"Globale perspektiver innen hydrogenteknologi,

- politisk og industrielt engasjement på området"

NMK, Møretanken, Ålesund, 26th September 2019

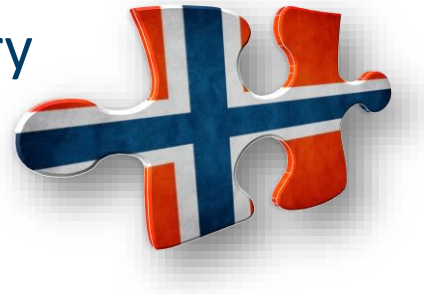
Steffen Møller-Holst
Markedsdirektør
SINTEF

Styreleder
NORSK HYDROGENFORUM
hydrogen.no

Chairman Transport
Hydrogen Europe Research

Outline

- H_2 in the European Climate and Energy Policy Framework
- Initiatives and activities towards a H_2-oriented global economy
- Norway's prospects for retaining the position as an energy exporting country
- Hydrogen technology for reduced emissions in transport & industry
- Potential for value creation from export of H_2 and H_2 technology
- Summary and Conclusions



Increasing political engagement

G20 2019 JAPAN

CEM10/MI-4 VANCOUVER

HYDROGEN INITIATIVE

AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

MISSION INNOVATION

accelerating the clean energy revolution

H2EM 2019

Hydrogen Energy Ministerial Meeting

25/9 2019

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Industry engagement_Hydrogen Council

The Hydrogen Council Members:

Originally 13 founding members (Davos):

- Investment 1,4 B€/a in H_2-technologies
- Pledges 10,7 B€ next 5 years

Press release:

September 7th 2017:

11 new members

(including Statoil)

Collectively representing

- total revenues of 1.3 trillion
- and > 2 million employees
- 2018:

HEXAGON COMPOSITES

nel

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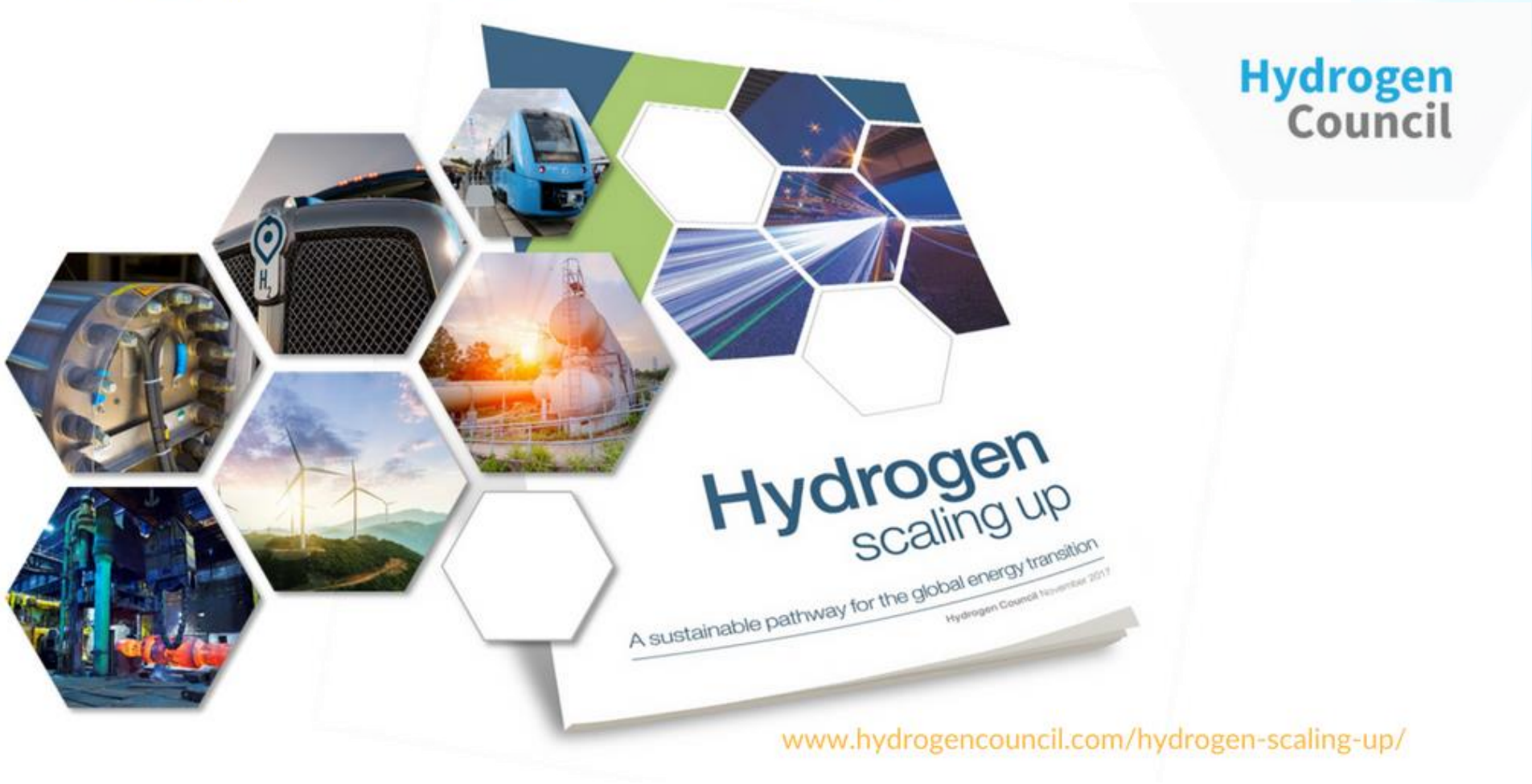
Hydrogen Council, *"Hydrogen - Scaling Up"*



Hydrogen Council, November 2017

Hydrogen Europe

Climate Neutral Europe 2050

Detailed assessment supported by scenario analysis

	Electrification (ELEC)	Hydrogen (H2)	Power-to-X (P2X)	Energy Efficiency (EE)	Circular Economy (CIRC)	Combination (COMBO)	1.5°C Technical (1.5TECH)	1.5°C Sustainable Lifestyles (1.5LIFE)
Main Drivers	Electrification in all sectors	Hydrogen in industry, transport and buildings	E-fuels in industry, transport and buildings	Pursuing deep energy efficiency in all sectors	Increased resource and material efficiency	Cost-efficient combination of options from 2°C scenarios	Based on COMBO with more BECCS, CCS	Based on COMBO and CIRC with lifestyle changes
GHG target in 2050	-80% GHG (excluding sinks) ["well below 2°C" ambition]					-90% GHG (incl. sinks)	-100% GHG (incl. sinks) ["1.5°C" ambition]	
Major Common Assumptions	• Higher energy efficiency post 2050 • Deployment of sustainable, advanced biofuels • Moderate circular economy measures • Digitilisation					• Market coordination for infrastructure deployment • BECCS present only post-2050 in 2°C scenarios • Significant learning by doing for low carbon technologies • Significant improvements in the efficiency of the transport system.		
Power sector	Power is nearly decarbonised by 2050. Strong penetration of RES facilitated by system optimization (demand-side response, storage, interconnections, role of prosumers). Nuclear still plays a role in the power sector and CCS deployment faces limitations.							
Industry	Electrification of processes	Use of H2 in targeted applications	Use of e-gas in targeted applications	Reducing energy demand via Energy Efficiency	Higher recycling rates, material substitution, circular measures	Combination of most Cost-efficient options from "well below 2°C" scenarios with targeted application (excluding CIRC)	COMBO but stronger	CIRC+COMBO but stronger
Buildings	Increased deployment of heat pumps	Deployment of H2 for heating	Deployment of e-gas for heating	Increased renovation rates and depth	Sustainable buildings			CIRC+COMBO but stronger
Transport sector	Faster electrification for all transport modes	H2 deployment for HDVs and some for LDVs	E-fuels deployment for all modes	Increased modal shift	Mobility as a service			• CIRC+COMBO but stronger • Alternatives to air travel
Other Drivers		H2 in gas distribution grid	E-gas in gas distribution grid				Limited enhancement natural sink	• Dietary changes • Enhancement natural sink

Brussels, November 2018

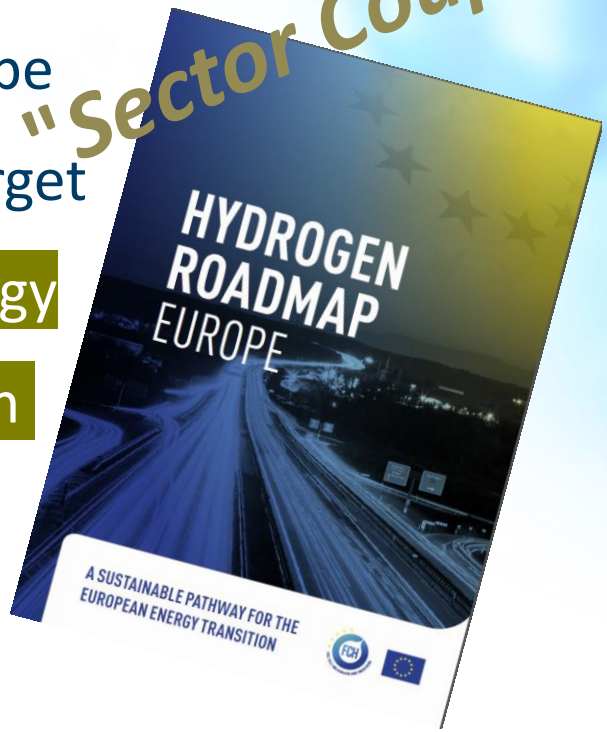
Hydrogen Europe

Increasing focus on Hydrogen in Europe

Hydrogen Roadmap Europe:

- Hydrogen is required to achieve the energy transition in Europe
- Hydrogen may close up to ~ 50 % of the gap towards a 2°C target
- Points at import of H_2 from regions with abundant wind energy
- Concludes that the most cost optimal decarboniztion solution include both water electrolysis and reforming of natural gas
- Asks for immediate and concerted action to establish a masterplan for decarbonization for the European Union

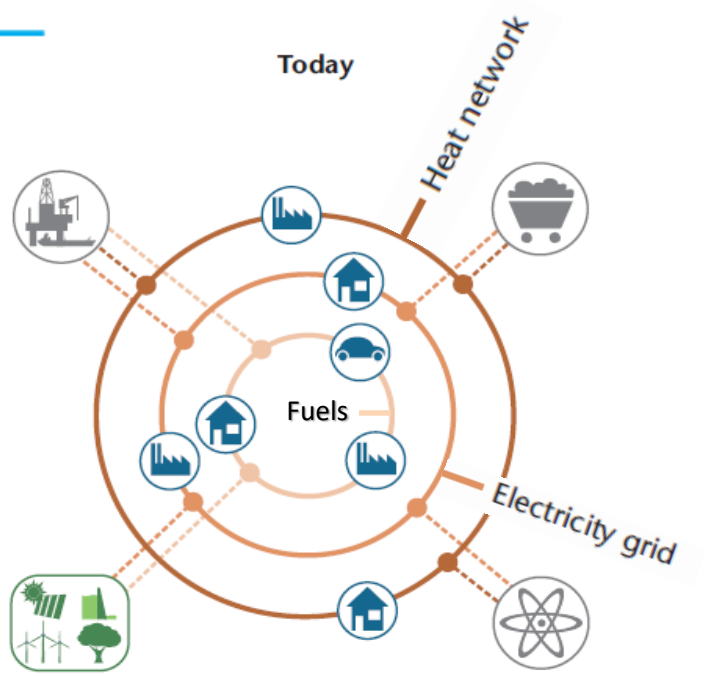
"Sector Coupling"



Brussels, February 2019

Hydrogen Europe

Hydrogen provides increased flexibility



"Sector Coupling"

KEY POINT: Hydrogen can link different energy sectors and energy T&D networks and thus increase the operational flexibility of future low-carbon energy systems.

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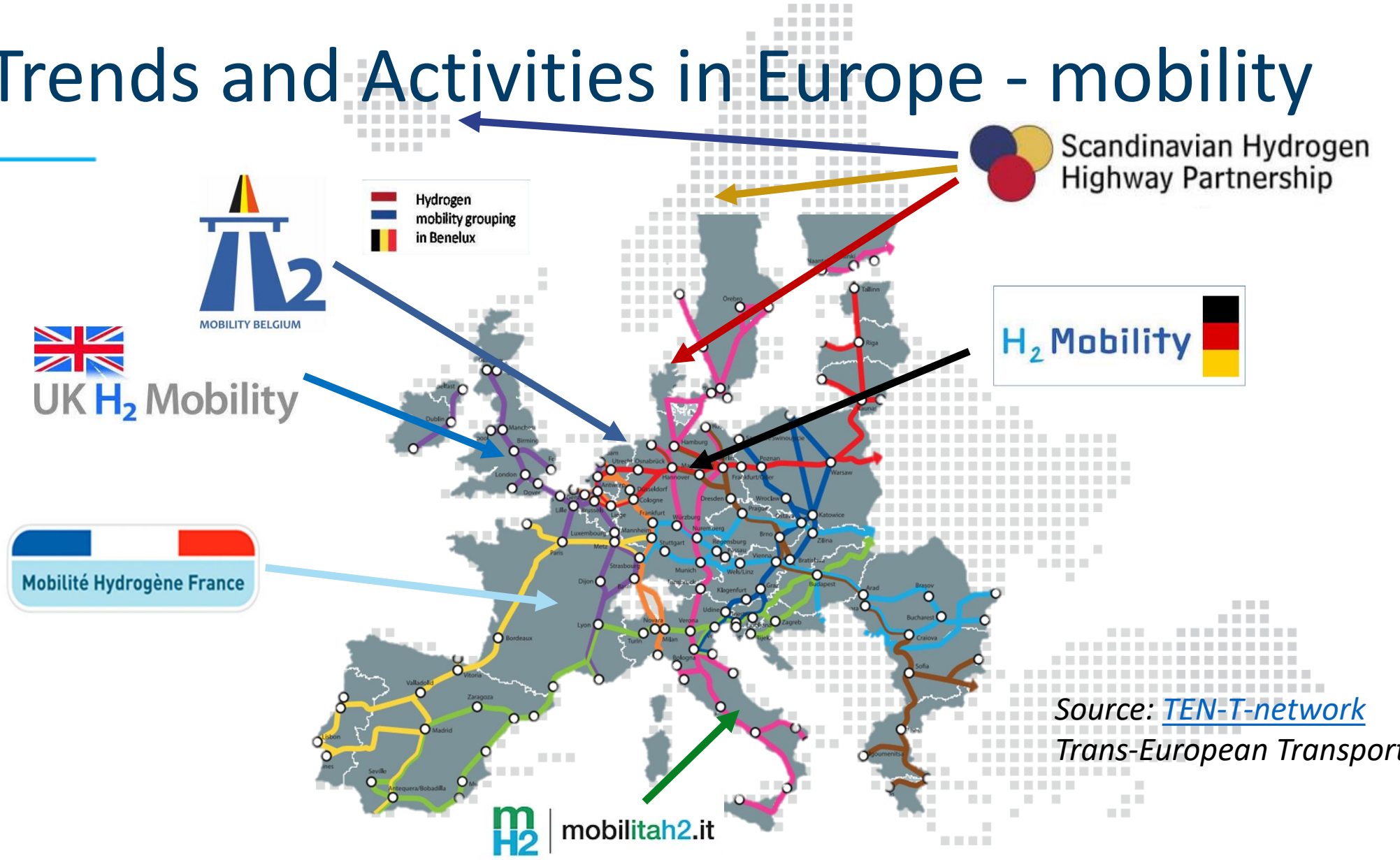
Trends and Activities in Europe - mobility



Source: [TEN-T-network]
Trans-European Transport Network

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Trends and Activities in Europe - mobility

Press release
27th September 2018:

"H2busEurope"

- 600 hydrogen buses
- Connecting Europe Facility (CEF) program
- 40 M€

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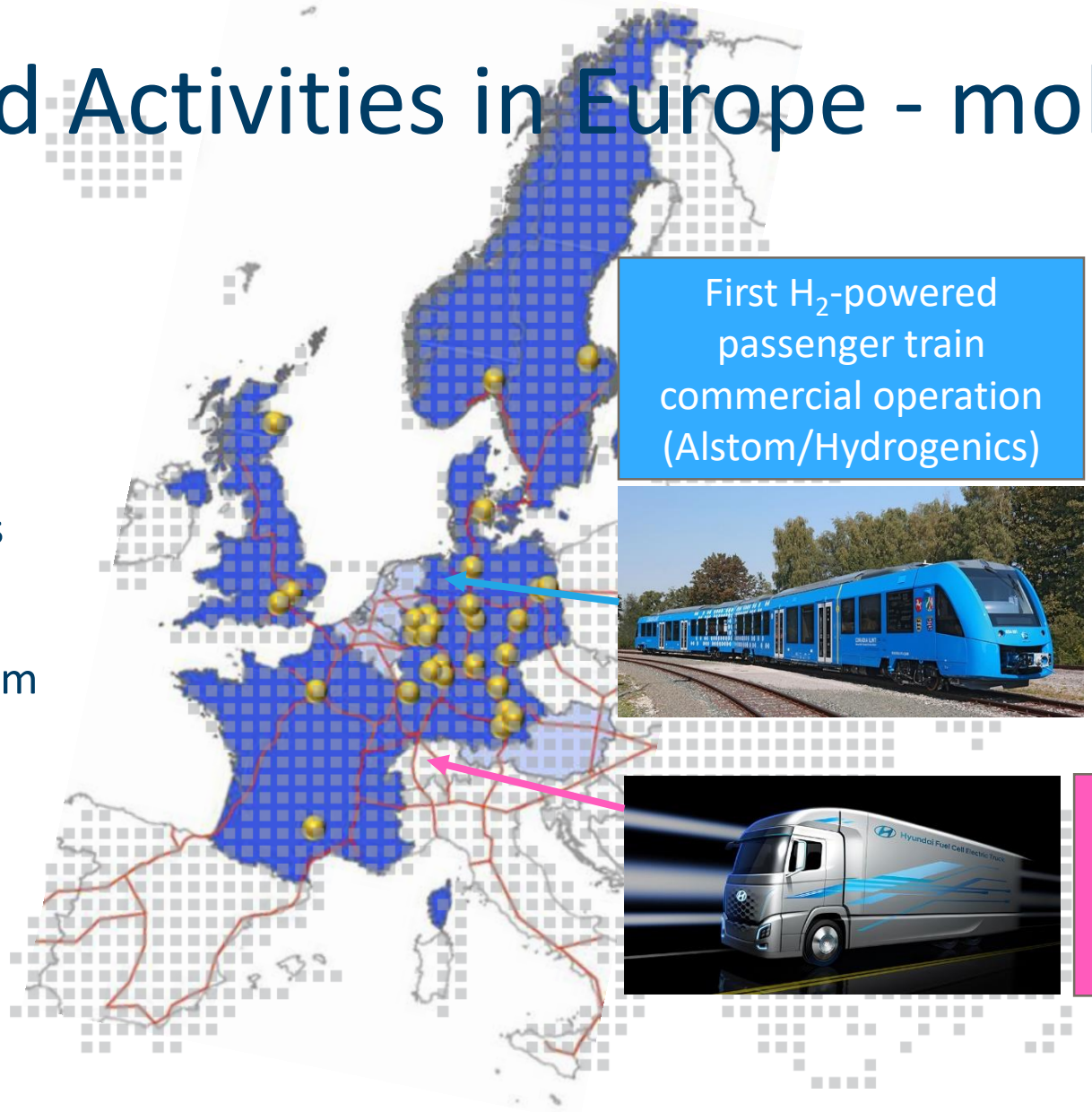

