

Collaborative Innovation

Collaboration between research & industry
to address societal challenges



*Stakeholders' Forum,
Brussels, 22nd November 2017*



Dr. Steffen Møller-Holst
Vice President Marketing



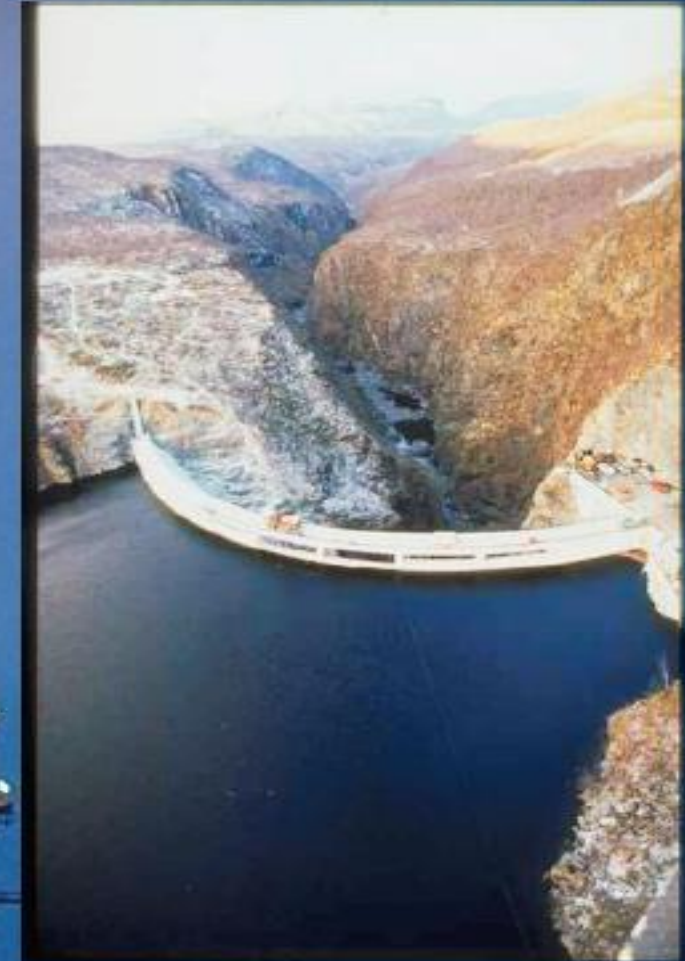
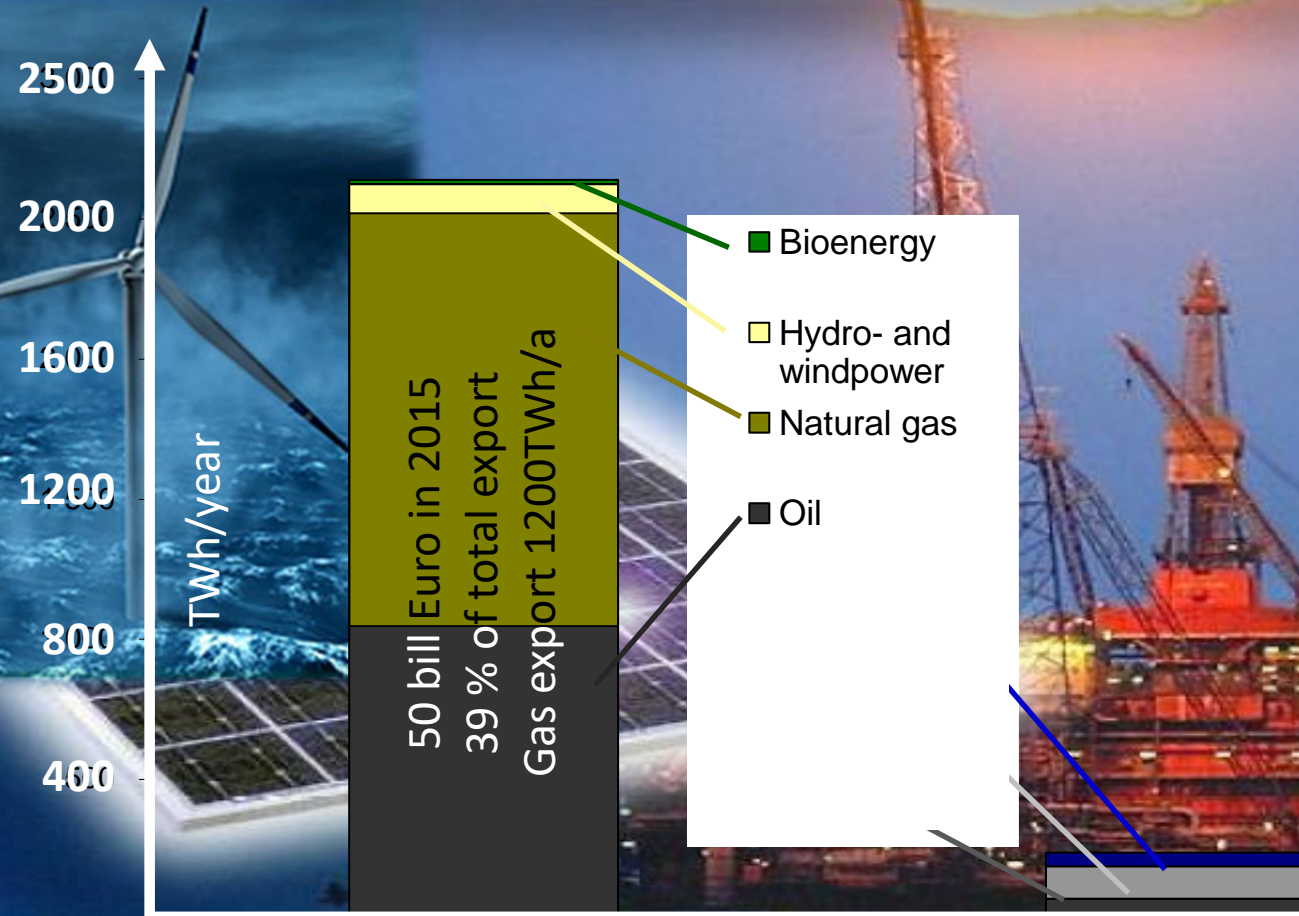
Chair for Transport



