

PNE AG

**Conversion and storage
of electric power**

Warsaw, June 21th, 2018



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WHO WE ARE

WE ARE A LEADING DEVELOPER OF WIND ENERGY PROJECTS...

- PNE Group, consisting of the companies PNE AG and WKN AG, is a leading wind farm developer located in Northern Germany
>2,600 MW realised onshore
- Germany's most successful project developer with **8 offshore projects sold totalling 2,852 MW**
- No 2 player in operations & management in Germany with **>1,500 MW under management**
- **> € 9bn euros** of investment done or initiated
- Active in **13 countries on 3 continents**

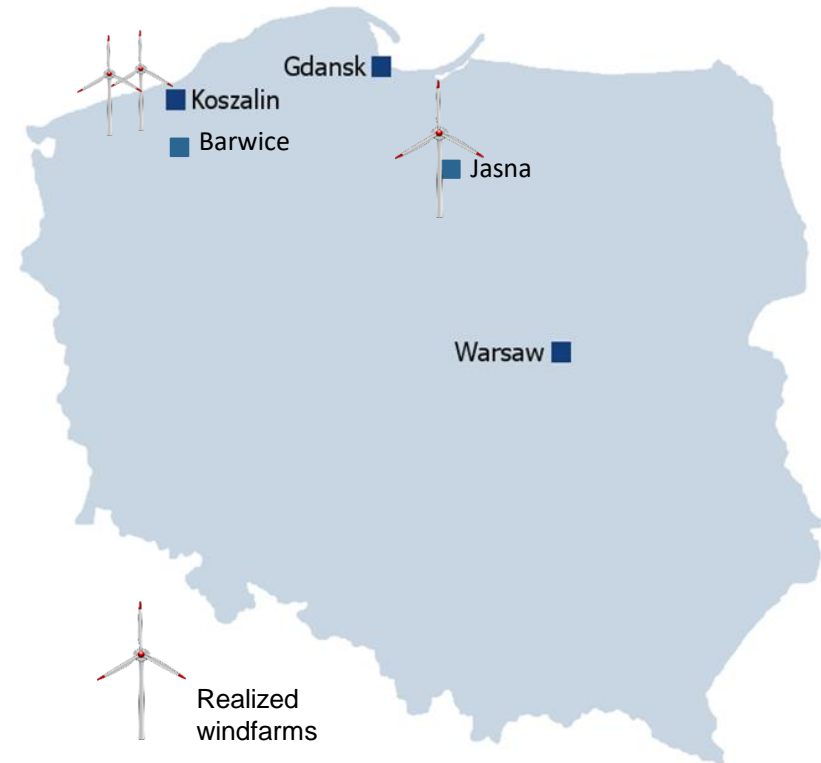


... WITH A STRONG MARKET POSITION – NATIONAL AND INTERNATIONAL

ACTIVITIES POLAND

WE HAVE A STRONG PARTNERSHIP WITH A LOCAL PLAYER

- WKN AG and the polish consulting engineer AOS have founded the joint venture Sevivon in 2007. Today offices in Koszalin, Gdansk
>151 MW realised onshore
(Karcino, Bardy, Linowo)
- Today two wind projects are at a late stage of development and are planned to be constructed in 2019 and 2020.
>174 MW ready to built
(Barwice, Jasna)
- Poland is a very interesting market for renewable energies with a large growth potential.
- WKN AG will continue to push project development activities in Poland.



