



ludwig bolkow
systemtechnik

sphera™ prognos

Imported hydrogen fuels for long distance trucking in Germany (70 MPa, LH₂, CcH₂)

NOW/CEP Heavy Duty Event

Jan Zerhusen (LBST), April 21st 2021

Content of this presentation



ludwig bolkow
systemtechnik

- **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



ludwig bolkow
systemtechnik

- 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 H₂ 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



Analysis of environmental impact, consortium coordination



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

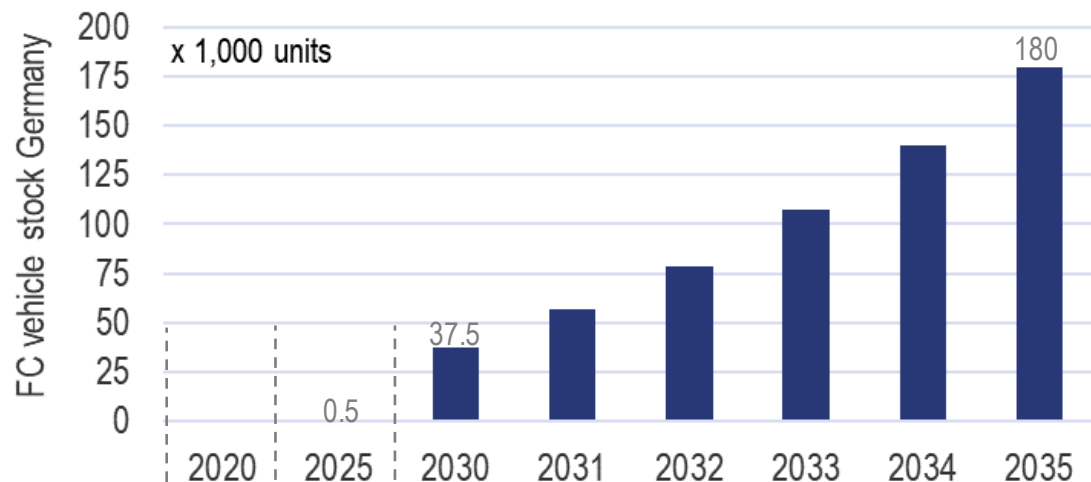
GHG target & considered truck classes



ludwig bolkow
systemtechnik

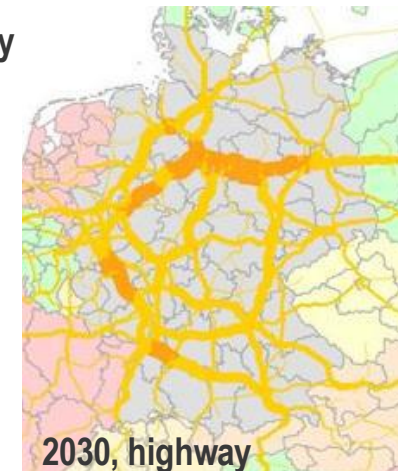
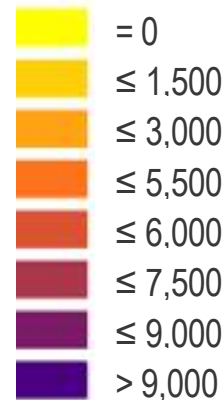
- Vehicle roll-out to achieve EU's emission targets (new sales, 2019 base year, 2030: -30%, 2035: > 50% not official target)
 - Overachievement of EU goals within Germany to compensate fewer new technology sales in other countries
 - Impact of battery trucks also considered (battery trucks for applications 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

