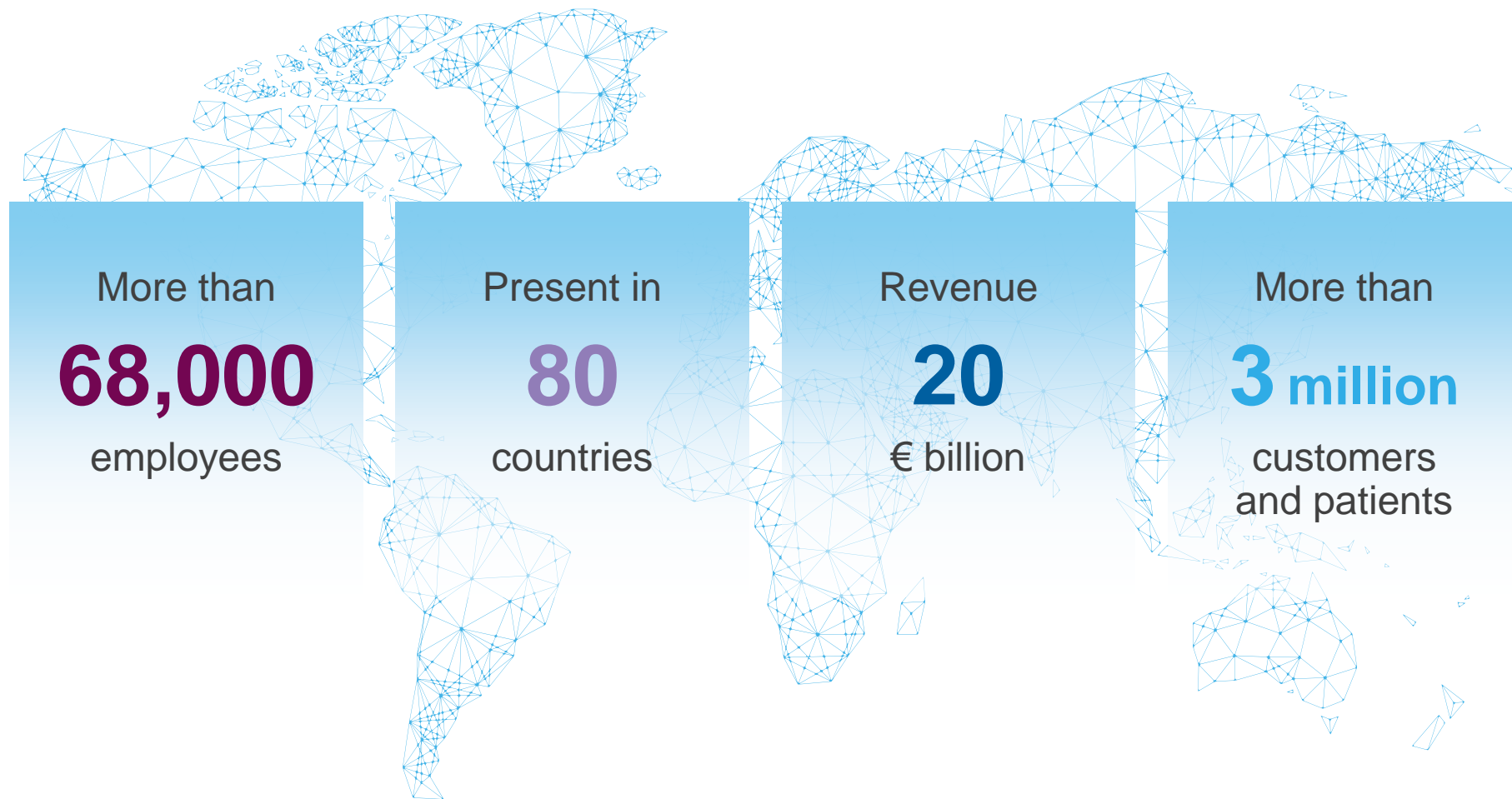


# H2 Mobility In Denmark HyBalance project

Air Liquide aB&T / HyBalance Inauguration / February 13th 2017



# Air Liquide key figures 2015



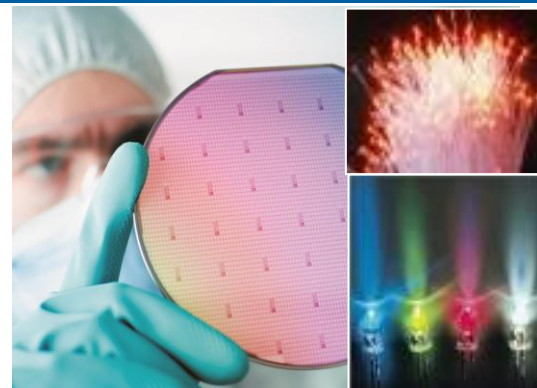
# Hydrogen, many existing applications...



Heat Treatment



Glass



H<sub>2</sub> Ultra pure  
<1ppb



Chemicals &  
Petroleum refining



Rockets



Fuel cell vehicle



# Global climate change crisis



**Must reduce emissions  
of CO<sub>2</sub> and CH<sub>4</sub>**

**Regulation & Financing**



**PARIS2015**  
UN CLIMATE CHANGE CONFERENCE  
COP21-CMP11

Europe

**-80%**

GHG emissions by 2050

Japan

**-80%**

by 2050

U.S.