 **Norwegian hydrogen forum**
NORSK HYDROGENFORUM
hydrogen.no **Chairman**

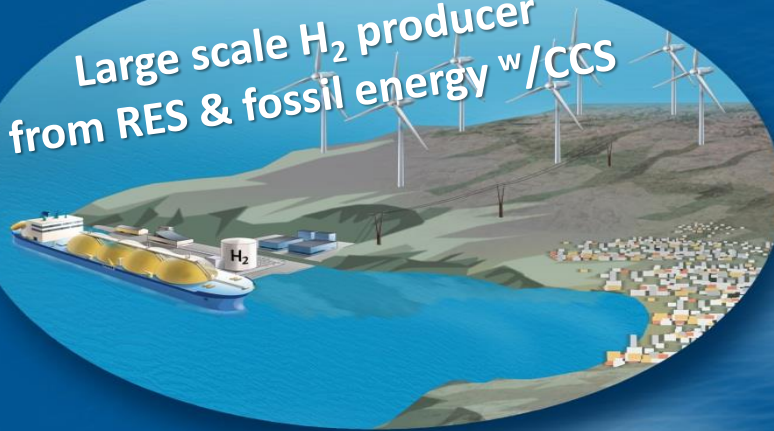
***"Market developments for hydrogen in Norway
– the crucial role of the FCH JU-programme"***

Norway - an energy nation.....

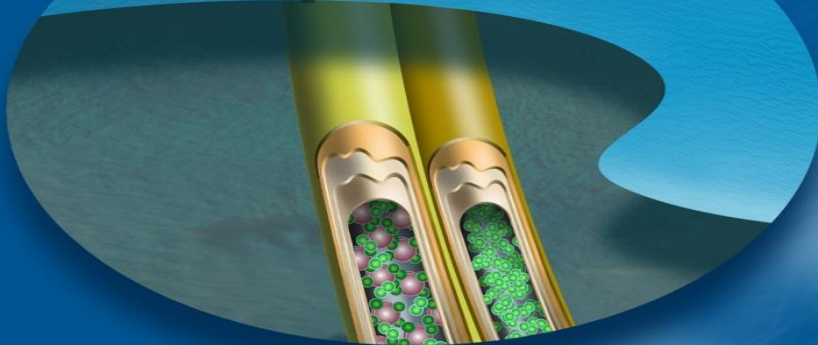


*Areas where Norway
can play a key role
internationally
within hydrogen
and fuel cells*