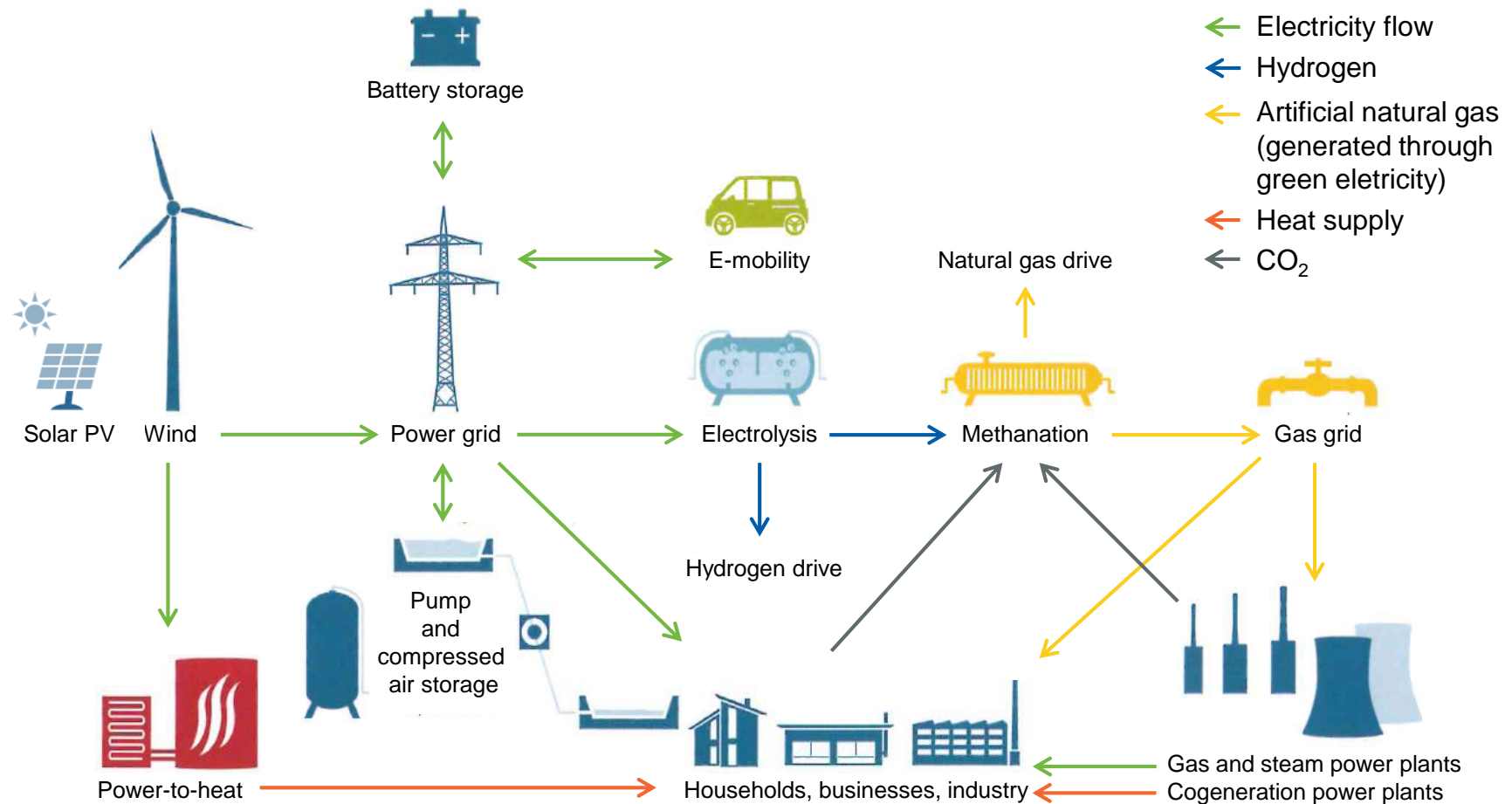


**Market
changes
create
challenges...**

**...as well
as huge
opportunities!**

MARKET & GROWTH DRIVERS

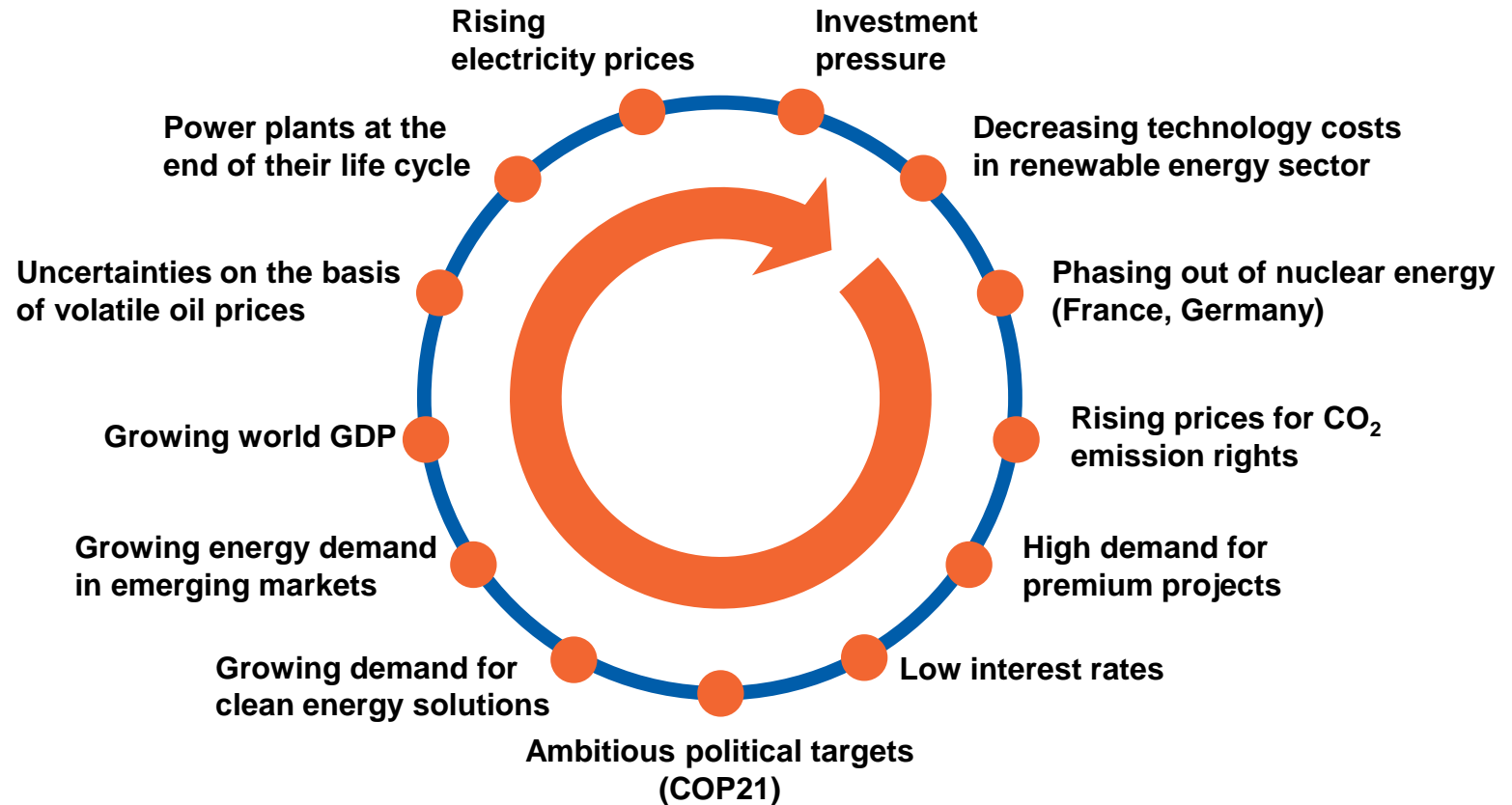
