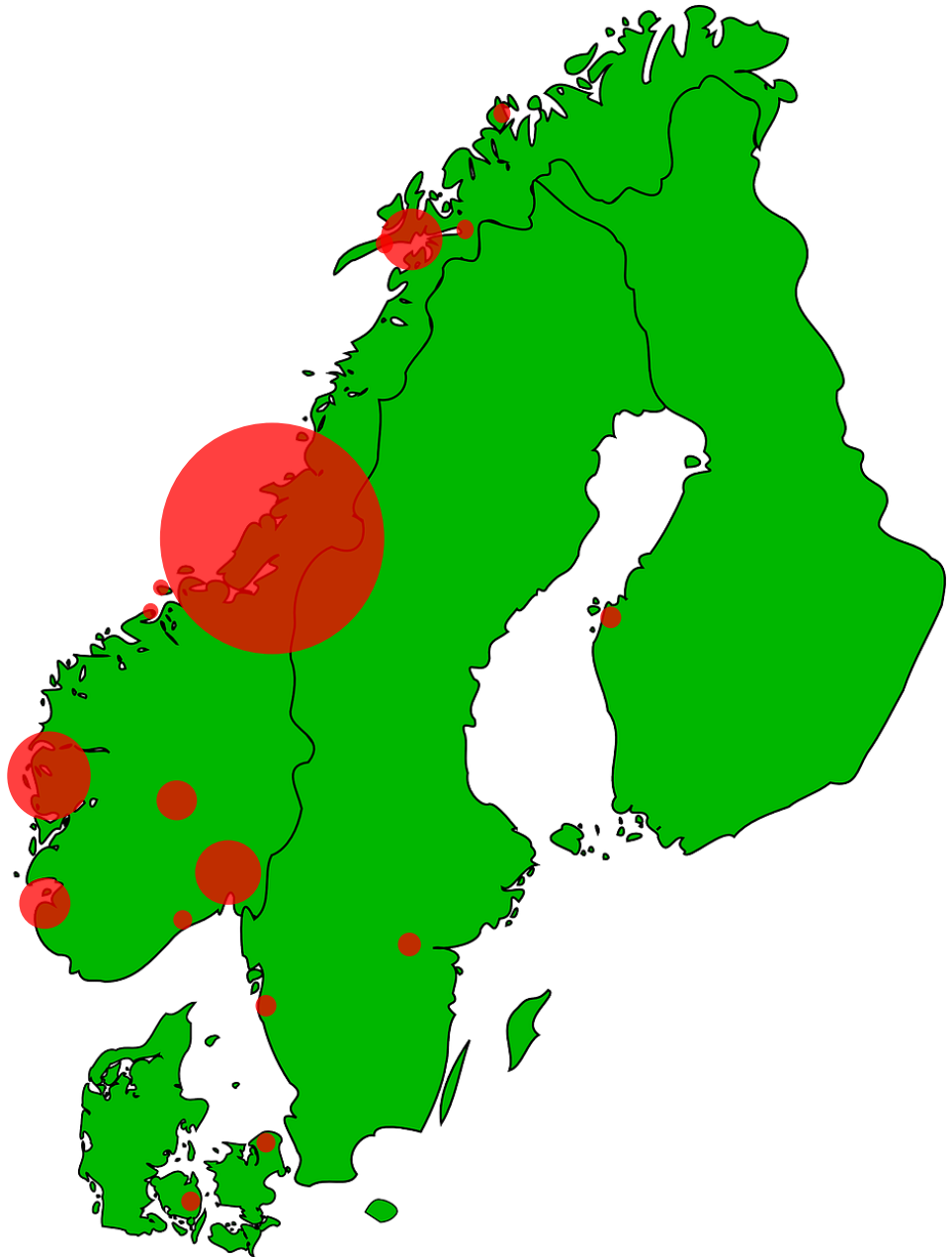
1200 Welcome Thomas Bjørdal, Renergy
1202-1230 Decarbonizing the energy system by 2050 – reflections on success factors Steffen Møller Holst, Chairman Norwegian Hydrogen Forum
1230-1300 Presentation on Dutch research and innovation from our guests
1300-1310 Reflections and discussions, short break.
1310-1350 Orientation of ongoing innovation projects in the Norwegian maritime sector Thomas Bjørdal, CEO Renergy, and Sigrid Lædre Sintef
1350-1405 Presentation from IC Technology – a game changing solution for storage and transport of LH2, Karl Otto Merz IC Technology
1405-1415 Break
1415-1515 Discussions, reflections, further cooperation etc.

