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"Hydrogen og kjemisk energilagring"

Status, marked og muligheter for storskala energilagring

Seminar om energilagring,
Oslo, 27.september, 2016

CEDREN

BELLONA

Steffen Møller-Holst
Markedsdirektør

SINTEF

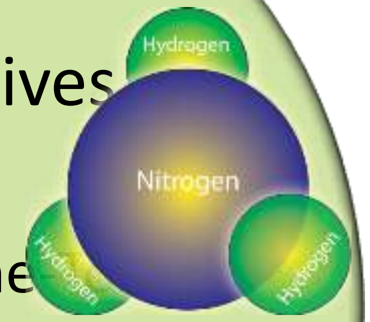
Norsk Hydrogenforum
Styreleder

hydrogen.no

Chairman for Transport,
EU-programme FCH JU

Chemical Energy Storage - alternatives

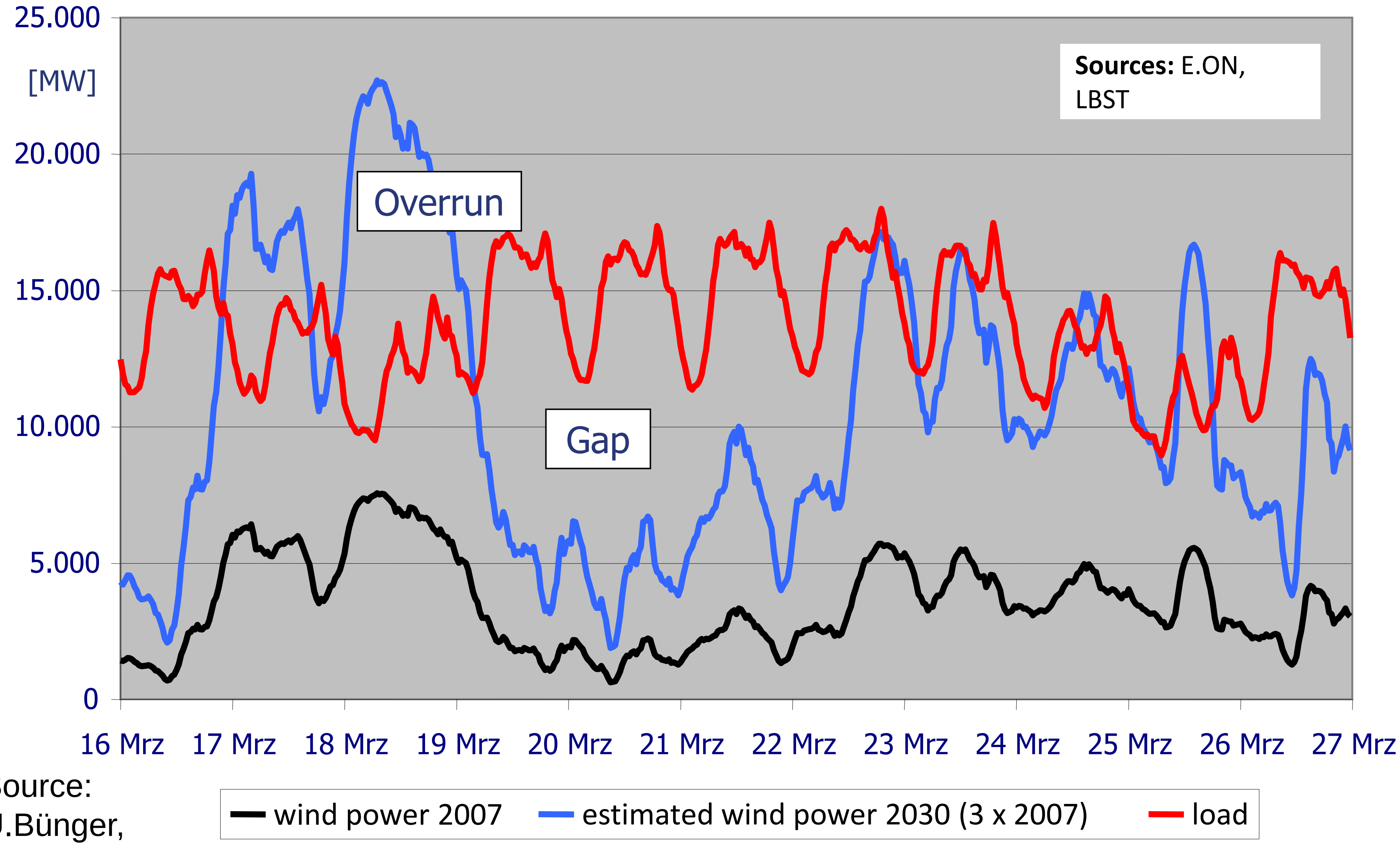
- Hydrogen
- Hydrogen derivatives
  - Ammonia
  - Methylcyclohexane



- Synthetic fuels (NG, etc.)
- Solar energy derivatives
  - Bioenergy
  - Fossil hydrocarbons
    - Coal, Oil, NG etc.

1) Chiyoda Corporation, Japan

Storing intermittent REN electricity



Source: U.Bünger, NTNU

Possible 10 day production versus end-use profile

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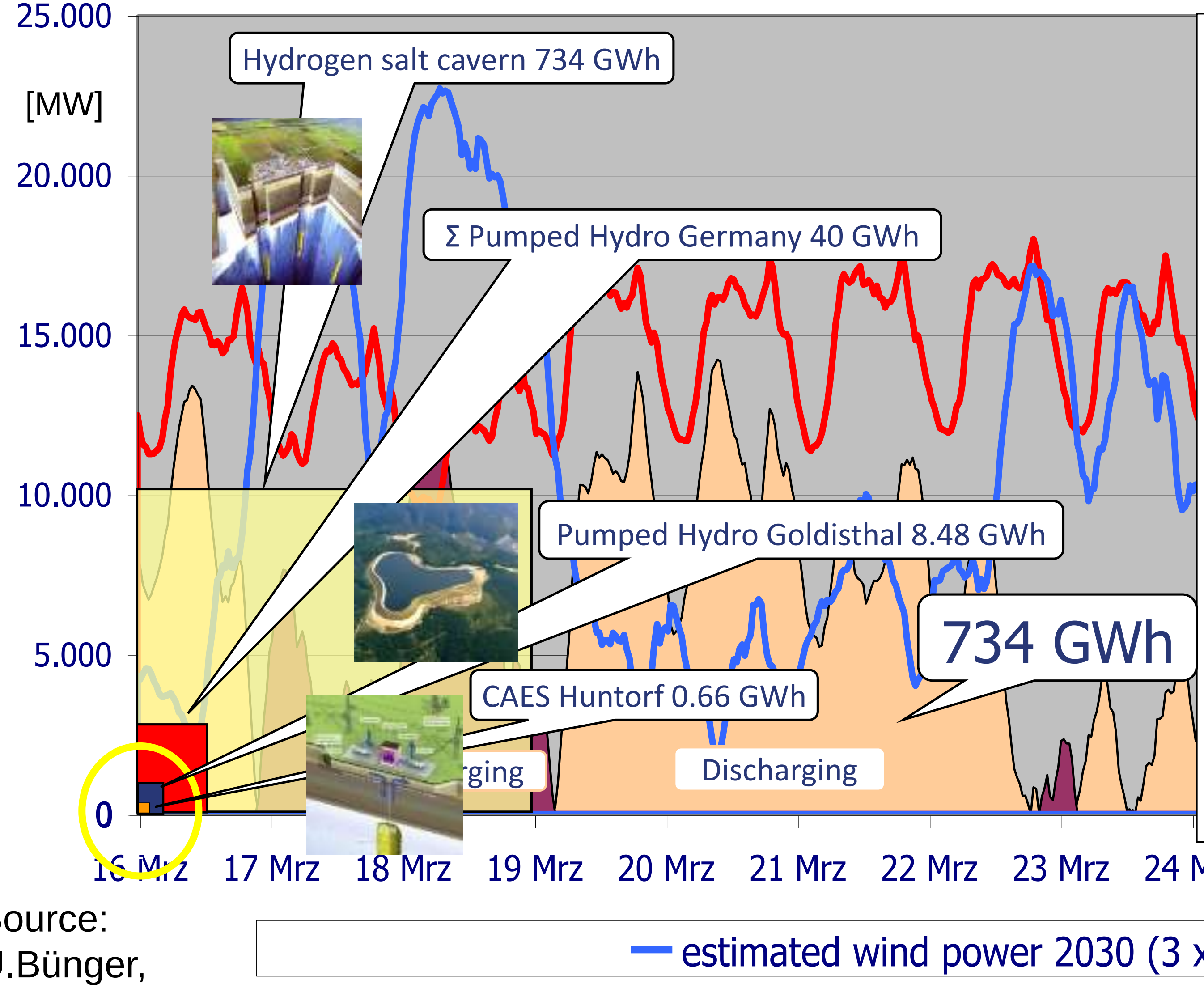
Storing intermittent REN electricity