MARKETS BECOME MORE INTEGRATED...




Source: e/m/w 2017, PNE AG

MARKET & GROWTH DRIVERS

...BUT GROWTH DRIVERS ARE INTACT

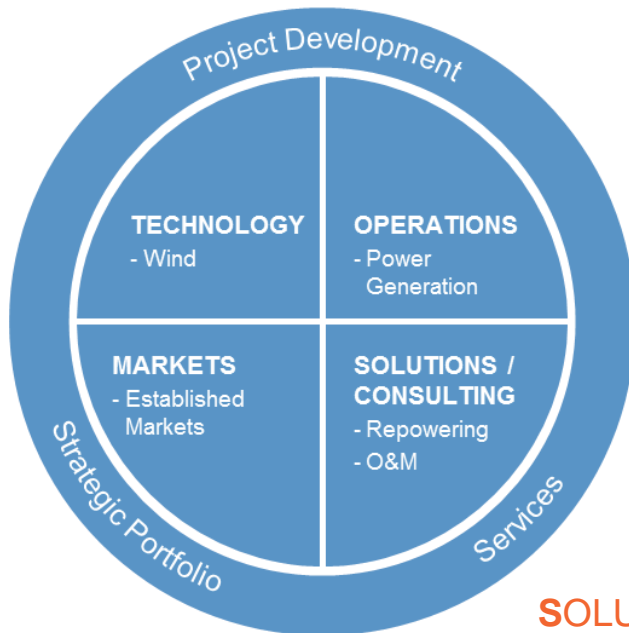


OUR ANSWER TO THE MARKET CHANGES:



We are adapting
to become a
**Clean Energy
Solution Provider**

WE SCALE UP OUR BUSINESS

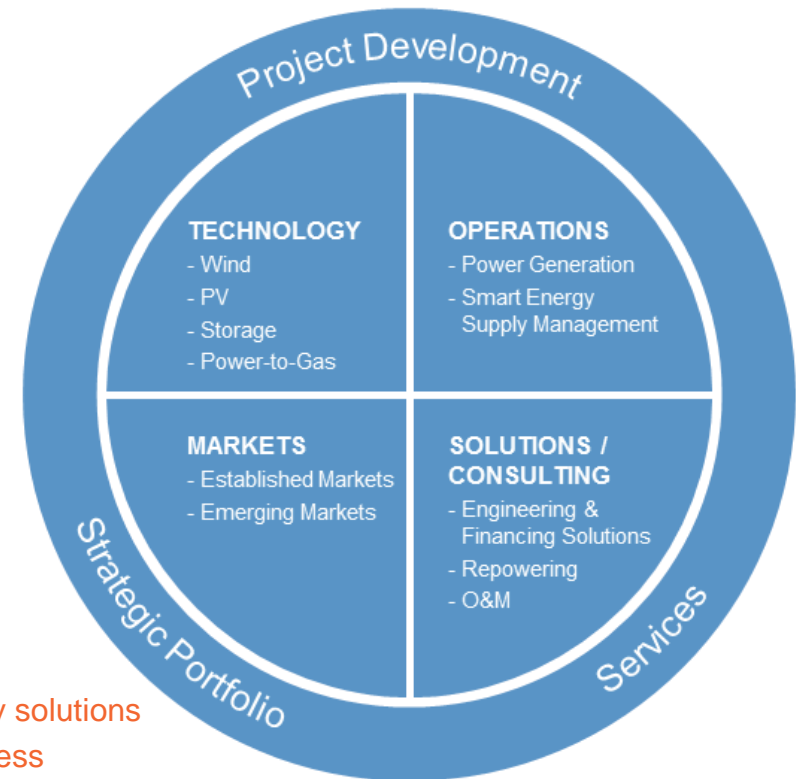


PROJECT DEVELOPER

We develop and implement wind farms onshore and offshore.



SOLUTIONS Provide clean energy solutions
CORE Grow our core business
ADAPT Optimize our structures
LEVERAGE Leverage our expertise
EXPAND Expand along the value chain



CLEAN ENERGY SOLUTION PROVIDER

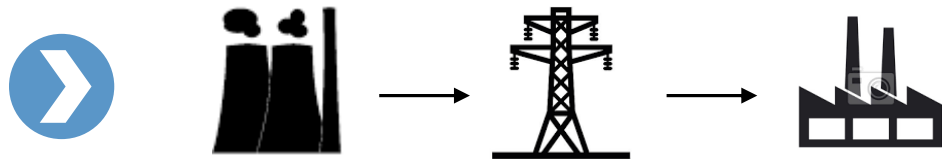
We develop and implement projects and solutions for the planning, construction and operation of renewable energy power plants.

CONVERSION AND STORAGE

WHAT DOES CONVERSION AND STORAGE MEAN?