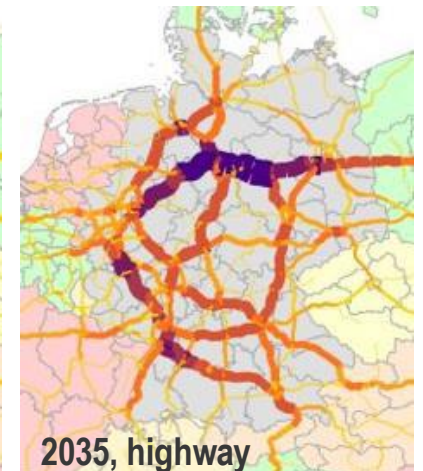


Long-distance freight traffic with FC

FC trucks per day



2030, highway



2035, highway

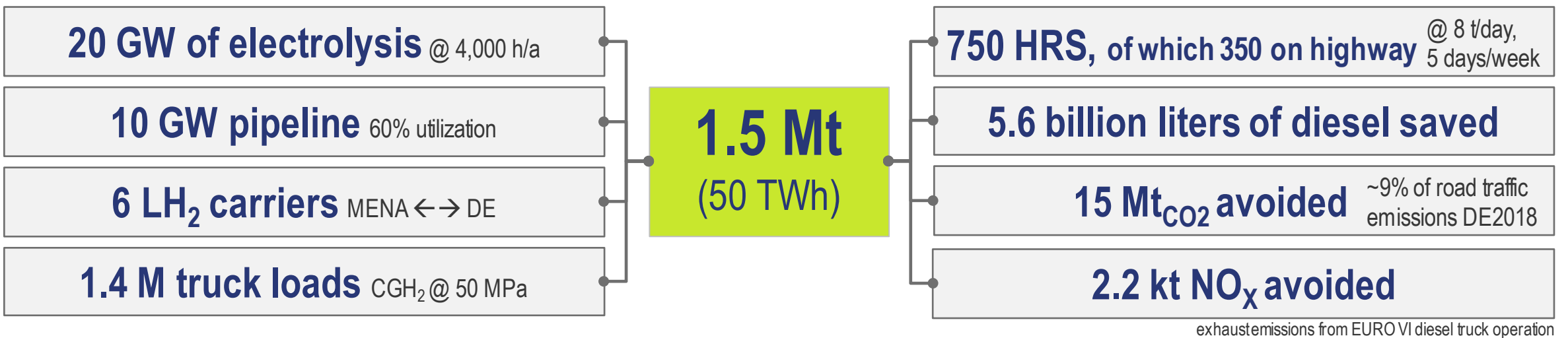
Fuel demand for long-distance road freight



ludwig bolkow
systemtechnik

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)



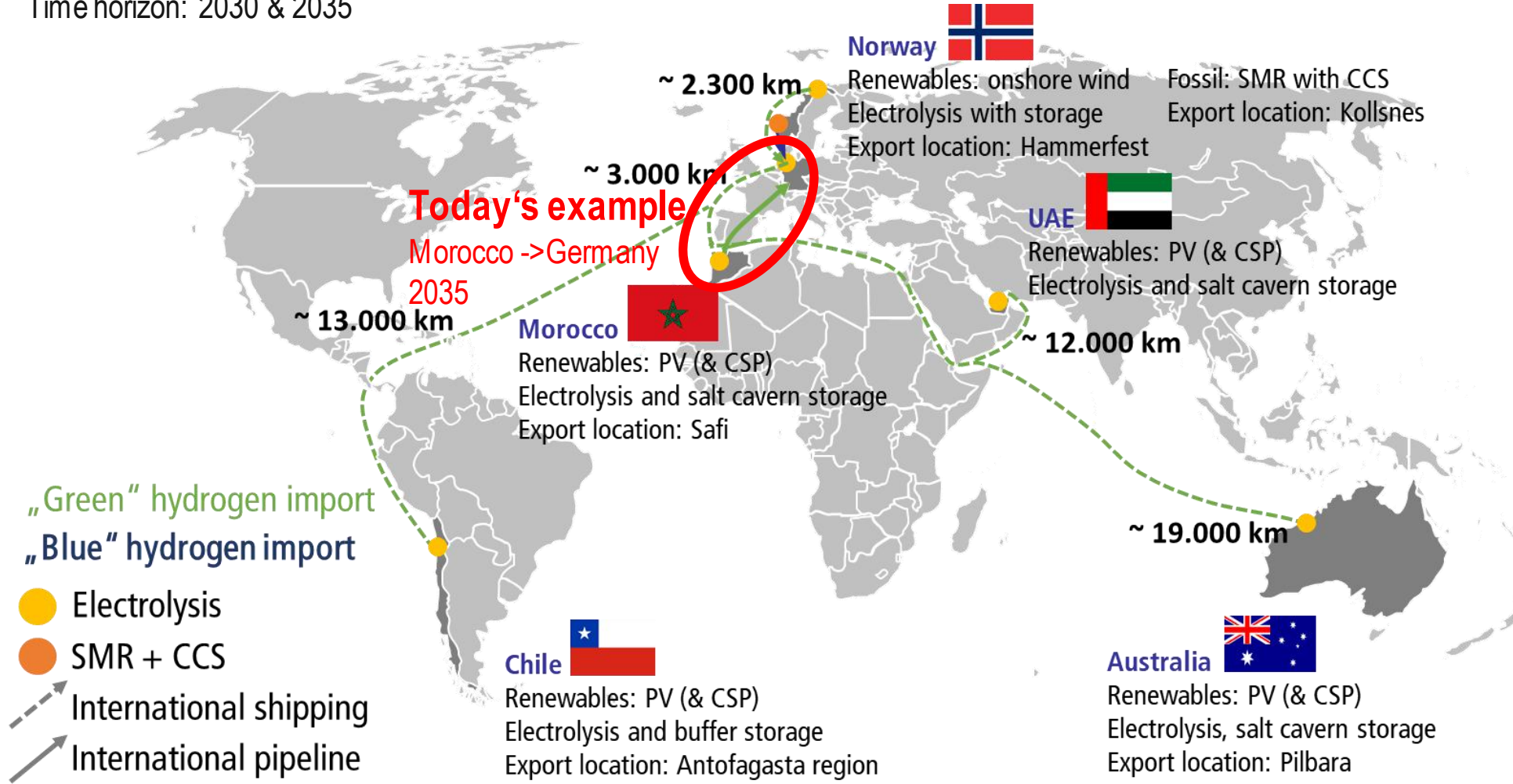
Current total H₂ demand in Germany: **1.65 Mt (55 TWh)**; expected 2030: **2.7 to 3.3 Mt** (national H₂ strategy)