Large scale H₂ producer
from RES & fossil energy w/CCS



Exporter of H₂
& H₂-technologies



Early user of H₂ in
transport & industry





Four consecutive SINTEF coordinated FCH JU-projects (2010→2021)

NEXPEL - Next-Generation PEM Electrolyser for Sustainable Hydrogen Production

NEXPEL main objective:
Develop and demonstrate a PEM water electrolyser integrated with RES:
75% Efficiency (LHV), H₂ production cost ~ €5,000 / Nm³h⁻¹, target lifetime of 40,000 h

①

New catalysts
Improved MEAs
Improved DC-DC converter
New membrane materials
Novel stack design and new construction materials

Jan 2010 - Dec 2012
Co-ordination: SINTEF
Funding: Fuel Cells and Hydrogen JU
Total Budget: € 3,353,549
www.nexpel.eu

Coordinated by SINTEF, Magnus.S.Thomsen@sintef.no

SINTEF Technology for a better society

NOVEL

Novel materials and system designs for low cost, efficient and durable PEM electrolyzers

②

- Continuation of novel materials development from NEXPEL
- System design and optimization
- Increased understanding of lifetime and degradation issues in PEM electrolyzers

The NOVEL Consortium

SINTEF **Johnson Matthey Fuel Cells** **Fraunhofer ISE**
TEER COATINGS LTD **CEA** **BENEQ** **HELION**

Sept 2012 - Aug 2016
Total Budget: € 5,743,445

Coordinated by SINTEF, Magnus.S.Thomsen@sintef.no

SINTEF Technology for a better society

MEGASTACK – design and construction of MW PEM electrolyser

③

- Multiphase flow modelling of bubble formation and distribution in large scale PEM electrolyzers
- Model validation through high speed image capture and processing
- Pressure drop and flow distribution prediction

Coordinated by SINTEF, Magnus.S.Thomsen@sintef.no

SINTEF Technology for a better society



10 MW PEM-electrolyser, Rheinland Refinery, Germany



H₂ stations:

- 6 in operation
- 3 new 2017
- 20+ by 2020

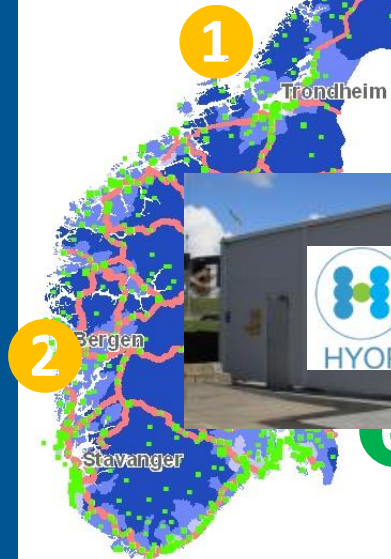


Demand Density
Fuelling Stations (t H₂ / a)

- 0 - 120
- 120 - 240
- 240 - 480
- 480 - 960

Corridors (t H₂ / km / a)

0.01 - 0.20



- 0.20-2.00
- 2.00-10.0
- 10.0-50.0



supplier to e.g.,

DAIMLER



H2movesScandinavia

FCH JU Flagship project 2011-2012, Oslo

- Demonstration of 17 Fuel Cell Electric Vehicles



Using
4,6 tons
of H₂

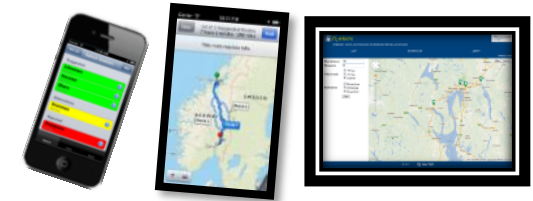
Reducin
g
CO₂
49 tons

- Establishment of one HRS + one mobile refueler



Feedback to R&D-activities

- Where is the nearest open hydrogen station?
- Hydrogen gas quality assurance → HyCora, SDO (ISO, CEN)
- Lowering the cost of H₂ at nozzle by 'clever' production (next slide)