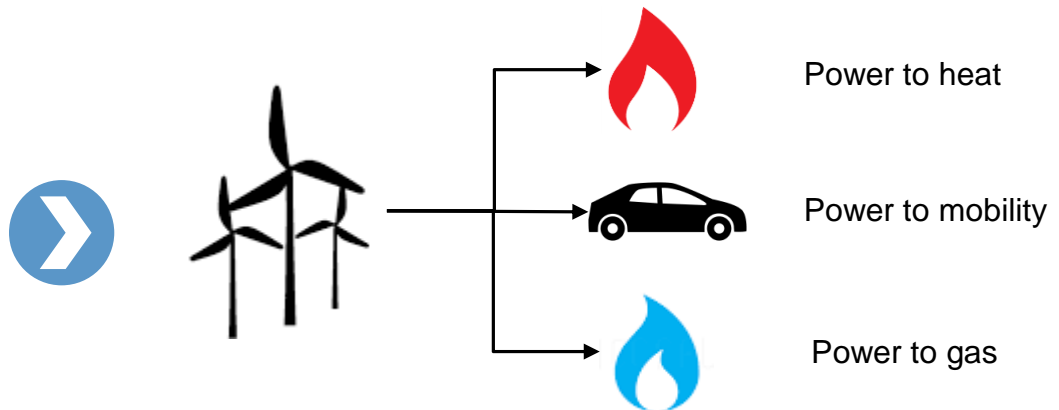
Energy Systems: TODAY

- Large central power generation
- Distribution of electricity only via power grid leads to massive problems in the feed-in of fluctuating energy (e.g. Wind)
- Disconnecting renewable energy sources (in case of overload) leads to a great waste of energy



Energy Systems: CONVERSION & STORAGE

- Small decentralized power generation
- Distribution of electricity is significantly simplified by conversion into other energy carrier (e.g. heat, gas, mobility)
- Large fluctuations of wind and solar generated power can be compensated by conversion and storage in other energy carriers.



CONVERSION AND STORAGE

COUPLING DIFFERENT SECTORS CREATES NEW BUSINESS MODELS

Power
To
gas



- Hydrogen in mobility: fuel cell vehicles particular in passenger and heavy load traffic.
- Hydrogen in chemical industry: Polymer production especially Polyethylene, Polypropylene, Polyoxymethylene
- Hydrogen in heat supply: Injecting hydrogen into the natural gas grid and use it in the gas heating.
- Hydrogen for reconversion into power: Gas power plants; combined heat and power stations.

Power
to
heat



- Heat supply: Injecting into heating grid for heating households, commercial companies, industrial facilities.
- Heat to reconversion into power -> “Power to heat to power” -> heat generators.

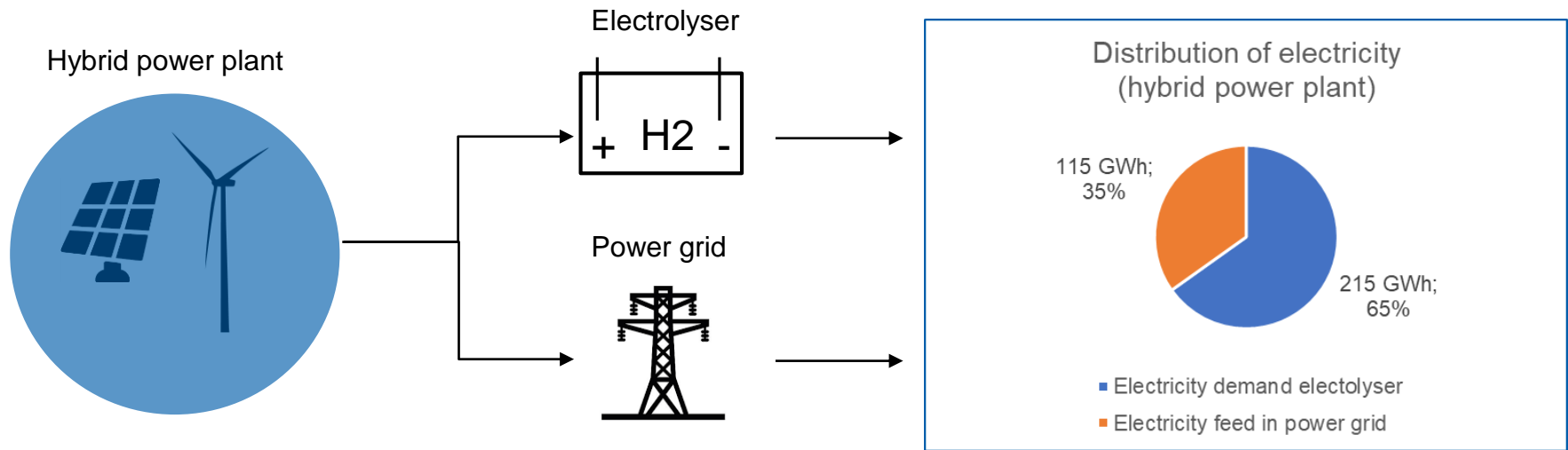
Power
to
mobility



- Smart charging: Charging for a large number of vehicle batteries
- Balancing power: Electric vehicles can provide their charging capacity on the market for balancing power