Hydrogen fuel import supply chains



Ludwig Bolkow
systemtechnik

Time horizon: 2030 & 2035



Main supply chain elements (Example case Morocco)

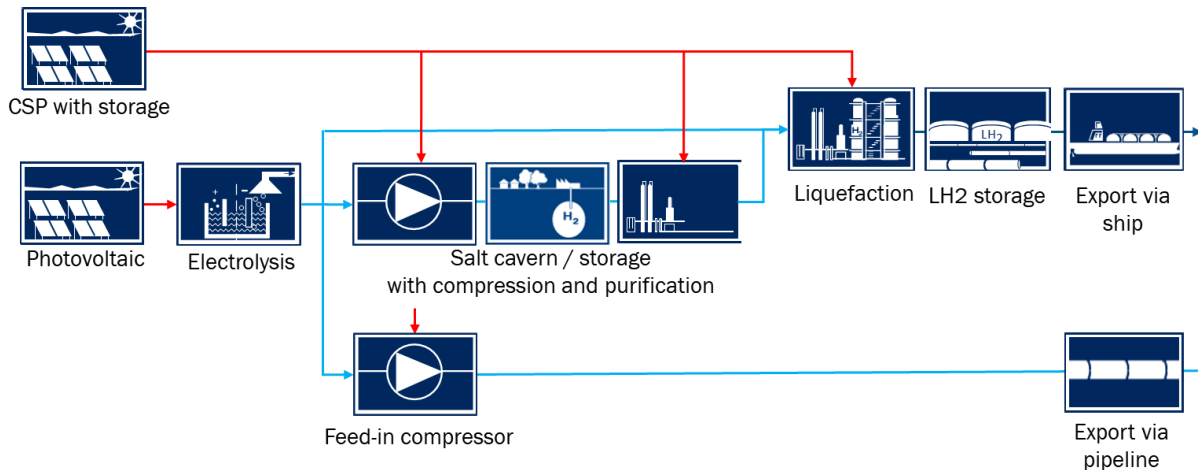


ludwig bolkow
systemtechnik

- 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 (LH₂, CcH₂)
- Distribution to HRS via road transport (gaseous or liquid)

