

# Heavy duty hydrogen projects

## How to reach commercial business cases

May 2019, Icelandic New Energy - 20year  
Jacob Krogsgaard, SVP Nel Hydrogen

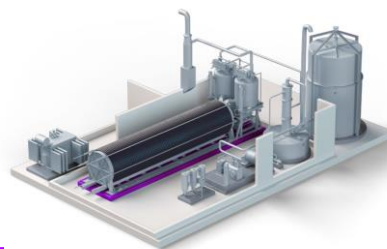
# One slide on Nel Hydrogen

- World's largest pure-play hydrogen company with a market cap of 1B USD.
- +270 employees in Denmark, Norway and USA with world-class experience and skills.
- Offering hydrogen technology and solutions for industrial, energy and transport applications.
- More than 3500 hydrogen solutions delivered in 80 countries world wide since 1927, of which 60 are hydrogen fueling stations.
- World's #1 on hydrogen electrolyzers and hydrogen fueling – unrivalled performance and track-record.



## ALKALINE ELECTROLYSERS

Dates back to 1927



## PEM ELECTROLYSERS

Acquired in 2017

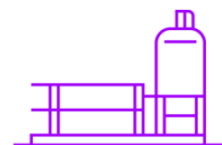


## HYDROGEN FUELING

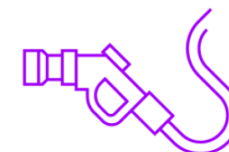
Acquired in 2015



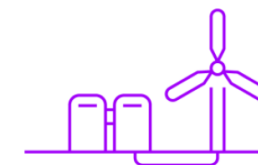
Three business segments



Hydrogen Electrolyzers



Hydrogen Fueling



Hydrogen Solutions

# H2Station<sup>®</sup> variants

## Compression and fast fueling of hydrogen

- Capacity up to 120kg/hour
- Fueling protocols: 3-5min(CARS) | down to 5min(BUS)
- Inlet pressure range 2-70MPa – Multiple H<sub>2</sub> sources
- H2Station control of multiple storages
- Dimensions L: 3.3m W: 2.2m H: 3.6m | 17.5 ton
- Approvals PED – CE marked | UL listed | KGS
- Noise <60dB | no venting of hydrogen
- Multiple dispensers connections



35MPa



Both 35/70MPa



70MPa

Valley of death



## Demonstration

- Get funding
- Test vehicles (just a small fleet)
- Test hydrogen fueling

## Commercialization

- Increase volume of vehicles
- Make a plan to replace your ICE fleet with H2
- Make standard fuel supply contracts

## FUEL CELLS IN 2017 ARE WHERE SOLAR WAS IN 2002

- Solar at 0.3 \$/W (2017) and keep dropping
- Low cost solar, wind → Low cost green hydrogen

## FUEL CELL LEARNING RATE AT 25%

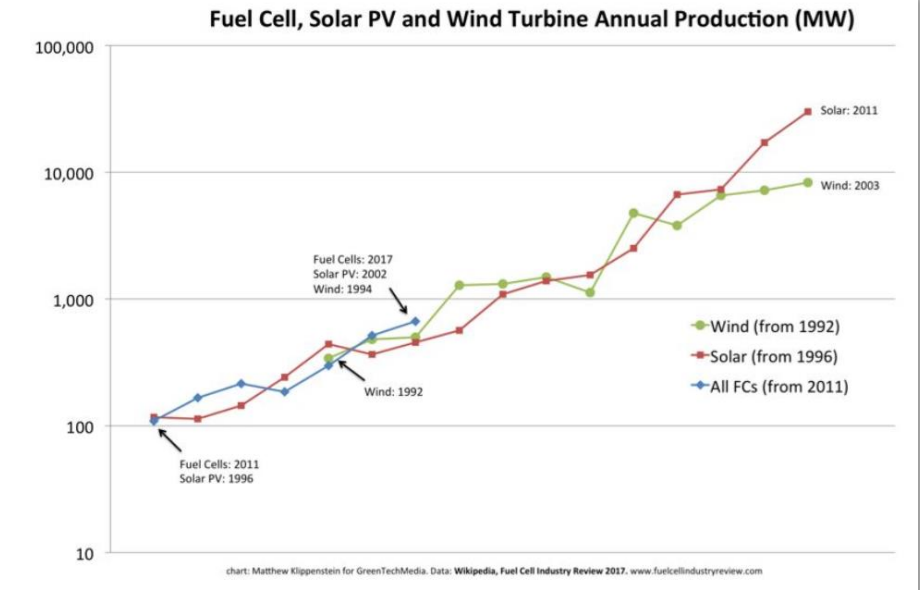
- Fuel cell learning rate similar to PV
- Much more dependent on volume than time

## ACCELERATE COST DOWN

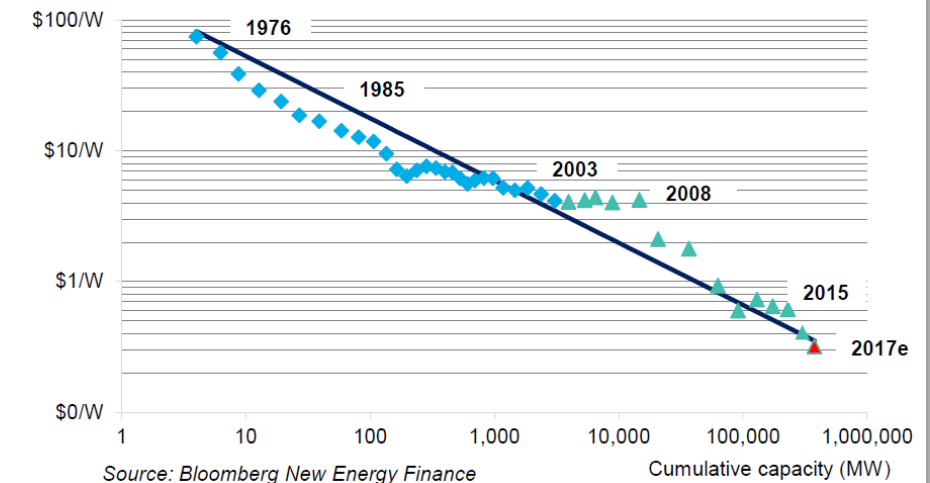
- Mass manufacturing of fuel cell and hydrogen technology
- Similar will be seen on H2 storage, electrolyzers & H2Stations