POWER TO GAS – PRODUCTION

DECENTRALIZED HYDROGEN PRODUCTION WITH WIND & PV POWER



Installed capacity

electrolyser	35,0 MW
wind	130,0 MW
solar	30,0 MW

Produced electricity

wind	300 GWh
solar	30 GWh
total	330 GWh

Electrolyser output

hydrogen production	5.205 t
efficiency	80%

POWER TO GAS – APPLICATIONS IN MOBILITY

HOW TO USE 5,000 TONS HYDROGEN IN MOBILITY?

5,000 tons of hydrogen can power the following mobility applications:



...**30.300 cars** p.a., or



...**9.300 lcv*** p.a., or



...**800 busses** p.a., or



...**350 trucks** p.a.



...**85 trains** p.a.

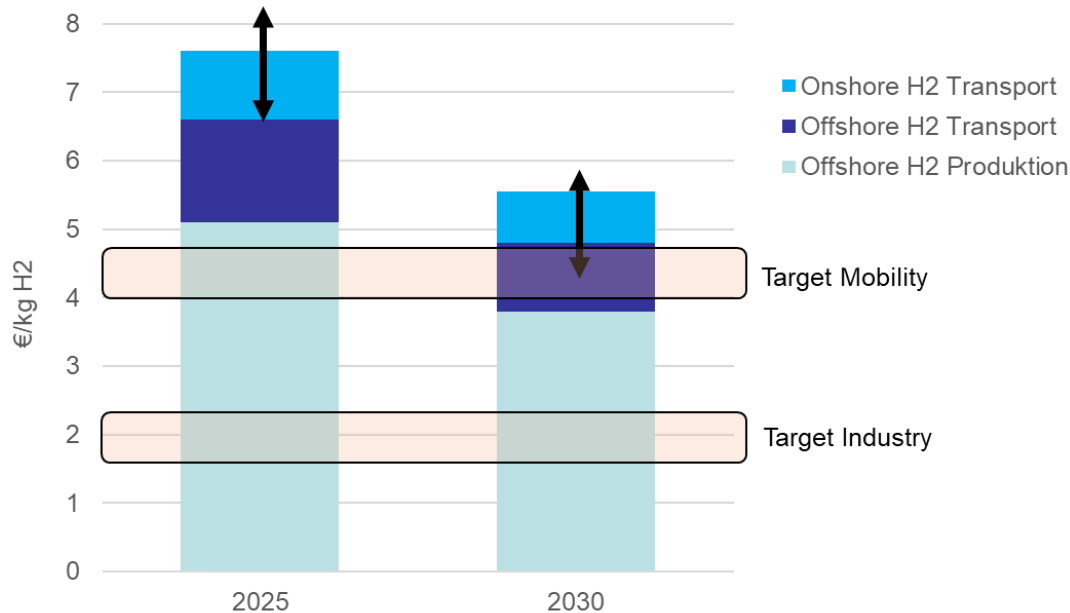
Assumed driving performance p.a.: car = 15.000 km; lcv = 21.500 km; bus = 45.000 km; truck = 100.000 km

Assumed hydrogen demand: car = 1,1 kg/100km; lcv = 2,5 kg/100; bus = 14 kg/100km; truck = 15 kg/100km

lcv = light commercial vehicle

Source: Shell, hydrogen study, Shell Deutschland Oil GmbH, Hamburg 2017

WHEN WILL HYDROGEN BECOME COST EFFICIENT?



