Imported hydrogen fuels for long distance trucking in Germany

(70 MPa, LH_2, CcH_2)

NOW/CEP Heavy Duty Event

Jan Zerhusen (LBST), April 21st 2021

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Content of this presentation

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- Hydrogen fuel demand of long-distance FC trucks in Germany
- Main elements of an import based hydrogen fuel supply chain
- Resulting fuel costs
- The impact of hydrogen distribution on fuel costs
- GHG emissions of hydrogen fuel
- Key messages

Supply chain analysis as part of current Daimler project

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- Daimler Truck AG presented their current FC truck activities, in Sept. 2020.
- Their overall target: Development of technical foundations for 40t long-distance FC trucks including certification and real world testing of two vehicle prototypes.
- As part of the project, a market ramp-up and H_2 fuel supply analysis was contracted.

Consortium ramp-up & fuel supply analysis

Vehicle roll-out scenario and total fuel demand

prognos

Analysis of hydrogen fuel supply economics

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Analysis of environmental impact, consortium coordination

sphera™

https://www.daimler-truck.com/innovation-sustainability/efficient-emission-free/mercedes-benz-genh2-fuel-cell-truck.html

GHG target & considered truck classes

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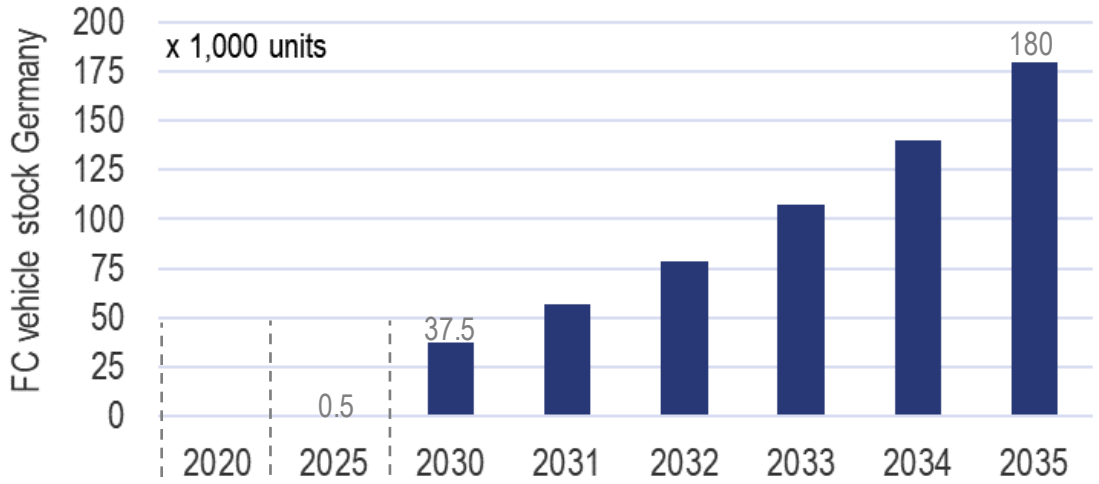
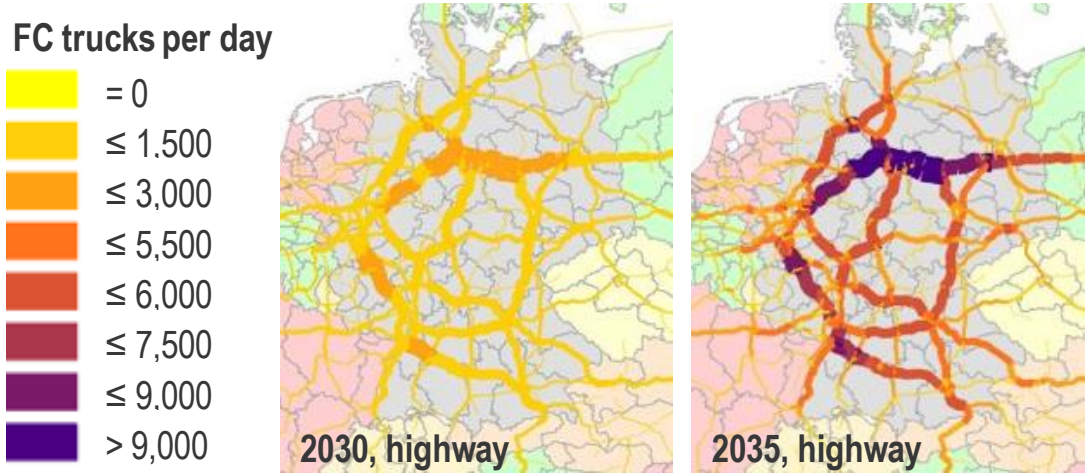
- Vehicle roll-out to achieve EU's emission targets (new sales, 2019 base year, 2030: -30%, 2035: > 50% not official target)
  - Overachievement of EU goals within Germany to compensate fewer new technology sales in other countries
  - Impact of battery trucks also considered (battery trucks for applications e.g. < 400 km, space and weight characteristics)
- Trucks considered for FC deployment: Heavy-duty & long-haul (VECTO classes 5 & 9, most relevant classes in EU)
  - Responsible for a high share of trucking emissions due to specific consumption and high milage