734 GWh storage capacity requires

- Pumped hydro
  86 x Goldisthal
  or

- Compressed air
  1 112 x Huntorf

  or

- Salt cavern (hydrogen)
  ~1,2 x cavern field Etzel
  ~0,5 x cavern field Nüttermoor
  (both currently in used for NG)

Source:
U.Bünger,
NTNU

Possible 10 day production versus end-use profile

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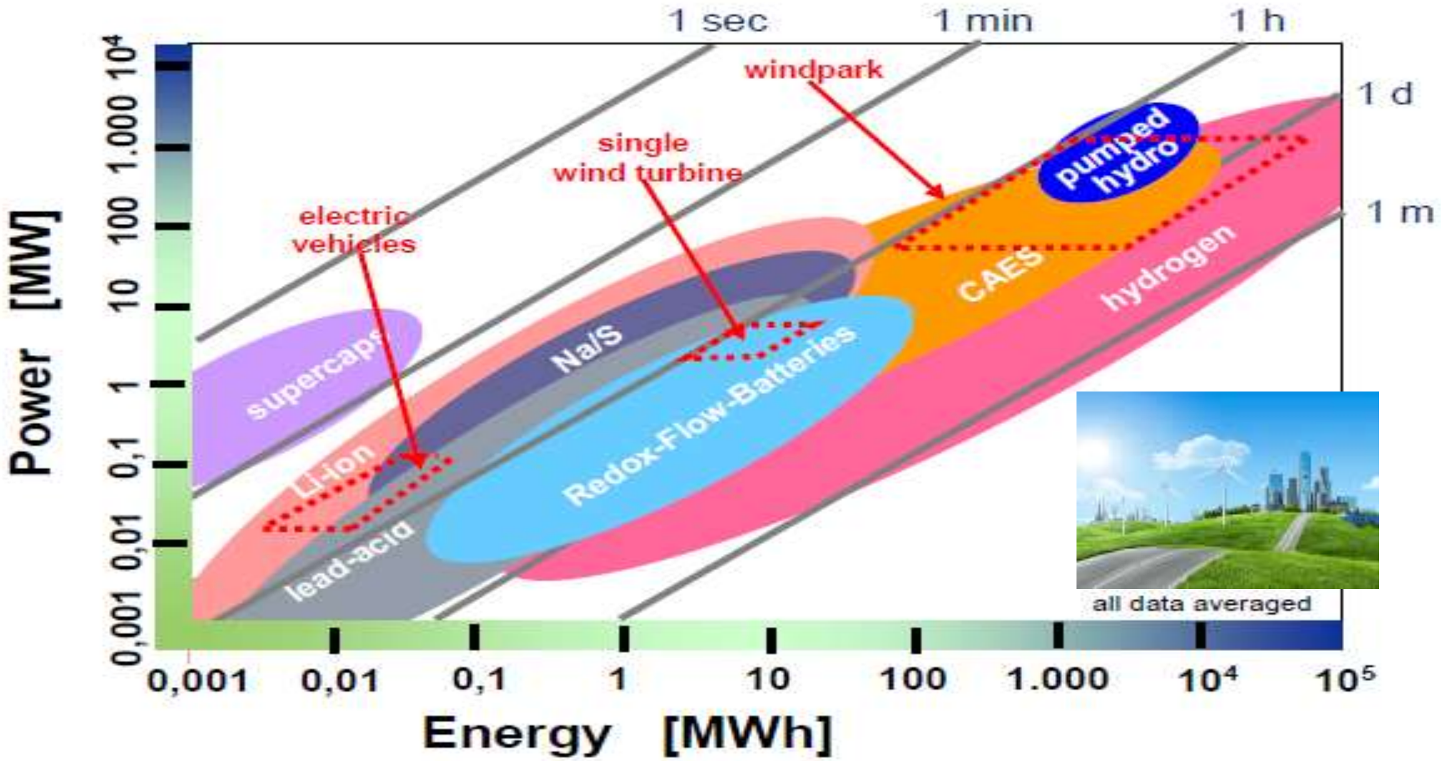
Large Scale Energy Storage
Options to address `grid storage´ are limited

SIEMENS

segmentation of large-scale (electrical) energy storage



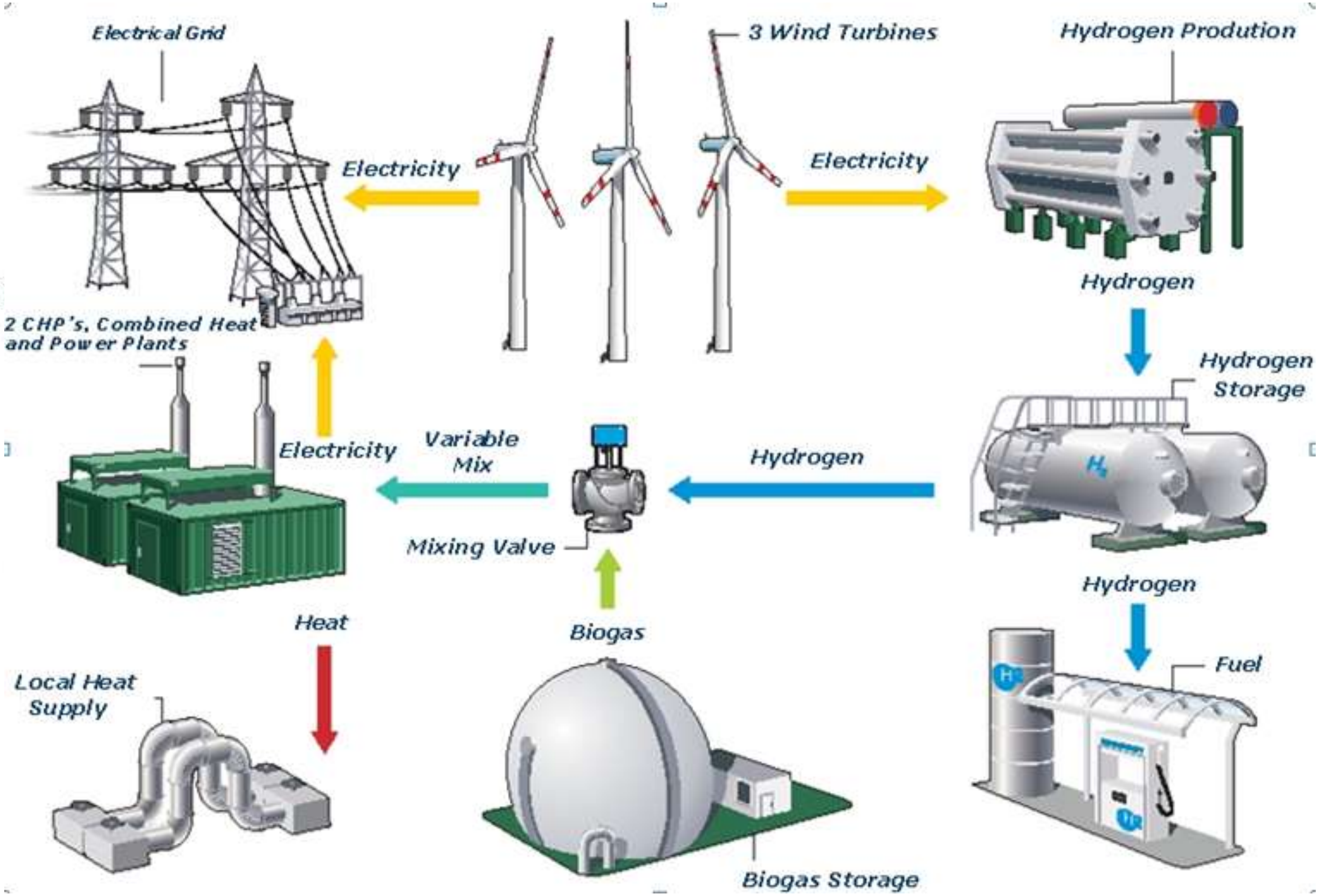
key statements:

- Battery storage applications are limited in the hour range
- Energy storage >100 MW can only be addressed by Pumped Hydro, Compressed Air (CAES) and Hydrogen
- The potential to extend pumped hydro capacities is very limited
- CAES has limitations in operational flexibility and capacity

Hydrogen is the only option to cover energy capacities > 10 GWh

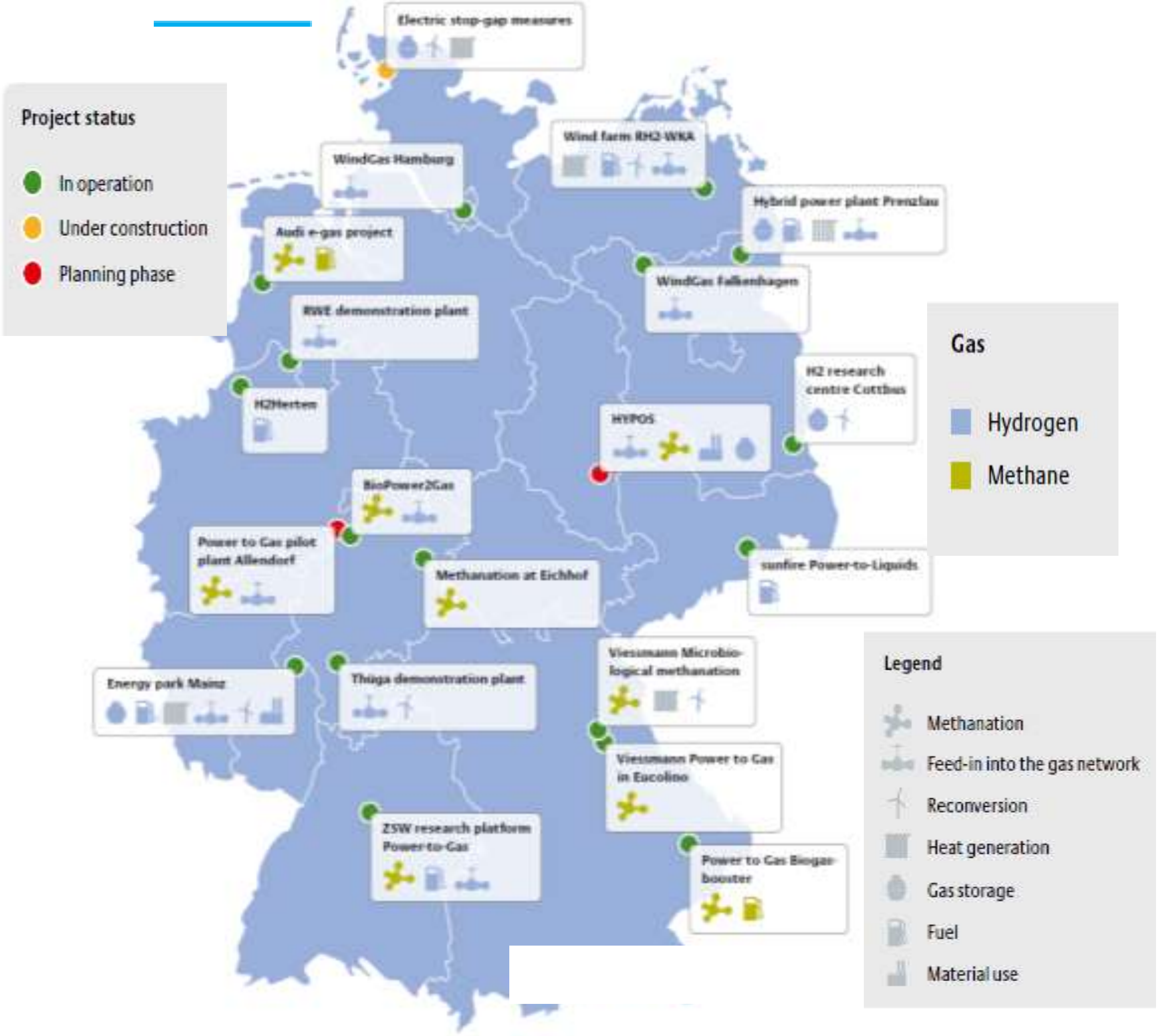
Hydrogen Storage – Hybrid Power Plant

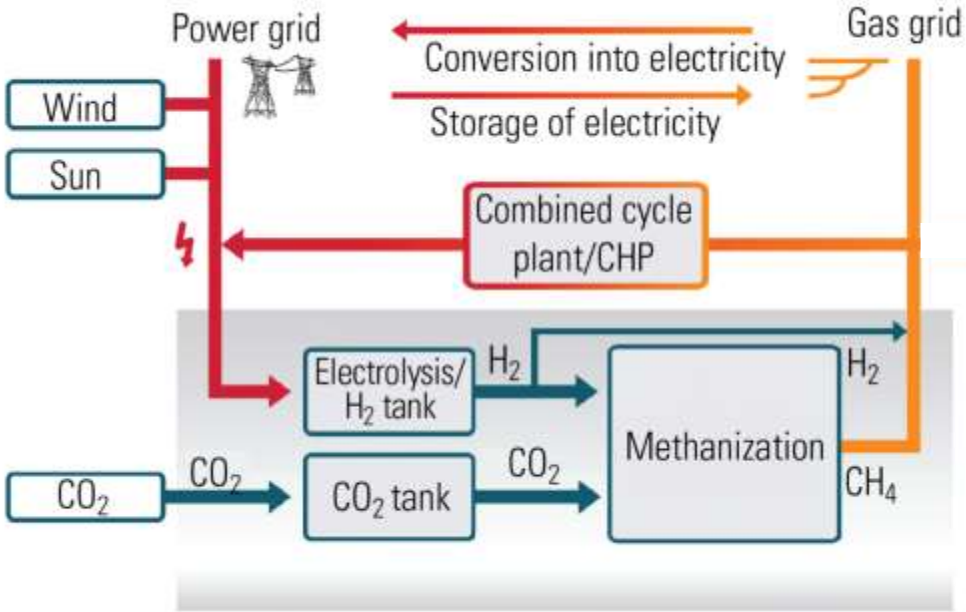
- Enertrag, Vattenfall, Total are developing a wind-hydrogen hybrid power plant
- Wind farm with direct coupling to electrolyzer
- Hydrogen storage
- Utilization of hydrogen in small scale CHP and for external use