First H_2-powered passenger train commercial operation (Alstom/Hydrogenics)

Viable business case for 1600 H_2-fuelled (FC) Heavy Duty Trucks in Switzerland

Hydrogen Mobility Europe

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

- 49 new stations
- > 1400 cars & vans
- M€ 170 total cost
- M€ 67 funding
- > 40 organisations

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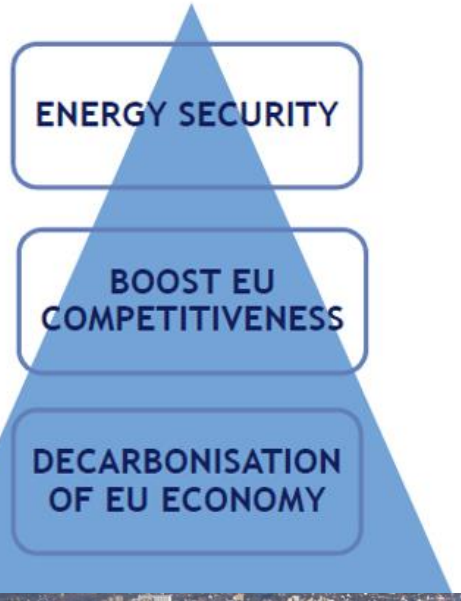
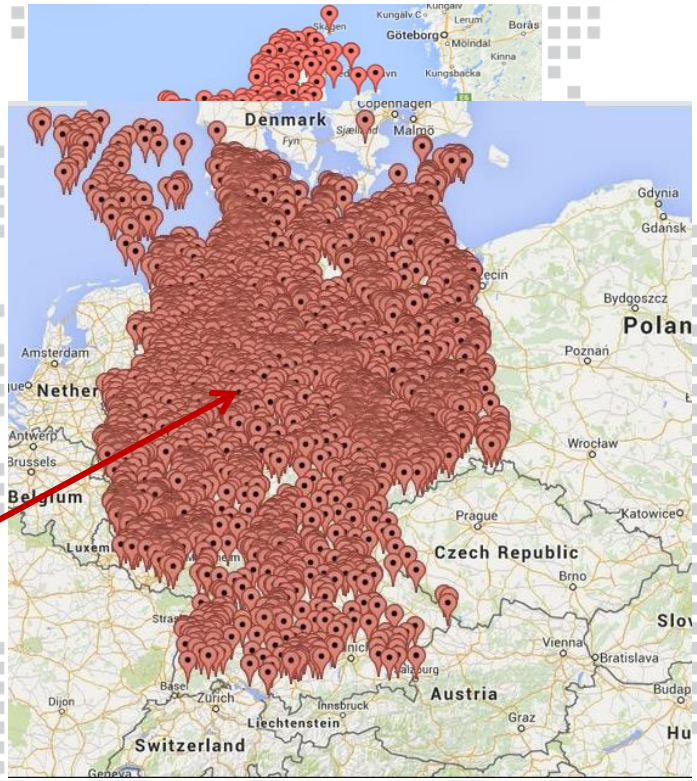
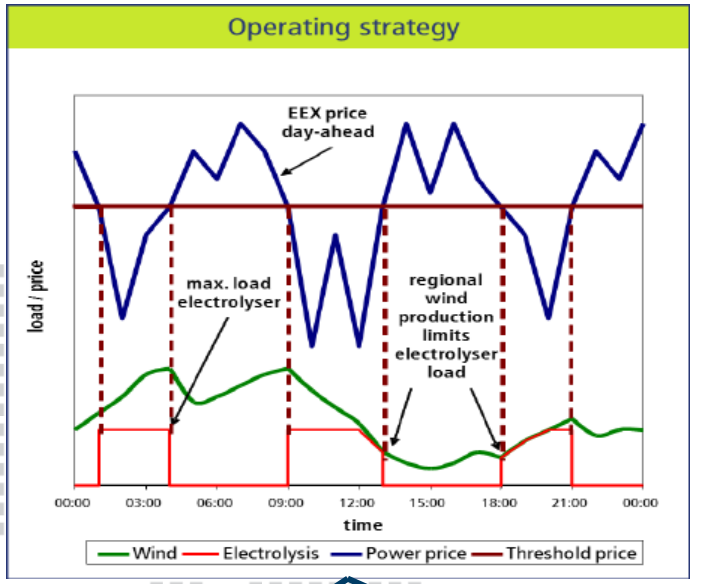
Trends and Activities in Europe - energy





Hydrogen is an energy vector
facilitating an increased share of RES



ludwig bölkow systemtechnik

Water electrolysis (PtG)
- High power (MW-GW)
- Coupling w/intermittent energy sources

Hydrogen storage
- Underground storage
- Solid state storage
- LH_2

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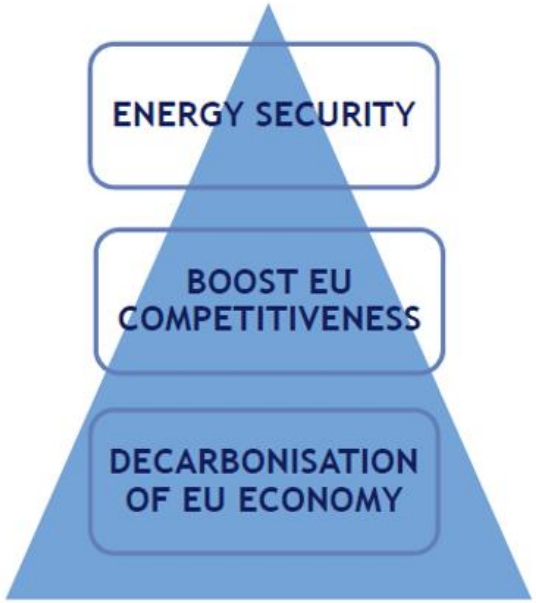
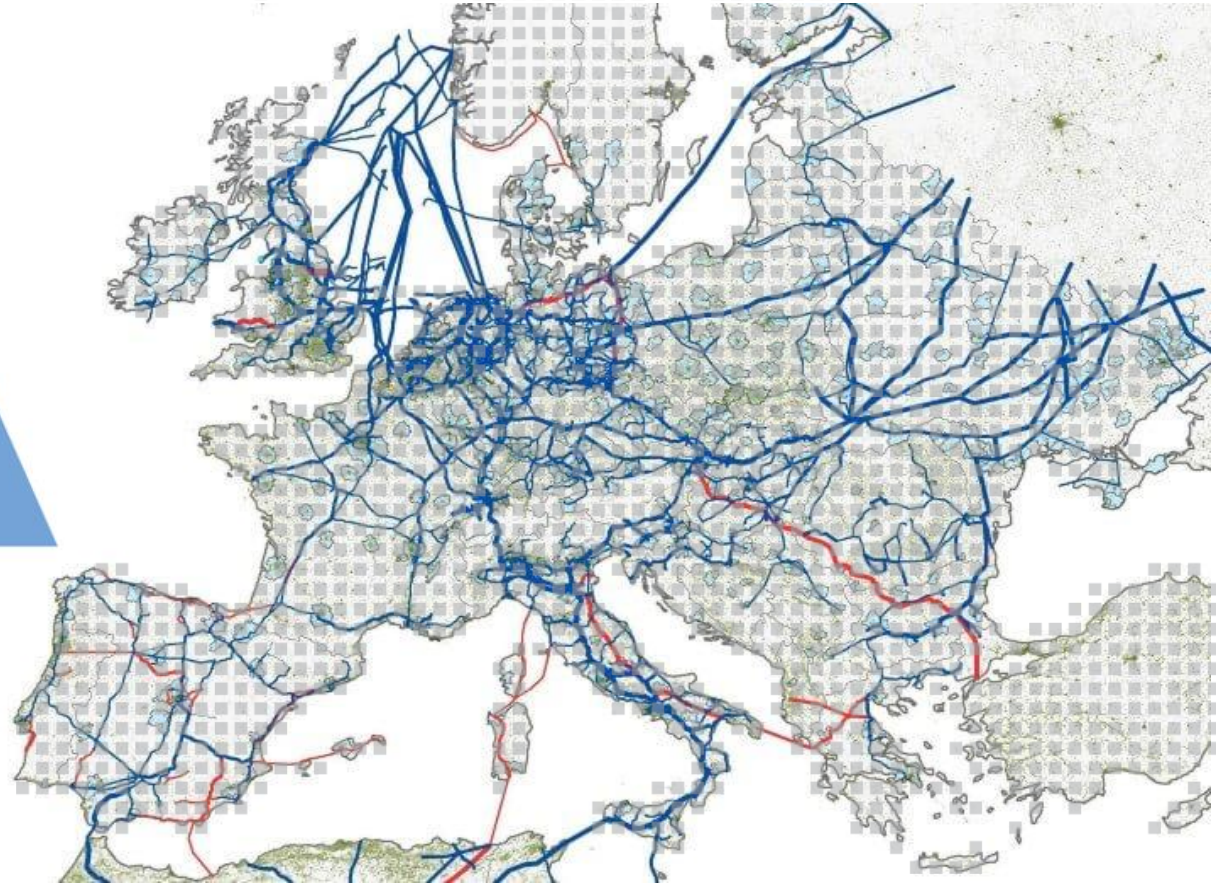
Trends and Activities in Europe - gas grid