**-28%**

by 2030

China

**20%**

Non-fossil by 2030

# Everything we do leads to CO<sub>2</sub>- free H<sub>2</sub> mobility

**50% of H<sub>2</sub> energy  
from carbon-free processes by 2020**

A commitment to meet  
both **environmental requirements**  
and **economic constraints**

## Achieving “Blue H<sub>2</sub>”

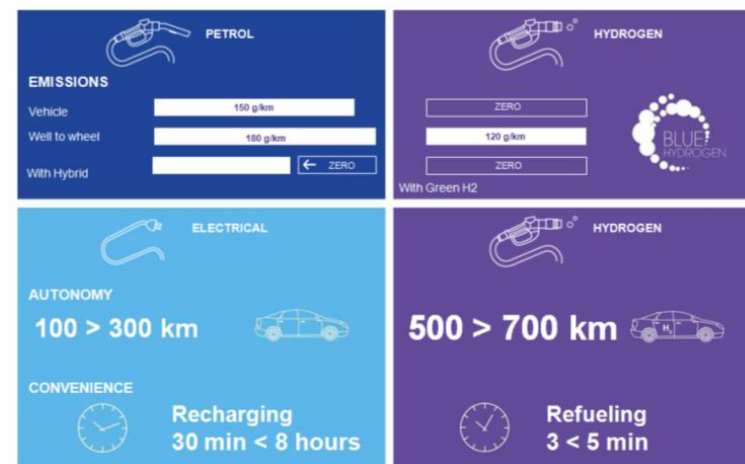
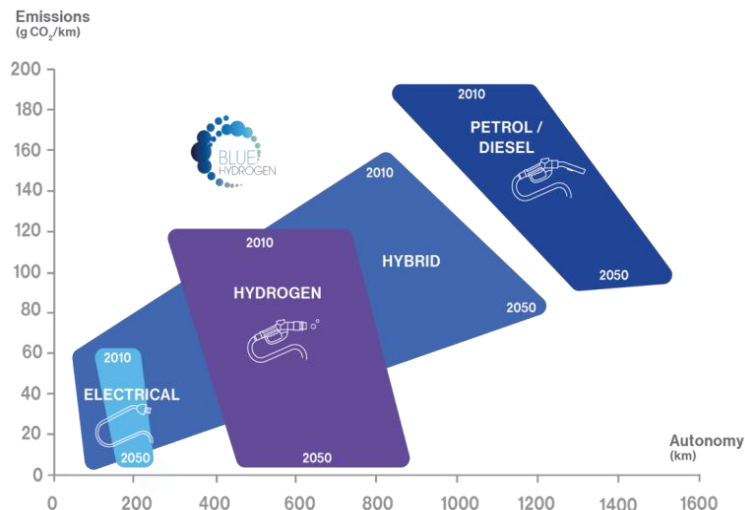
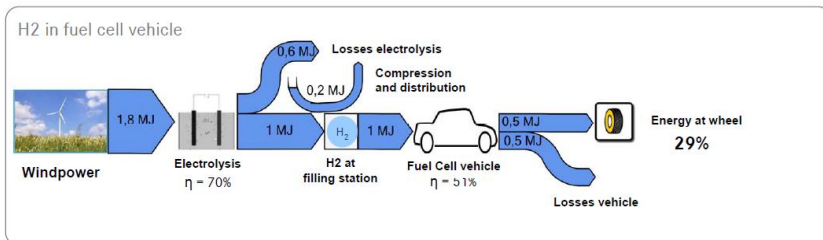
1. Natural gas reforming + CCS
2. Water electrolysis (renewable, nuclear)
3. Biomass gasification
4. Biogas reforming



# Power mix and GHG reduction in the Transport

- The increasing share of green power with excess of production during windy off-peak periods is a good opportunity to reduce GHG in the mobility sector

➔ **Power to H2 → A consistent Value chain Fuelling FCEVs**



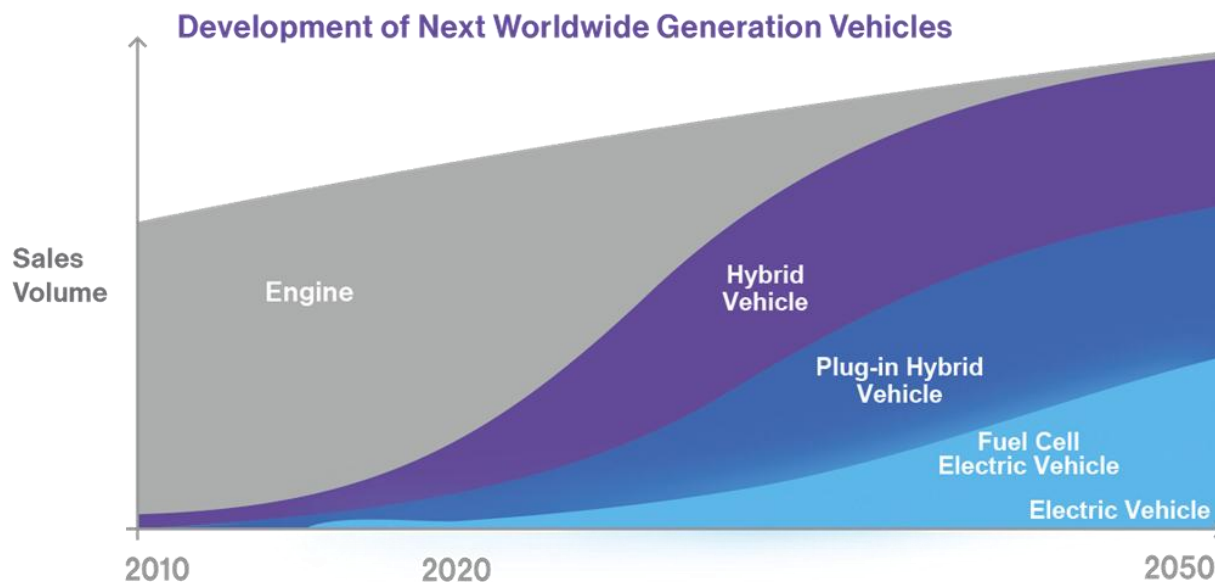
# The engine revolution favours H<sub>2</sub>...

## By 2050, 1 in 4 of us

will already be driving a Hydrogen energy car.  
Hydrogen will be on every corner like  
petrol is today.