## NEL IS LEADING THE WAY TO REDUCE COSTS IN H2 INFRASTRUCTURE

- Factory in Denmark to manufacture up to 300 H2Stations/year
- Factory in Norway to manufacture up to 360MW Electrolyser/year

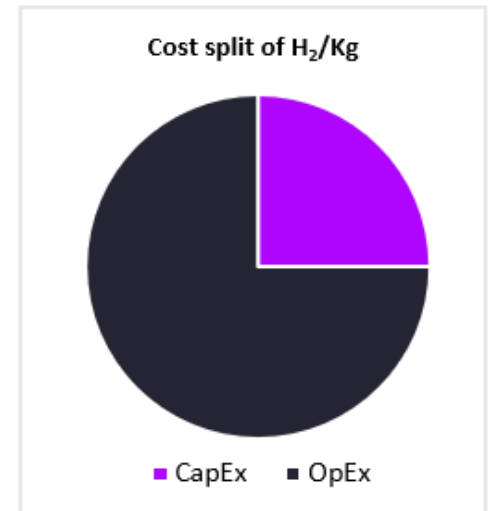


## Crystalline silicon solar PV experience curve



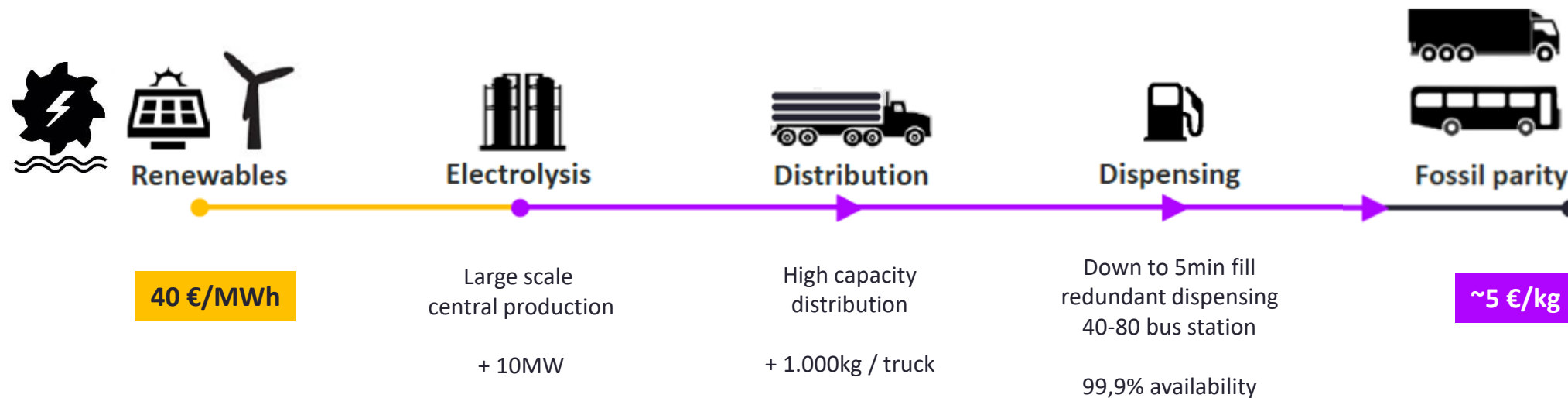
	~2015	~2020	~X-years
Nel electrolysis [€/kW]	<700	<500	<350
Solar (utility scale) [€/kW]	~1,500	~700	<500
Solar PPA [€/kWh]	0.04 – 0.06	0.02 – 0.04	0.015 – 0.02
<b>Total hydrogen production cost [€/kg]</b>	<b>2.4 – 3.3</b>	<b>1.3 – 2.7</b>	<b>1.0 – 1.3</b>

- Large electrolyzer facilities from Nel already at CapEx parity with medium scale SMR<sup>1</sup>
  - Nel targets to reach CapEx parity with large scale SMRs in foreseeable future
  - Fully automated production line + next generation electrolyser
- At right regions with green electricity <40€/MWh, fossil parity (5€/kg at pump) is possible from 2020 at right scale.



# Green competitive hydrogen – at cost of diesel

- Nel Hydrogen solutions are developing sustainable business cases including FC buses
- If risk is managed and multiple parts of the supply chain are included in one SPV, H2 @ ~5€/kg is possible
- Electrolyser can operate ON/OFF depending on renewable electricity input