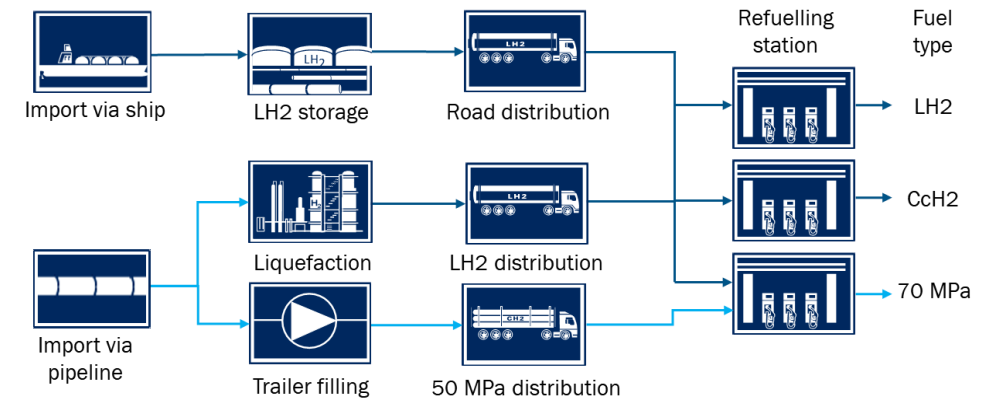
Export country

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



Import country

Electricity from grid for hydrogen conditioning and refuelling station

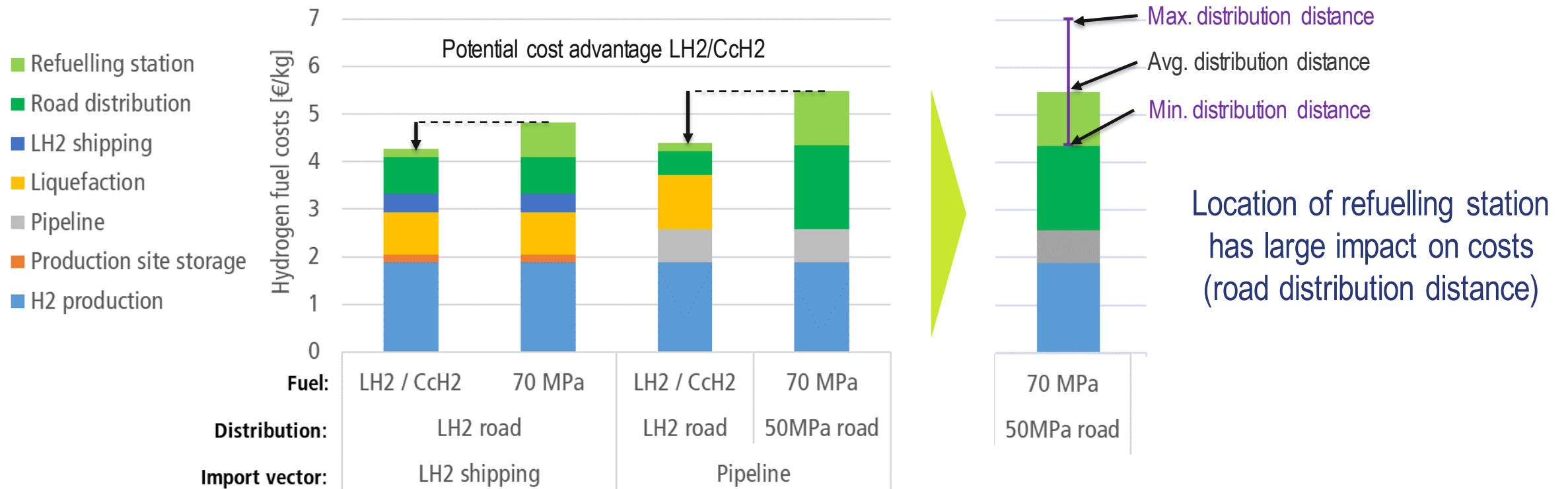


Hydrogen fuel costs (Example case: Morocco 2035) (1/2)



ludwig bolkow
systemtechnik

- Green hydrogen fuel costs of about 4 to 5 €/kg feasible for 70 MPa, LH₂ and CcH₂
- Potential fuel cost advantage for LH₂/CcH₂ due to lower distribution and refuelling station costs
- LH₂/CcH₂ show very similar fuel costs with minor differences resulting from the refuelling station