DAIMLER



Source: Toyota

Electrification of  
vehicles will help  
transitioning towards  
Hydrogen FCEVs

# Pioneering innovative H<sub>2</sub> mobility projects worldwide

## Air Liquide Hydrogen Stations

75

delivered  
*end 2015*

12

invested and operated  
by Air Liquide in 2015

26

in 2017

40

in 2017



America



Europe



Asia



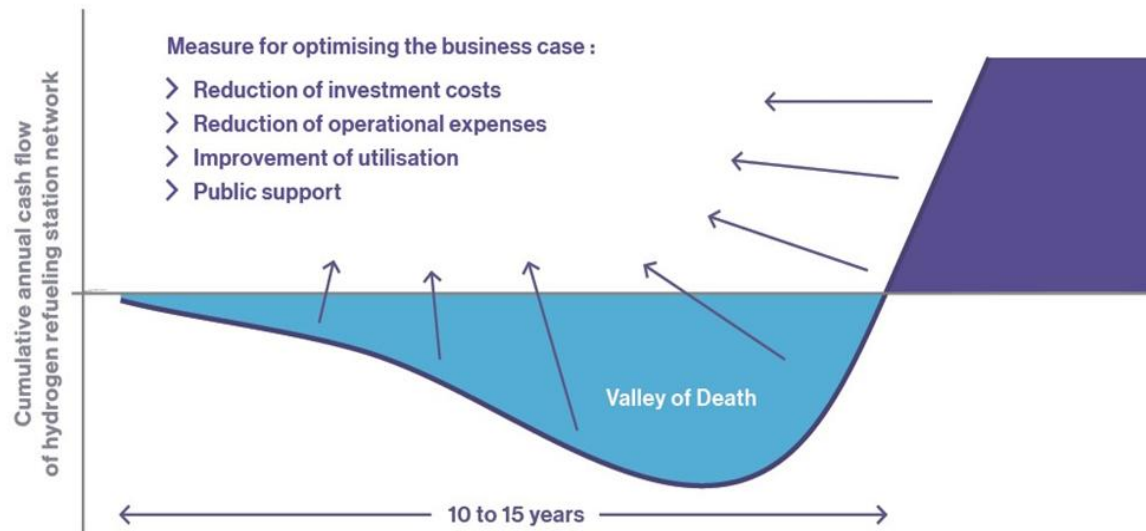


# We are finding solutions to infrastructure challenges

## Main issue

- Under-utilization of Hydrogen Stations and **“Valley of Death”** periods

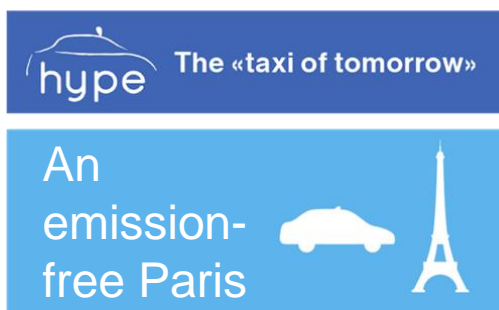
### H2 Station – cash flow curve



Source : IEA, H2 roadmap 2015

# Innovative business models to accompany new usages...

## Captive fleets are catalysts for take-off



**Targeting  
70 taxis**

by the end of 2017

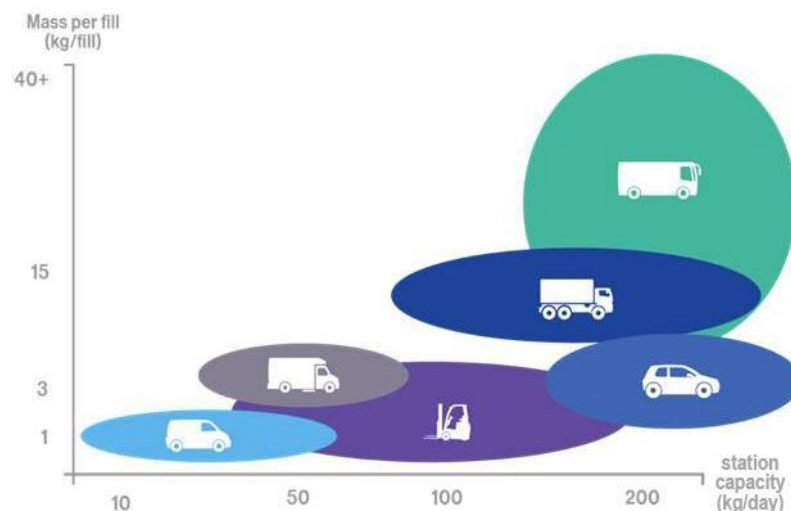
**and 600**

within 3 years

Speeding-up energy  
transition for taxis



## Captive fleet niches: buses, light commercial vehicles, taxis



Value is created by mutualising Hydrogen Stations infrastructure with private users

# Established in the Nordics since 1906

- Specifically in Denmark, Air Liquide;
  - More than 150 employees
  - A 50 M€ turnover
- *Since 2014, Air Liquide has decided to invest in Denmark's clean transportation sector, more specifically in Hydrogen (H<sub>2</sub>) mobility, because of Denmark pioneering in Renewable energy development, its 100% fossil fuel 2050 independence target & its specialized H<sub>2</sub> cluster of enterprises.*
  - Copenhagen Hydrogen Network ⇒ 10M€ investment
  - Hybalance Project ⇒ 15M€ investment

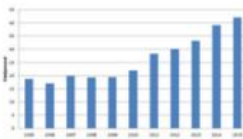


# An attractive force → Denmark walking the talk

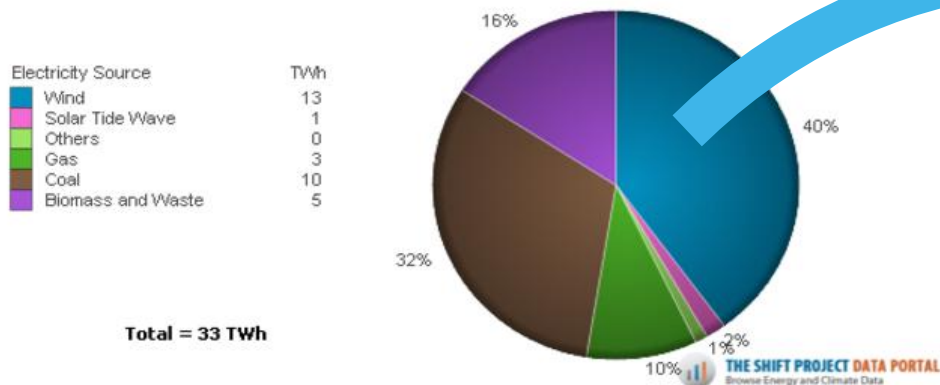
## The energy system is changing

Europe is in the middle of a historic transition of the energy system  
- Denmark has a leading position

- By 2020, wind power must constitute 50% of the electricity consumption  
In 2015 it constituted 42%.
- By 2050, Denmark must be 100% fossil-free.