RENERGY

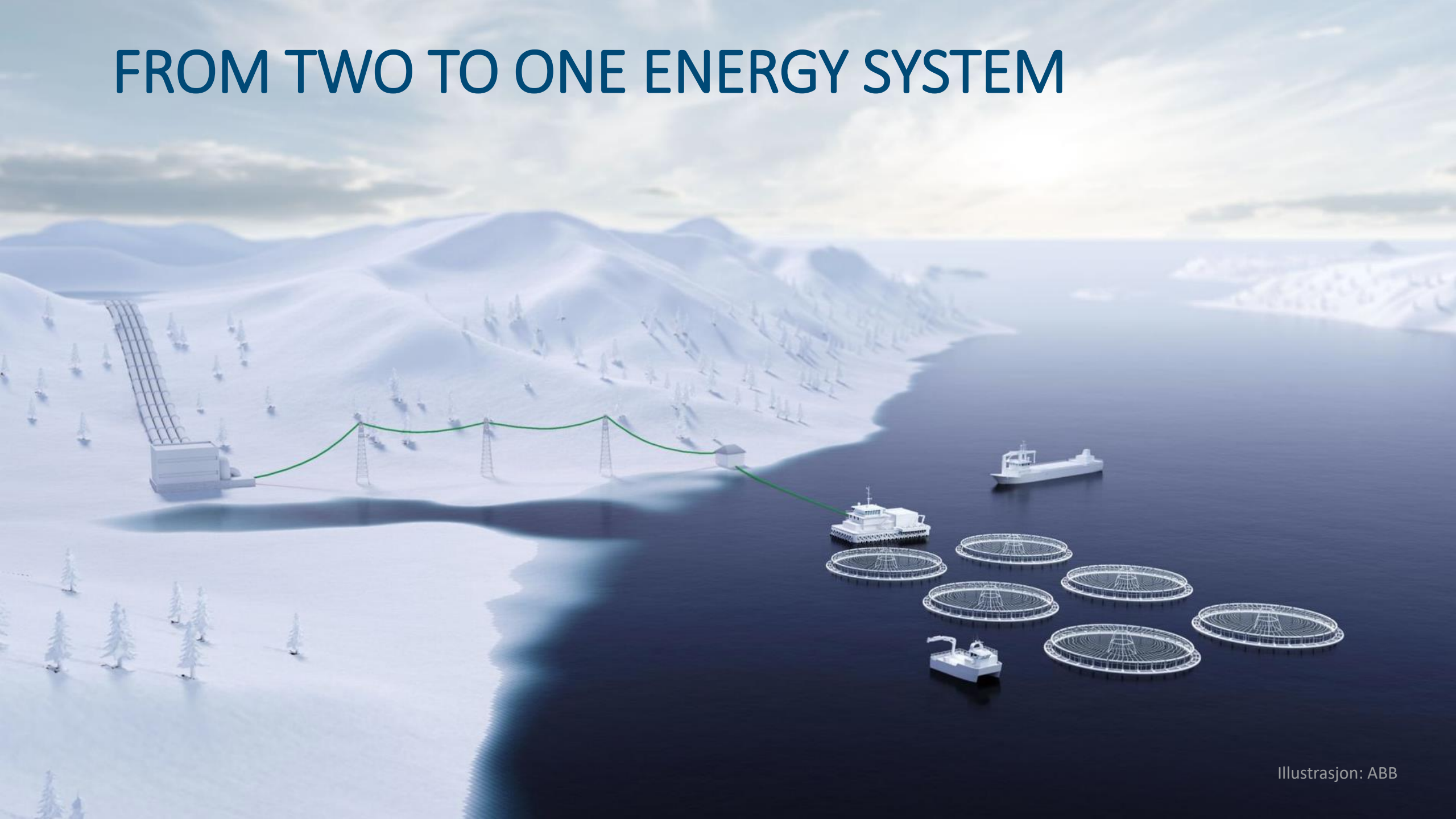
THE NORWEGIAN RENEWABLE ENERGY CLUSTER

A tech and sector neutral cluster gathering 109 businesses and organisations from the energy- and transport sector