FC truck ramp-up Germany



Long-distance freight traffic with FC



Fuel demand for long-distance road freight

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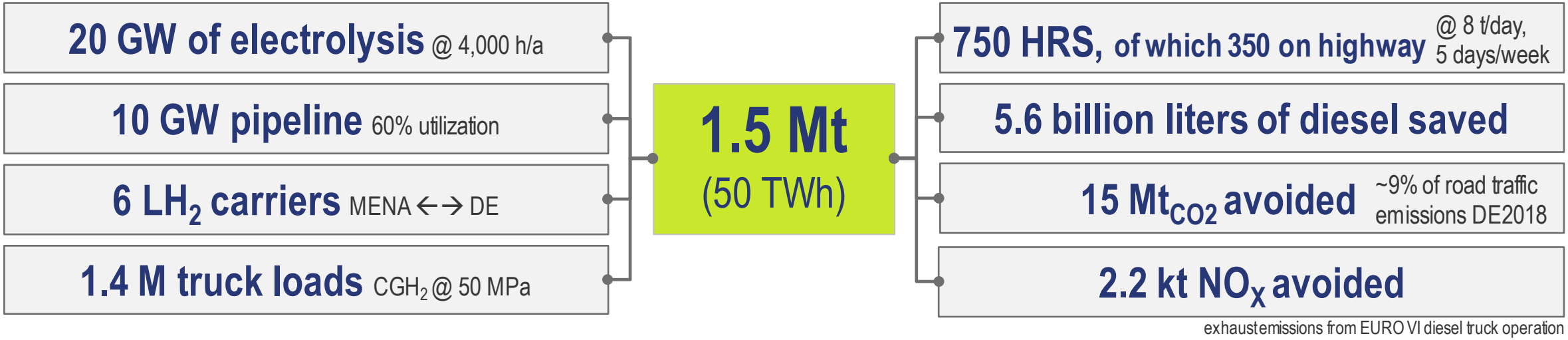
Resulting hydrogen fuel demand:

- 2030: **0.3 Mt_{H2}** (37,600 vehicles, 7.5 kg/100km, 120.000 km/a)
- 2035: **1.5 Mt_{H2}** (180,000 vehicles, 7.0 kg/100km, 120.000 km/a)



Current total H2 demand in Germany: **1.65 Mt** (55 TWh); expected 2030: **2.7 to 3.3 Mt** (national H2 strategy)

