Look to Norway: Technology Updates

Ingve Sørfonn, Chairman NCE Maritime CleanTech

NORWAY IN FRONT WITHIN SUSTAINABLE OPERATIONS

Hybrid operation with battery from 2012

- 15% reduced fuel consumption
- 25% reduced NOx emission
- 30% reduced CH_4 emission

5 years with battery operation

Viking Lady

Hybrid operation from 2009 with fuel cell

- Demonstrated sucessful use of Fuel Cells in ships
- Existing class notations developed during the project
- H2 storage on-board
- LNG used as fuel

4 years with FC operation

Results :

Operation with fuel cell very stable over years

Operated approx. 20 000 hours without major degradation of cells

No major maintenance during the operation time

Batteries required to balance FC slow respons time for large power peaks.

Cost reduction important for further market development

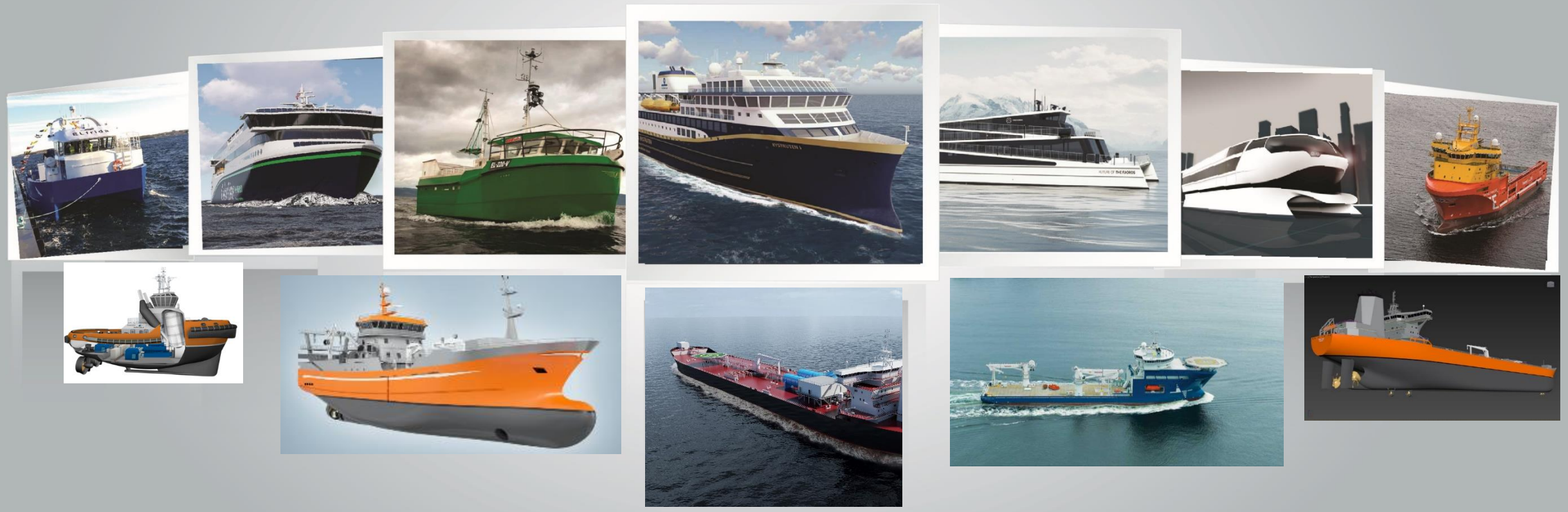
Safety concept demonstrated

Ampère: The start of zero emission ferry operations

SHIP OF THE YEAR AWARD
SKIPSREVYEN

- The world's first commercial electric ferry in operation in 2015
- Fuel cost reduced by more than 50%
- By 2021 about 50-60 electricial ferries will be in operation.