Electricity Production  
from All Energy Sources in 2014 (Denmark, TWh)



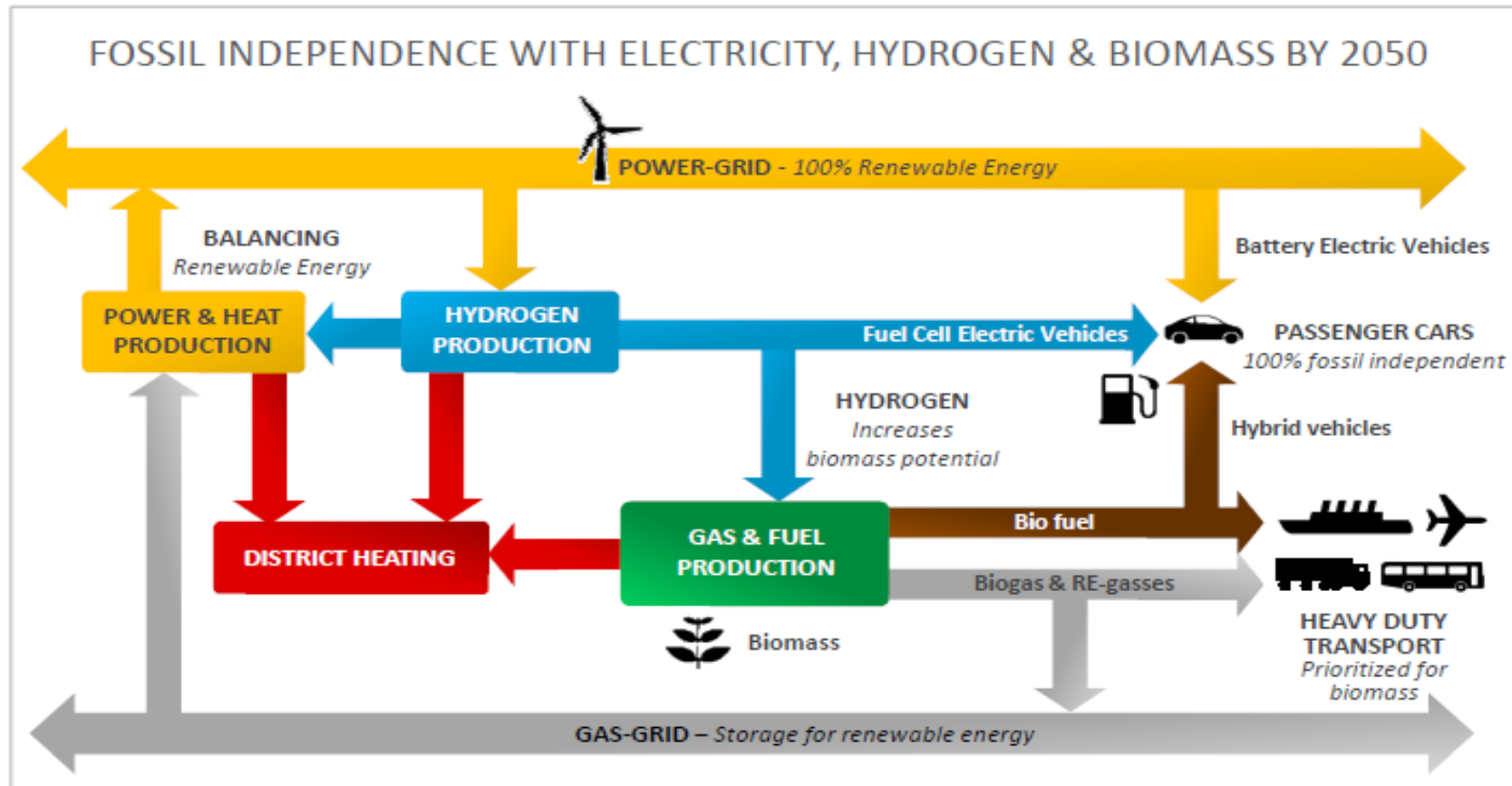
→ The need for energy storage will become more & more important