# Three game changing projects...

1

2

3



# Hydrogen train opportunity in North Germany

1

## Efficient centralized H<sub>2</sub> production

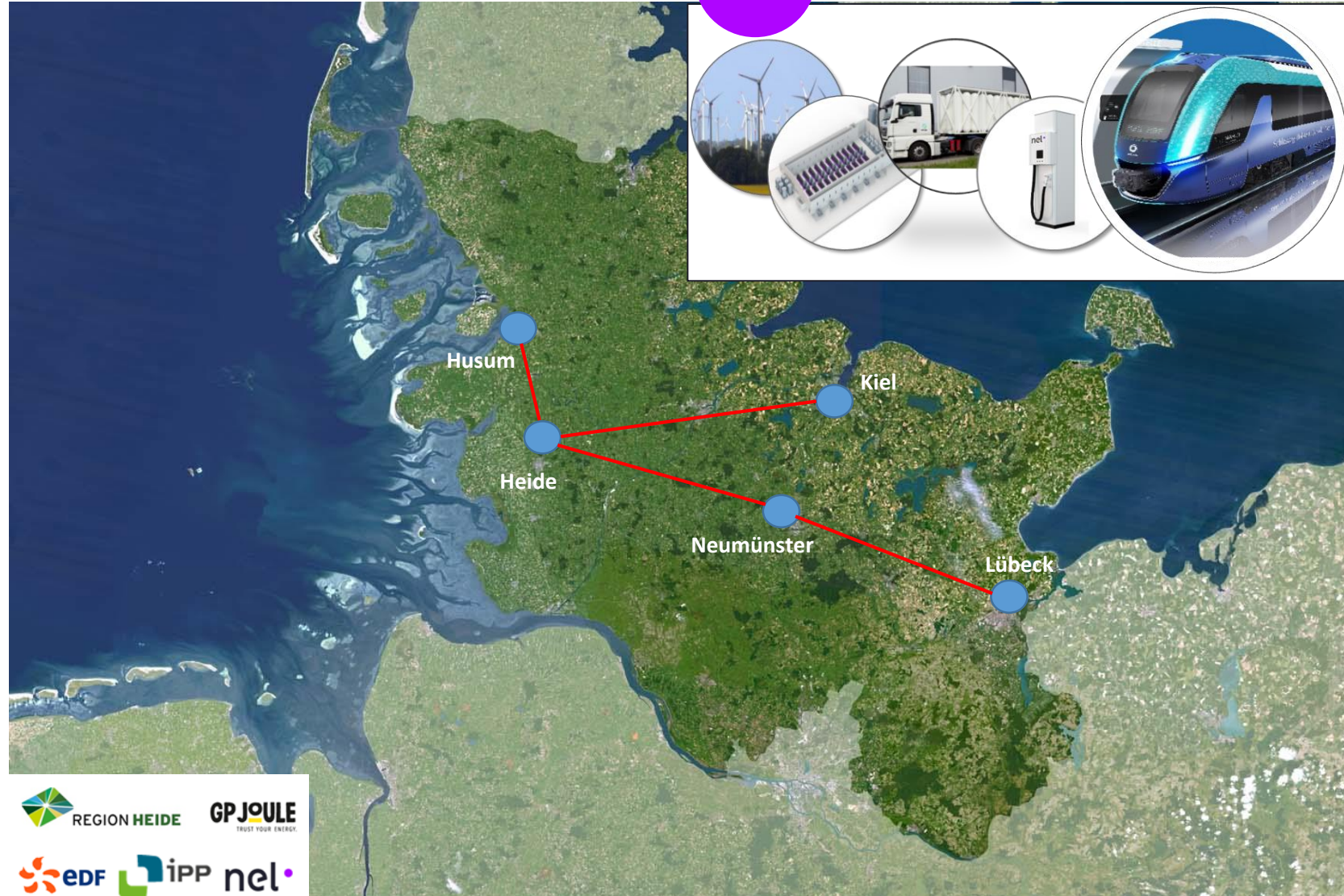
- 100% green hydrogen production by centralized electrolysis plant situated near Heide, in Schleswig-Holstein
- Produced via local renewable energy
- 7-10 T/day supply for 56 Trains

## Flexible distribution setup

- Pre-compressed hydrogen distributed by truck in 50/70MPa swap containers – flexible logistics ready for further scale

## Compact fueling equipment at stations

- State-of-the art hydrogen fueling equipment located at train stations in Husum, Kiel, Neumünster and Lübeck



2

# FREE HEAVY-DUTY LONG-HAUL TRUCKS





- 100% ZERO TAILPIPE EMISSIONS
- 100% ELECTRIC DRIVE
- HYDROGEN POWERED
- 750 km - 1,200 km RANGE
- AUTONOMOUS CAPABILITIES
- 2,000 FT. LBS TORQUE
- 1,000 HORSEPOWER
- 125kW-250 kWh BATTERY
- 240 kW FUEL CELL





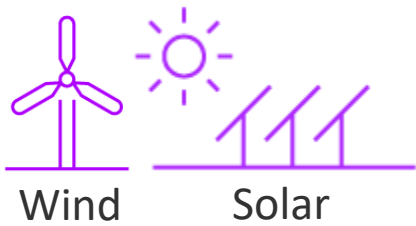


**Nikola Motor Company** @nikolamotor · 1 t

Behold, the Nikola Tre (Three). The Tre is to enter production by 2023. Come see it in person at Nikola World 2019. Europe, here we come and here we come fast. This thing will out pull most every diesel in its class [nikolamotor.com/tre](http://nikolamotor.com/tre) #dieselisdeal #emissionsgameover

# NEL + NIKOLA: Zero emission – Zero compromise

- Solution for green hydrogen production and fast refueling of hydrogen at MEGA stations
- Zero emission fuel and freight based on renewable energy: same convenience and higher performance