Hydrogen fuel import supply chains

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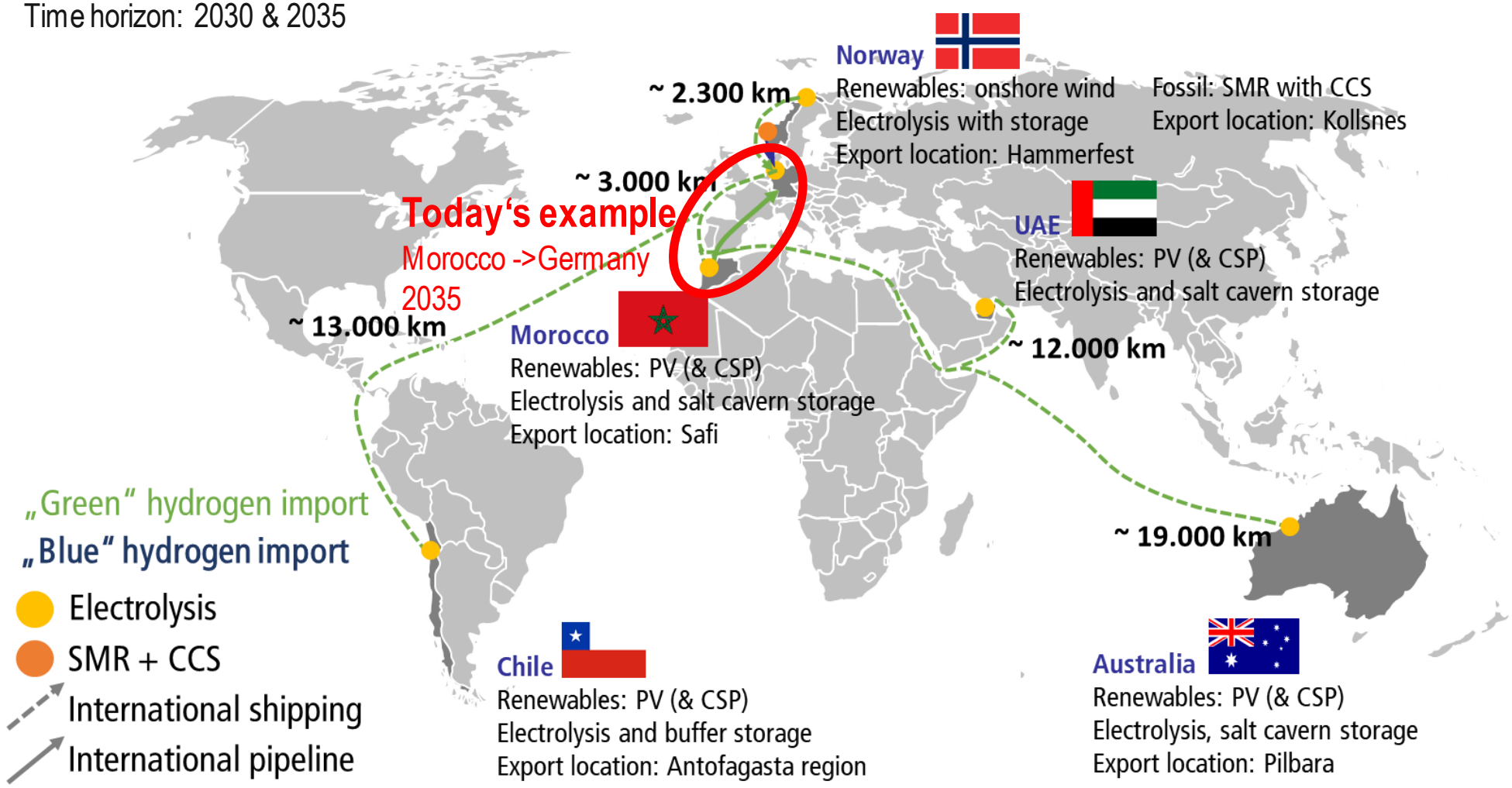
Time horizon: 2030 & 2035



Main supply chain elements (Example case Morocco)