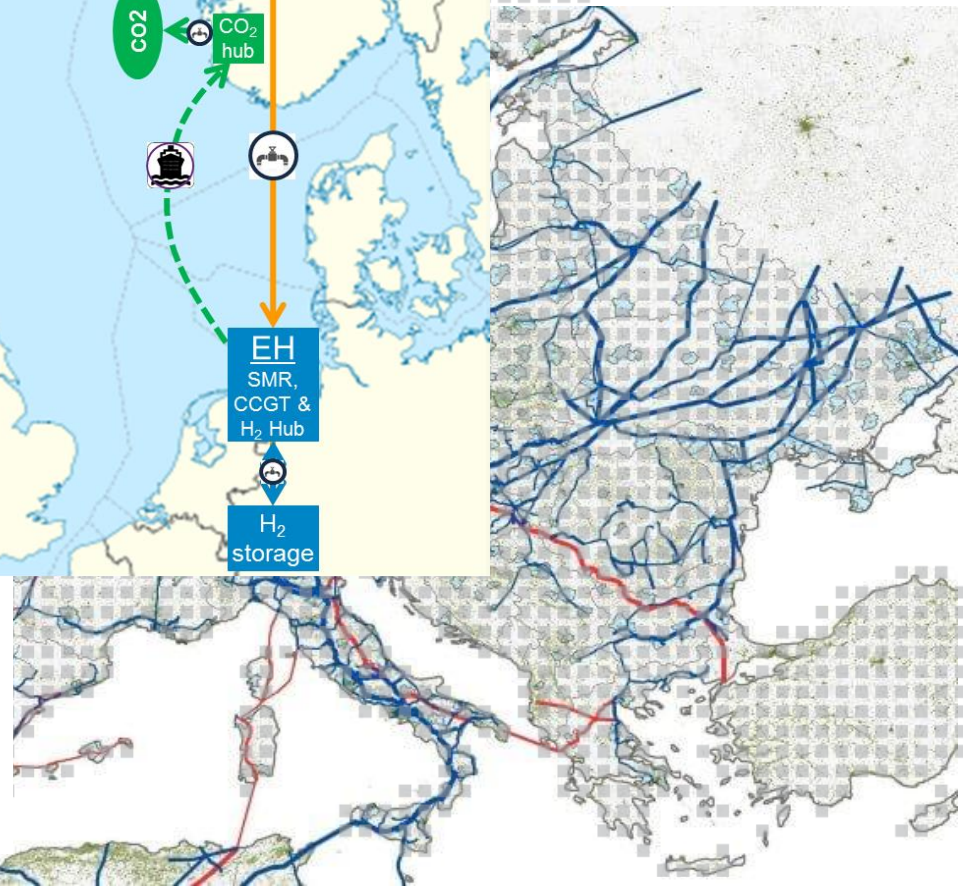




Admixture of H_2

- Business cases
- Injection system
- End user equipment
- Regulating authorities

Trends and Activities in Europe - energy



Vattenfall's gas power plant Magnum.
Plans to convert it to hydrogen.
Three 440 MW CCGT, the plant today emits 4 Mtonnes CO_2/annum.

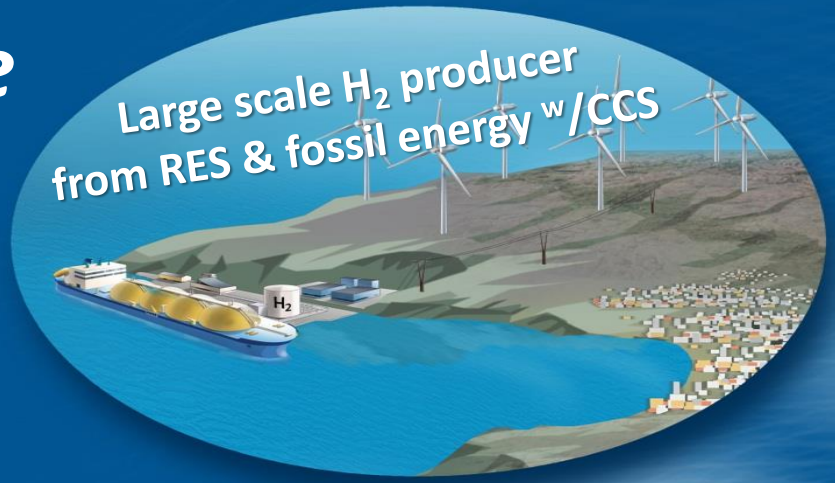
(Photo: Koos Boertjens/Vattenfall)