RENERGY



FROM TWO TO ONE ENERGY SYSTEM



Illustrasjon: ABB

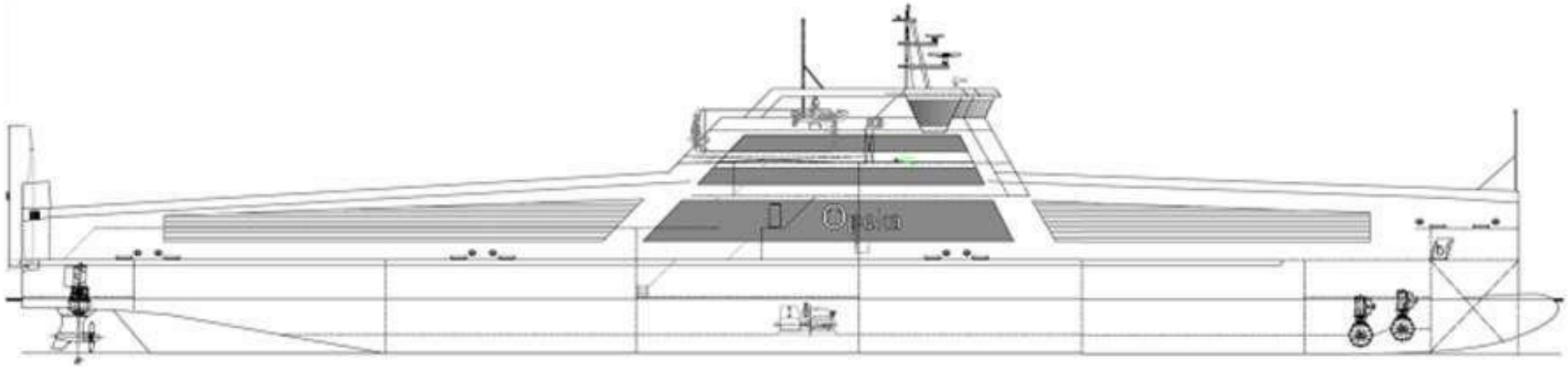
THE ENERGY VALUE CHAIN

RENERGY

RENERGY

Topeka; 2,500 m2 open deck RoRo vessels fueled by liquid hydrogen

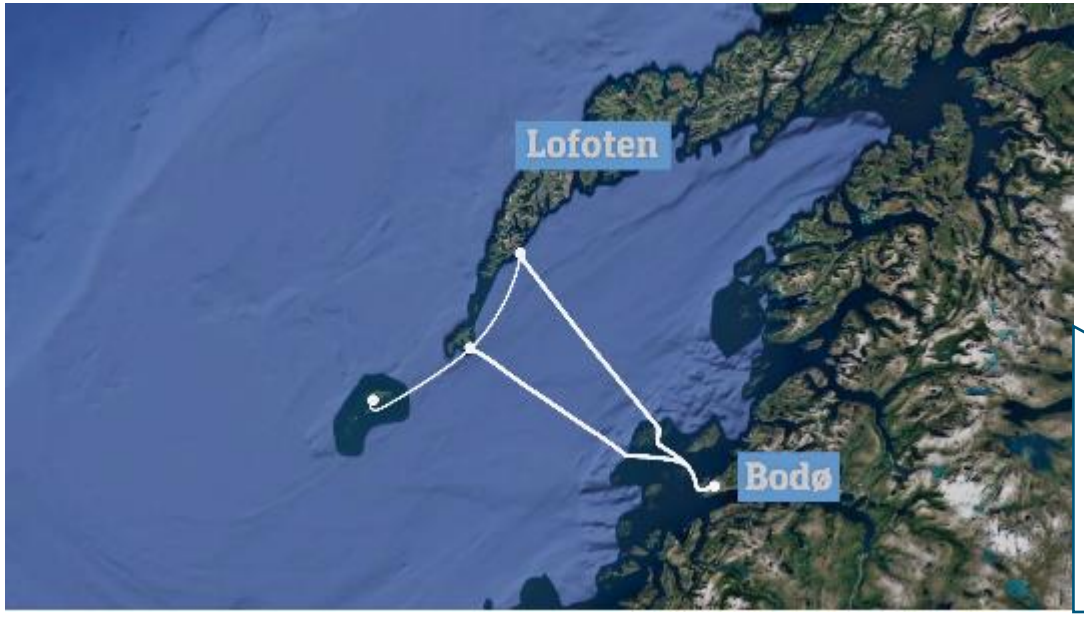
Design: LMG Marin



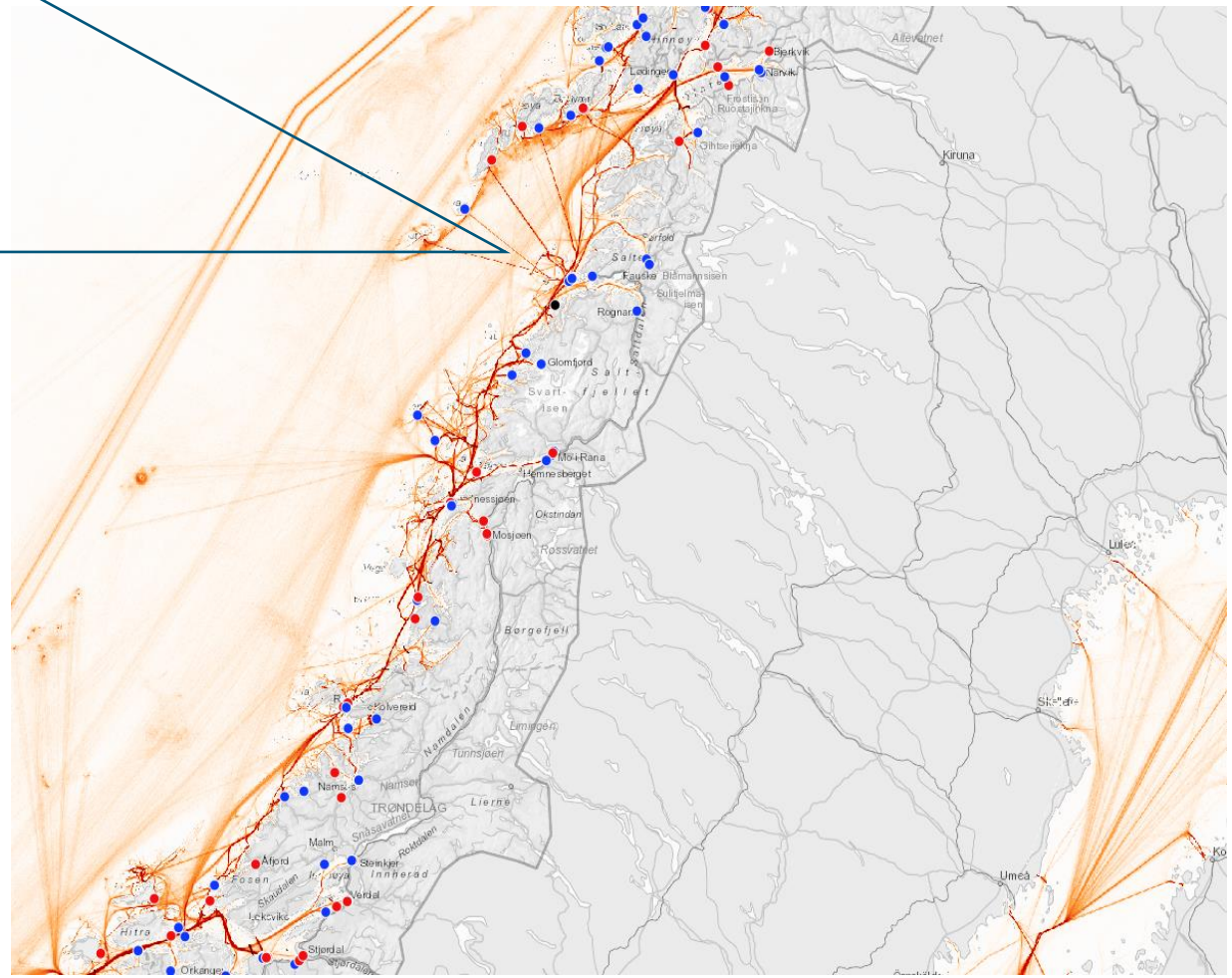
Main dimensions:	L: 125 m B: 24 m	Power demand, normal operation	app. 2 MW
Cargo capacity:	56 semi trailers	Installed Fuel Cell capacity:	app. 3 MW
Speed in service:	12 knots	Daily LH2 consumption in operation:	1,2 – 1,4 t/d
LH2 tank capasity;	65 – 100 cbm	Range/Endurance:	app 400 nm

RENERGY


HEIDELBERGCEMENT
Felleskjøpet
WITH ORCA
POWERED BY NATURE
©norwegianshipdesign.no



Lofoten 2 hydrogen ferries by 2025 3-4 hours route



Mulighetsstudie for etablering av maritimt hydrogenknutepunkt

Gjennom et Enovastøttet forprosjekt har NTE og H2 Marine utforsket muligheten for å etablere et maritimt hydrogenknutepunkt på Kråkøya ved Rørvik

Forprosjekt støttet av Enova for hydrogen til maritim sektor

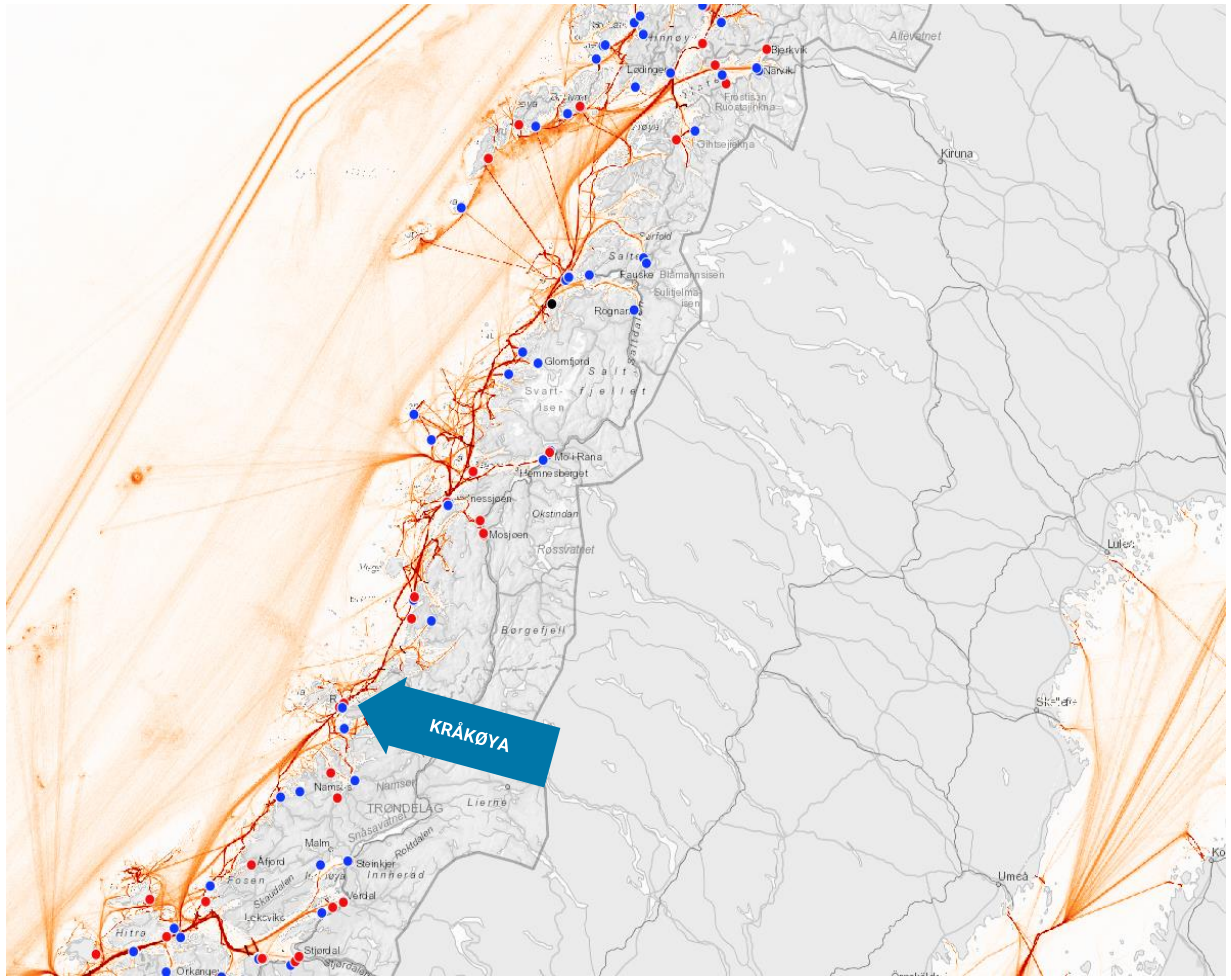
- Om støtteordningen:
  - 15 konsortier har fått støtte av Enova til å utrede potensialet for maritimt hydrogenknutepunkt på ulike lokasjoner.
  - 2-4 får støtte på opptil 150 MNOK for utvikling av fullskala hydrogenfabrikk
  - Tilstøtende Pilot-E prosjekter for modifisering av fartøyer er også mulig