Partners

Coordinator



Vehicles and infrastructure



Communication



Safety



CO-Funded by



Local partners

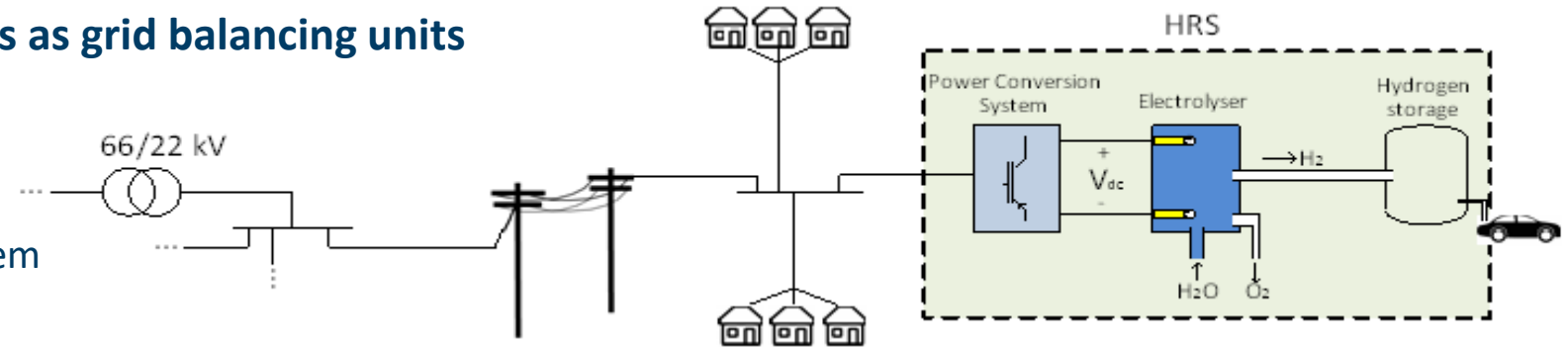


H2movesScandinavia

Lowering the cost of H₂ at nozzle by 'clever' production

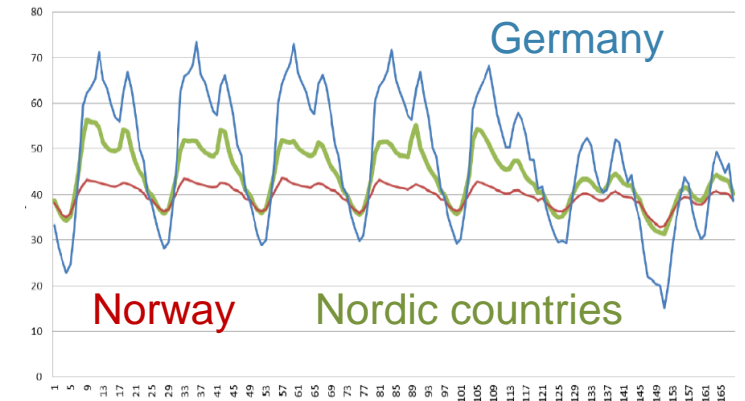
- Concepts & models for using HRSs as grid balancing units

- Grid support – what and why?
- Power conversion system topologies
- Modelling & control of the HRS-system
- Frequency, Fault & Voltage support



- Optimal design and operation of H₂ refuelling stations in various markets

- *"Minimal electrolysis capacity"*: Constant production, require significant storage.
- *"Minimal electricity cost"*: Production only at night. Requires higher production capacity.
- *"Minimal storage"*: H₂ production follows demand. Higher el. cost & require large electrolyser.