2025	2030	Assumptions
750 €/kW _{el}	500 €/kW _{el}	CAPEX Electrolyser
4,500 h	4,500 h	Full Load Hours
55 kWh _{el} /kg H2	52 kWh _{el} /kg H2	Efficiency
4,00 €/MWh	4,00 €/MWh	Electricity Costs (Offshore)
10%	7%	WACC

Source: Department of Offshore Windpark Development , PNE AG, 2017

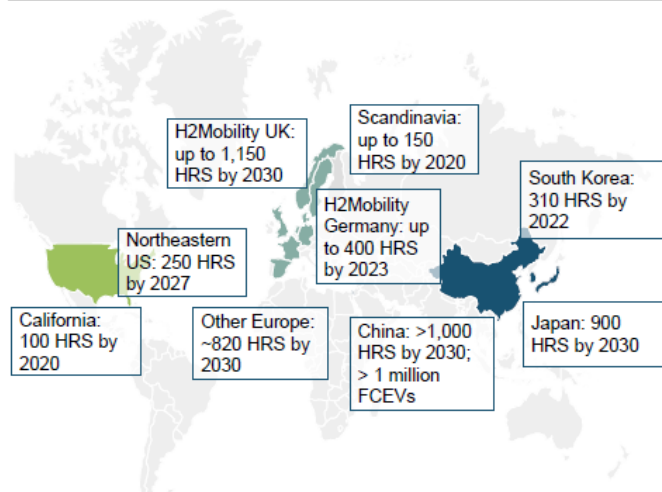
Results:

- Long term cost efficiency for hydrogen can only be achieved through economies of scale -> Offshore wind is highly suitable.
- Starting 2025, large scale applications will make it possible to achieve the cost targets in mobility.
- In the long run, the business model of hydrogen production will work for offshore and onshore wind

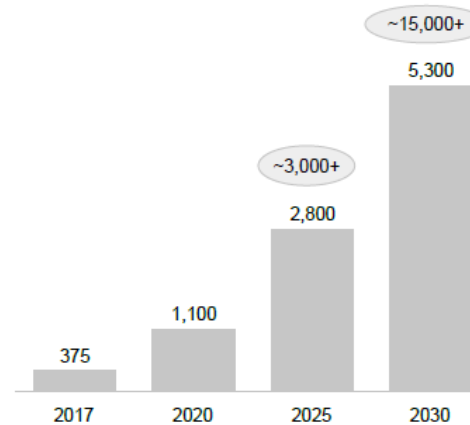
WHEN WILL HYDROGEN BE AVAILABLE FOR THE MOBILITY SECTOR?

More than 5,000 hydrogen refueling stations have been announced global

Latest announced investments in hydrogen refueling stations (selected countries)



Current global announcements¹



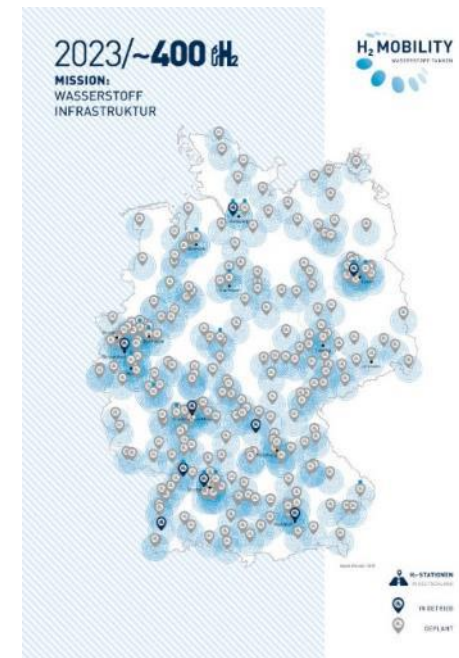
1 Announcements for shaded countries/regions: California, Northeastern US, Germany, Denmark, France, Netherlands, Norway, Spain, Sweden, UK; Dubai; China, Japan, South Korea

2 Equivalent number of large stations (1,000 kg daily capacity)

SOURCE: Air Liquide; Honda; Hydrogen Mobility Europe; H2Mobility; E4tech; NREL; web search

Source: Hydrogen Council, Hydrogen scaling up (November 2017)

400 stations in Germany



CONCLUSION AND OUTLOOK

- The Energy Transition in Europe is turn-around for the electricity sectors well as the heat, mobility and industry sector
- Coupling energy generation across multiple other sectors accelerates the integrated Energy Transition in Europe.
- Coupling sectors enables an independence of power grid expansions.
- The production of hydrogen makes it possible to link the energy transition in Europe with the world's growing demand of hydrogen.
- Economy of scale effects will provide the required cost efficiency for an inexpensive supply of hydrogen.
- Cost efficiency targets for hydrogen will be reached sooner than initially expected.

THANK YOU FOR YOUR ATTENTION