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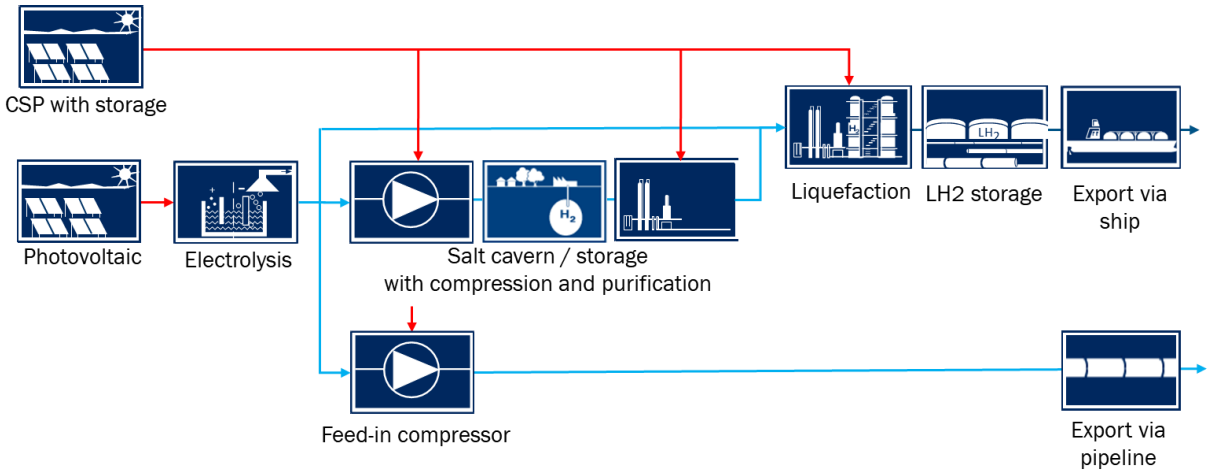
- Hydrogen production from low-cost PV electricity only; hydrogen storage
- 24/7 hydrogen liquefaction also using electricity from solar thermal plants with storage
- Domestic liquefaction after pipeline import if required (LH_2, CcH_2)
- Distribution to HRS via road transport (gaseous or liquid)

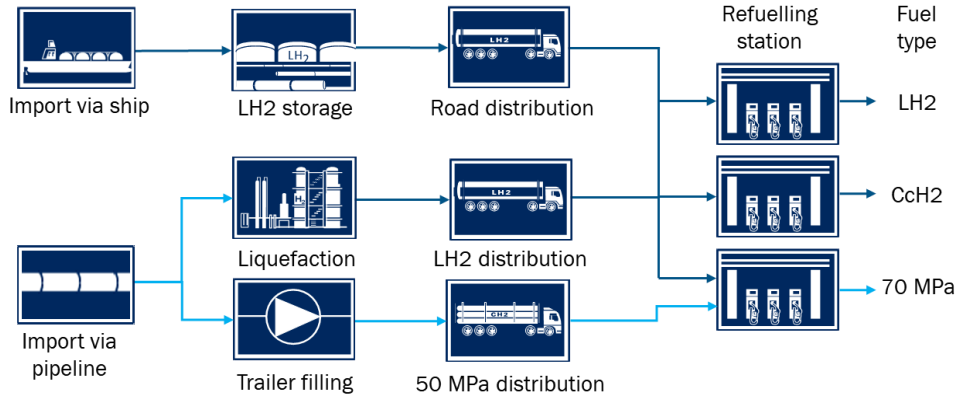
Export country

Large-scale desalination plant included in calculation (not shown)



Import country

Electricity from grid for hydrogen conditioning and refuelling station



Hydrogen fuel costs (Example case: Morocco 2035) (1/2)