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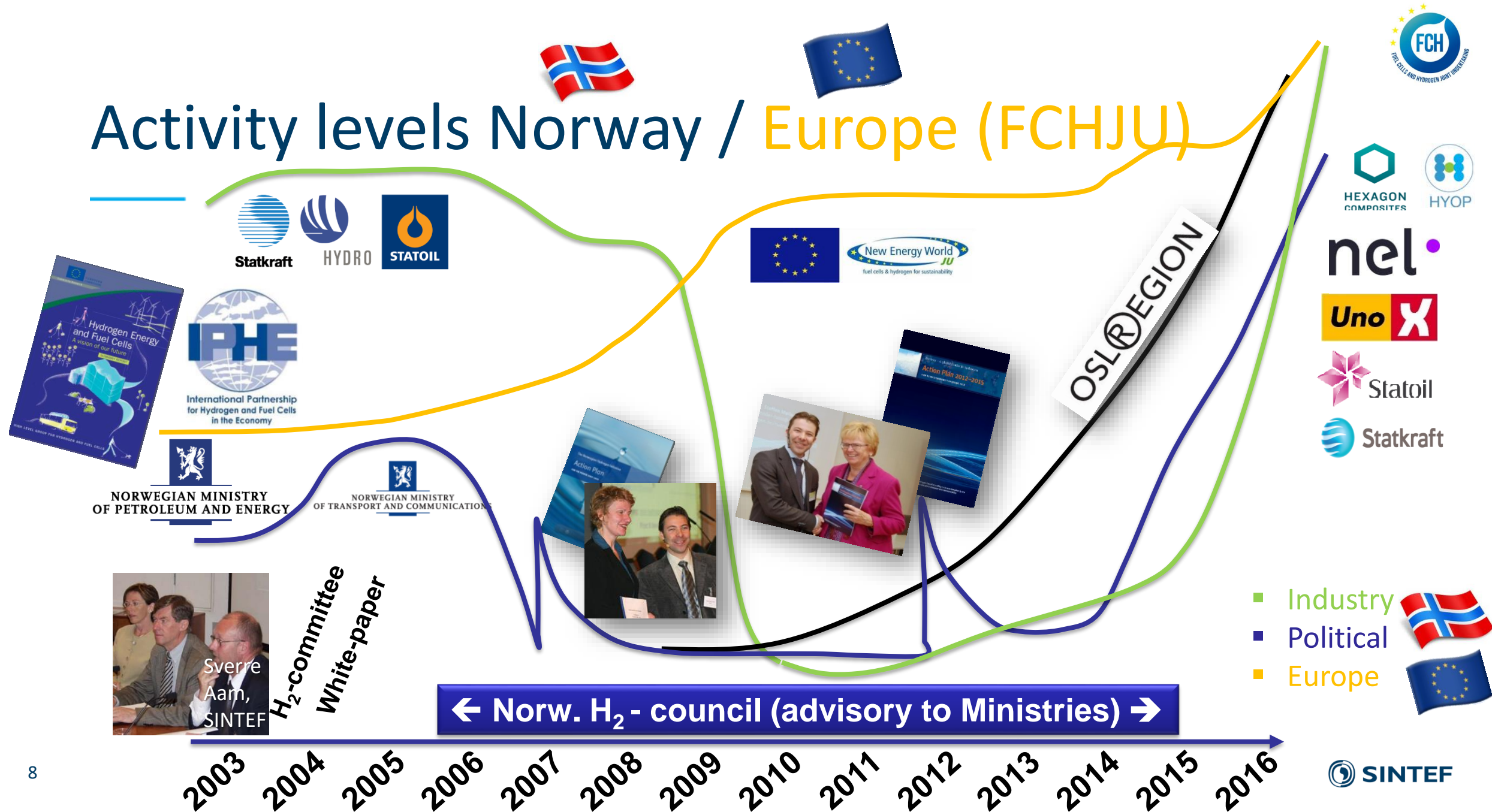
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Activity levels Norway / Europe (FCHJU)



GHG emissions and FCH-activities in transport



Passenger vehicles,
5,6 mill tonnes

CO₂

Vans and heavy duty vehicles
4,4 mill tonnes

CO₂



H₂-delivery trucks in 2018 →



Domestic maritime and fishing,
3.7 mill tonnes

Other mobile sources
2.3 mill tonnes

Motor bikes and scooters
0,1 million tonnes

Railroads
0,05 million tonnes



Domestic air traffic
1,3 million tonnes

100 passenger trains
2017-2021

ALSTOM

MoU with
4 regions in Germany



0-emission passenger trains in Norway?

Raumabanden 2020?

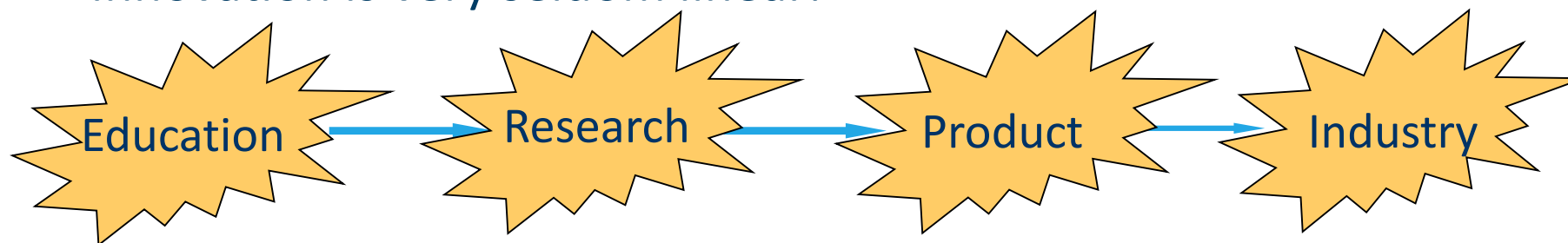


5,6 MW H₂/FC freight train in Norway by 2025?