- Hvorfor hydrogen som energibærer?
  - Hydrogen som energibærer fremstår i dag som et av de beste alternativene for det grønne skiftet i maritim sektor ettersom høyt energibehov, kort liggetid ved kai og lange seilingsruter gjør bl.a batterier uegnet.
  - Hydrogen har en høy energitetthet, kan fremstilles uten utslipp og kan bunkres tilnærmet likt fossile drivstoffalternativer.

Hvorfor Rørvik?

Lokaliseringen på Kråkøya utenfor Rørvik sentrum gir gode rammebetingelser for produksjon av grønt hydrogen og derivater til konkurransedyktige priser

- **Enormt markedsgrunnlag - 35 000 årlige skipspasseringer**
- **Full støtte for utbygging fra lokalt næringsliv og politikere**
- **Strategisk lokasjon for eksport til internasjonale kunder**
- **Gunstige kraftpriser i Trøndelag**
- **Samlokalisert med avtaker for biprodukter og sirkulærøkonomi**
- **Godkjent arealplan og nødvendig infrastruktur på plass**
- **Økende krafttilgang**
- **Tilstrekkelig areal for skalerbar produksjon**



Tekniske detaljer & Nøkkeltall

En skalerbar hydrogenfabrikk som effektivt kan levere hydrogen til en stor bredde av forbrukere

Produkt

Primært komprimert hydrogen, men planer foreligger for flytende hydrogen og ammoniakk basert på kundebehov

Produksjon

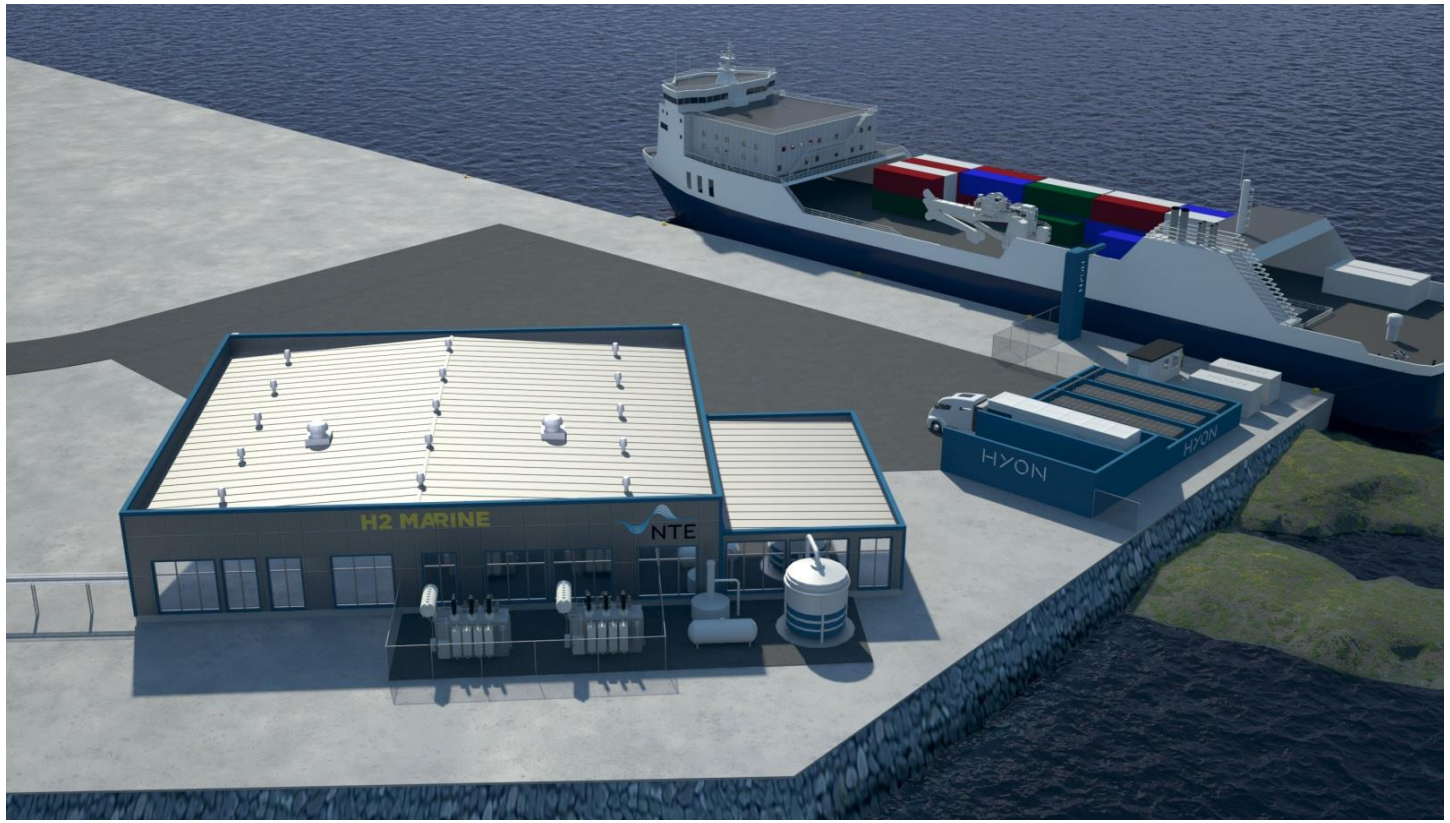
Gjennom fornybar energi direkte fra strømnettet og lokalt tilgjengelig vann – uten noen form for utslipp – produsere opptil *8 tonn* komprimert hydrogen i døgnet

Betingelser

Estimert salgspris levert på flens ved kai i Rørvik som er konkurransedyktig sammenlignet med marin diesel

Bunkring

- Hurtigbunkring med fyllekapasitet på opptil *1000kg/time+* (større fartøy) – potensiale for oppskalering etter markedsbehov
- Lavtrykk kaskaderegulert bunkring (mindre fartøy)
- Container-swap
- Kjøretøy



PRESSEMELDING - 23. JUNI 2022 12:00

Enova støtter hydrogenprosjekter i maritim sektor med 1,12 milliarder kroner

Hydrogen kan bli en sentral klimaløsning i morgendagens Norge. Spesielt gjelder dette for maritim sektor og industrien.