Energy storage and low emission concepts across segments

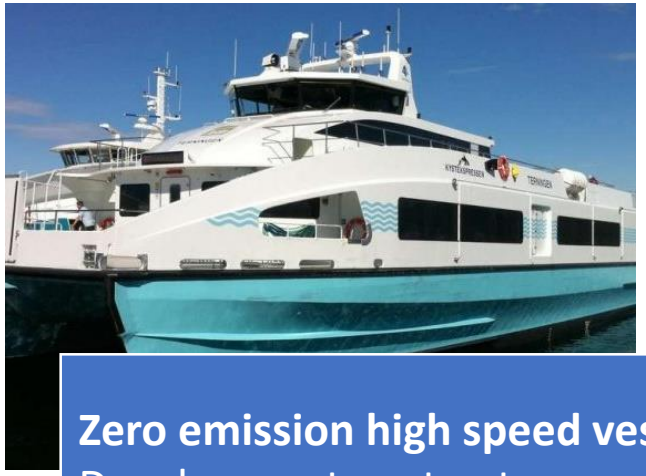


De-carbonize operations from large ships

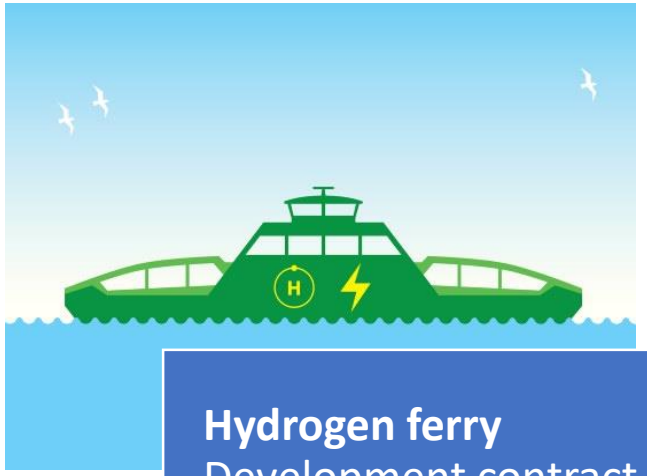
- The Cruise segment need over time to demonstrate more sustainable operations
  - Introduce new “green” fuels
  - Introduce fuel cells
  - Hybrid energy systems
  - Energy management
  - New infrastructure and logistics
  - Shore connection in harbors or green power on-board

365 cruise vessels – average 34MW power capacity
CAGR 2018-23 – 8%
Total power 13GW
Total energy 25-30 TWh