Wind

Solar



## Electrolyzers

Hydrogen production  
A-3880 - 8T/day



## H2Station®

Hydrogen fueling  
80 kg / 10 min



© Nikola Corporation



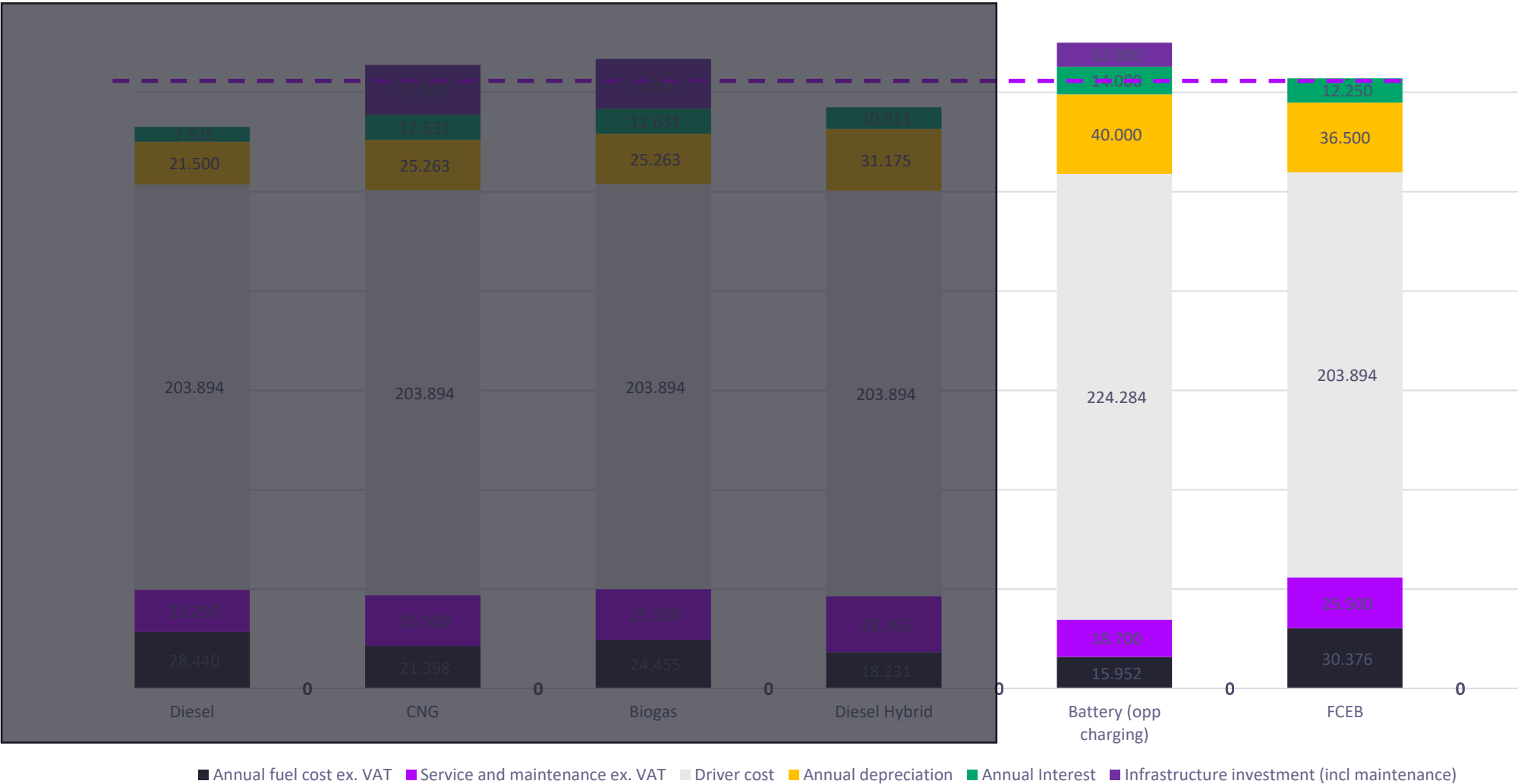
# H2Bus Europe

3

# H2Bus Europe – H2Bus TCO

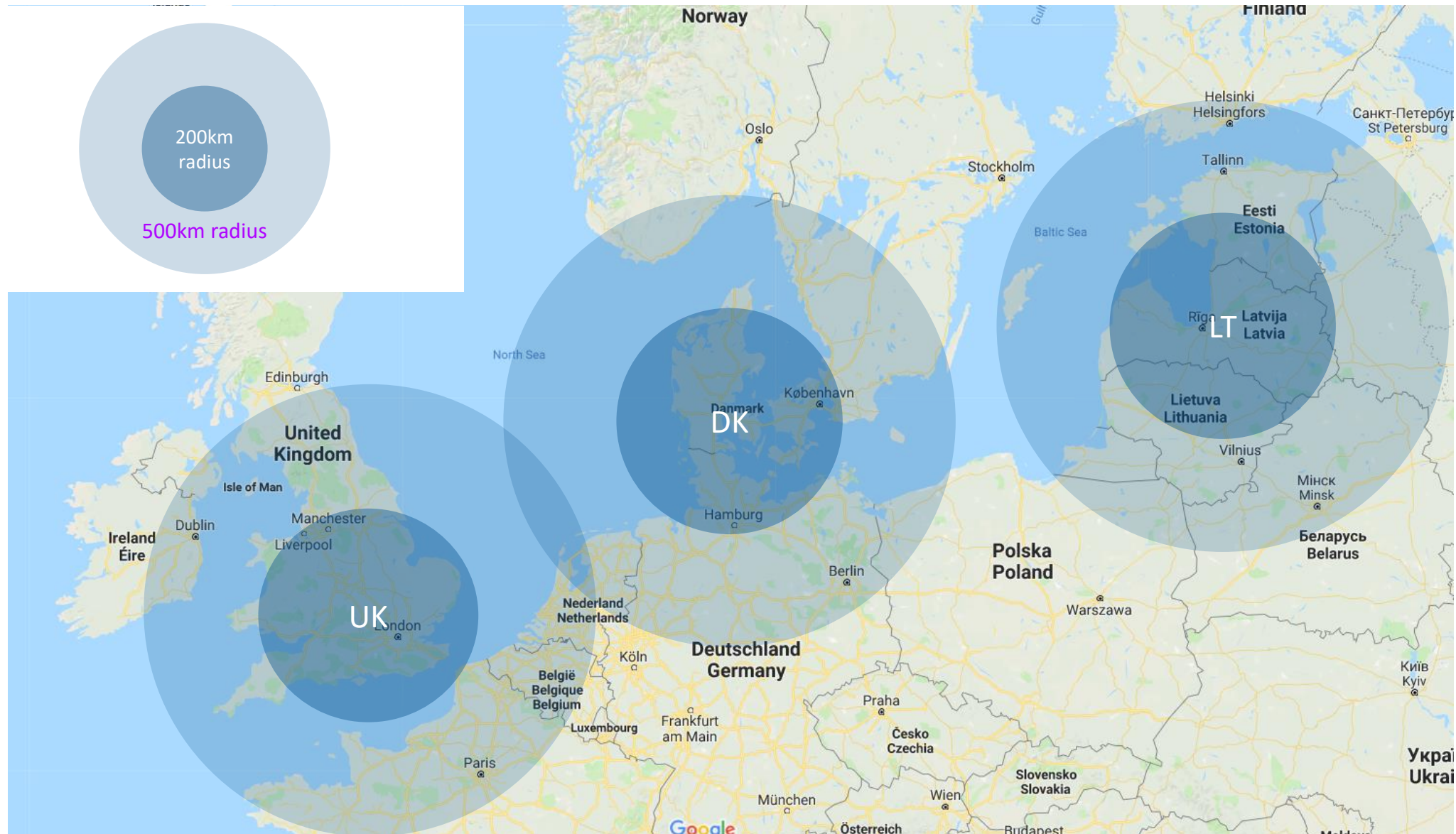
Assumptions – H2Bus Europe targets