- Lykkes vi her, vil Norge styrke sin posisjon som en drivkraft for utslippsfrie løsninger i skipsfarten, sier Nils Kristian Nakstad, adm. direktør i Enova.

Her er bevilgningene:

- Enova støtter etableringen av fem produksjonsanlegg for fornybart hydrogen langs norskekysten med 669 millioner kroner.
- Enova støtter sju banebrytende hydrogen- og ammoniakkdrevne fartøy med 451,3 millioner kroner.

Forprosjekt støttet av Enova for hydrogen til maritim sektor

Prosjekteier
1 Troms Kraft AS
2 Statkraft AS
3 Mosjøen og omegn Næringsselskap KF
4 NTE Energi AS
5 TrønderEnergi Kraft AS
6 Green H AS
7 Norwegian Hydrogen AS
8 Hyfuel AS
9 Htwo-Fuel AS
10 Hydrogen Solutions AS
11 Glencore Nikkelverk AS
12 North Ammonia AS
13 Green Industry Cluster Norway
14 Borg Havn IKS
15 Hydro Hydrogen AS

PROJECT | ZeroCoast

ZEROKYST RENERGY

Decarbonising the fisheries and aquaculture industry

PROJECT | ZeroCoast

ZEROKYST RENERGY

Decarbonising the fisheries and aquaculture industry

The ZeroCoast-project will set in motion a rapid technology shift for all vessel types in the fisheries and aquaculture industry:

Develop and demonstrate a zero-emission powertrain

Develop a new zero-emission vessel

Retrofit 10 vessels to zero-emission propulsion

Flexible supply of electricity and hydrogen

The project will develop and demonstrate a new zero-emission powertrain (Siemens Blue Drive and HybridZ), a new zero-emission vessel, 10 retrofitted vessels, services for retrofitting and maintaining zero-emission vessels, and a complete solution for a flexible supply of electricity and green hydrogen as maritime fuel.

ZeroKyst will contribute to a 50 % emissions reduction from fishing and aquaculture vessels by 2030 and has a value creation potential of upwards of 100 billion NOK.

A hybrid zero-emission solution, consisting of combination of battery and fuel cell technology, will ensure long range and short bunkering times.

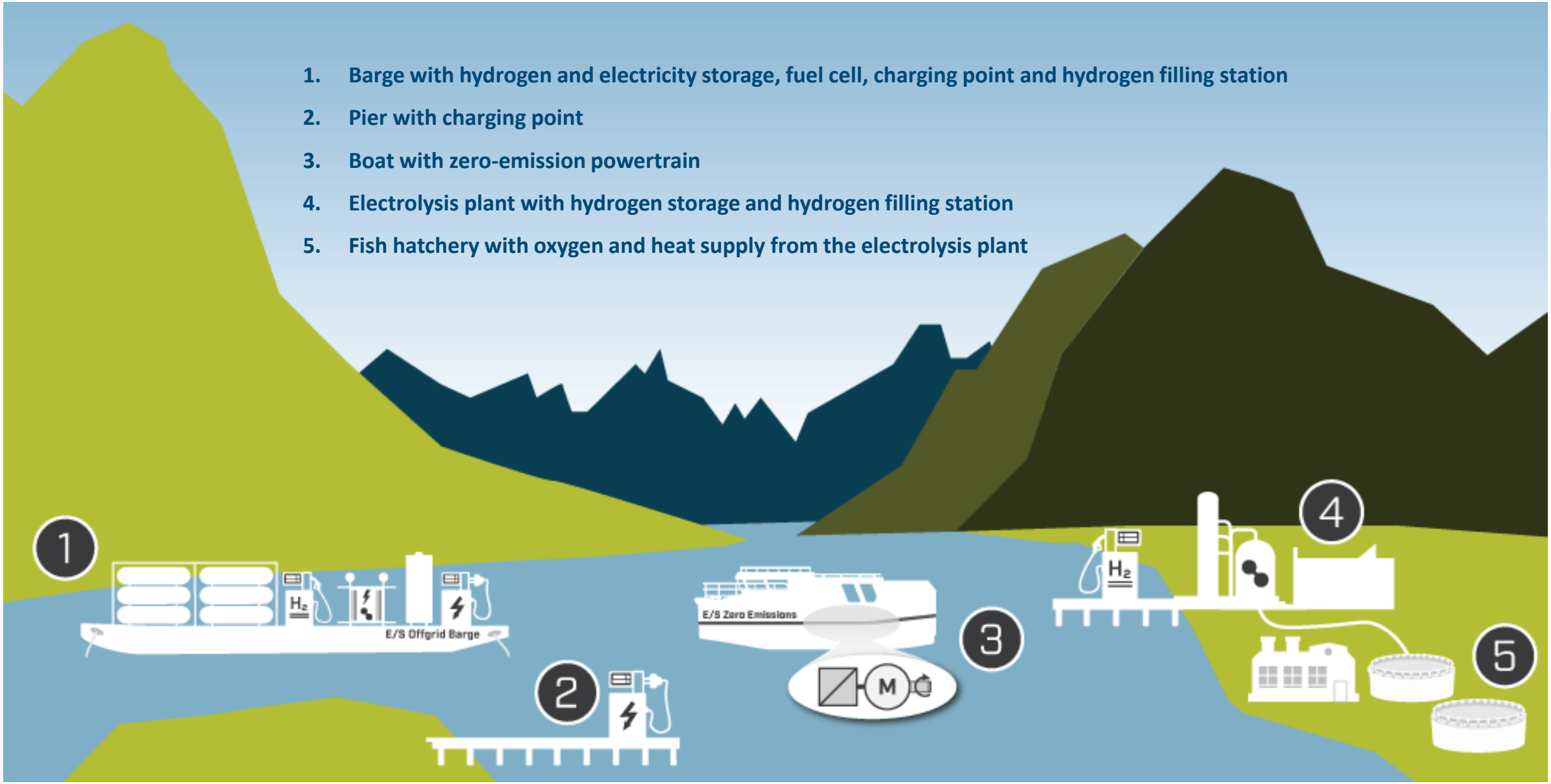
The project will develop new solutions for flexible and cost-efficient hydrogen production, distribution and refueling.

It will also develop and test charging infrastructure that efficiently leverages the existing power grid.