This is ongoing in Norway

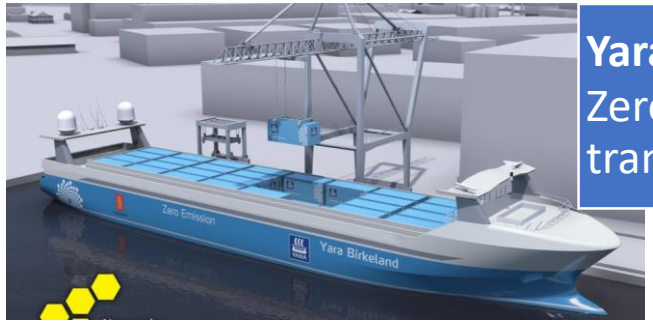


Zero emission high speed vessel
Development contract



Hydrogen ferry
Development contract

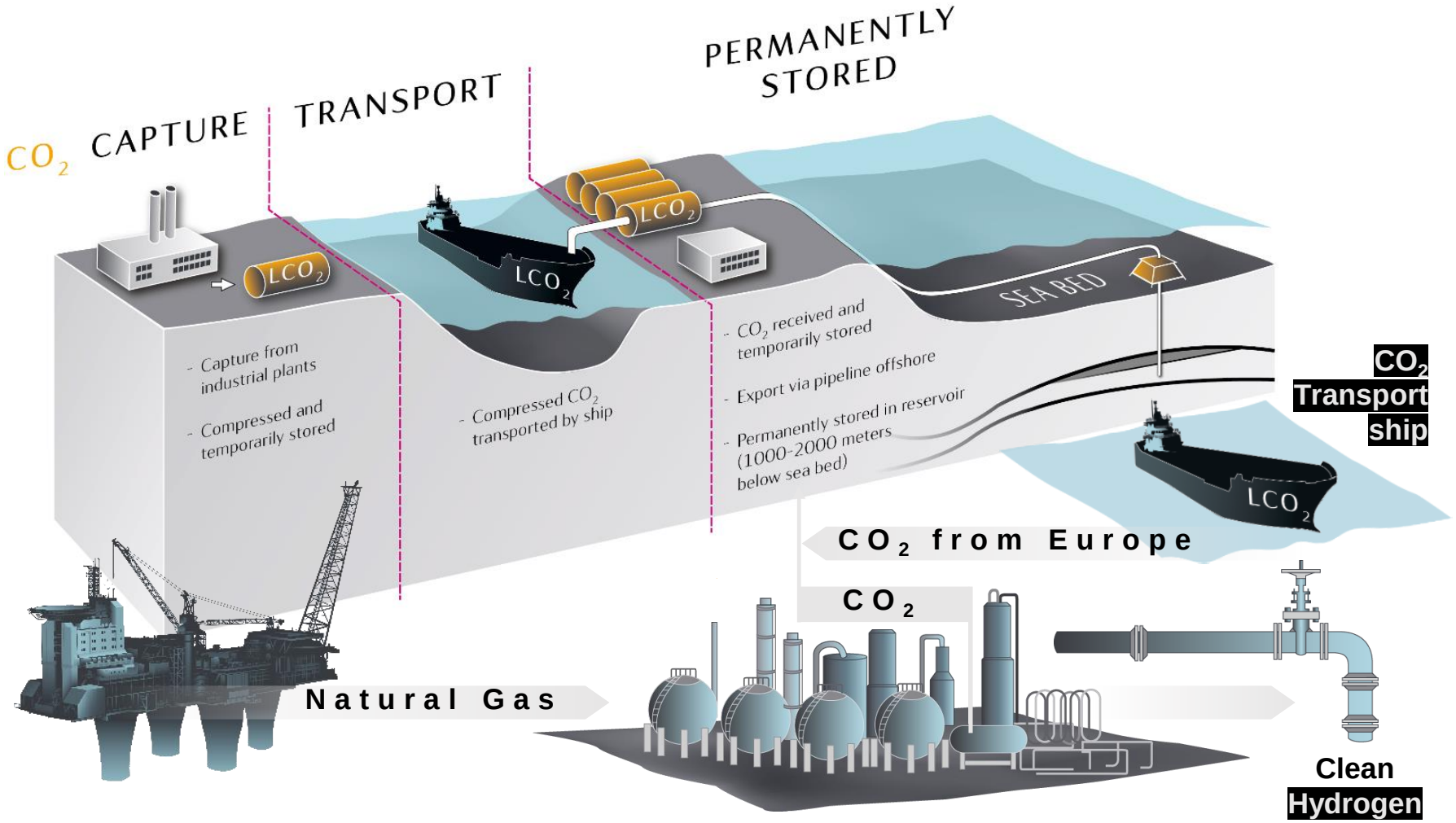
Zero emission PSV
Cluster project



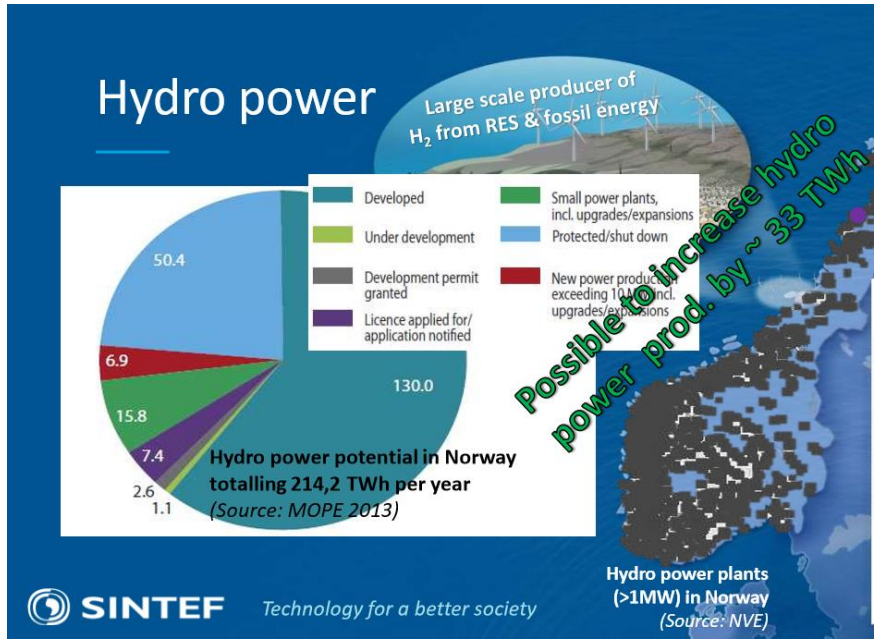
Yara Birkeland
Zero emission cargo transport pilot