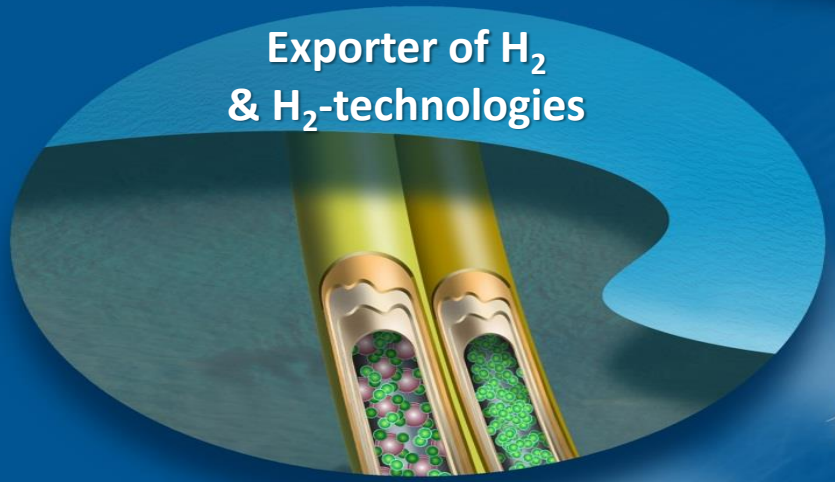
VATTENFALL

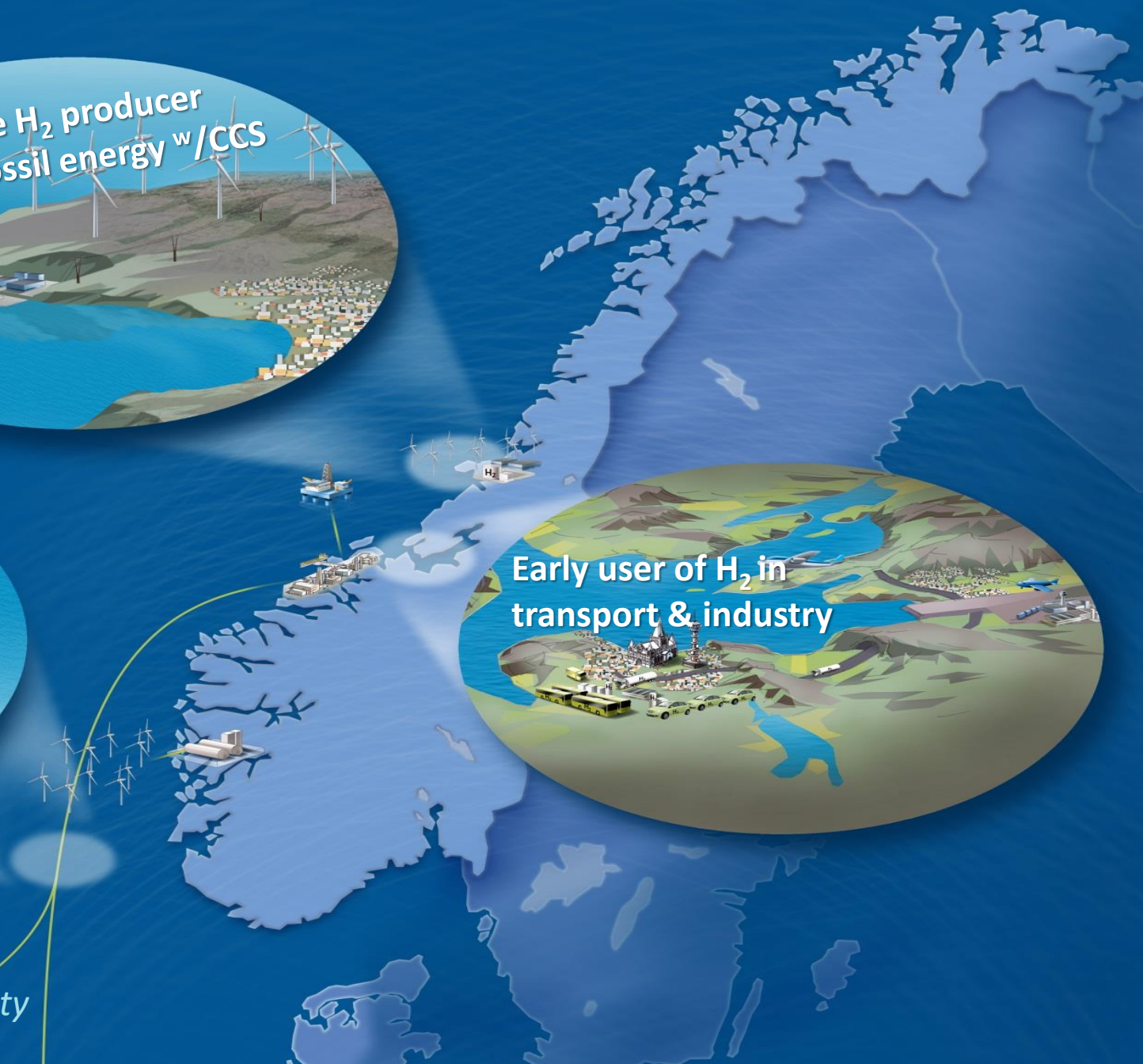
gasunie

equinor

Areas where Norway can play a key role internationally within hydrogen and fuel cells







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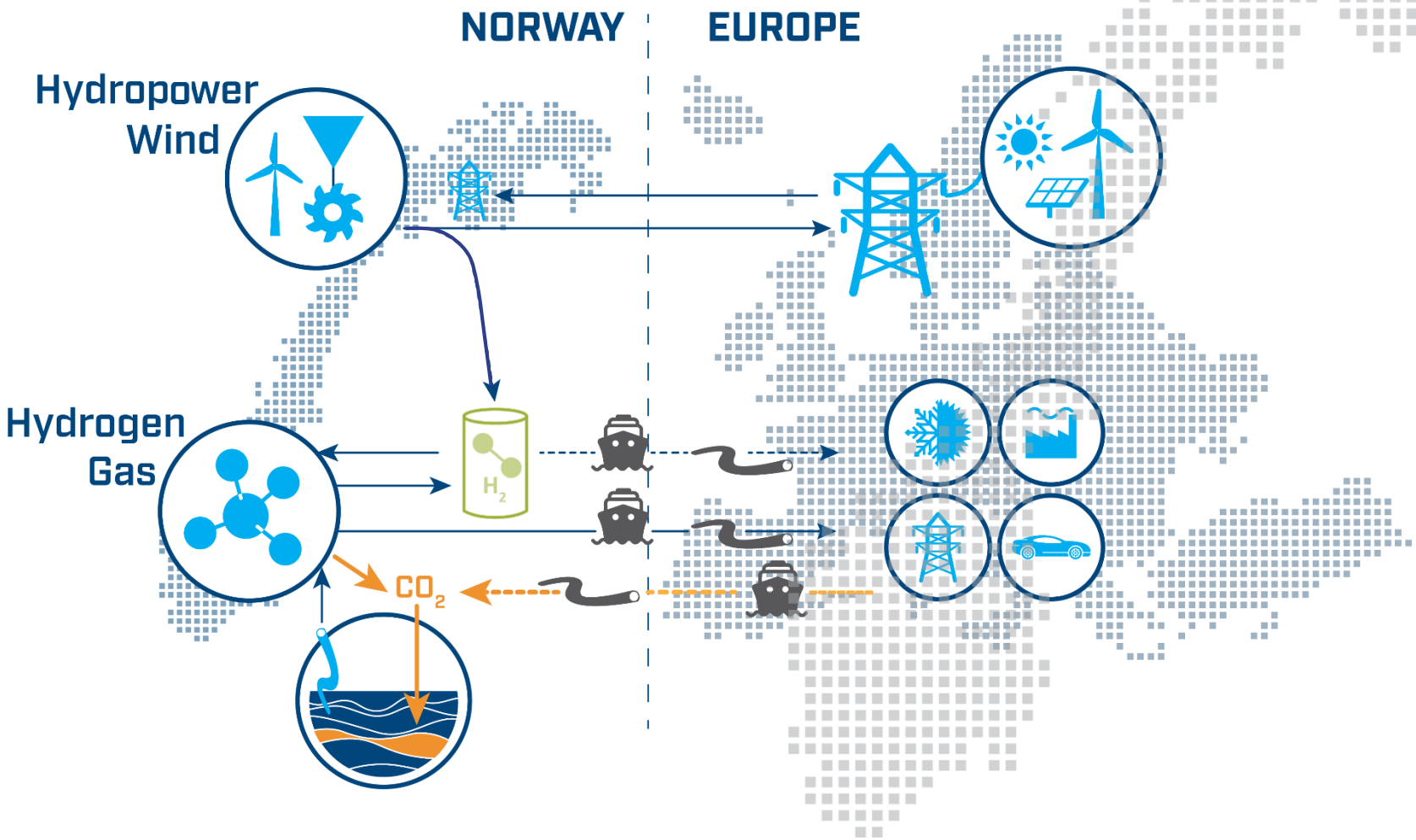
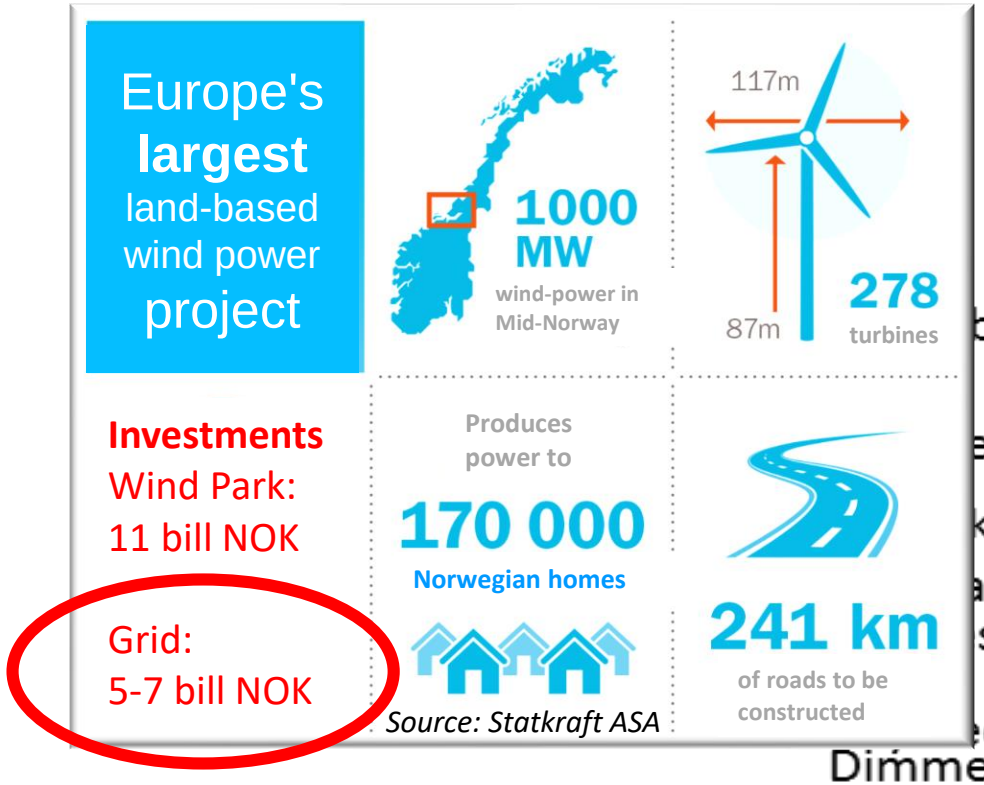
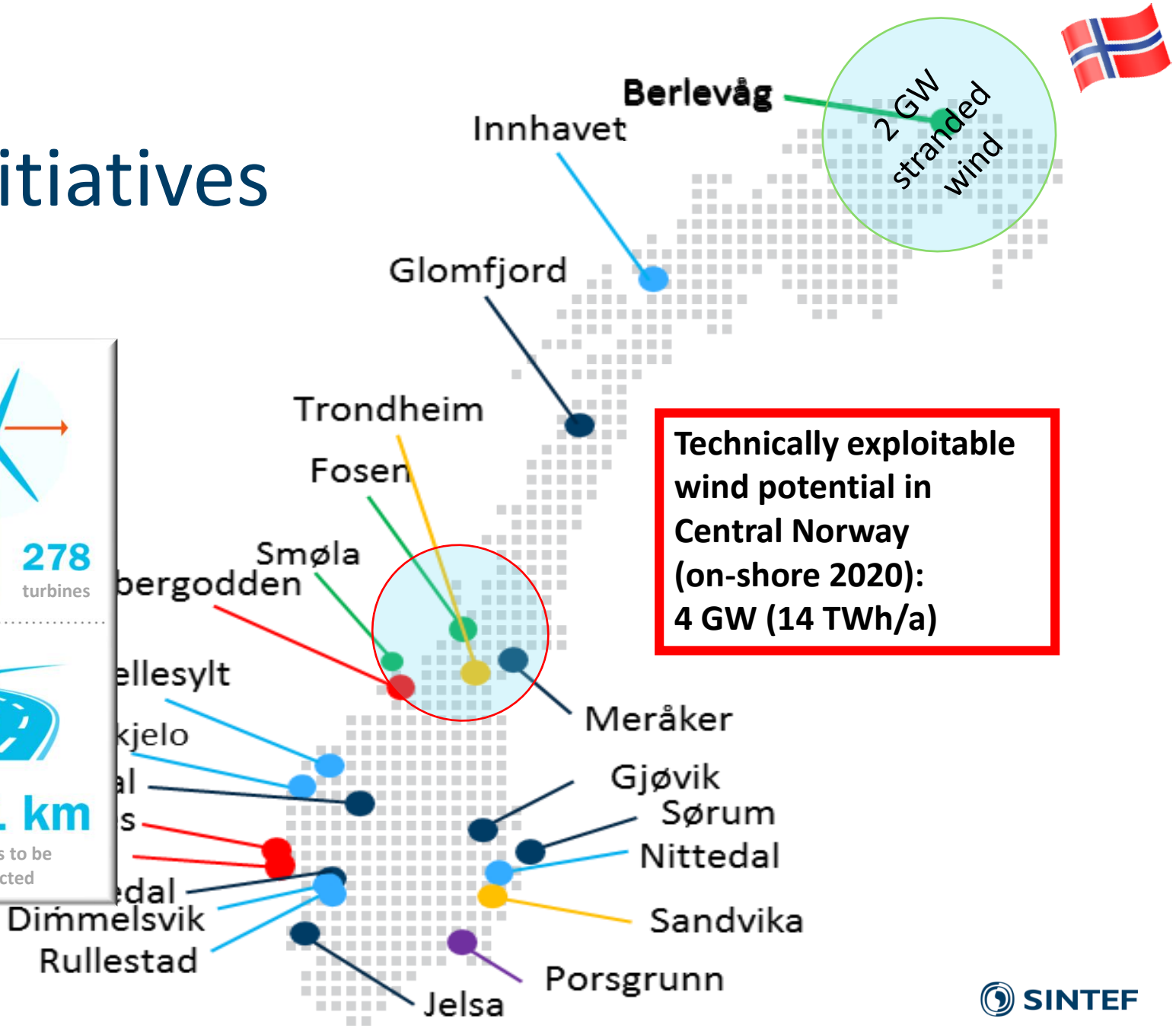
Norwegian energy export