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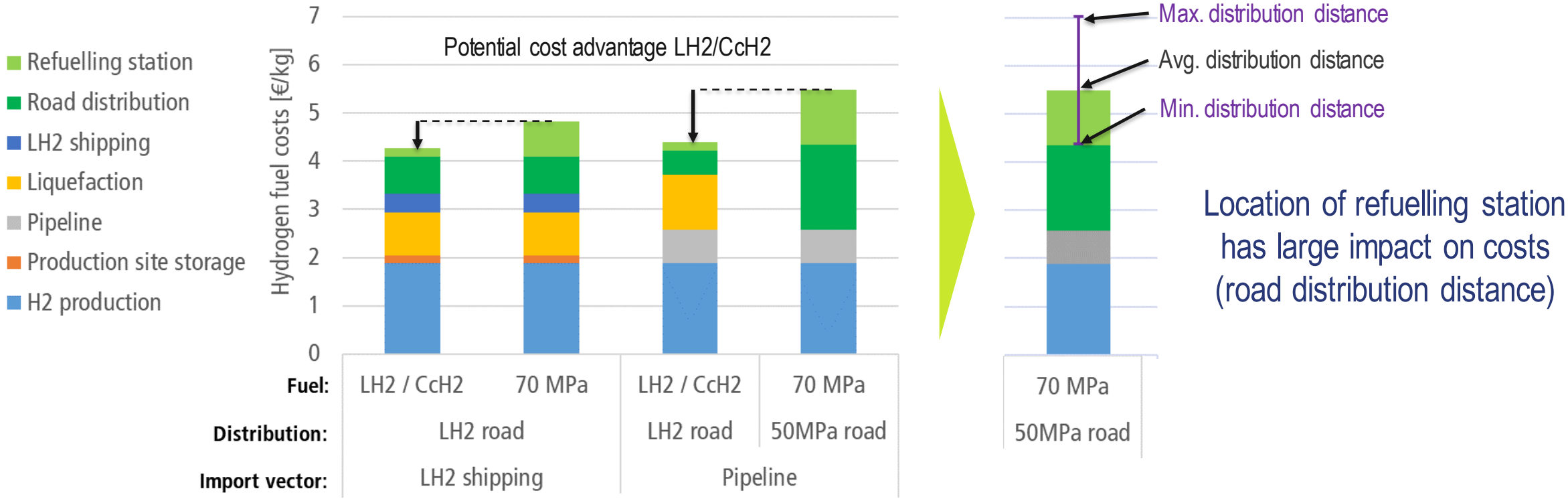
- Green hydrogen fuel costs of about 4 to 5 €/kg feasible for 70 MPa, LH_2 and CcH_2
- Potential fuel cost advantage for LH_2/CcH_2 due to lower distribution and refuelling station costs
- LH_2/CcH_2 show very similar fuel costs with minor differences resulting from the refuelling station



Location of refuelling station has large impact on costs (road distribution distance)

Hydrogen fuel costs – reduction by efficient infrastructure

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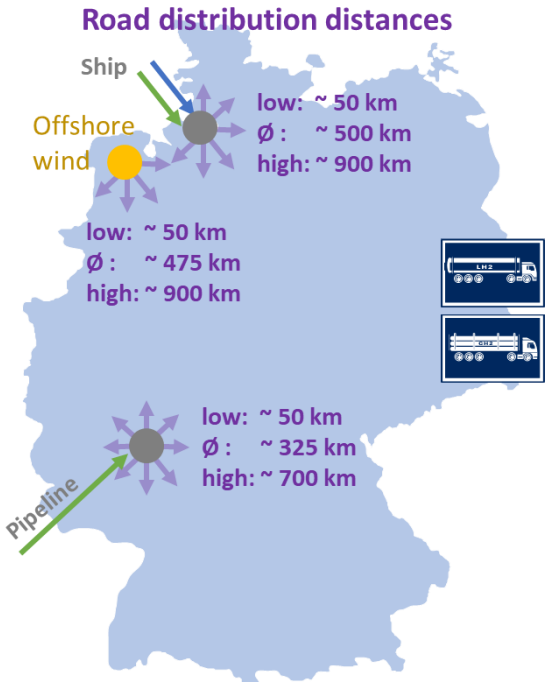
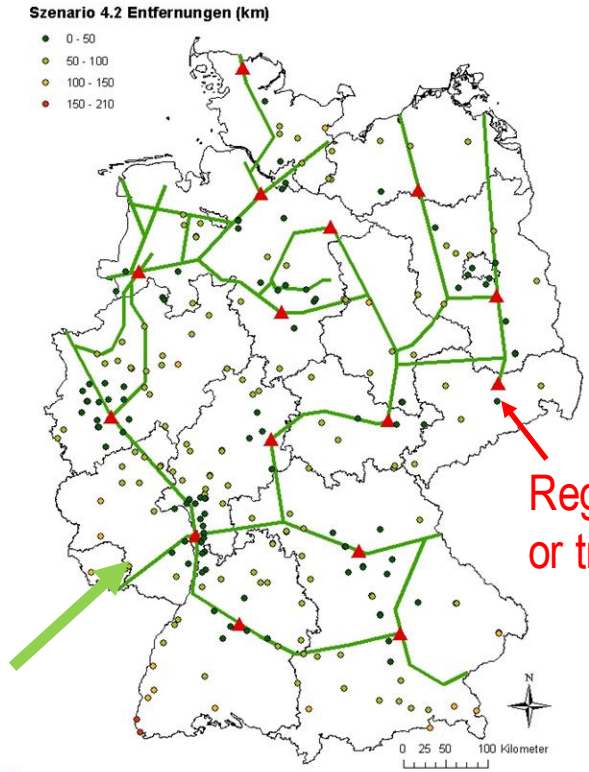
- A national pipeline infrastructure can reduce last mile road distribution to about 75 km
- Significant impact on total hydrogen fuel costs
- Other (new) distribution infrastructures are likely to have similar effect (e.g. inland shipping, rail transport,..)





