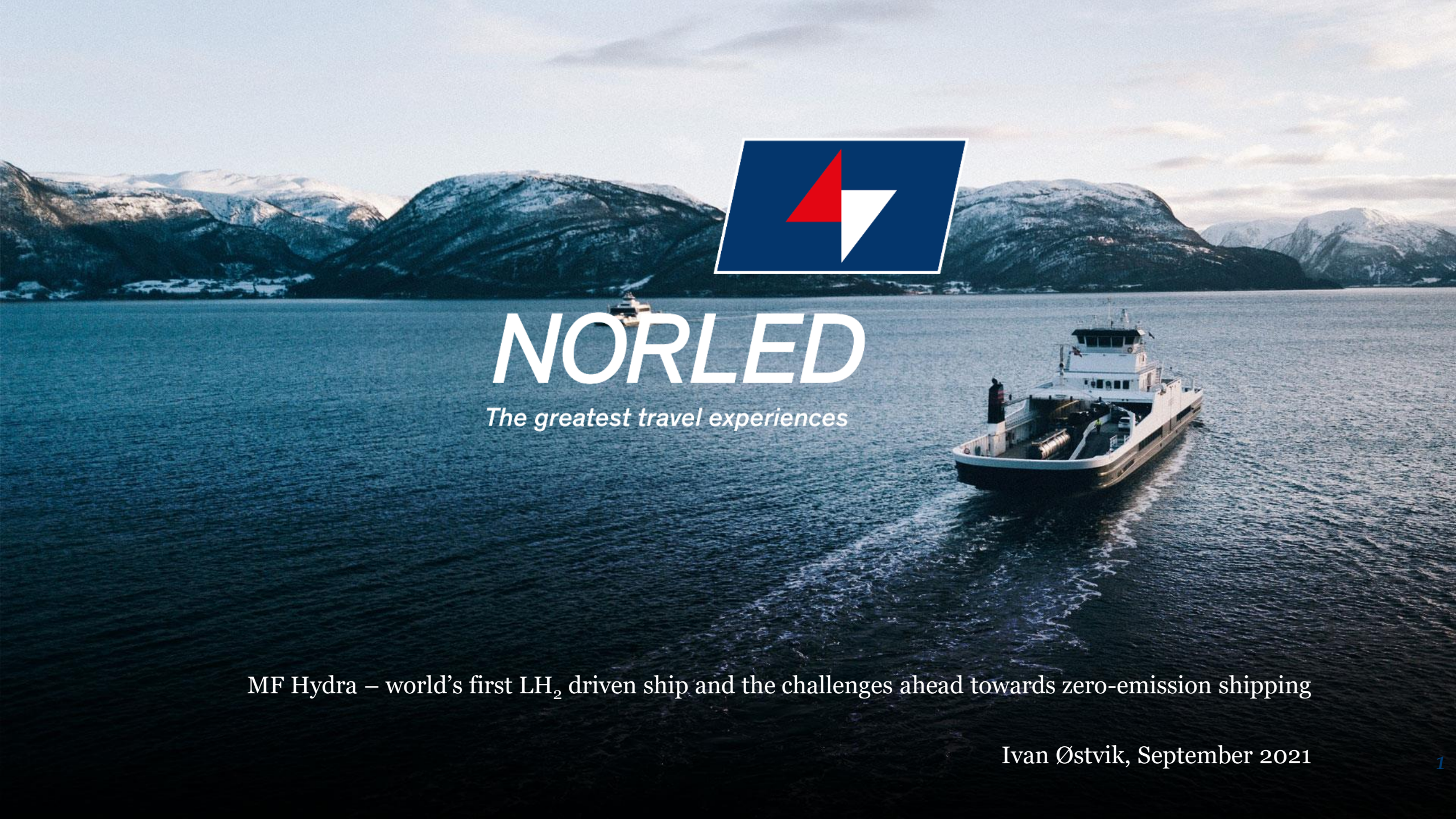


MF Hydra – world's first LH_2 driven ship and the challenges ahead towards zero-emission shipping

Ivan Østvik, September 2021

A major ferry operator in Norway

NORLED
The greatest travel experiences

#2 Ferry company

57 ro-ro ferries

29 routes

#1 Express boat company

28 fast ferries

18 routes

The “green ferry” revolution in Norway

NORLED
The greatest travel experiences

2015: The first el-ferry “Ampere” is launched

2022: About 80 el-ferries in Norway

2022: World-first LH2-driven ship “Hydra” in operation with others to come

The MF Hydra project

- Contract signed with Westcon Yard, Ølensvåg in May 2019
- Delivered for el-operation July 2021 for the Hjelmeland-Nesvik-Skipavik route
- LH_2 plant installation and testing Q1 2022 and in operation Q2 2022
- Hydra is 82m long, carries 80 cars and 299 passengers.
- LH2-tank 4 tons capacity, PEM FC 400 kW, Battery 1,5 MWh
- Route utilised to demonstrate/develop hydrogen ship technology:
  - Hydra can sail on a full fuel-cell mode with only peak loads required to be supplied from batteries – FCs providing 85-90% of required power
  - Hydra can operate 12 days on one LH_2 tank filling
- Hydrogen system solutions on Hydra are scalable to ocean-going vessels (coastal and shortsea)
- Alternative design process (IMO 1455) applied and system risks accommodated by ship design