VATTENFALL

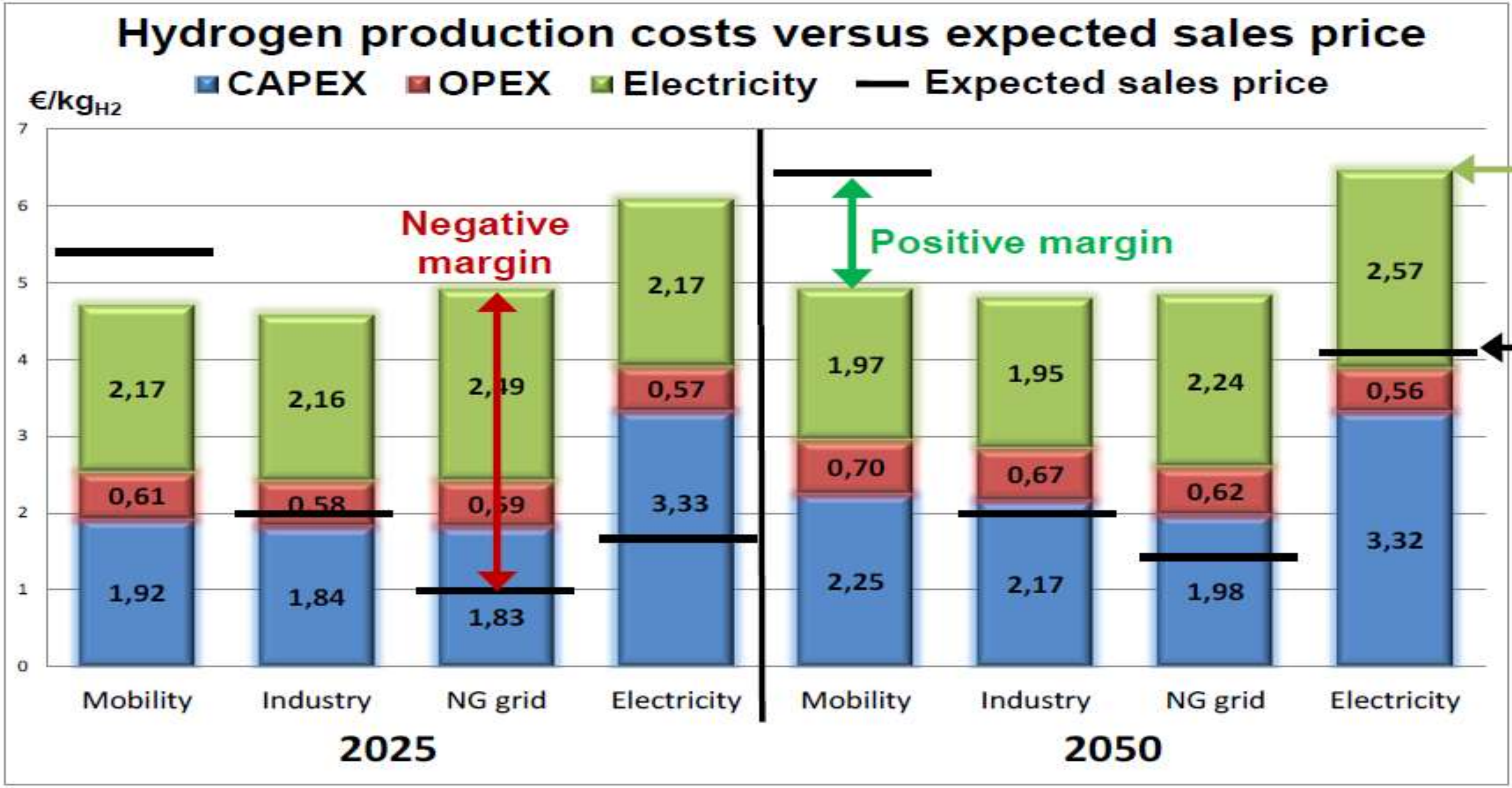
Power to Gas





- Interconnecting Power grid and Natural Gas (NG) grid
- NG distribution network has huge storage capacity (ΔP)
- Hydrogen injection limited to < 10% (depending on materials)