PROJECT | ZeroCoast

ZERO KYST RENERGY

1. Barge with hydrogen and electricity storage, fuel cell, charging point and hydrogen filling station
2. Pier with charging point
3. Boat with zero-emission powertrain
4. Electrolysis plant with hydrogen storage and hydrogen filling station
5. Fish hatchery with oxygen and heat supply from the electrolysis plant



PROJECT | ZeroCoast

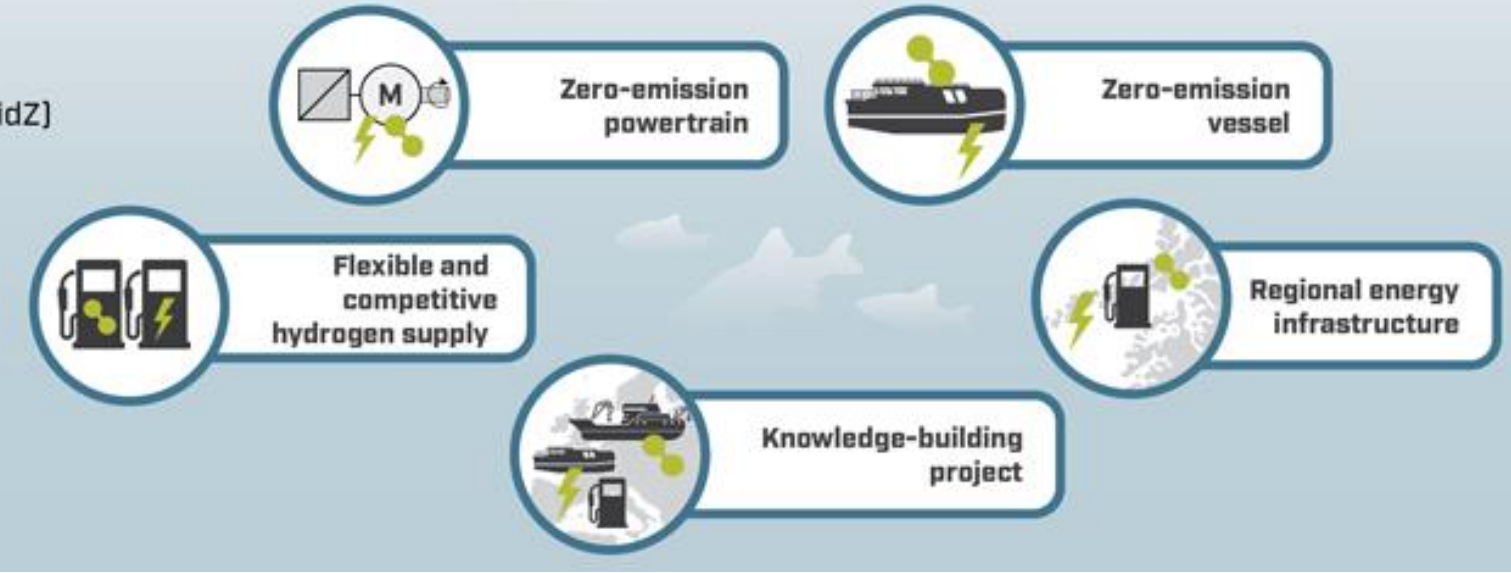
ZEROKYST RENERGY

ZEROKYST

Decarbonising the fisheries and aquaculture industry through hydrogen-electric propulsion

The project will deliver:

- Zero-emission powertrain for fishing vessels (HybridZ)
- Zero-emission vessel with HybridZ
- 10 vessels prepared for retrofitting
- Retrofitting and maintenance services
- Hydrogen plant and mobile supply unit
- Regional zero-emission infrastructure
- Knowledge about the future's powertrains and infrastructure
- New business models



PROJECT | ZeroCoast

Zero-emission powertrain

Developing a flexible and standardised powertrain to be sold for use in over 6000 vessels in the fishery and aquaculture industry

Expected results

- Approved zero-emission powertrain for smaller aquaculture vessels, with large potential for export and technology transfer to other vessel categories
- Standardisation of powertrains in various sizes, at Siemens Energy AS and Hymatech AS
- Develop skills and establish capability at the workshops that will install such powertrains

Subproject lead

Zero-emission powertrain is led by **Siemens Energy**, international technology supplier with over 90 000 employees in 90 countries.

PROJECT | ZeroCoast

ZERO KYST RENERGY

Zero-emission vessels

Developing and demonstrating a zero-emission vessel concept

Expected results

- World's first zero-emission vessel in operation
- Operational experience and improved skills on the implementation of hydrogen-electric solutions at Norwegian shipping companies, which will lower the threshold for adopting zero-emission solutions in the future
- Contribution to regulatory framework development for such vessels, that can be transferred to other segments
- Establish production of zero-emission fishing vessels, reaching a value of 100 million NOK per year

Selfa

Subproject lead

Zero-emission vessels is led by **Selfa Arctic**, a shipbuilder that has developed and manufactured hybrid fishing vessels, and has market, production and industry experience.

PROJECT | ZeroCoast

ZERO KYST RENERGY

Flexible and competitive hydrogen supply

Developing solutions for production, storage and bunkering of hydrogen to ensure a predictable supply to the maritime sector. Developing circular solutions to enable fish hatcheries to utilise heat and oxygen from hydrogen production plants.

Expected results

- Full-fledged zero-emission onshore facility that can produce 300 kg of hydrogen per day
- Hydrogen and electricity supply barge for vessels and aquaculture facilities

H2 MARINE

Subproject lead

Flexible and competitive hydrogen supply is led by **H2 Marine**, an energy and infrastructure supplier for green hydrogen.

PROJECT | ZeroCoast

Regional energy infrastructure

Developing and implementing infrastructure for zero-emission energy, adapted to the fishing flotilla's operations, with a possible expansion to other vessel categories

Expected results

- Assessment of needs
- Establishment of charging points
- Local skill building about the retrofitting of diesel-powered vessels

Lofotkraft

Subproject lead

Regional energy infrastructure is led by **Lofotkraft Muligheter**, electrification company part of the Lofotkraft energy group, owned by the municipalities of Lofoten.

PROJECT | ZeroCoast

ZEROKYST RENERGY

Regional energy infrastructure

Developing technology, models and analyses of powertrains, infrastructure, security and sustainability, to enable a 50 % emissions reduction from fishing and aquaculture vessels by 2030

Expected results

- Skills, models and tools for the development of safe, durable and reliable hydrogen-hybrid systems with optimal energy efficiency
- A comprehensive plan for hydrogen bunkering and battery charging infrastructure along the Norwegian coastline
- Map out the market potential, societal risk and environmental consequences of the green transition in the fishery and aquaculture industry

SINTEF

Subproject lead

The collaborative and knowledge-building project is led by **SINTEF**, a world-leading research institute with expertise in the fields of maritime technology and energy supply.

PROJECT | ZeroCoast

ZEROKYST RENERGY

Project partners

The consortium gathers companies from the whole value chain for future fishing and aquaculture vessels. Such a varied group is needed because the project will require efforts across the value chain to unlock the potential for innovation and enable value creation. It will also to build the necessary trust to realise the transition to zero-emission, which will in turn give the Norwegian fisheries and aquaculture industry a competitive advantage.