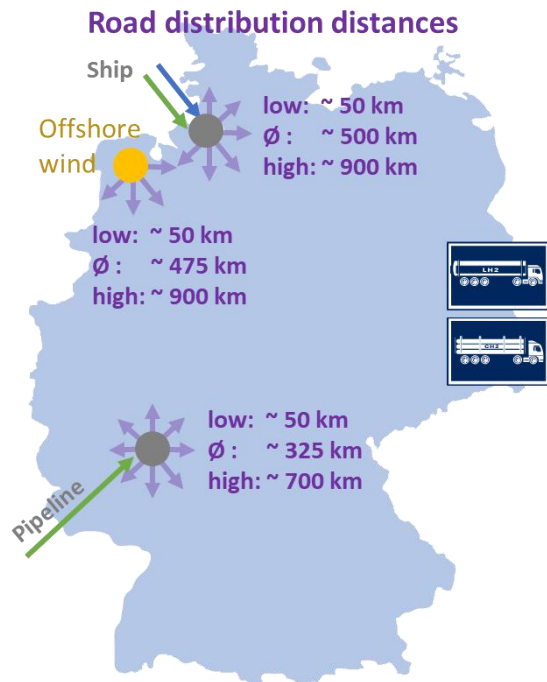


Hydrogen fuel costs – reduction by efficient infrastructure



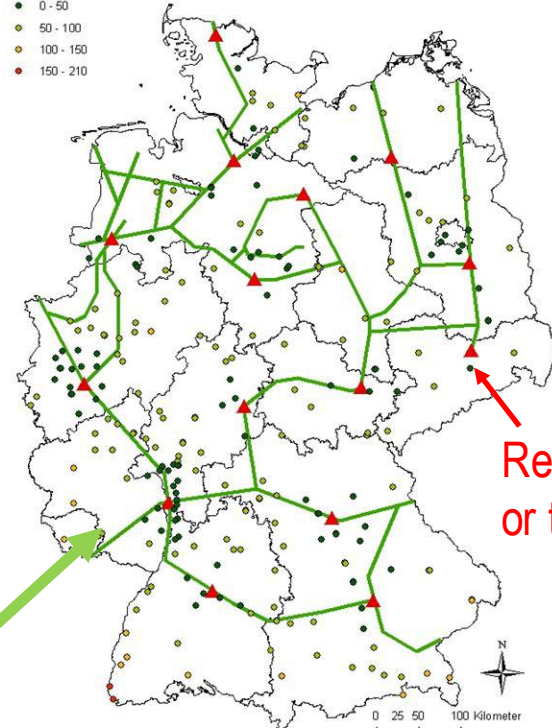
ludwig bolkow
systemtechnik

- 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,..)



Szenario 4.2 Entfernungen (km)

- 0 - 50
- 50 - 100
- 100 - 150
- 150 - 210



Regional liquefiers
or trailer filling centers

Pipeline from
Morocco

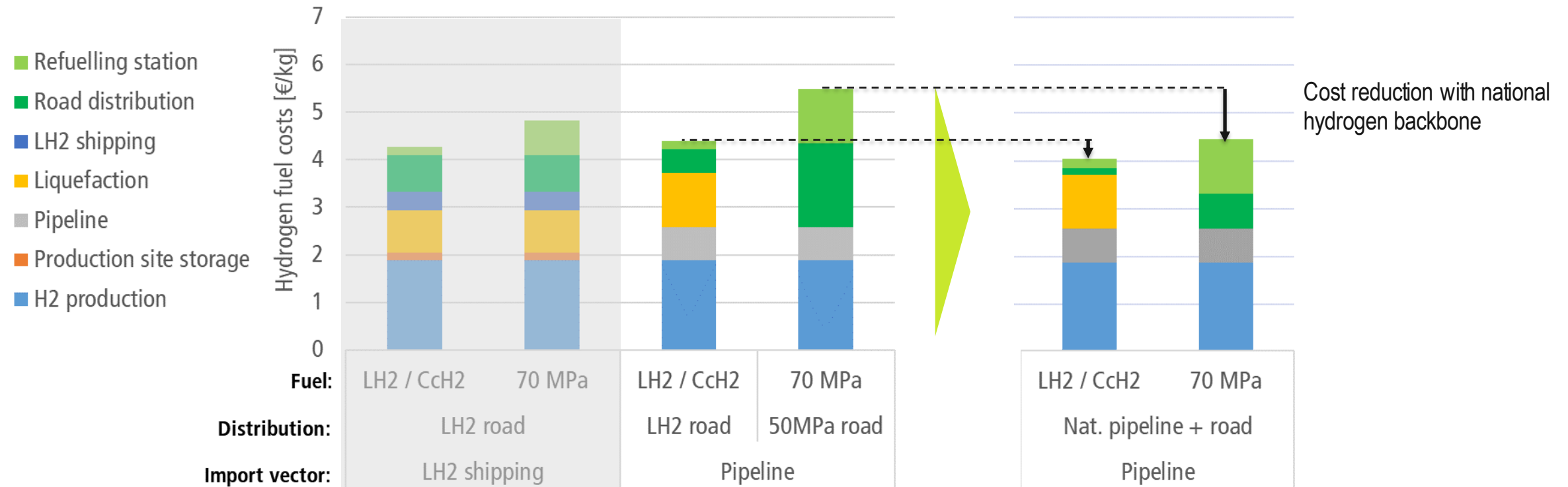
Indicative illustration

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



ludwig bolkow
systemtechnik

- Distribution costs significantly reduced with nat. H₂ 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