3 HyUnder – Mobility as Only Short-term Business Case



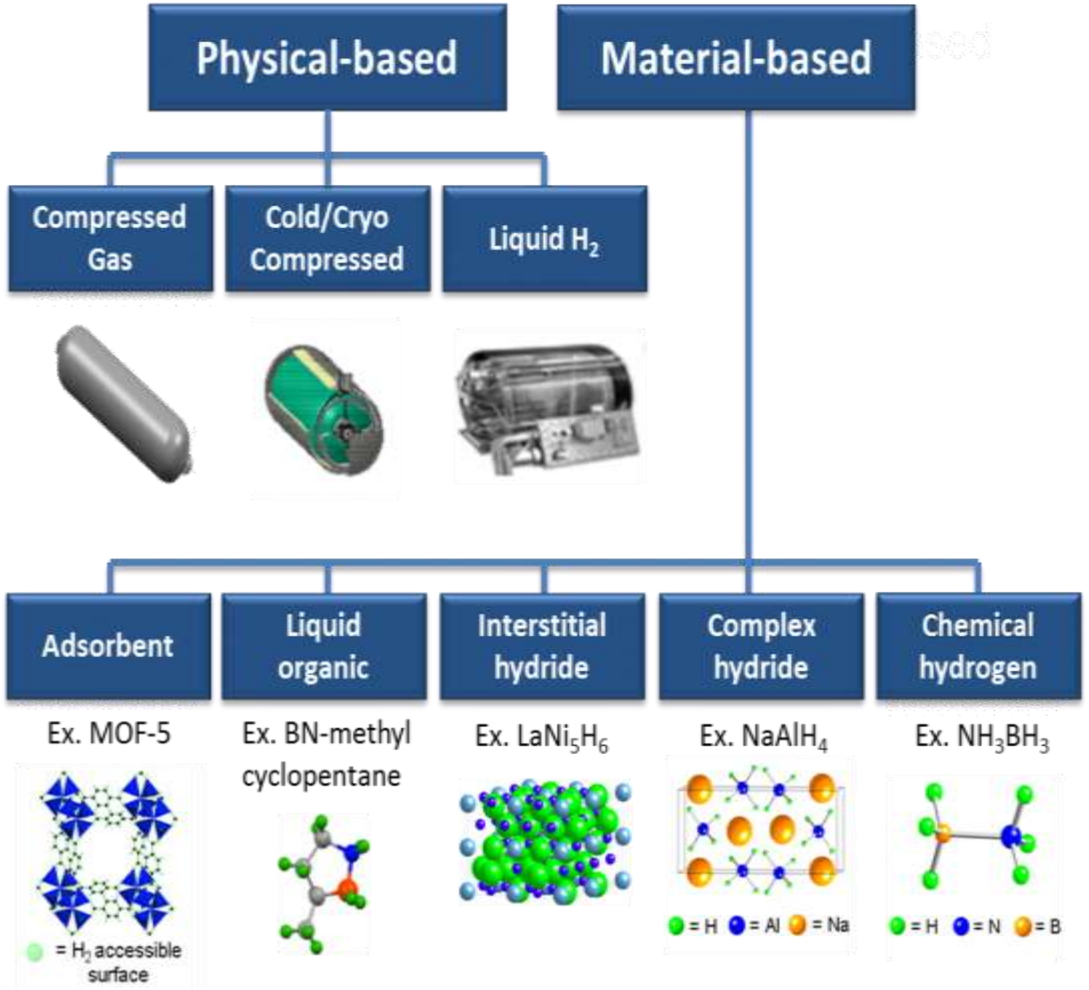
Delivery costs

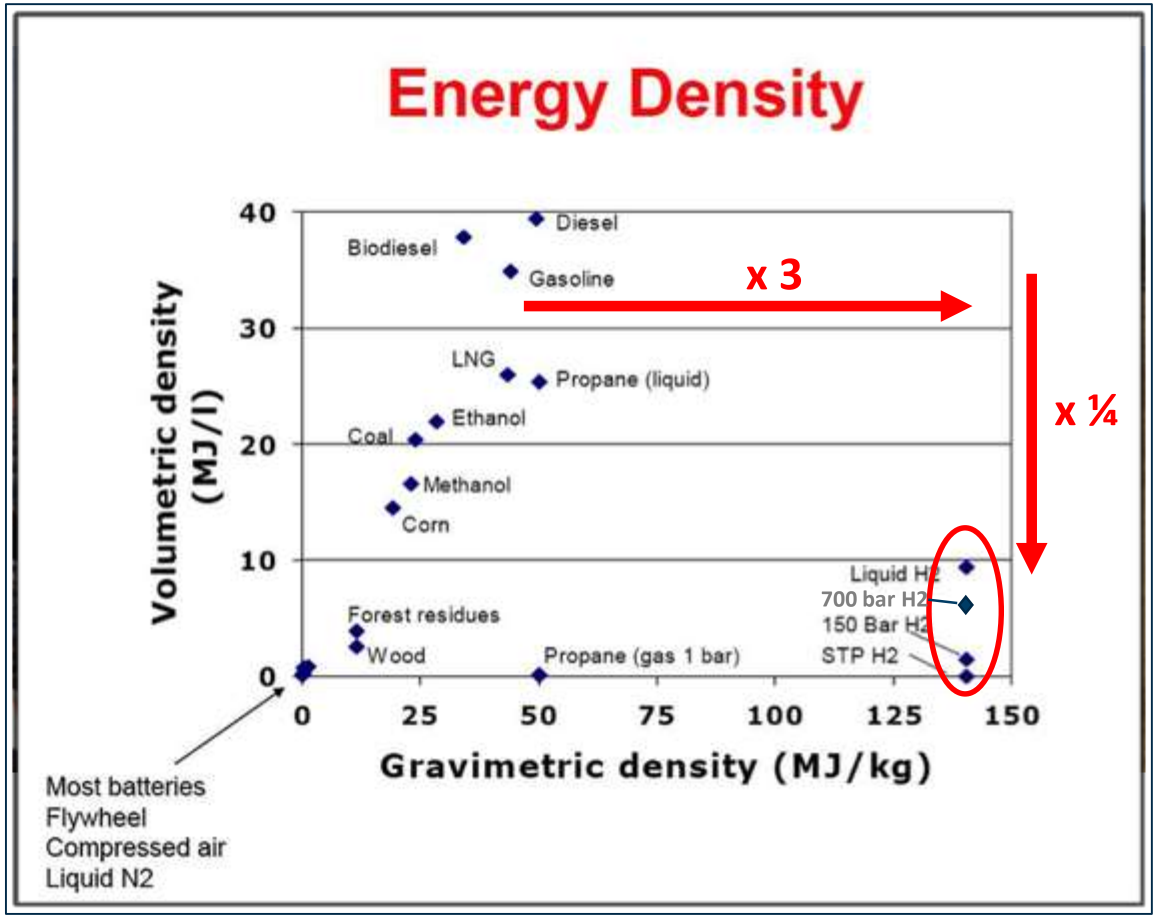
Expected sales price

Strongly depending on assumptions

Source: HyUnder – German Case Study report, 2014

Hydrogen storage technologies





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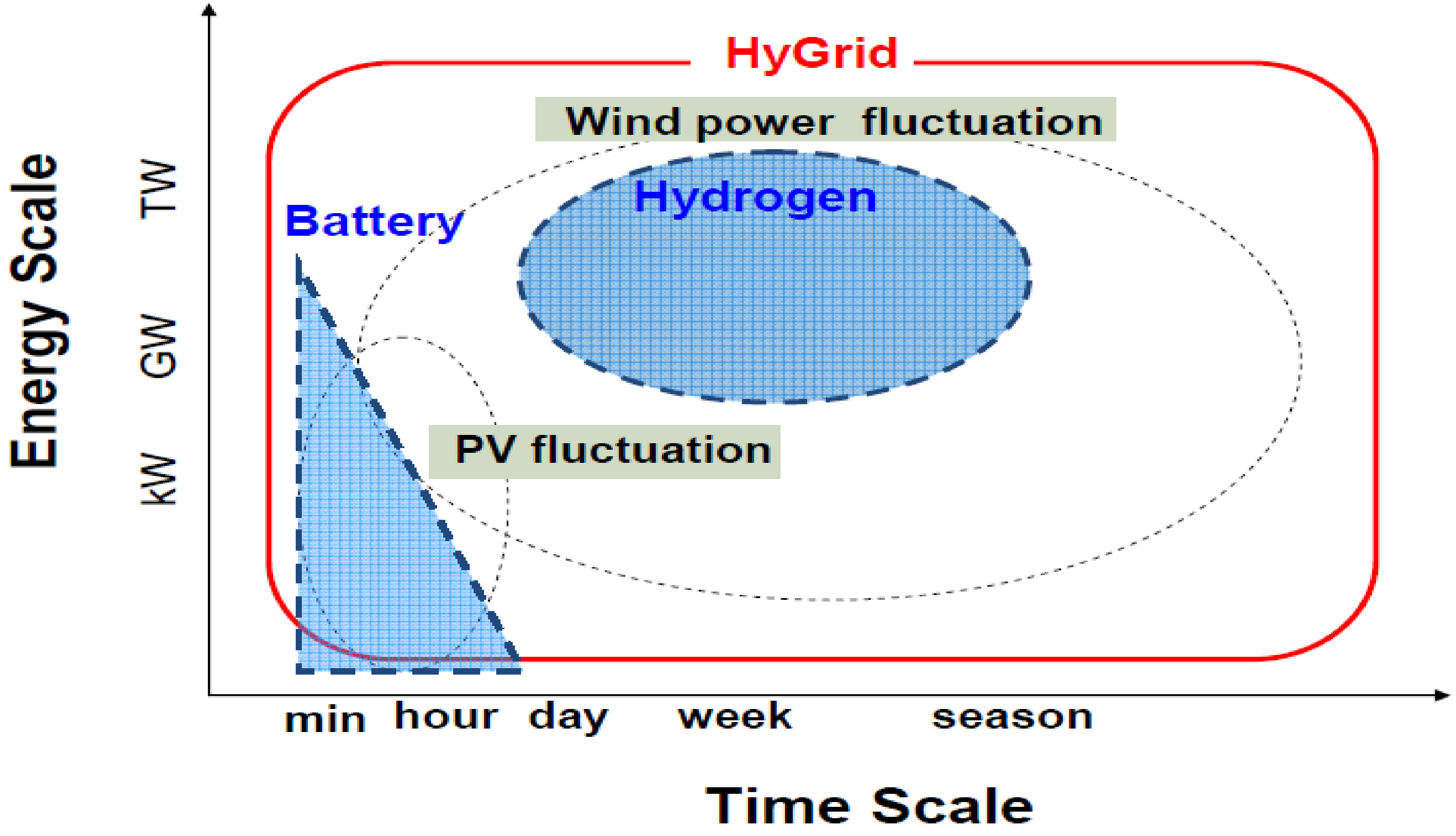
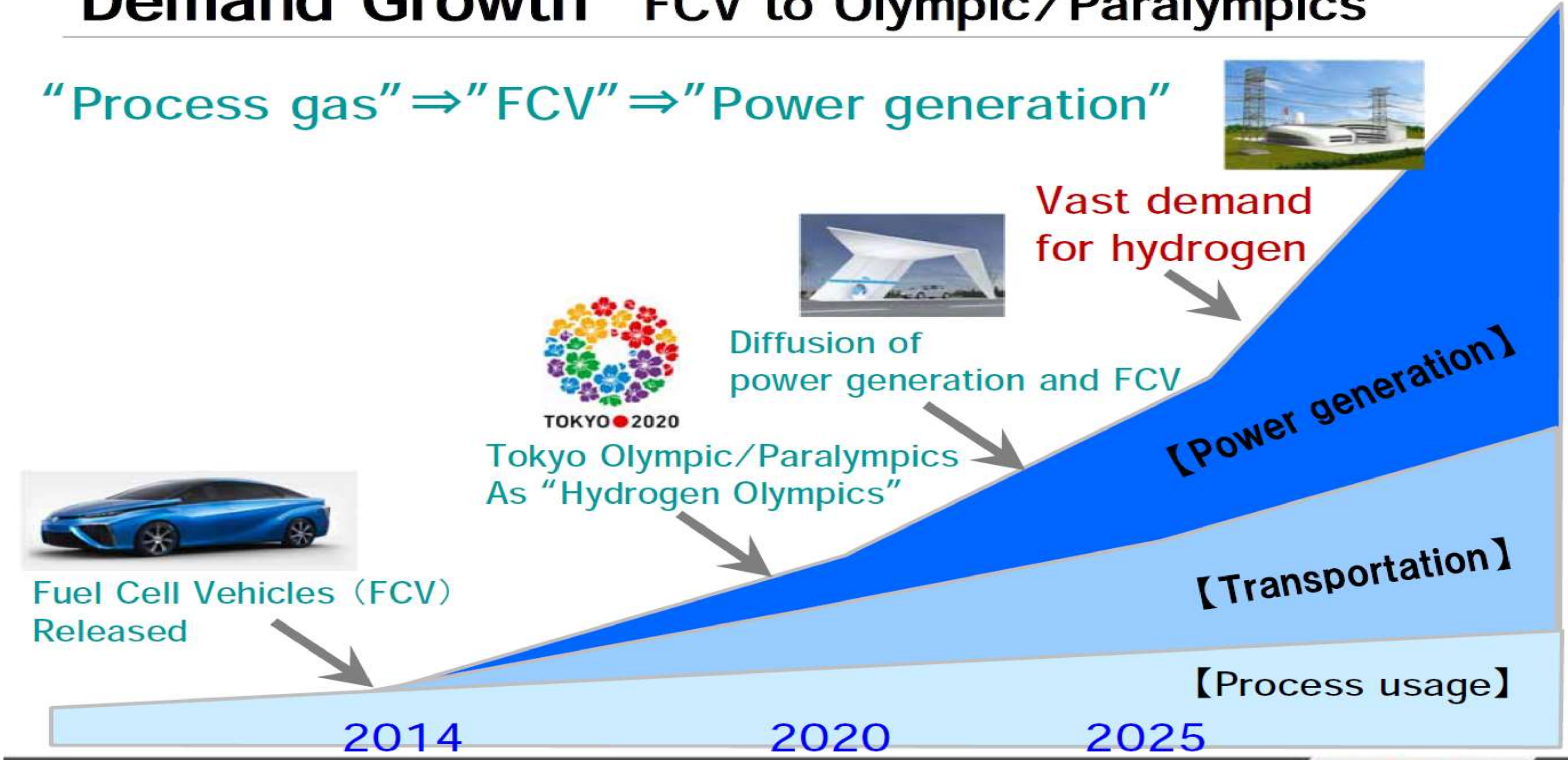
HyGrid basic concept