Hydrogen from carbon fuels

equinor



Hydrogen from water and renewables or other

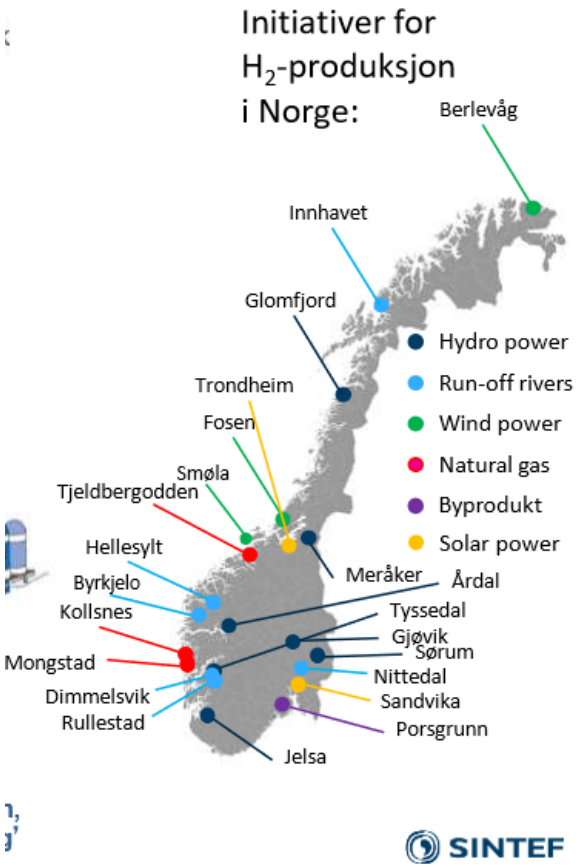


Large scale industrial production

Norway may take a leading position in using their hydro power and other renewable power production.

Our yearly hydro power production is in avareage about 130 TWh.

Large electrolyse plants still existing in Glomfjord, Rjukan, Notodden.



On demand on-board

Then we need to think innovative :

- carbon fuels with onboard CO2 capture – requiers a business model for CO2
- new ways of splitting H2 from water - the winner, if we can reduce the conversion energy substansial

Political ambitions

- Climate friendly energy technologies for the maritime sectors, with batteries, hydrogen and bio-fuel as energy carriers, are defined as a strategic focus area by the Norwegian government.
- Norway has ambitious targets for emission reduction, and hydrogen is seen as an important contributor in reaching these targets.
- The Norwegian government is developing a comprehensive national strategy for research, technology development and use of hydrogen as energy carrier.
- Public financing schemes and programmes are instructed to encourage increased use of hydrogen in the maritime sector.

Zero emission in the Norwegian Fjords

May 3rd 2018:

*"*The Parliament calls on the Government to implement requirements for zero emissions from tourist ships and ferries in the world heritage fjords as soon as feasible and no later than 2026*".*

TOWARDS ZERO EMISSIONS

- IMO GHG strategy
- Need for new zero and low emission solutions
- Energy Management focus
- Hybrid energy systems
- Cooperation & co-innovation
- Heavy infrastructure need to be in place