"Recent development in Norway:
-H₂ ships, national programme, & international cooperation"

H₂@ports Workshop, Marines' Memorial Club & Hotel
San Francisco, September 10-12, 2019
Areas where Norway can play a key role internationally within hydrogen and fuel cells.
Outline

• Why Norway is heavily involved in new technologies within maritime transport
• Recent and ongoing activities and projects to reduce emissions from shipping
• Political engagement & National programs to foster market development
• Examples from recent public procurement processes
• Regional activities in central Norway
• International collaboration
• Summary/Conclusions
SINTEF - Scandinavia's largest independent research organization

2000 Employees

75 Nationalities

4000 Customers

NOK 3.1 billion Revenues

NOK 450 MILL International sales

SINTEF, a key player in low & 0-emission technologies (R&D → Implementation):

- development of Combustion-, Battery- as well as H₂ & Fuel Cell technologies
- > 30 years in H₂-technologies, 28 EU-projects (2010 →), budget 60 MNOK/a (2016)
- interdisciplinary approach: Technology ↔ Economy ↔ Societal aspects
Rationale for why Norway is engaged

- Norway has the second longest coast-line of all nations (>20 000 km)
- Norwegians is a people of the sea, fishing / ship building / coastal transport
- Maritime industry is the 2\textsuperscript{nd} largest, total value creation of NOK 130 billion
- Maritime activities contribute significantly to Norway's GHG emissions
- Cruise ships frequently visit our World Heritage Fjords \(\Rightarrow\) NO\(_x\), SO\(_x\), PM
- Norway has world leading H\(_2\)-technology suppliers (e.g. NEL, Hexagon)
- Ambitions to 5 times increase the fish farming industry \(\Rightarrow\) emissions
GHG emissions by sector in Norway

Electricity production from RES,
No natural gas grid!

- Oil & gas extraction ~ 28 %
- Transport contributes by > 30 %
- Electricity production: 1.7 %

Source: Statistics Norway 2015
GHG emissions & H₂ initiatives in Norway

- **Passenger vehicles, 5.3 mill tonnes**
- **Vans and heavy duty vehicles, 4.5 mill tonnes**
- **Domestic maritime and fishing, 2.9 mill tonnes**
- **Other mobile sources, 2.3 mill tonnes**
- **Domestic air traffic, 1.3 million tonnes**
- **Motor bikes and scooters, 0.1 million tonnes**
- **Railroads, 0.1 million tonnes**

- **Passenger trains, Germany 2018 →**
- **5.6 MW H₂/FC freight train in Norway by 2025?**

Question: 0 emission passenger trains in Norway?
Towards 0-emission ships

- Regulatory framework for LNG as maritime fuel established during 1990s
- World's first LNG-powered ferry in operation 2000
- Conceptual design of H₂-ferry (1999-2001), Grove Symposium 2001
- FCSHIP, 1st EU-project (FP5) 2002-2004 (SINTEF), recommendations to EC
- FellowShip-project, Viking Lady, 320kW MCFC, 2003 → 2011
- World's 1st LNG-bunker vessel M/S Seagas, Fiskerstrand (2014), refuelling Viking Grace
- World's 1st battery powered (120) car ferry (1MW) Ampere in operation 2015
- Design of 1 MW FC powered H₂-ferry (Fiskerstrand Yard) 2017-19, construction 2020-21
- Parliament decision: 0-emission regulations in Norwegian fjords 2026
Low and zero emission initiatives/projects

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

- Berlevåg, fishing boats

- Caroline, Tromsø

- H₂-ferries, public procurement

- Statens vegvesen 
  Norwegian Public Roads Administration

- Wilhelmsen / Equinor 
  LH₂ pilot tanker

- Container Ship Project

- SeaShuttle H₂/FC

- Statens vegvesen 
  Norwegian Public Roads Administration

- Havila, FC/Hybrid

- Glutra ferry (2000)
  Now 21 LNG ferries

- Ampere, Norled (2015)