HyGrid is absorbing larger energy scale and longer fluctuation



Demand Growth "FCV to Olympic/Paralympics"

"Process gas"⇒"FCV"⇒"Power generation"

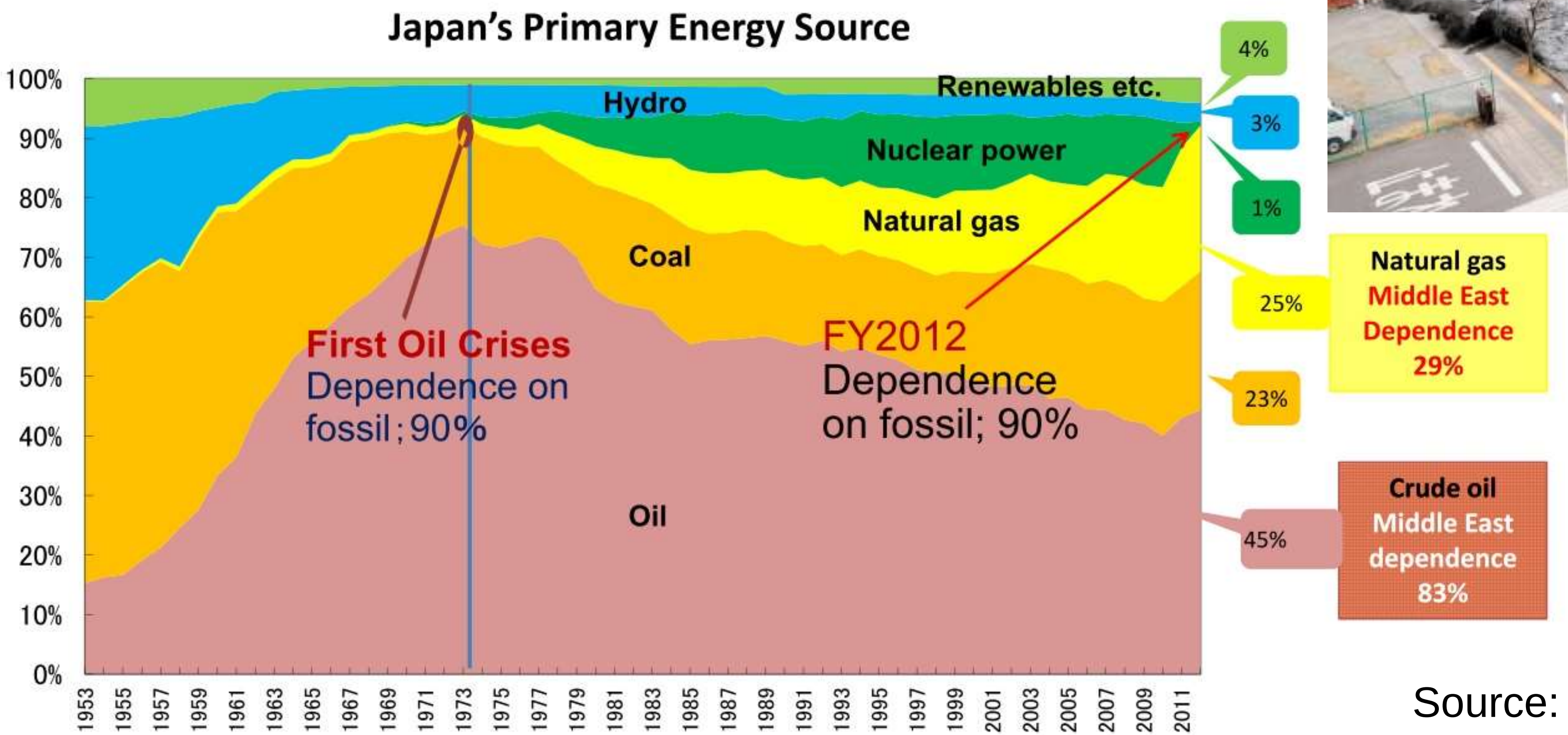


OL Tokyo 2020
Utstillingsvindu
for H_2-teknologi


OL Tokyo 2020
Utstillingsvindu
for H_2-teknologi
H_2-basert sjøtransport
med brenselceller
RESIDENCE
B
RESIDENCE
A
RESIDENCE
C
Elektrisitet og varme fra
H_2-drevne brenselceller
Transport ved H_2-drevne
brenselcellekjøretøyer