H_2-production initiatives





Technically exploitable wind potential in Central Norway (on-shore 2020): 4 GW (14 TWh/a)

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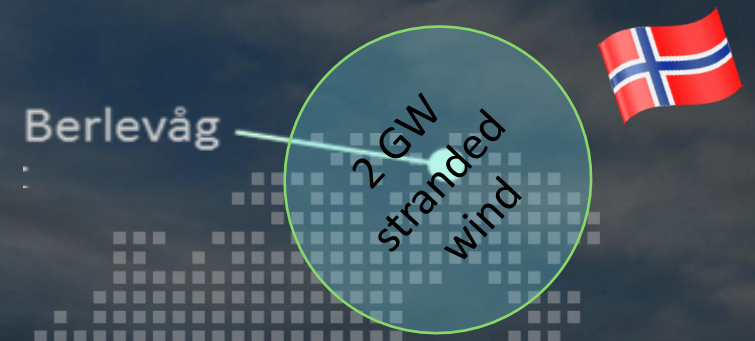
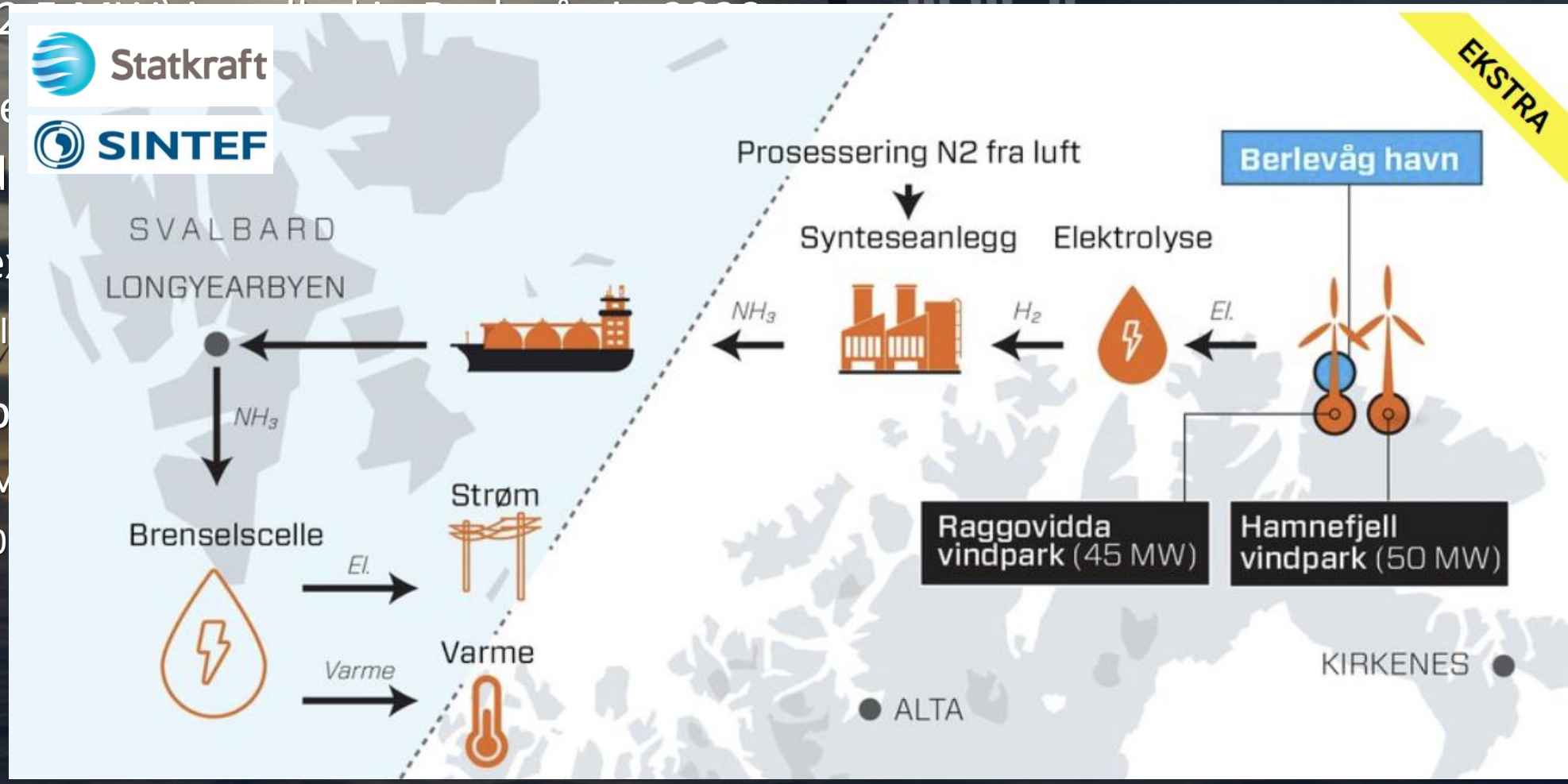
One of SINTEF's 28 EU-projects under the FCH JU-program

Wind → 1000 kg H_2/day



- Electrolyser (2
- Directly conne
  (avoiding grid
- Electrolyser e
  - Stabilize grid vol
- EU (FCHJU) -p
  - Total budget 7 M
  - Start January 20