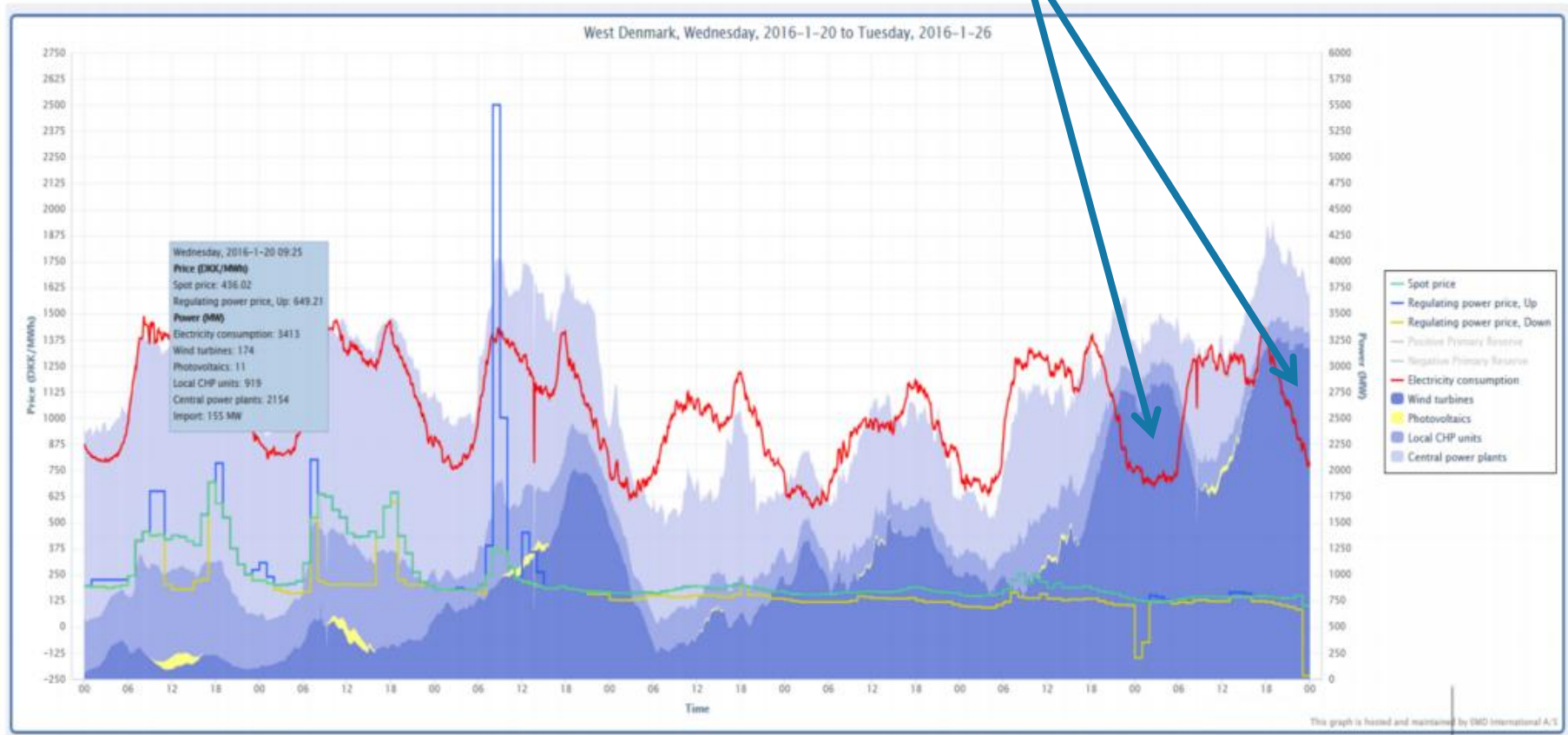
# An attractive force

## Danish goal: 100% fossil independence by 2050



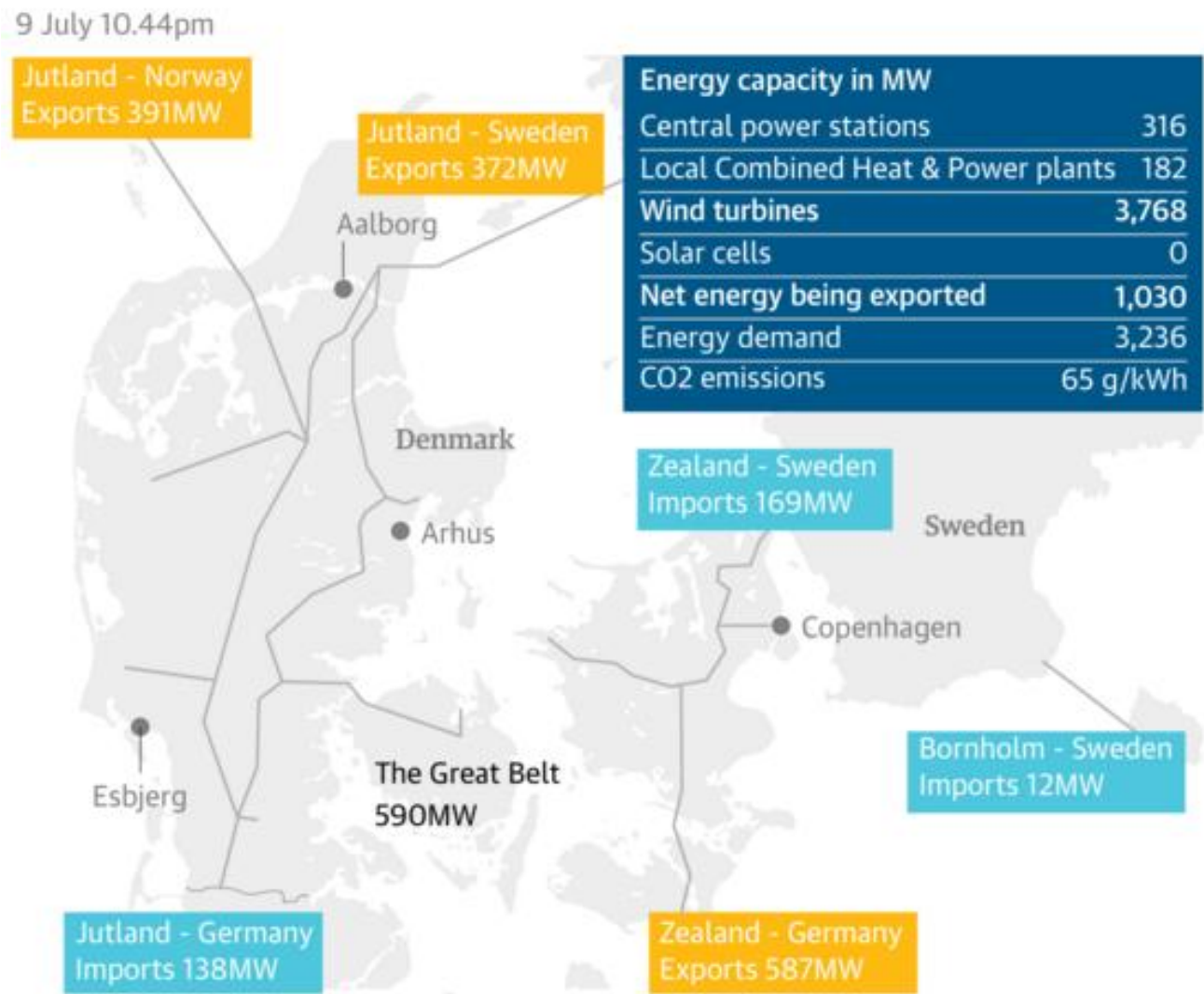
# Some illustrations

- A week in the spot and regulating markets in Denmark West (DK1))
  - January 2016
  - Excess of production during windy off-peak periods