TCO comparisson



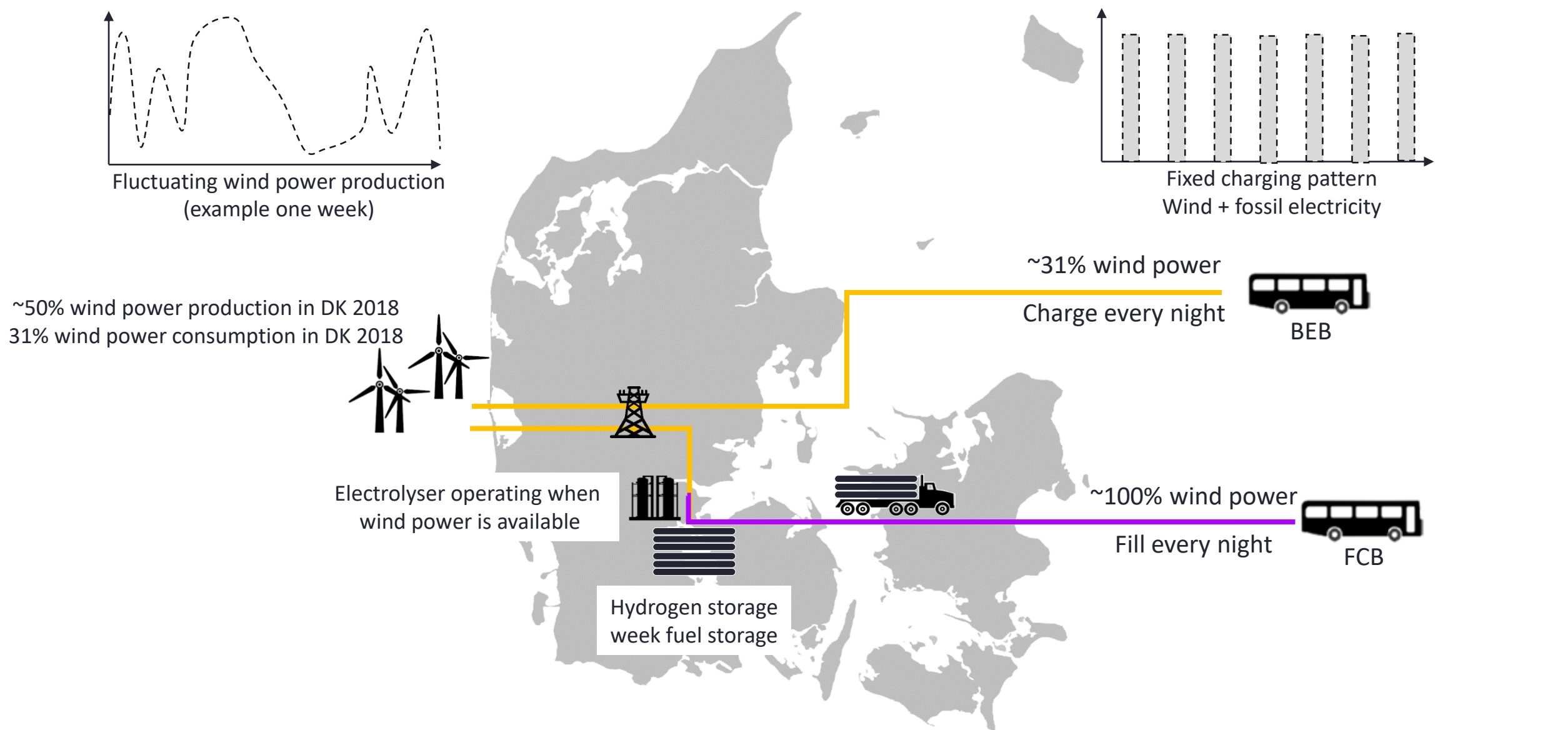


# H2Bus Europe – location of hubs





# Hydrogen: The true renewable fuel



FUEL CELL BUS PERFORMANCE ✓

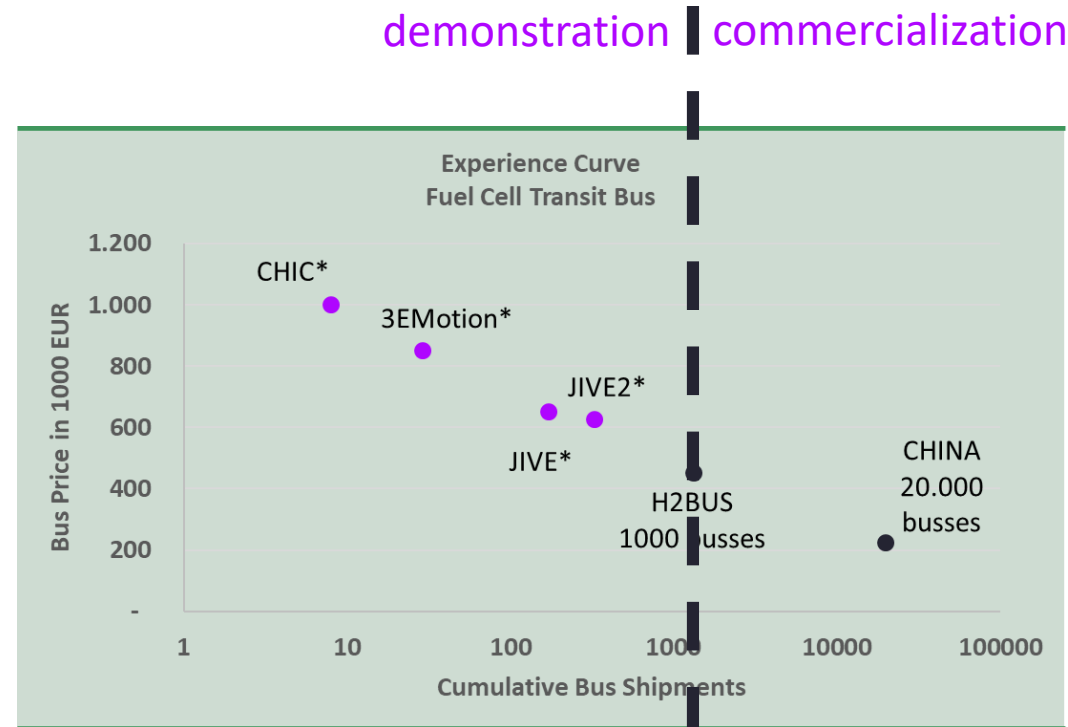
MAINTENANCE ✓

H2STATION RELIABILITY ✓

COST OF FC BUS (@ SCALE)

COST OF MAINTENANCE (@ SCALE)