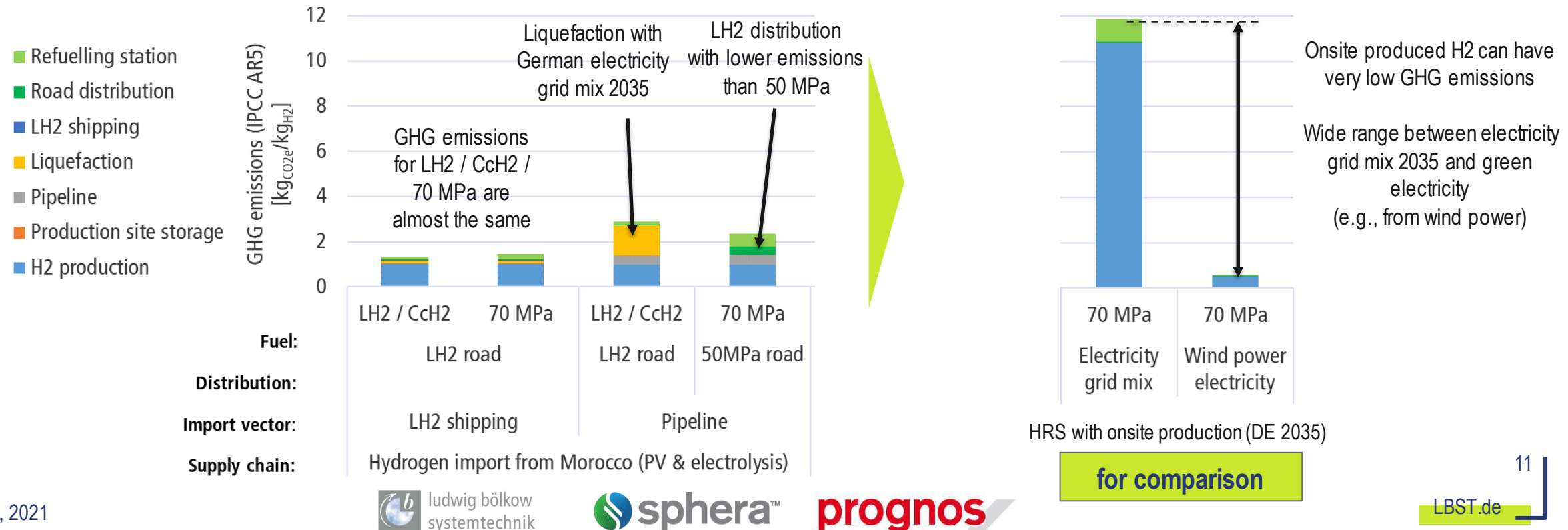
GHG emissions (Example case: Morocco 2035)

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



ludwig bolkow
systemtechnik







- Most important for GHG emissions: electricity mix for H₂ production & conditioning
- Increased emissions for LH₂/Cch₂ 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 H₂ infrastructure less relevant



Key messages



ludwig bölkow
systemtechnik

- 1** 2035:
1.5 Mt/a **Fuel demand justifies nationwide comprehensive refuelling network** 
- 2** 2035:
750 HRS **Demand enables 750 H₂-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
H₂-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



ludwig bolkow
systemtechnik

Thank you for your attention!

Your contacts:



Jan Zerhusen

Senior Project Manager

Jan.Zerhusen@lbst.de

Ludwig-Bölkow Systemtechnik,
Daimlerstr. 15, 85521 Ottobrunn,
Germany

www.LBST.de



Dr. Michael Baumann

Project coordinator

mbaumann@sphera.com

Sphera Solutions GmbH,
Hauptstr. 111-113, 70771 Leinfelden-
Echterdingen, Germany

www.sphera.com



Alexander Labinsky

Project Manager Mobility & Transport

Alexander.Labinsky@prognos.com

Prognos AG, Werdener Str. 4,
40227 Düsseldorf, Germany

www.prognos.com

 **sphera™ prognos**



ludwig bolkow
systemtechnik