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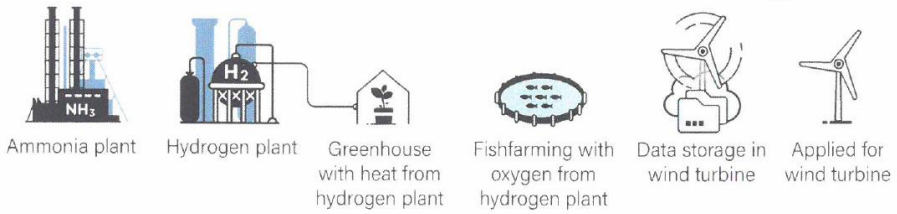
Stranded wind power

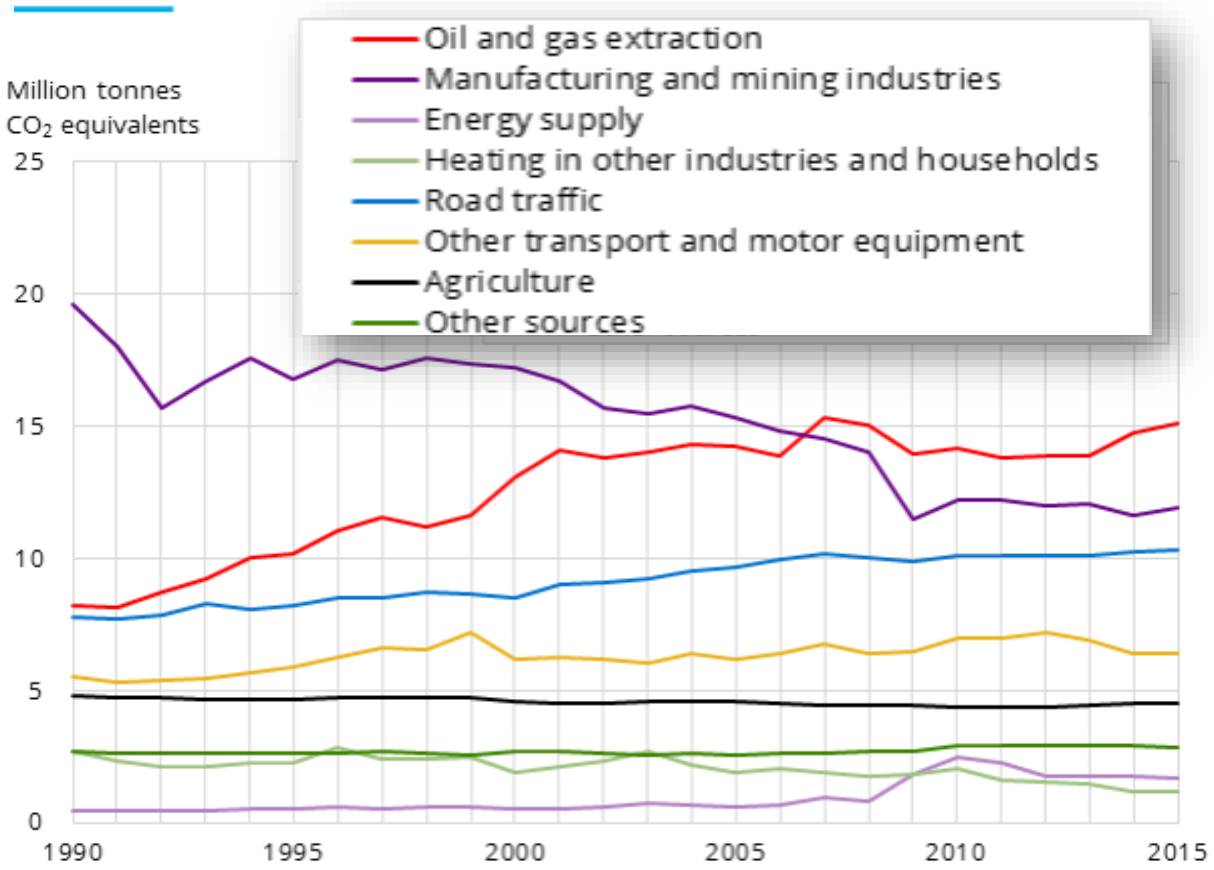
- Pilot-project: 2,5 MW ➔ 1 ton H_2/day
- Concessions 225MW ➔50 ton H_2/day
- Wind potential 2 GW ➔ 500 ton H_2/day
- Enough fuel for ½ mill. passenger cars (20%)
- Applications in Finnmark region:
  - Passenger cars, light & heavy duty trucks, Snow mobiles
  - Fishing vessels, Trawlers, Coastal 'steamers' (Hurtigruten)
  - Fish farming/Agriculture (O_2 & heat), Industry (NH_3?)



FINNMARK FYLKESKOMMUNE
FINNMÁRKKU FYLKKAGIELDA

LH2

Norway's domestic GHG emissions



Source: Statistics Norway 2015

Current GHG-emissions by sector:

- Oil & gas extraction ~ 28 %
- Transport contributes by > 30 %
- Electricity production by 1,7 %

GHG emissions & H_2 activities in Norway

Passenger vehicles, 5,3 mill tonnes

CO_2

Vans and heavy duty vehicles 4,5 mill tonnes

CO_2

H_2-delivery trucks in 2019 →

nel · HEXAGON SCANIA
HYDROGENICS SINTEF
SHIFT POWER | ENERGIZE YOUR WORLD
ENOVA

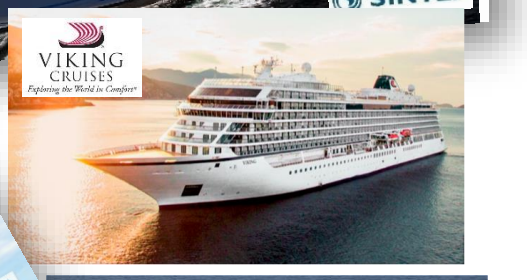
Domestic maritime and fishing, 2.9 mill tonnes

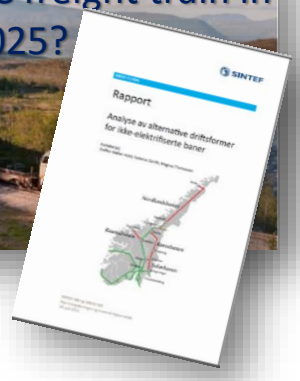
Other mobile sources 2.3 mill tonnes

Motor bikes and scooters 0,1 million tonnes

Railroads, 0,1 million tonnes

Domestic air traffic 1,3 million tonnes





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San Francisco 10.-11.September 2019

International Workshop, H2@Ports

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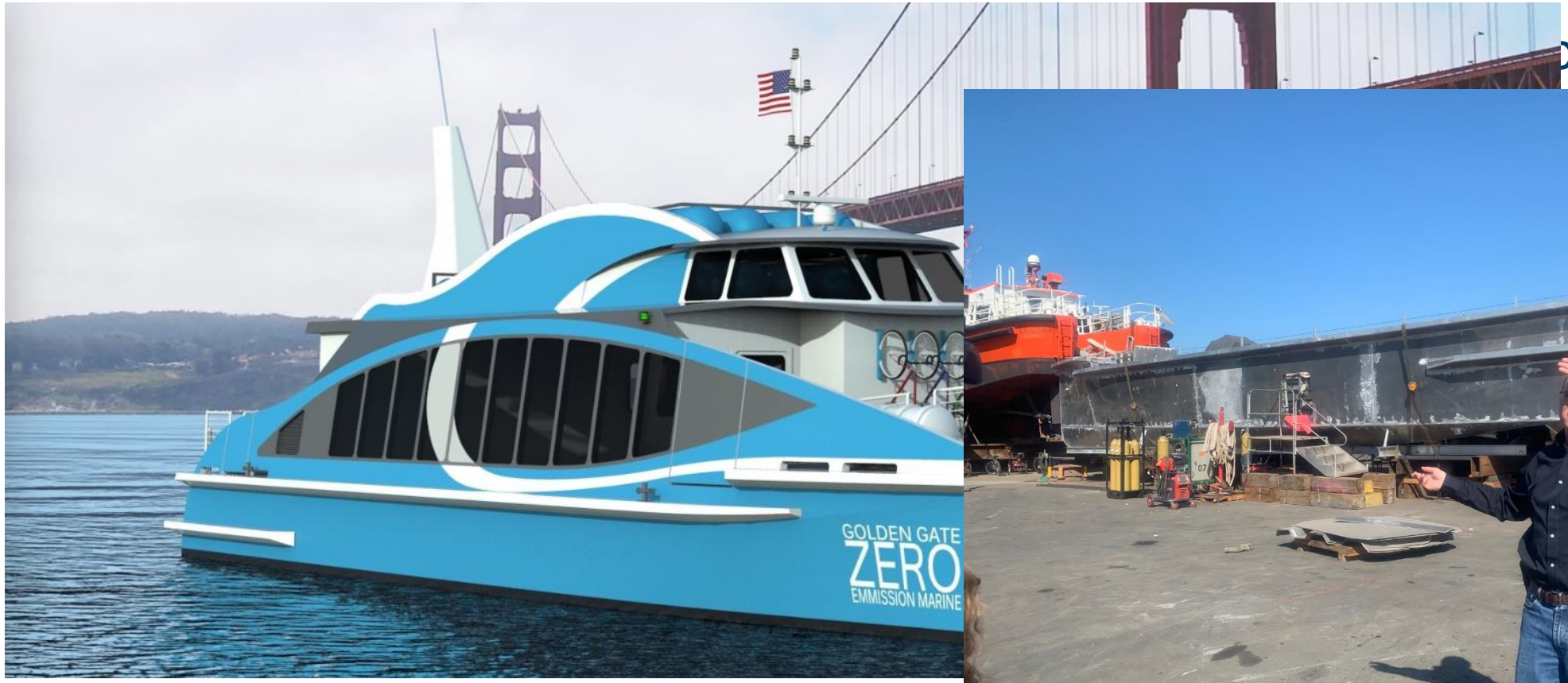