Powertrain developers

HYMATECH

SIEMENS energy

Shipbuilders and shipyards

Selfa

Ballstad Slip

Energy and infrastructure suppliers

H2 MARINE

plug

Lofotkraft

Municipality

Flakstad kommune

Industry cluster

RENERGY Renewable Energy Cluster

Research partners

SINTEF

NTNU

Shipping company

Øra AS

PROJECT | Zero-emissions fish farm vessel

RENERGY

Enabling a fast-track market introduction for hydrogen vessels

PROJECT | Zero-emissions fish farm vessel

RENERGY

A complete hydrogen value chain for the maritime sector

Production, storage and bunkering of green hydrogen

Hydrogen-electric fish farm vessel

PROJECT | Zero-emissions fish farm vessel

RENERGY

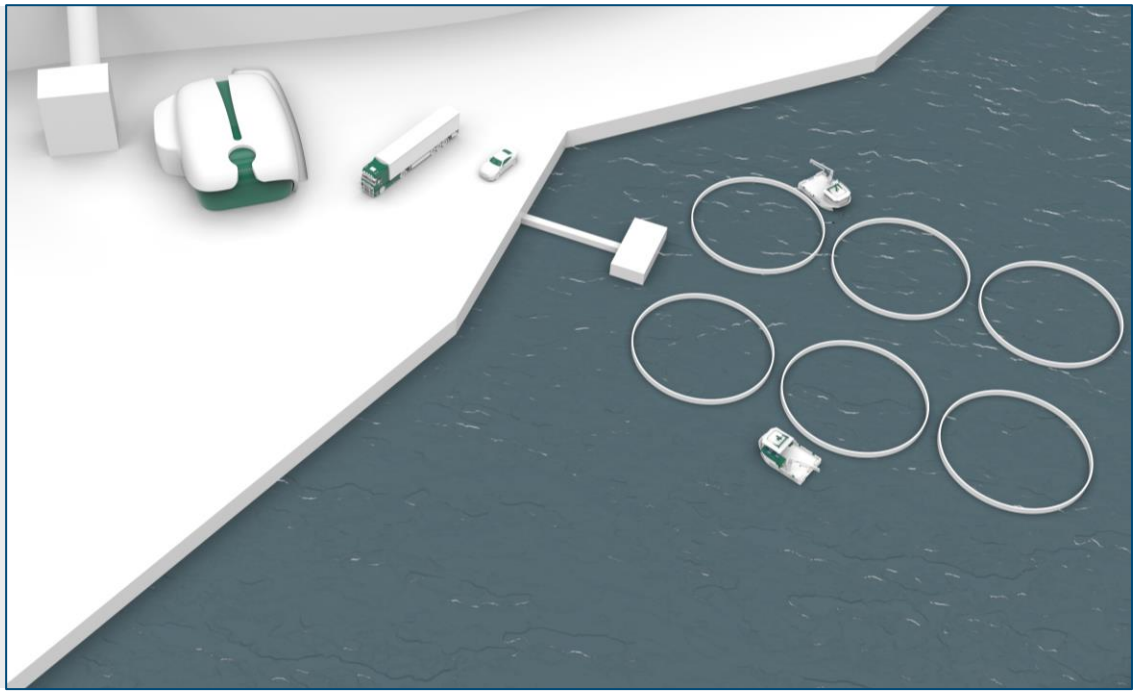
Enabling a fast-track market introduction for hydrogen vessels

Based on existing technologies, we are developing new solutions to achieve the most flexible and cost-effective solution for producing and distributing hydrogen. This includes a hydrogen-electric fish farm vessel, first of its kind, as well as a scalable facility for local production of green hydrogen and a combined mobile unit for storage and distribution. With our innovative solutions, we will be able to produce and distribute hydrogen at a competitive price – even at low production volumes.

Building of vessel, production facility and mobile unit will all commence in 2022. By 2023, the worlds first hydrogen-electric fish farm vessel will be able to bunker locally produced green hydrogen.

Key points

- **Significantly reduction of emissions from aquaculture**
- **The vessel itself will reduce emissions by approx. 230 000 kg C02 per year compared to conventional fish farm vessels**
- **Joint venture with leading industry actors representing the entire value chain – from hydrogen production to aquaculture**
- **Highly scalable solution that can be adapted for other vessel segments and end-users**
- **Great market potential for all partners, both national and globally**



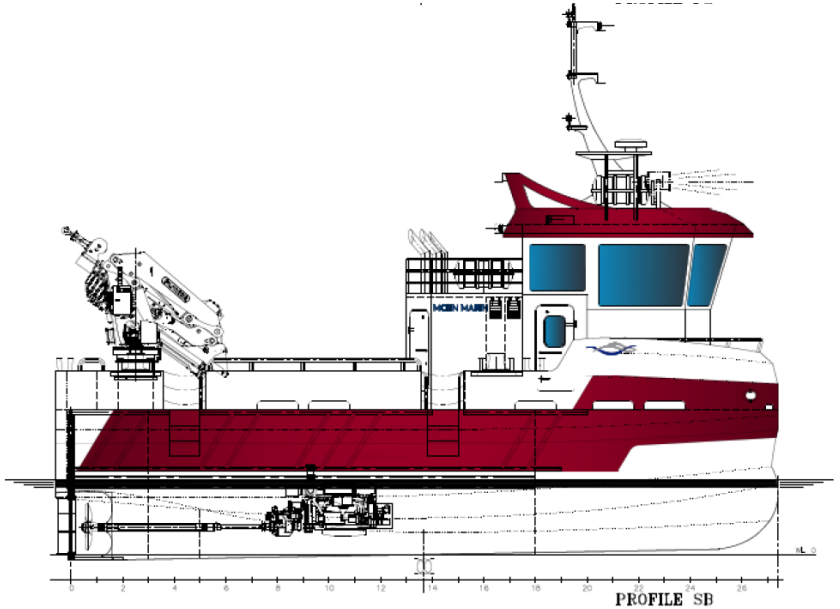
PROJECT | Zero-emissions fish farm vessel

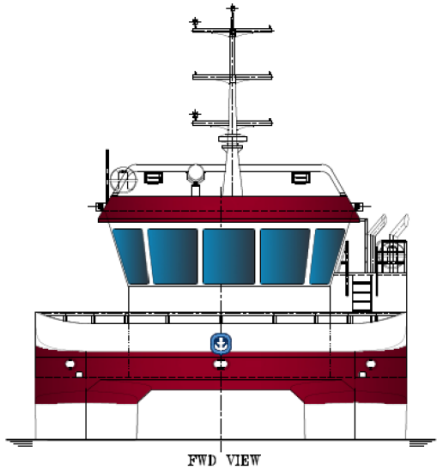
From low emission hybrid to zero emission –Moen Marin Nabcat 1475 diesel-battery hybrid

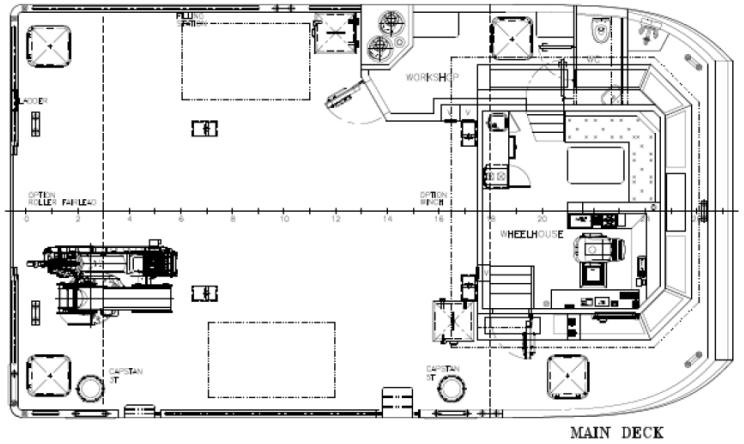
PROJECT | Zero-emissions fish farm vessel