Energi-Mix i Japan

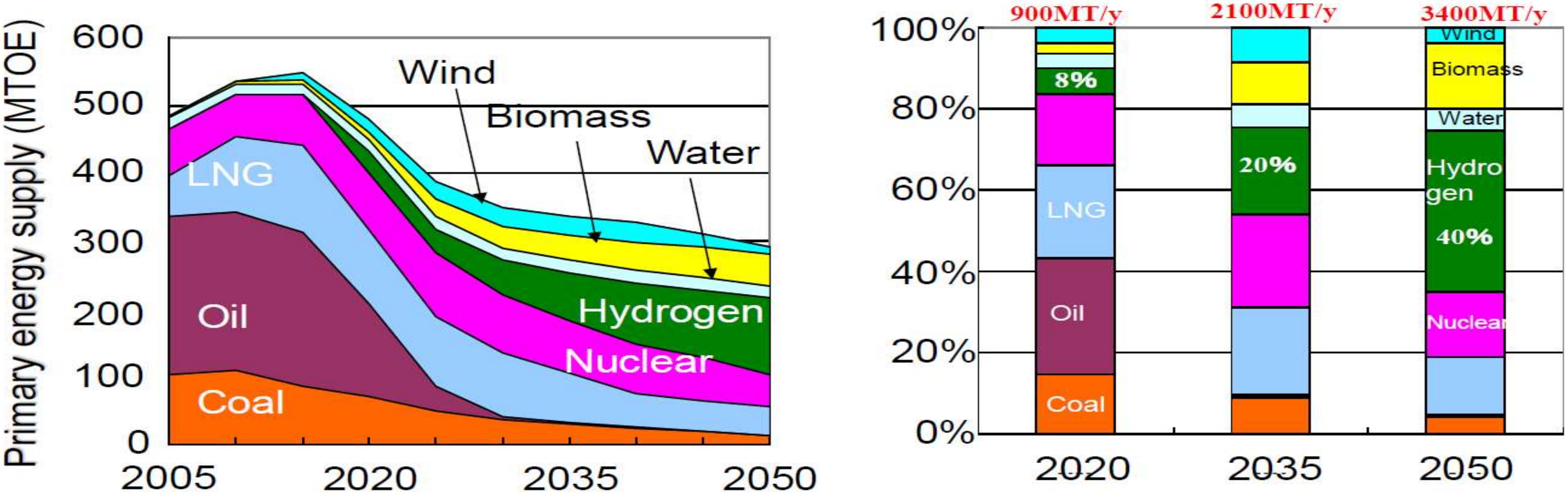
- 90% av primærenergien er fossilbasert



Source: METI

Future Hydrogen Supply

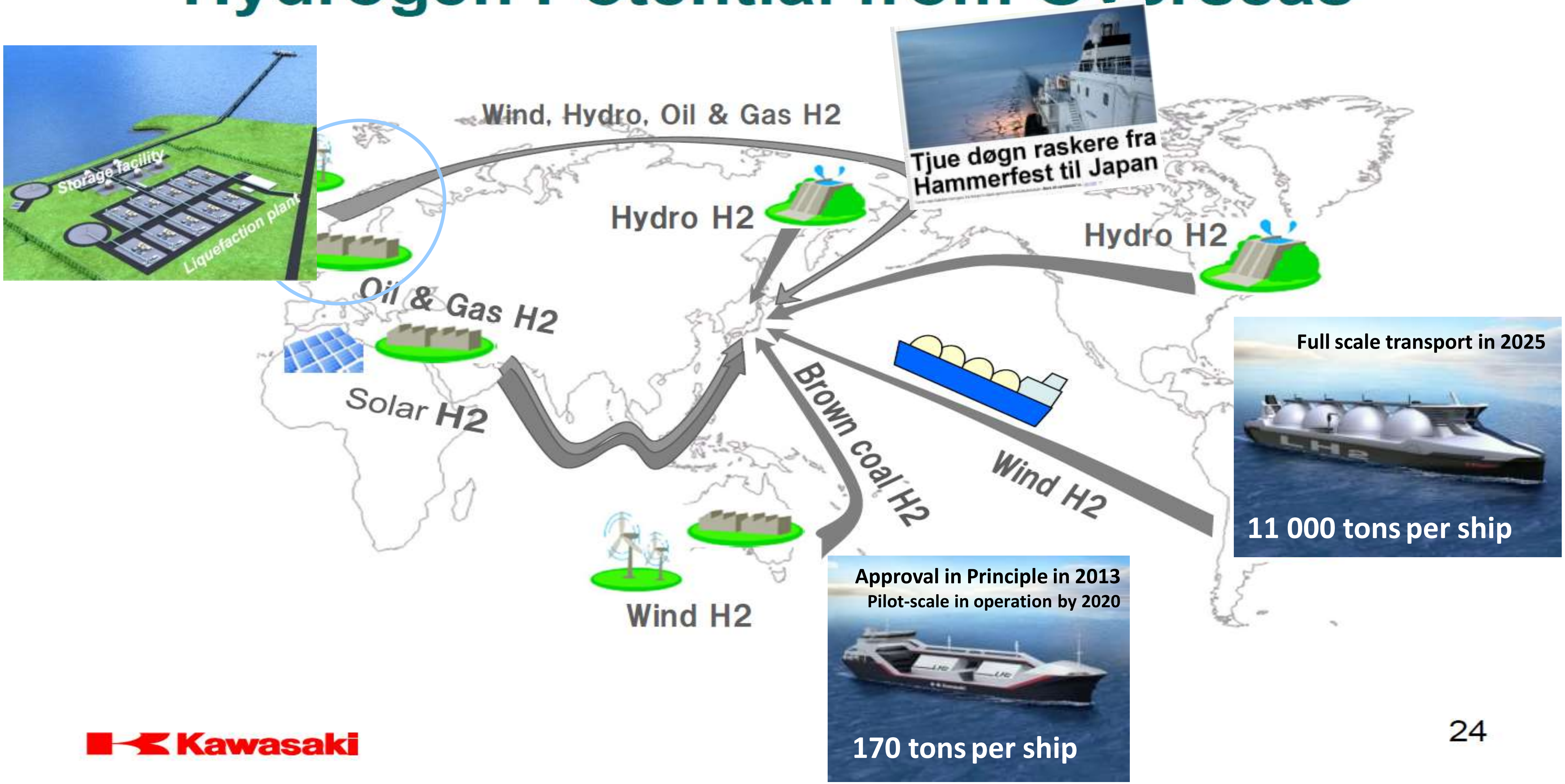
Prediction of hydrogen supply (primary energy supply)



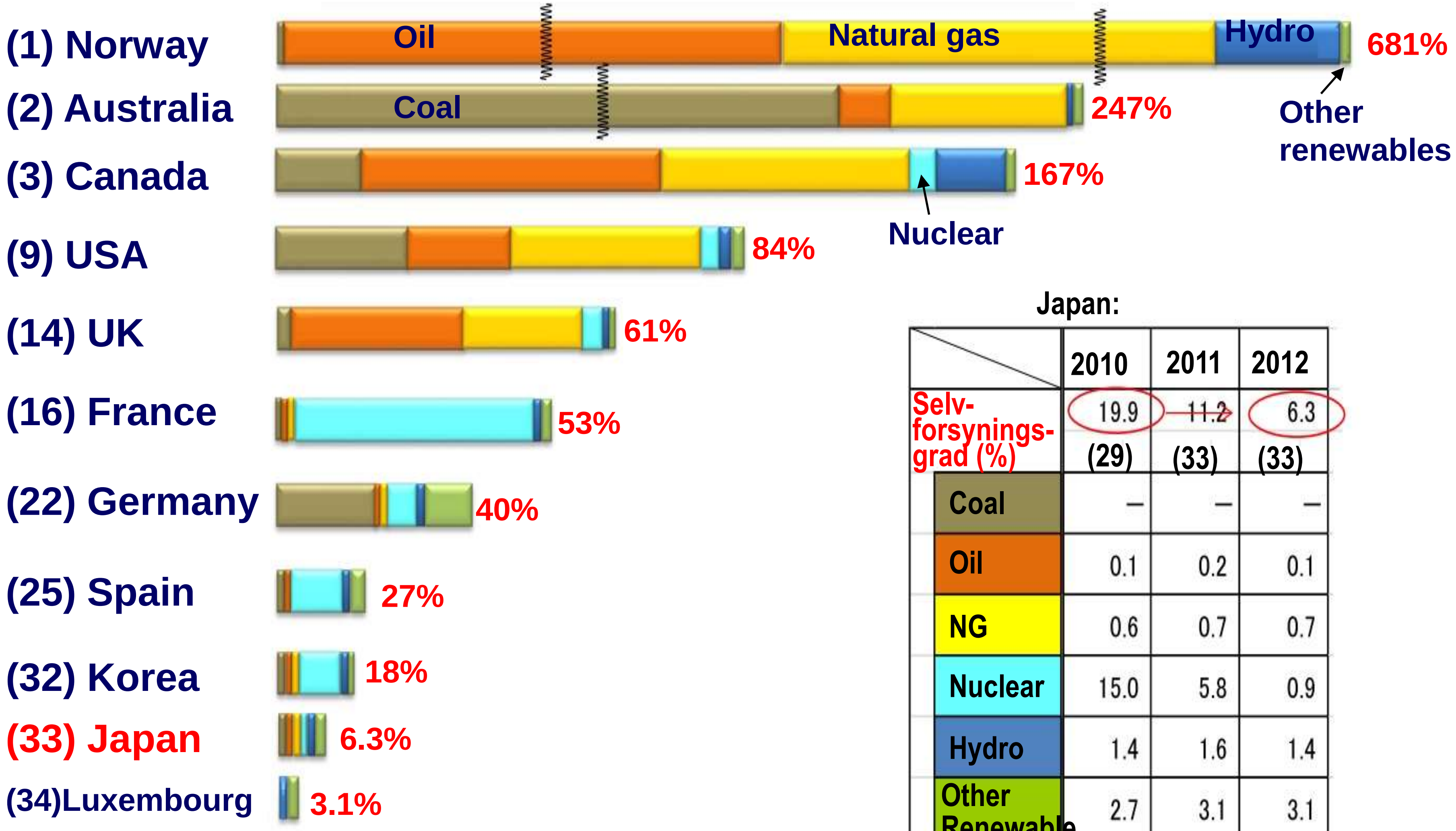
- In 2020 introduction of hydrogen (hydrogen cost: CIF25 yen/Nm^3)
- Switching to CO_2-free fuels is necessary by 2050
- This switch is necessary even if the hydrogen cost is 35 yen /Nm^3 or 45 yen/Nm^3
- Supply for power generation is introduced earlier than that for heat

Kawasaki

Hydrogen Potential from Overseas



Energi: Selvforsyningsgrad blant OECD-land (2012)