- Grenland, Yara Birkeland (autonomous)

- Hjelmeland: LH₂/battery ➔ 2021

- Battery

- LNG

- Hydrogen

- Hybrid
Liquid hydrogen?
Government's Ocean Strategy

• Ambition to cut by half the emissions from domestic maritime traffic and fisheries by 2030
• Support R&D development across the ocean industries
• Strategy recently updated

• Few direct implications for hydrogen as maritime fuel
• National hydrogen strategy to be launched early 2020
Ferry market development

- 130 routes, 200 ferries, 20 mill vehicles & 40 million passengers/a
- Involvement and commitment* from Norwegian authorities and NPRA
- Funding that reflects the level of ambition
- A competent, efficient and professional procurement organization
- Joint effort from the public procurers (critical mass)
- Consistent and predictable requirements
- Individual tenders – assessment of economic risk on the ferry companies and predictable conditions

“The Government is requested by the Parliament, to ensure that requirements for zero-emission technology (and low-emission technology) are included in all future tenders for public ferries, when the technology allows for it.”
Areas where Nor can play a lead international role within and fuel cells.
The City of Trondheim

Large scale subsea hydrogen storage in ports

H₂-refueling station for:
- High Speed passenger boats
- HD Trucks and Buses
- Car ferries
- Train?

Subsea hydrogen storage
The Region around Trondheim
REGIONAL PUBLIC TRANSPORT

CO₂-emissions

600 buses

6 ferries

5 High-speed passenger boats

2015

Biogas & Battery

Biogas, Battery & Hydrogen

High Speed Passenger Boats

Ferries

Local buses

Regional buses
High speed passenger boats

• Trondheim to Kristiansund, ~3.5 hours, 2,5 tons H₂/day
• Pre-study to investigate feasibility of H₂ as fuel (SINTEF):
  • H₂-infrastructure, bunkering and supply
  • Techno-Economic assessments (vessel)
• Dialogue w/technology suppliers 2018→
• Concept developments/testing 2019→
• Public Procurement of vessels 2020 →
• Vessels in operation (target) 2023 →
Towing Tank @SINTEF/NTNU, 1939
Ocean Space Center

- 2000 Ocean Space Center initiative by SINTEF & NTNU
- A wide range of concepts/designs/approaches
- Governmental grant for realization secured last week
- 2020 – 2021 Pre-study
- 2022 – Construction to start
- 2025 – Completion of Ocean Space Centre
World's 1st H₂/FC car ferry?

Pilot-E funded project 2017-2021:

✓ Optimal FC/battery/H₂-storage capacity for various operation profiles (kW/time)
✓ Design, safety and risk assessment
✓ Testing of a down-scaled hybrid system (FC/battery) in SINTEF's laboratories

• Ferry service (location), Approval ➔ Rebuild vessel, Pilot operation 2021?
International cooperation

• Safety, Regulation, Codes & Standards (SH2iFT-project (SINTEF), DNV GL, ABB, Siemens etc.)
• Inter-governmental Oceanographic Commission (food production, health, transport)
• The Arctic Council (8), circumpolar political collaboration body at government level
• The International Council for the Exploration of the Sea (North Atlantic)
• Washington Maritime Blue (US) / NCE Maritime CleanTech (N) (MoU June 2019→)
• Europe/Norway: FCHJU-funded RD&D-projects, Maritime WG (Hydrogen Europe)
• Japan/Norway, H₂-technologies, Bilateral Workshops (2003 – 2019)
Summary/Conclusions

- Norway is a shipping nation with long traditions
- Maritime activities contribute significantly to value creation and emissions
- Norwegian stakeholders have engaged in low emission maritime transport since 1990
- Hydrogen is becoming an integral part of the portfolio of maritime fuels
- Government, public administrations, industry & R&D institutions are joining forces
- Administrative and regulatory frameworks are being developed, Public Purchasing
- *International collaboration is key to accelerate implementation of FCH technologies!*
Thank you for your attention!

Technology for a better society