Pipeline from Morocco

Regional liquefiers or trailer filling centers

Indicative illustration

Hydrogen fuel costs (Example case: Morocco 2035) (2/2)

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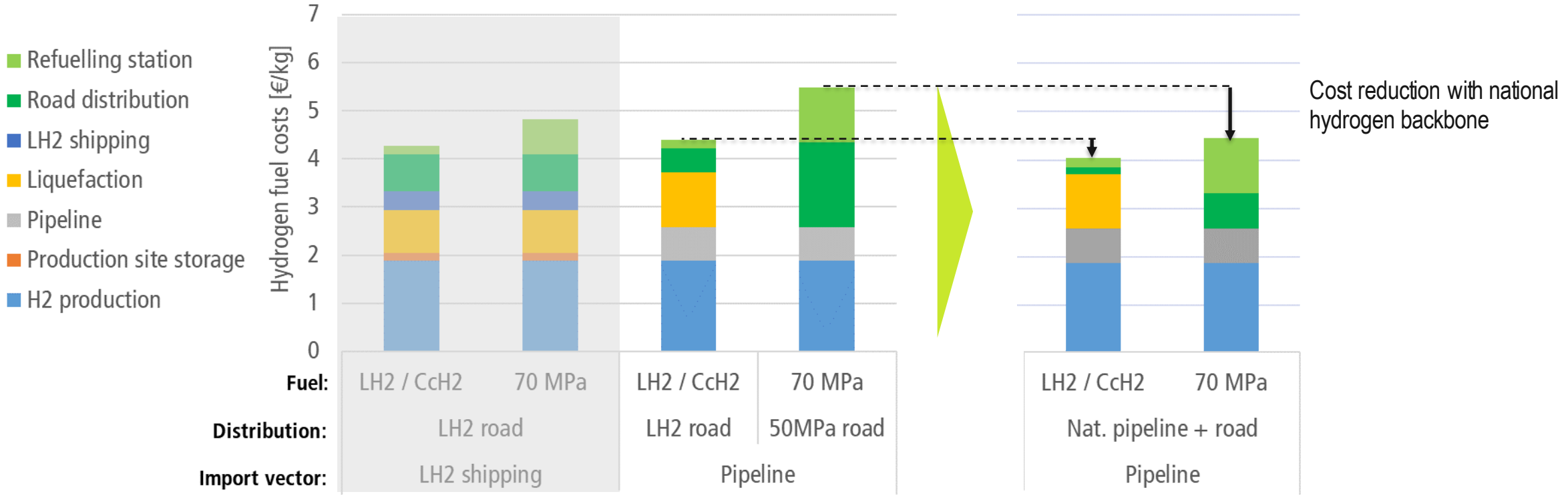
- Distribution costs significantly reduced with nat. H_2 backbone (especially for 70 MPa fuel)
- An efficient distribution system narrows cost differences between different hydrogen fuels
- Low distribution costs are key for low hydrogen fuel costs