Hydrogen-driven ship projects

NORLED
The greatest travel experiences

2017

Energy Observer

Race for Water

Beffen 2009

2019

Elektra

Maranda

2020

2022

HYSEAS III

Susio Frontier

Hydra

Water-Go-Round

2023

Heidelberg/Felleskjøpet

Hydrogen Viking

Finnøy

2025

YANMAR TOYOTA

Topeka

Hydrogen fast ferries

Vestfjorden ferry

Havila

Ulstein OSV

Bill Gates Yacht

Viking Cruises

Østensjø OWSP

Samskip

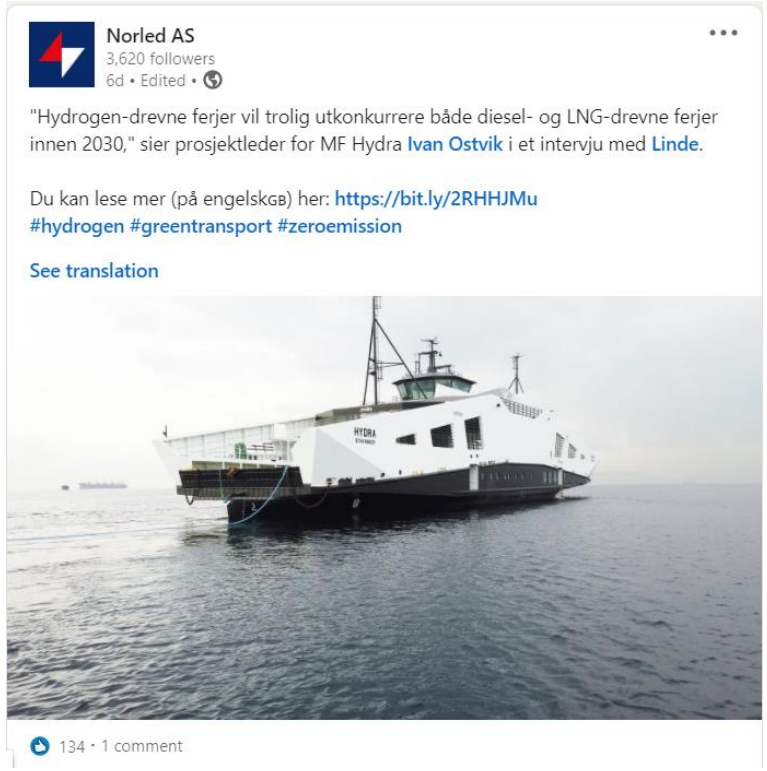
Moss LH2 carrier

DFDS

Veidekke

Kawasaki LH2 carrier

Why hydrogen-driven ship projects?



- **Ship technology** (storage and fuel cells) will develop, improve and see cost reductions. The new technology will be effectively integrated in new ship designs, as other techs have been earlier.
- **Hydrogen fuels** can be provided as GH_2, LH_2, NH_3 and LOHC and need to have a low carbon content
- **Maritime hydrogen supply chains** will be established and see a high-rate growth towards 2030 - costs will be greatly reduced and hydrogen will be available in port areas.
- **Target costs** quoted from suppliers range 2-3 Euro for GH2 in 2030. NH3 and LH2 will initially see a cost premium.
- **CO2 taxation** will add costs to fossil fuels, and cost parity between MGO and hydrogen is expected by 2030.
- **Risks and safety** issues being targeted and solved by industry.

Challenges ahead

- Lack of **hydrogen supply chains and bunkering hubs** to realise hydrogen as maritime fuel.
  - Current developments by new actors/companies in a **“project-by-project approach”**
  - Difficult for projects to reach investment decision as risk is too high and costs unknown

- The **associated high costs** for hydrogen technology and fuels for the first projects:
  - Reduces ability for many ship types/owners to convert to hydrogen technology to meet CO2 reduction targets
  - **Contract for difference** (CfD) could be implemented to cover the price gap between MGO and GH2/LH2, and this will accelerate the technology shift in the shipping industry.

- The **ship tech solutions** will be tested and proven from 2022 and onwards world-wide:
  - **Storage systems** for hydrogen fuels (NH3, GH2, LH2, LOHC) are being developed for maritime use.
  - **Technology improvements and cost reductions** will be rapid for LH2/GH2 storage and PEM fuel cells as market increases for these items with an already high TRL.
  - **NH3 combustion engines** are undergoing testing for market introduction in 2023/2024.
  - High-temperature fuel cells (**SOFC**) are years from market introduction - can use all hydrogen-fuels

Ivan Østvik, ivan.ostvik@norled.no, September 2021

World's first LH_2-driven ship "MF Hydra"

NORLED
The greatest travel experiences

Length	82.40 m	Car capacity	80
Beam	16.75 m	Truck capacity	10
Draught	2.8 m	Passenger capacity	299

LMG MARIN