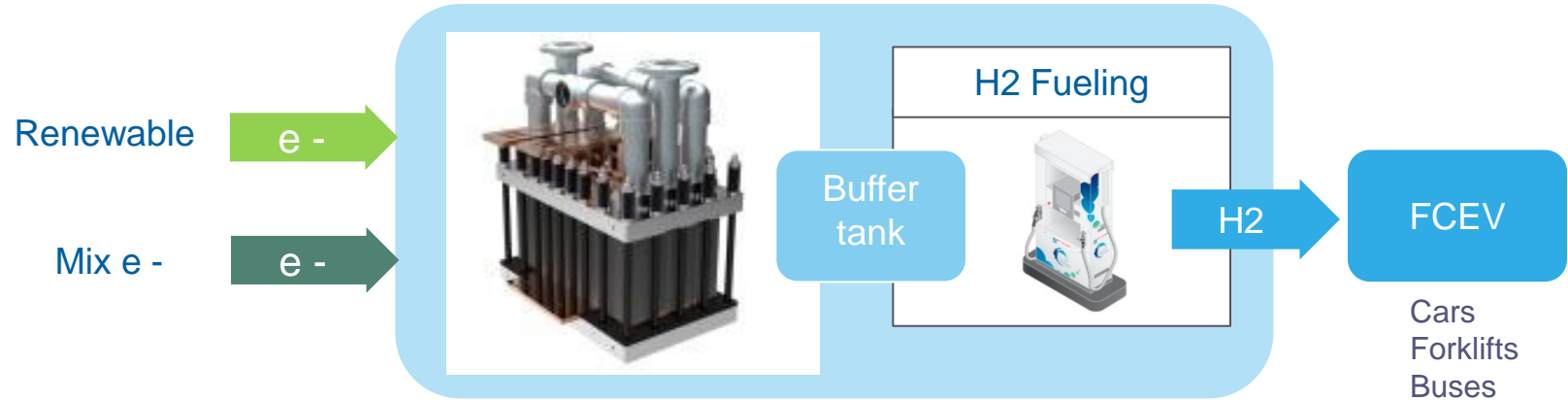
# The surplus are exported, but at low price

- On 2015/07/09, Denmark found itself producing 116% of its national electricity needs from wind turbines, and by 3 AM the next morning (Friday), when electricity demand dropped, the **figure had risen to 140%.**