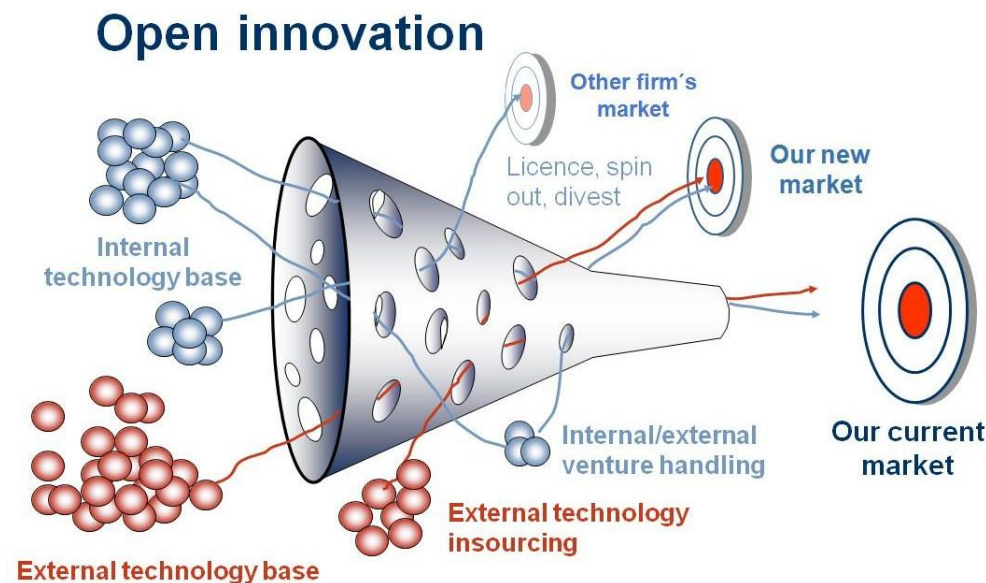
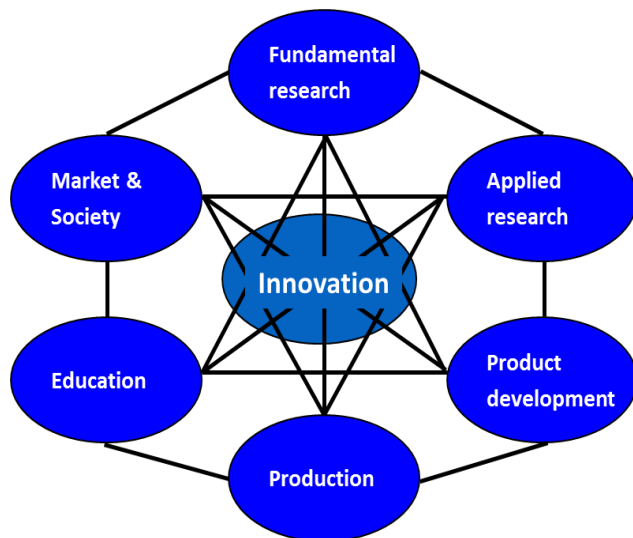


Innovation & Business development

- Innovation is very seldom linear:



- Better descriptions:





Summary

- Norway is in a key position to facilitate FCH commercialization
 - abundant fossil/renewable energy resources → large scale H₂ production & export at acceptable cost
 - strong public support schemes with enforced focus on H₂ / CCS / fleets / maritime & industrial applications
 - incentives for implementing 0-emission vehicles & is an attractive early market for FCEVs / maritime transport
- The FCH JU program has played a crucial role for Norwegian H₂-activities in
 - maintaining the momentum during the decade when Norwegian industry backed out of H₂ (2007-2016)
 - securing continued Norwegian competence building and increasing the FCH project portfolio
 - fostering H₂-technology implementation in Norway based on SINTEF's outreach
- Innovation is closely linked to successful collaboration between Industry & Research
 - FEEDBACK from Demonstration projects to R&D, SYNERGIES, TRUST as basis for consolidated strategies
 - **European-wide collaboration/network is especially important for a small country like Norway**



Thanks to FCHJU for
continuous support,
& for your attention!



Technology for a better society