GHG emission reduction, maritime initiatives

Trondheim Sept 3rd, 0-emission High speed passenger boat concepts

BLUE MARITIME CLUSTER
GLOBAL CENTRE OF EXPERTISE NORWAY

Norwegian Centres of Expertise
NCE Maritime CleanTech

Statens vegvesen
Norwegian Public Roads Administration

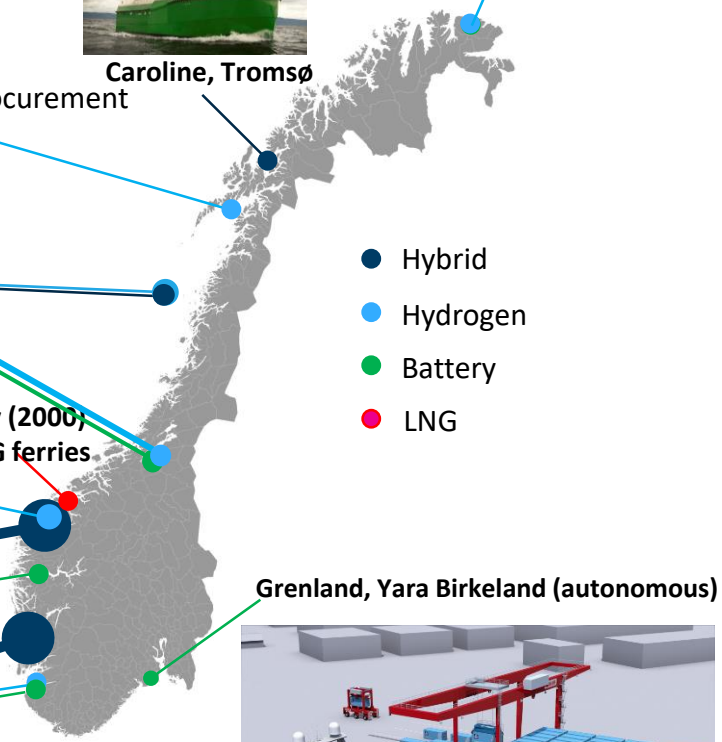
H_2-ferries, public procurement

Hjelmeland: LH_2/battery ➤ 2021

Statens vegvesen
Norwegian Public Roads Administration

Caroline, Tromsø

Berlevåg, fishing boats



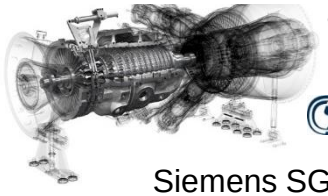
Glutra ferry (2000)
Now 21 LNG ferries

Grenland, Yara Birkeland (autonomous)

Hydrogen use in industry

Replacing NG with H_2 in gas turbines

#PowerTheEU



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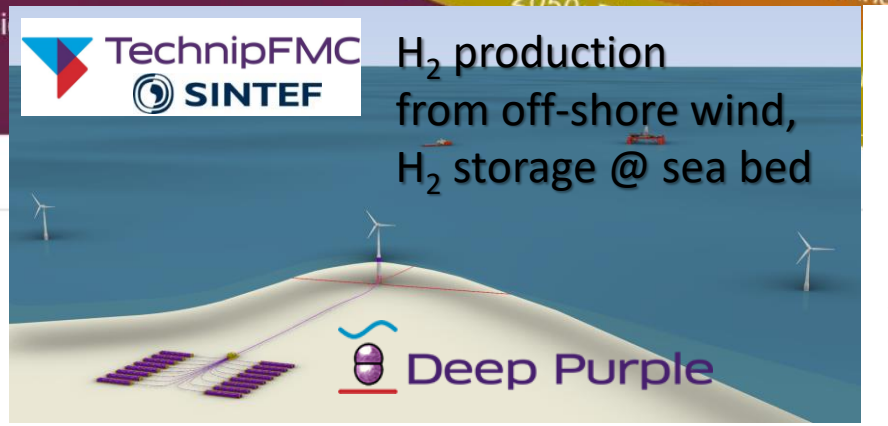
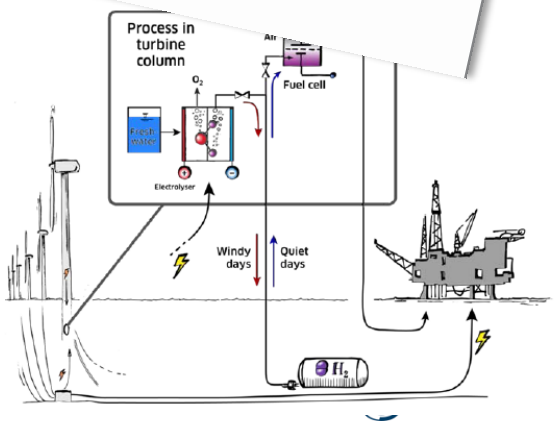
Siemens SGT-750



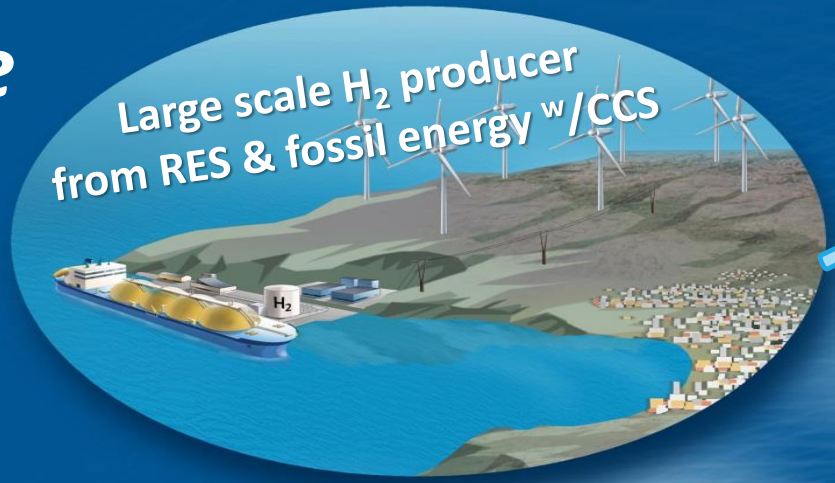


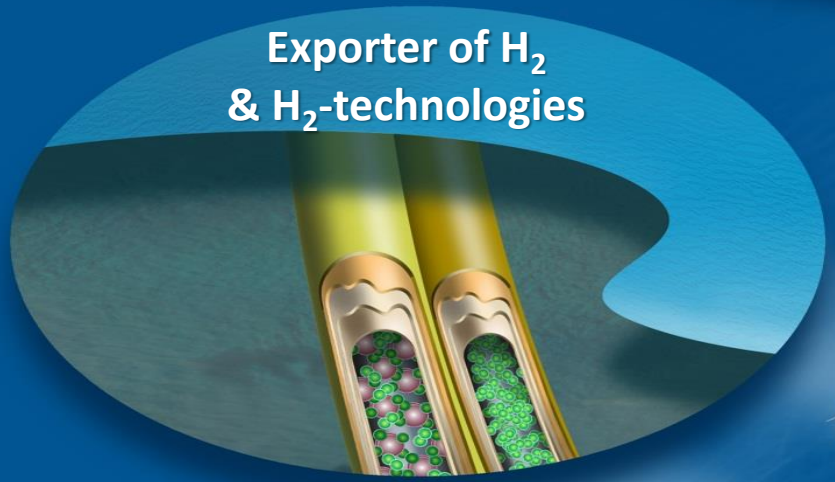
Value creation, H_2-technology export

Summary and Conclusions

- The contour of a H_2-oriented global economy is eventually emerging
  - Stronger alignment in Europe's energy & climate policies, H_2 for Sector Coupling
  - Hydrogen as feedstock for industry and a key solution to decarbonize the heat sector
  - Multiple H_2-mobility initiatives, increasing focus on heavy duty trucks, trains & maritime applications
- Norway is actively preserving its role as energy nation and front runner
  - Stranded renewable and abundant fossil resources suitable for H_2-production
  - Continued strong incentives for low and zero emission transport, new deployments @ road & sea
- High potential for value creation in Norway, not least in Ålesund region
- Looking forward to an ambitious national H_2-strategy ^{w}/binding targets

Areas where Norway can play a key role internationally within hydrogen and fuel cells





Thank you for your attention!

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