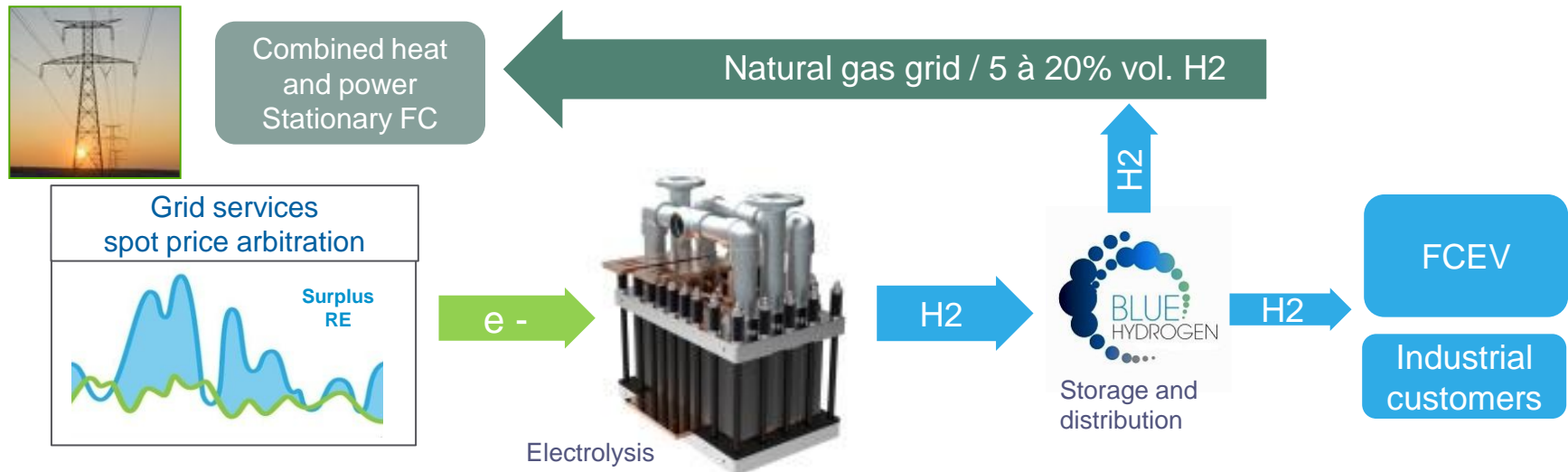


# Power to H2 – distributed or semi-centralized

## Distributed water electrolysis + H2 refueling station



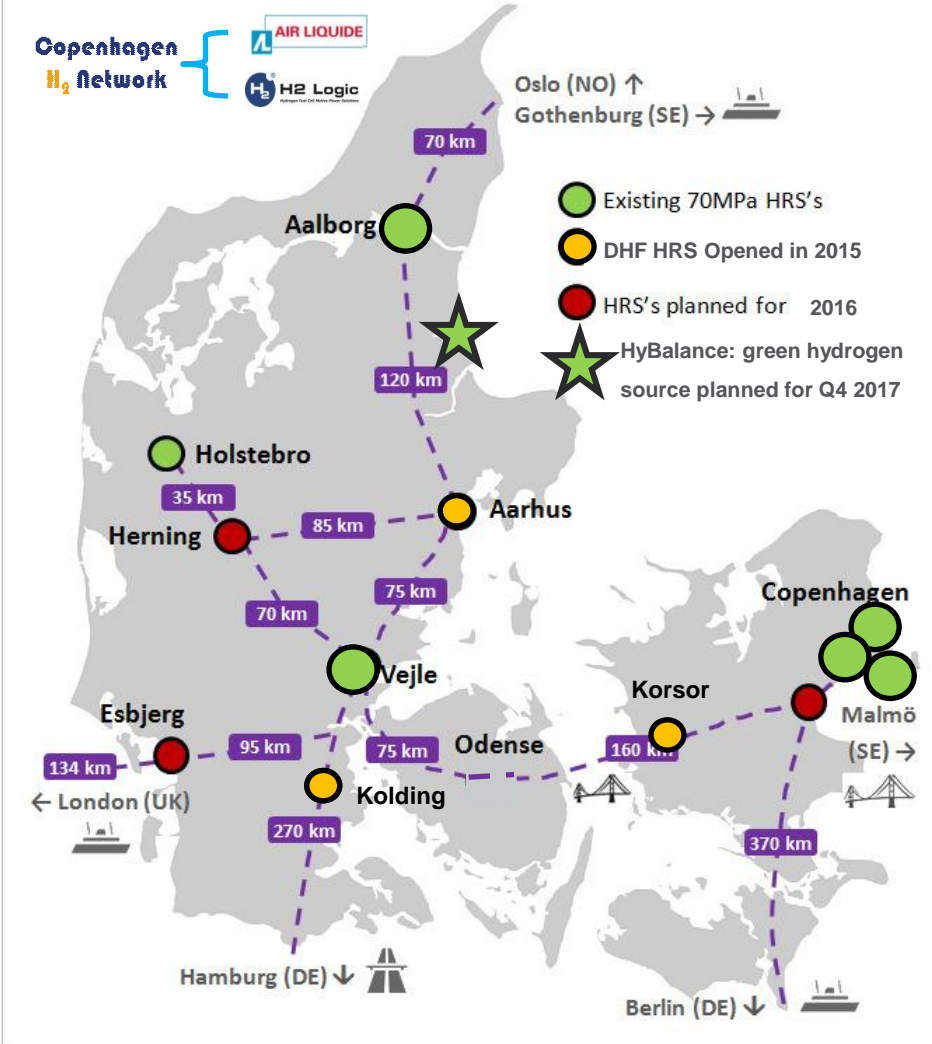
## Semi-centralized electrolysis





# Our involvement in Denmark → CHN

## Country-wide HRS network by 2015 | DENMARK



## Key figures

- Five (5) 700 b charging stations across Dk
- All stations fed with on-site electrolyzers
- Investment: ~ 10 M€ total**
- European & Danish Funding

# Implementing today tomorrows integrated energy systems

## ■ National HRS network already in place

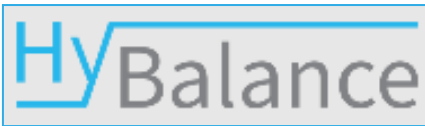
- More than 10 operating HRS
- 5 HRS operated by CHN, a JV between Air Liquide and H2-Logic.

## ■ Significant Government support

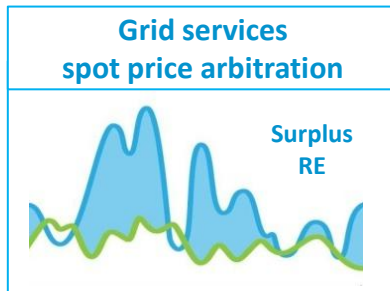
- For the development of renewables → 42% Wind penetration
- FCEV commitments through 2019 with tax exemption, one of the World's highest FCEV incentive

➔ Denmark is at the forefront of the energy transition. It is a key country to demonstrate the interest of fueling fuel-cell cars with the excess of wind power stored as hydrogen.

# HyBalance: an industrial demonstrator



<http://hybalance.eu/>

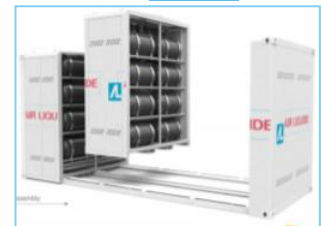


1,25 MW PEM Electrolyser

H<sub>2</sub>



H<sub>2</sub>



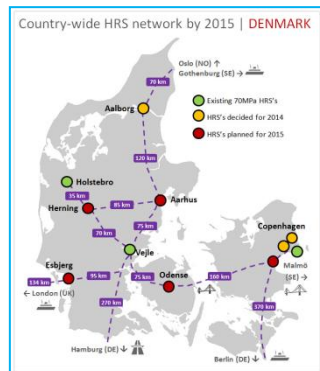
200bar – 700 bar  
Conditioning center

H<sub>2</sub> @ high pressure

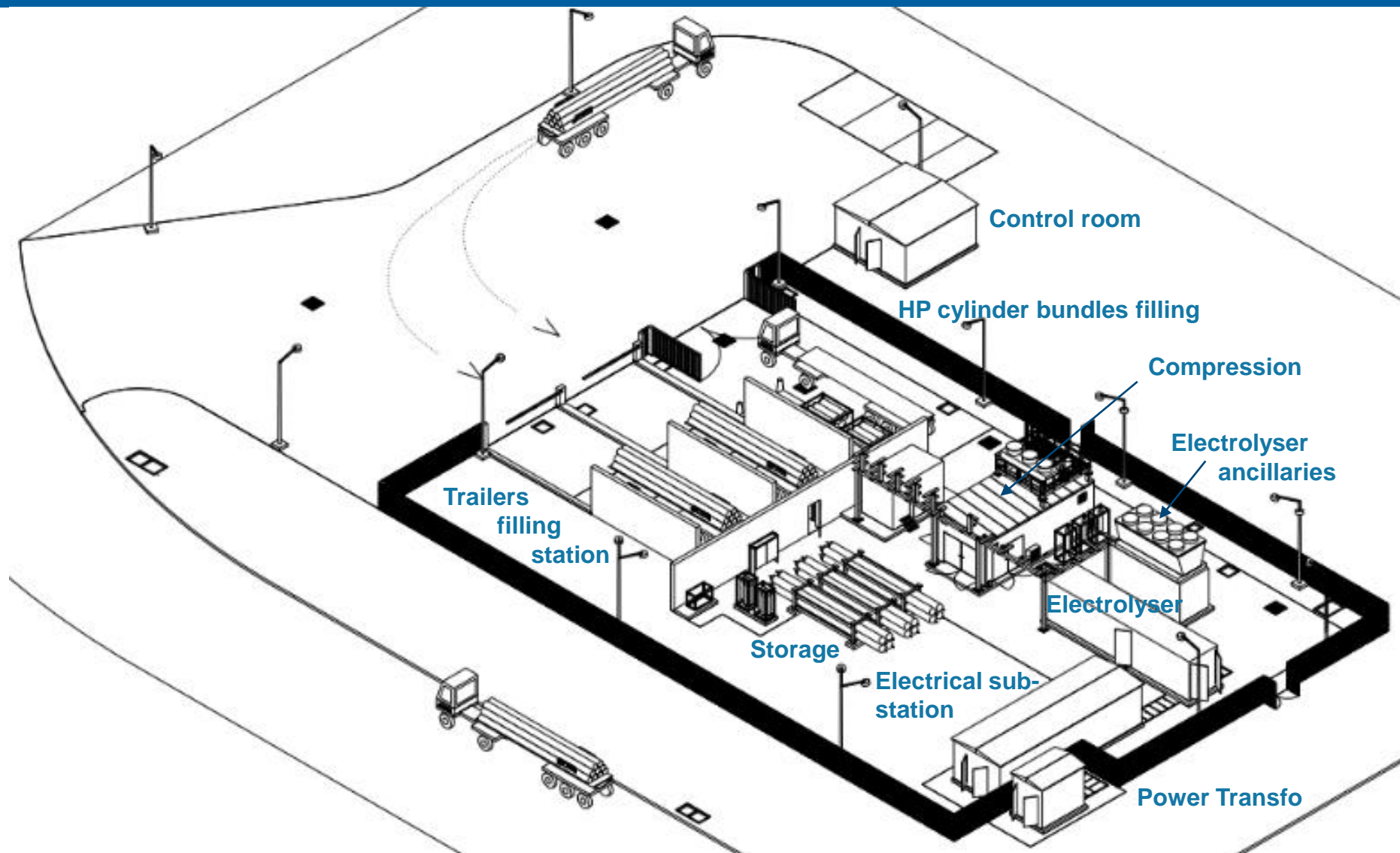
- HRS capacity → 50 to 100 kg/d
  - On-site Electrolyser
  - 700 b supply
- Complete Wind to H<sub>2</sub> supply chain