COST OF HYDROGEN FUEL (@ SCALE)



\*CHIC: <http://chic-project.eu/> / \*3Emotion: <http://www.3emotion.eu/> / \*JIVE2: Upcoming

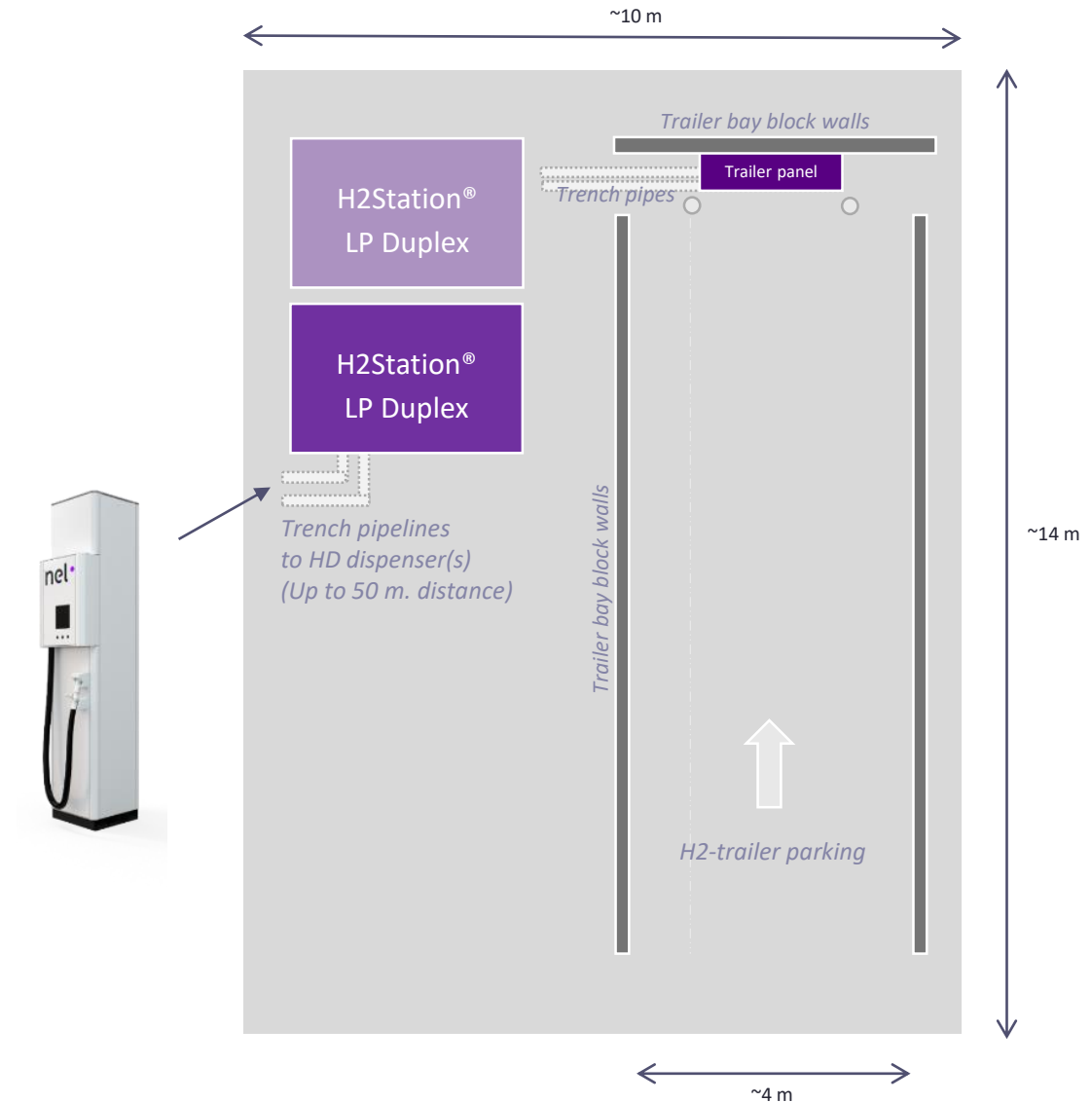
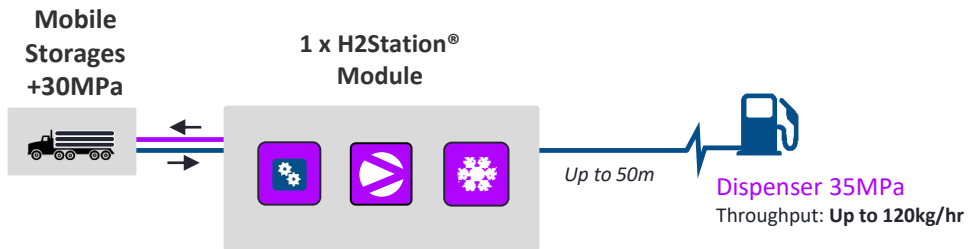
\*JIVE: <http://www.fch.europa.eu/project/joint-initiative-hydrogen-vehicles-across-europe>

