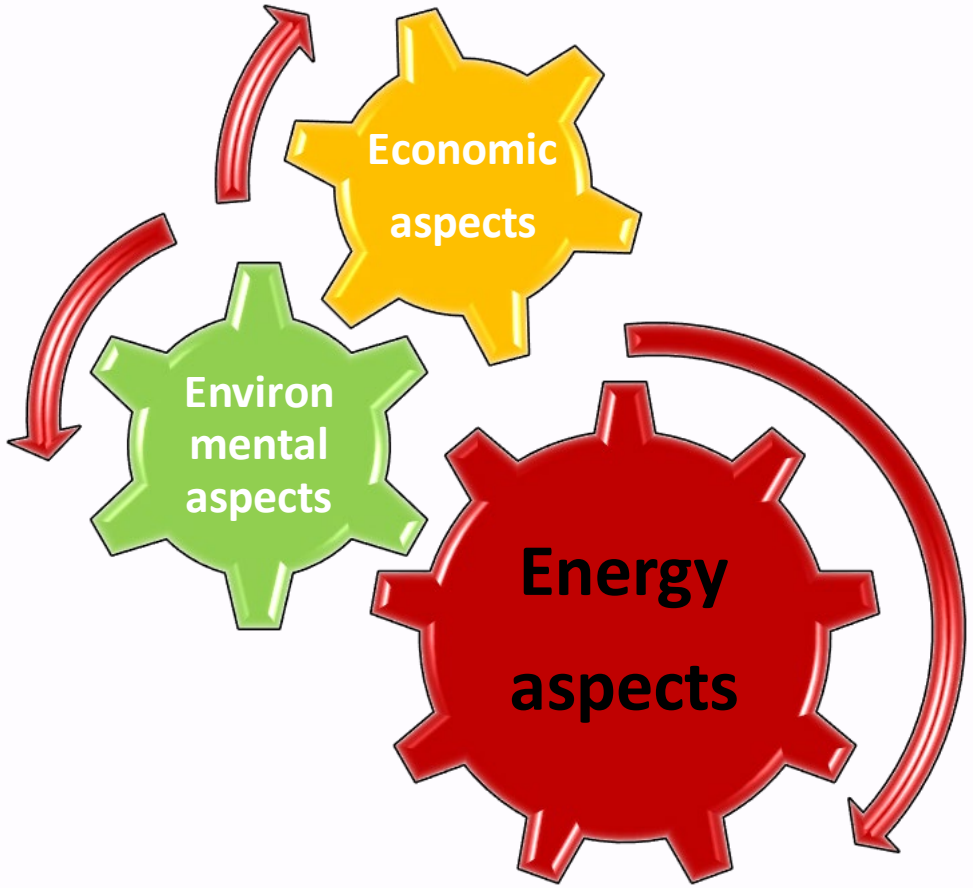
Hydrogen losses - 2

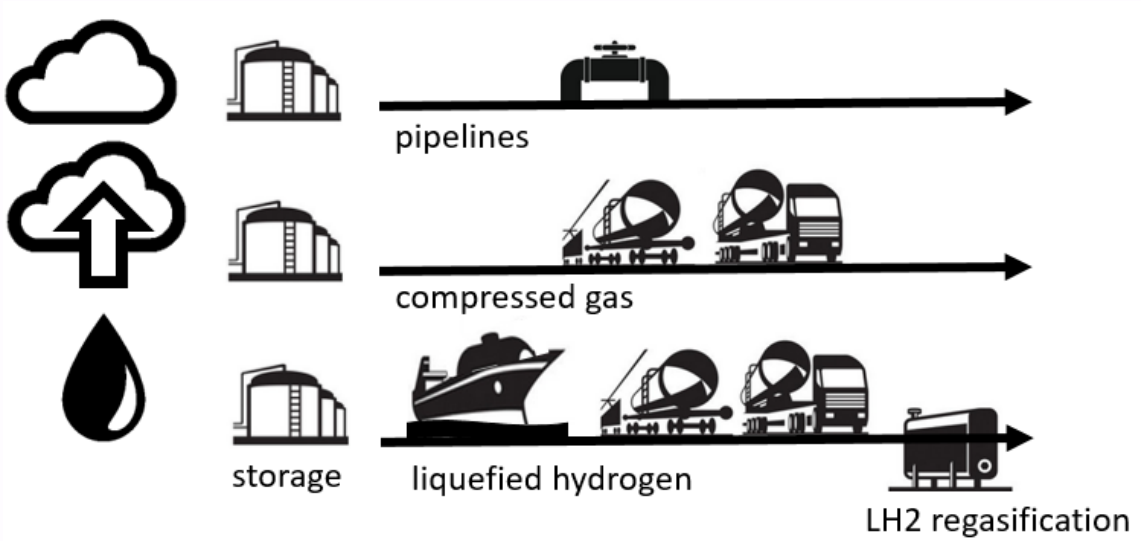
LH2 – 0.03%/day “boiled-off”
maximum recommended storage time of 10 days

5% of the unloaded amount



Conclusion: pro/contra





Towards to the energy, economic and environmental effective hydrogen economy

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Thanks for your attention

Thanks

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