Refueling stations



# HyBalance layout





# Hybalance project details

- Power to Hydrogen project in Hobro
  - ▣ 15M€ investment
  - ▣ Operations: 5 permanent jobs
  - ▣ Construction works – 1 year:
    - 15+ direct & 25+ indirect jobs
- European Funding: FCH2 JU
- Danish Funding: ForskEL
- Main partners:
  - ▣ Air Liquide / CHN: investor & operator
  - ▣ Hydrogencis: PEM electrolyser
  - ▣ Air Liquide Engineering & Construction: EPC of the plant
  - ▣ Hydrogen Valley: dissemination and local H2 development
  - ▣ NEAS: Grid balancing services and power trading ; LBST: life cycle analysis
- Timeline

Start-up in October 2017

CONSTRUCTION & TESTING

COMMERCIAL OPERATIONS (15 years)

HyBalance-DK – ForskEL

Dec. 2017

HyBalance – FCHJU

Sept. 2020



**Minister cut first sod** April 4th, 2016 the Danish Minister for Energy, Utilities and Climate, Lars Chr. Lilleholt cut the first sod for the facility that will deliver hydrogen from 2017 as part of the HyBalance project. The plant is to be located near Hobro in the Northern part of Denmark. Hydrogen is an important technology that Denmark will focus on going forward, the minister said.

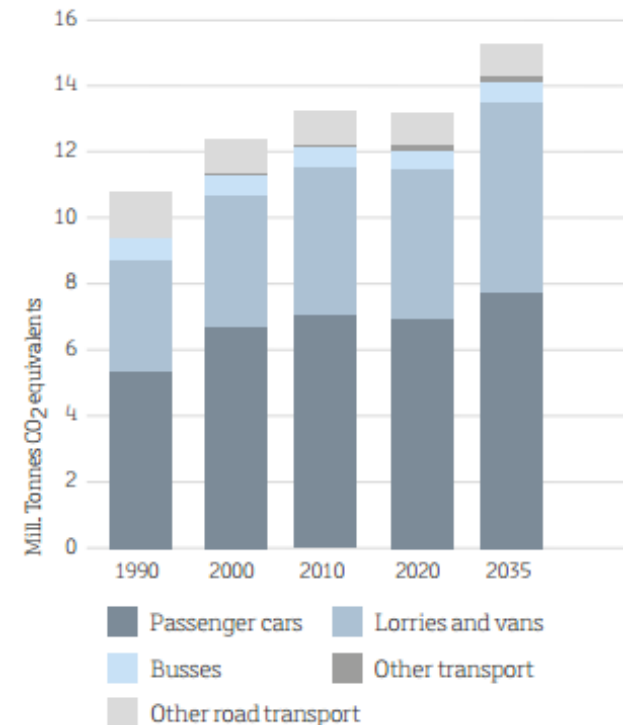
# The construction phase has started in January



# HyBalance contribution to transport GHG ↘



- Projections are showing a continuous growth of the emissions in the transport sector
- In the period 2010 to 2020, the passenger cars represent around **7 Mio tons CO2 equivalent**
- HyBalance is capable of **a fleet of more than 1 200 FCEV**
  - ▣ assuming 1kg H<sub>2</sub> / 100km & 12 500kms/ y per FCEV
- From green electricity to H<sub>2</sub> cars via HyBalance, **145 g CO<sub>2</sub> / km** can be avoided
- It represents:
  - ▣ 2 175 tons / year of CO<sub>2</sub> avoided
  - ▣ 0,03% CO<sub>2</sub> reduction of the overall GHG emissions from passenger cars



Source: The Danish Climate Policy Plan  
August 2013

# Working on resolving the key Challenges

## ■ Hybalance / CHN Project needs:

- FCEV tax exemption reconduction ✓ Done on October 10th 2015
- PSO exemption ✓ Progressive diminution starting in 2017 and full exemption in 2022

## ■ Current challenges

- Even if FCEV tax exemption have been reconducted, since the beginning of the year FCEV's sales are flat → 65 FCEVs.
- Need to debottleneck situation, some suggestions:
  - Company car taxable benefits exemption for FCEVs
  - Develop bus, taxis project/s or other fleet projects
  - Additional qualitative incentives: Free parking &/or Bus lane access



Thank you for your attention