# Small stations – services up to 20 buses at ~140 m<sup>2</sup>

## Nel Hydrogen<sup>®</sup> LP Duplex

Daily operations:

- One trailer, connected to trailer panel, integrated with H2Station<sup>®</sup>
- Intelligent controls and reloading between H2Station and trailers
- Once a trailer is depleted, it is easily replaced by the arrival of a new, full trailer
- Different H2-trailers and pressure ratings may be applied

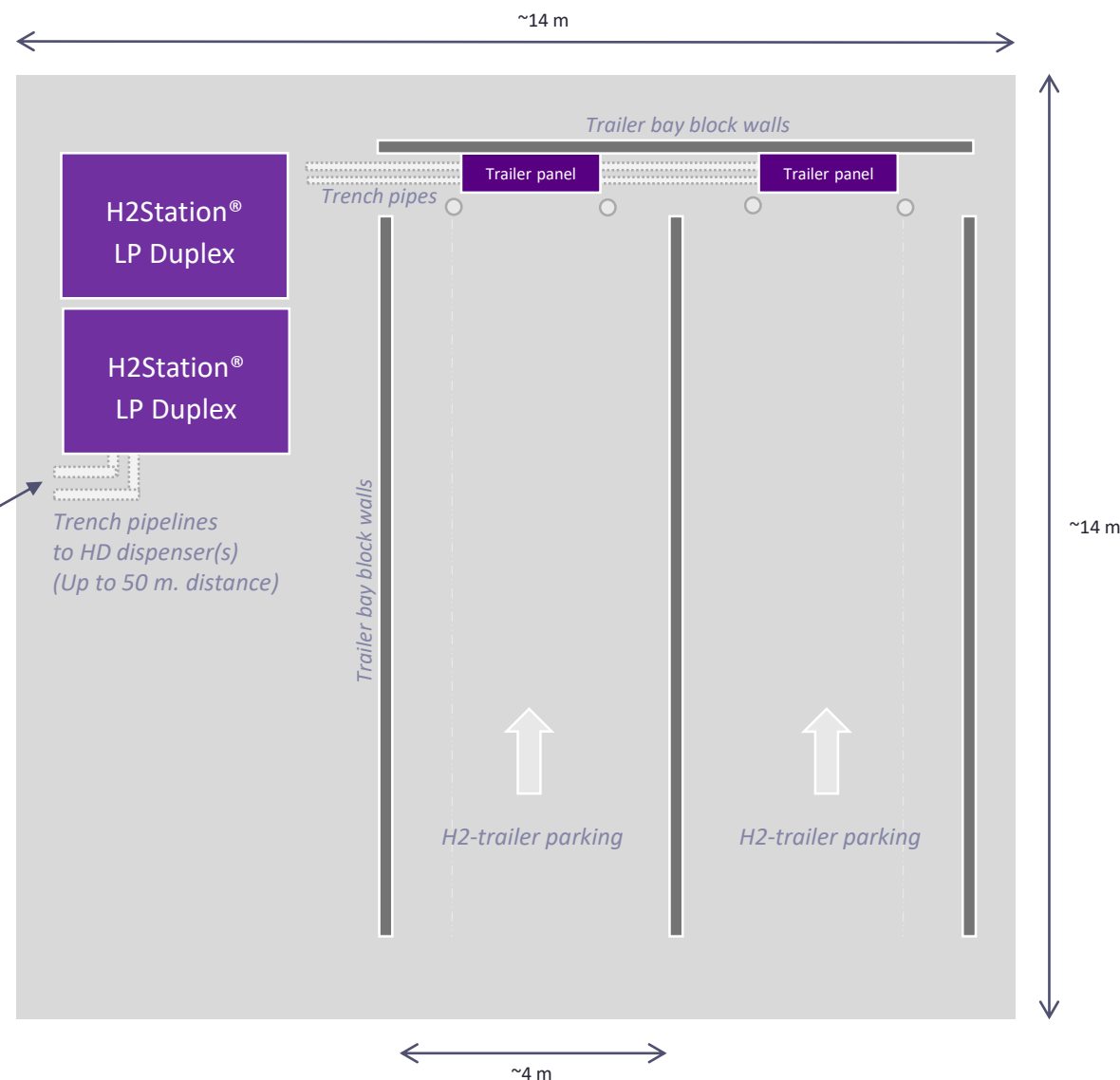
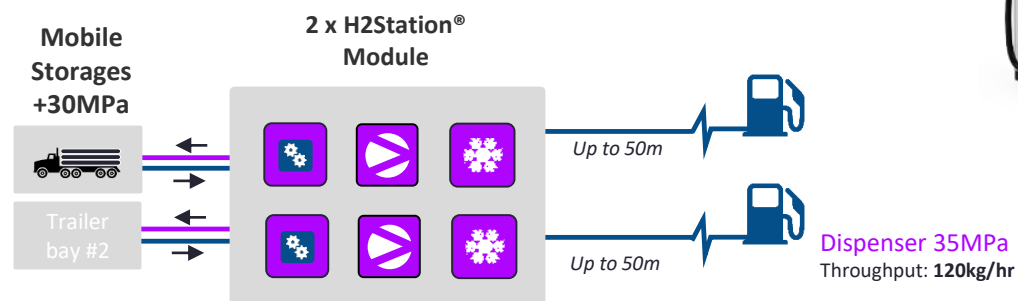