GHG emissions (Example case: Morocco 2035)

Incl. CAPEX emissions (infrastr. prod. & end-of-life)

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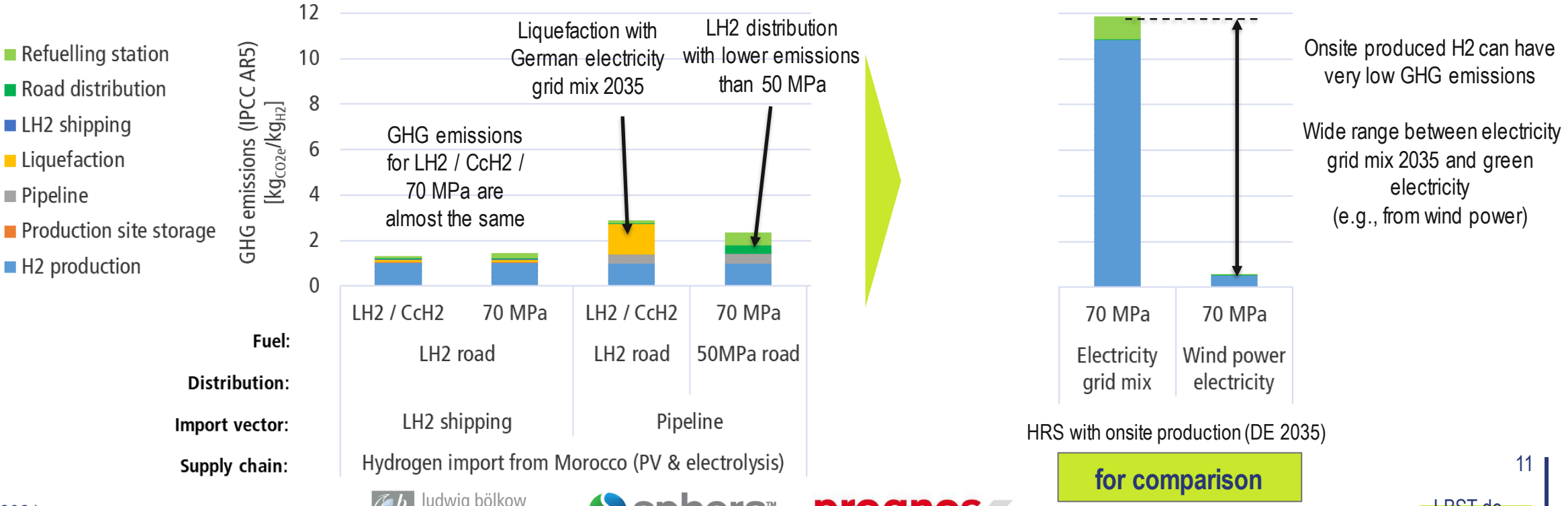
- Most important for GHG emissions: electricity mix for H_2 production & conditioning
- Increased emissions for LH_2/CcH_2 when liquefaction operated with DE grid mix
- Manufacturing and end-of-life of renewable power generation technology plays a major role
  - The production of the electrolyzer and other H_2 infrastructure less relevant



Key messages

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1	2035: **1.5 Mt/a**	**Fuel demand justifies nationwide comprehensive refuelling network**
2	2035: **750 HRS**	**Demand enables 750 H_2-stations of which 350 located at highway**
3	2035: **< 5 €/kg**	**All three hydrogen fuels are feasible from fuel cost perspective**
4	Imports & fuels **compatible**	**Liquid or pipeline imports do not exclude any of the three hydrogen fuel options**
5	e.g. national **H_2-Backbone**	**Efficient large-scale hydrogen transport and distribution systems required**
6	GHG emissions: **low**	**Electricity related emissions most relevant for overall GHG footprint**

Public project report will become available end of April 2021

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Thank you for your attention!

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