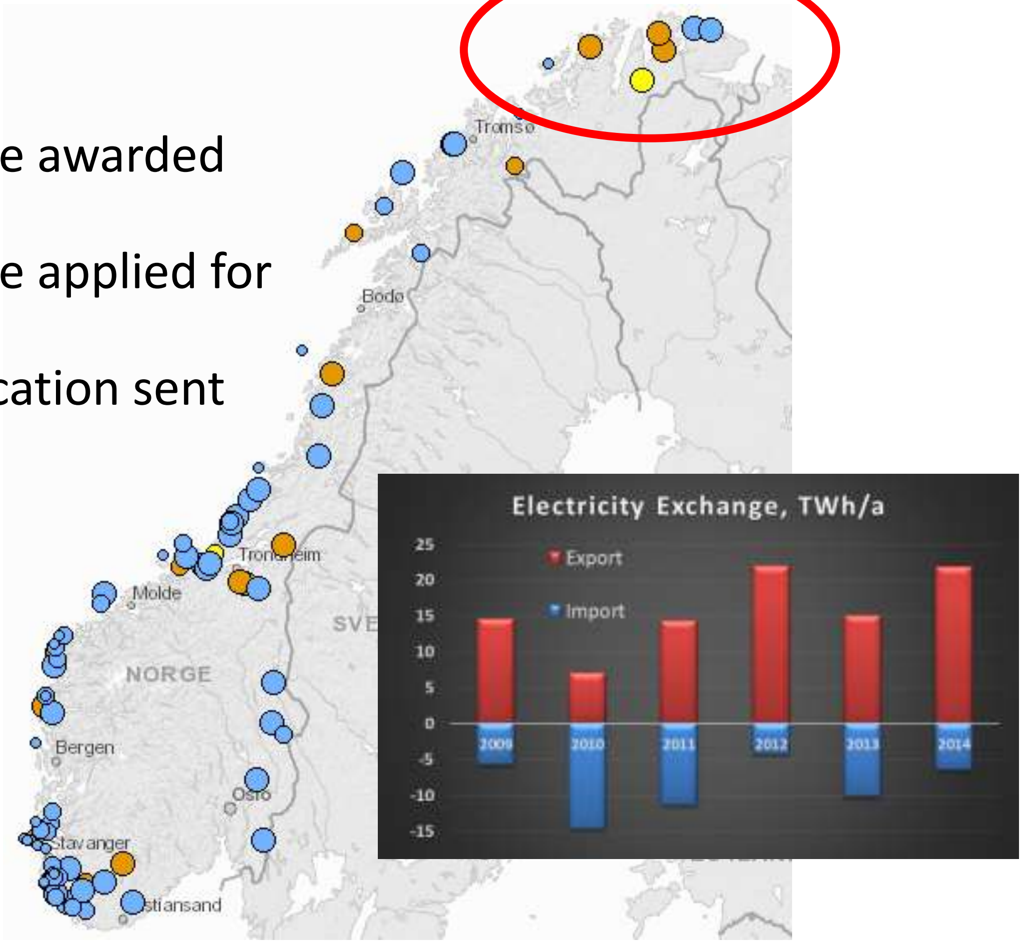
Japan:

	2010	2011	2012
Selv-forsynings-grad (%)	19.9 (29)	11.2 (33)	6.3 (33)
Coal	–	–	–
Oil	0.1	0.2	0.1
NG	0.6	0.7	0.7
Nuclear	15.0	5.8	0.9
Hydro	1.4	1.6	1.4
Other Renewable	2.7	3.1	3.1

Source: METI

Stranded wind power,

- License awarded
- License applied for
- Notification sent



Potential new plants for wind power production in Norway *(Source: NVE)*.

"Innestengt" vindkraft:

Finnmark (på land):

2000 MW = 8 TWh/år

Nettforsterkning tidligst i 2025

Kan omdannes til hydrogen, drivstoff til >1 million personbiler!

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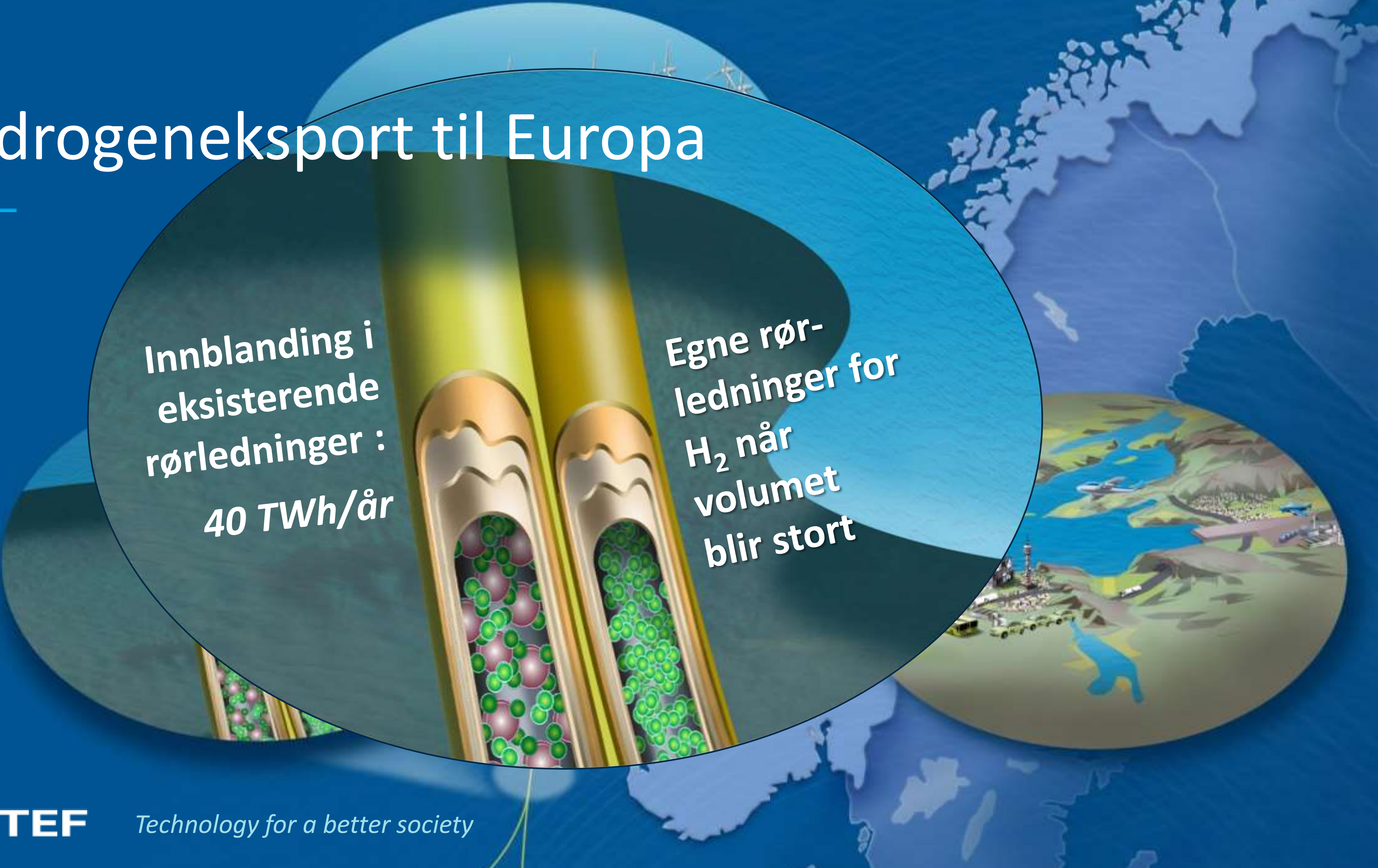
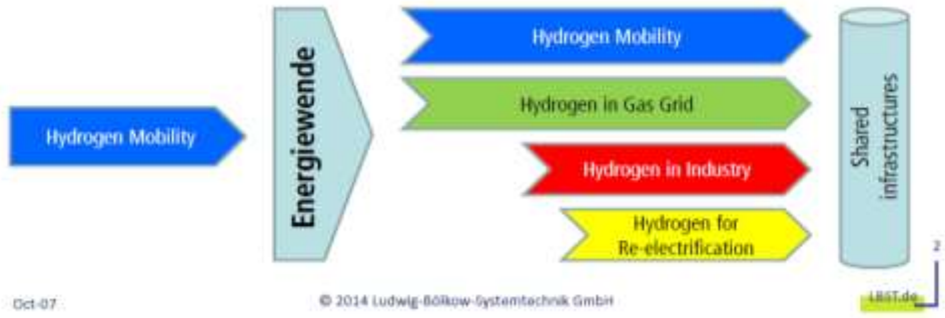
Hydrogeneksport til Europa



Konklusjoner



- Kjemisk lagring (H_2) er egnet for storskala energilagring (>10GWh)
- Ledende internasjonal industri peker på H_2 som energibærer
- Flerbruk gjør investeringer i infrastruktur akseptable (Tyskland)
- Japan går for full integrasjon av H_2 også i stasjonær kraftproduksjon
- Norge vil naturligvis primært benytte pumpekraft, men store uutnyttede energiressurser kan videreforedles til H_2 for eksport
- Teknologiene er her → Forretningsmuligheter i "det grønne skiftet"

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Technology for a better society