# Medium stations – services up to 50 buses at ~200 m<sup>2</sup>

## Nel Hydrogen® LP Duplex

### Daily operations:

- One trailer, connected to trailer panel, integrated with H2Station®
- Intelligent controls and reloading between H2Station and trailers
- Once a trailer is depleted, it is easily replaced by the arrival of a new, full trailer
- Different H2-trailers and pressure ratings may be applied

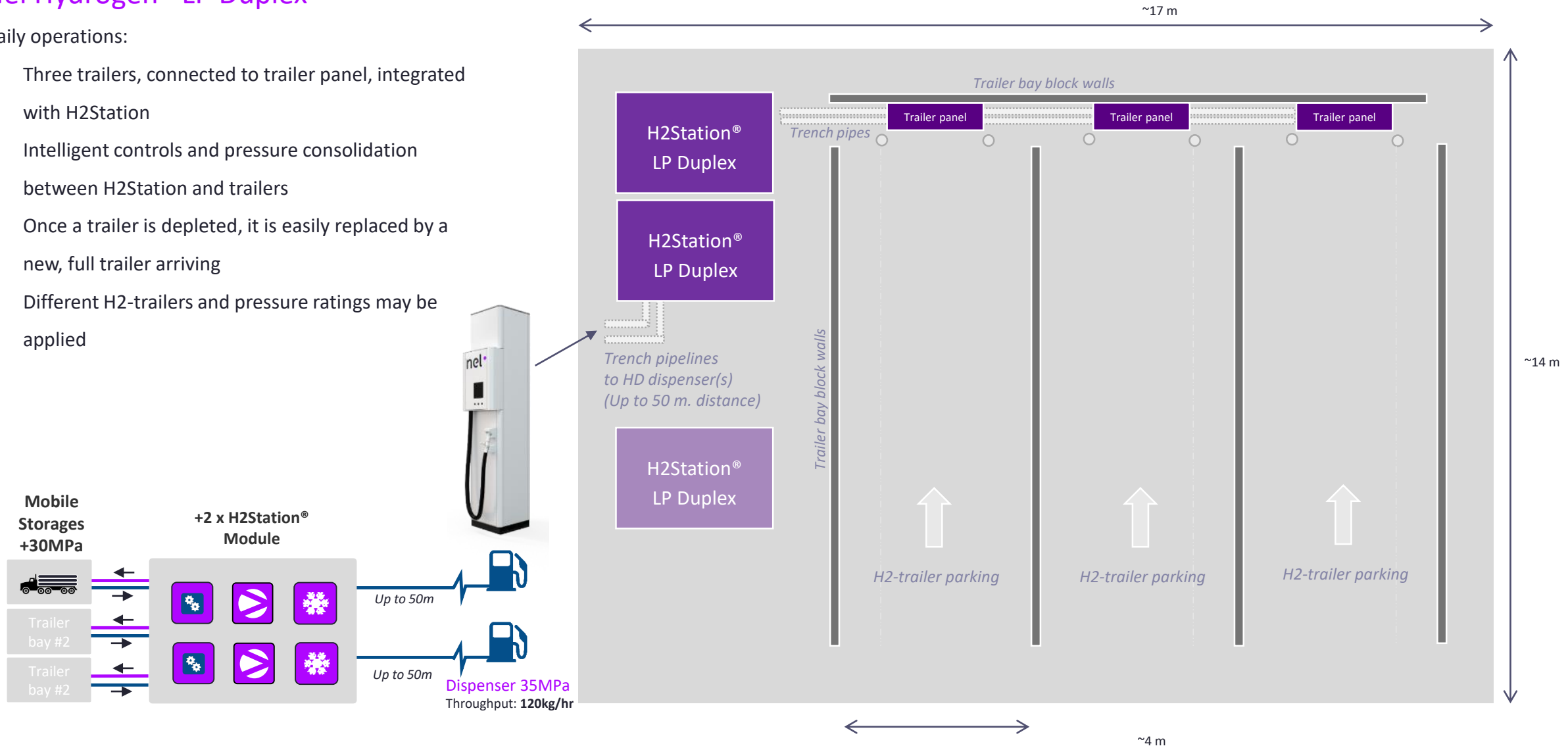


# Large stations – services up to 100 buses at ~240 m<sup>2</sup>

## Nel Hydrogen<sup>®</sup> LP Duplex

Daily operations:

- Three trailers, connected to trailer panel, integrated with H2Station
- Intelligent controls and pressure consolidation between H2Station and trailers
- Once a trailer is depleted, it is easily replaced by a new, full trailer arriving
- Different H2-trailers and pressure ratings may be applied



## Price examples for different fleet sizes\*

\* Prices are dependent on local factors

**10 buses**

**H2 price: 8.5 EUR/kg**



**50 buses**

**H2 price: 6 EUR/kg**



**100 buses**

**H2 price: 5 EUR/kg**



# Heavy duty Iceland

The next phase in Iceland?

**2.221 buses**

**20 kg/day**

**40 Ton/day**

**7.843 trucks**

**20 kg/day**

**150 Ton/day**

**589 taxies**

**3 kg/day**

**1,7 Ton/day**

**22.371 vans**

**3 kg/day**

**67 Ton/day**

**222.729 cars**

**0,5 kg/day**

**111 Ton/day**

## **IF ALL VEHICLES ARE INTENSIVELY USED:**

- 370Ton/day ~ 740MW Electrolyser
- 370MW Electrolyser if many vehicles are old or used less.
- 20MW project will be enough to make a case work.
  - 100 city buses
  - 100 trucks
  - 200 taxies



**Who is ready to move?**  
**..to make hydrogen business commercial**

**... let's go big**

**nel**•

Number one by nature

number one by nature