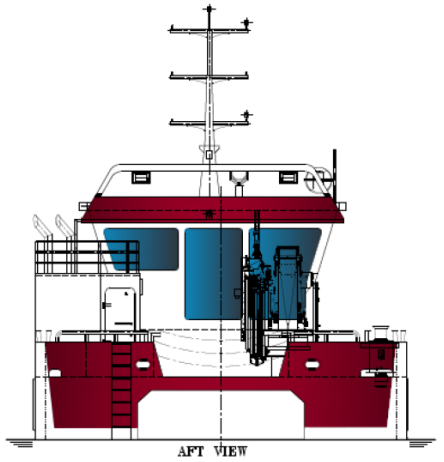
RENERGY

Moen Marin Nabcat 1480 hydrogen-battery









Moen Marin

PROJECT | Zero-emissions fish farm vessel

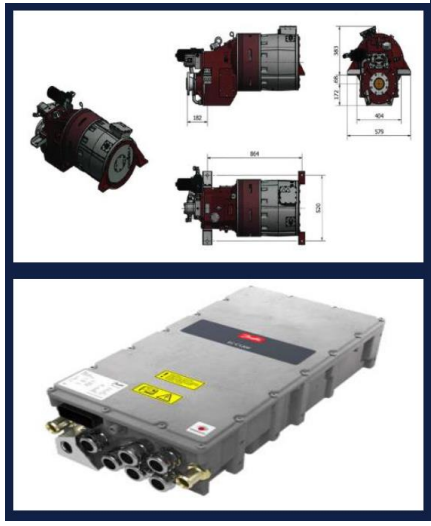
RENERGY

Key specifications for the Moen Marin Nabcat 1480

Crane	**PK50002)2,3 meters from starboard**
Engine room	**Standing height in engine room**
Deck area	**67,5 m3 + with additional space on starboard side**
Deck load	**Approx. 28 metric tonnes**
Speed (new hull)	**9 knot (normal operational speed)**
Length | Width	**14 meters X 8 meters**

Propulsion

- 100 kW fuel cell (PowerCell)
- 1 kg hydrogen equals 33,33 kWh
- 50 % energy loss in fuel cell equals 17 kWh per kg hydrogen (15 kWh)
- 6,7 kg hydrogen equals 1 hour of operations at 9 knots / 100 kWh
- 120 kg hydrogen capacity from 4 tanks (5,71 x 0,65) at 30 kg
- Need for refueling approx. every 10-12 days
- Hydrogen consumption approx. 3,900 kg per year
- Bunkering time approx. 2 hours
- Battery system 166,5 kWh (5 modules of 33,3 kWh per module).
- Recharging by night through power grid connection



PROJECT | Zero-emissions fish farm vessel

RENERGY

Conventional value chain

~60 → Electrolysis

~1,5 → Compression

Intermediate storage

~1,4 → Intermediate compression

~0,6 → Cooling and fast bunkering

Hydrogen-electric vessel

Total energy demand

~63,5 kWh/kg

H2 Marine and NTE's value chain

~60 → Electrolysis

~1,5 → Compression

Storage

Passive pressure transmission

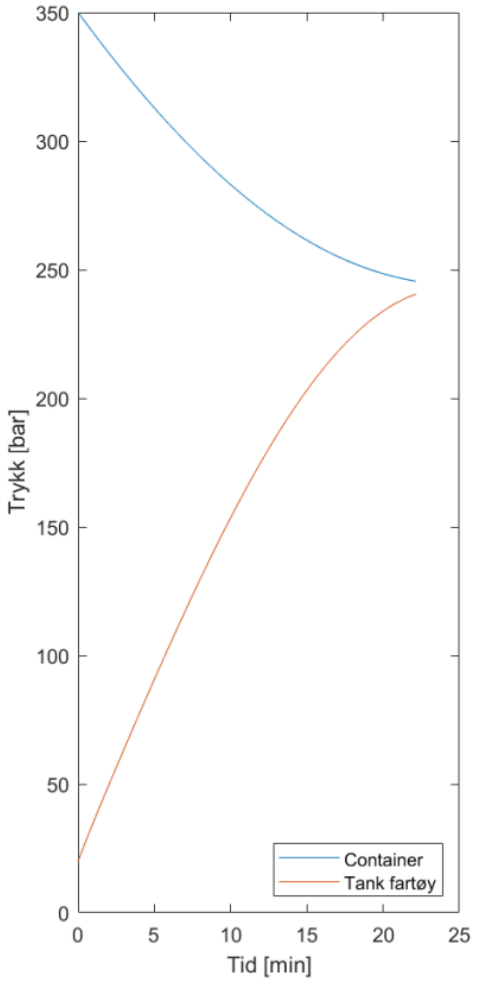
Hydrogen-electric vessel

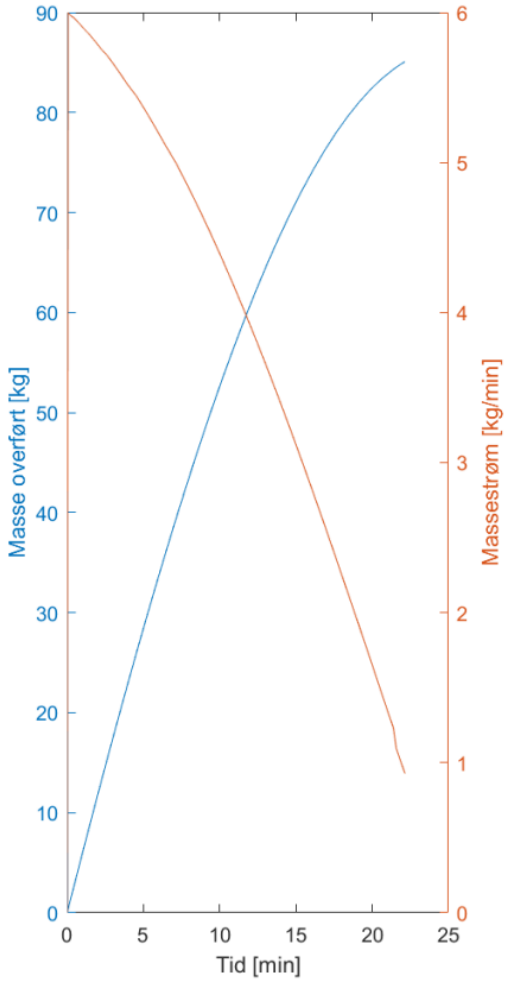
Total energy demand

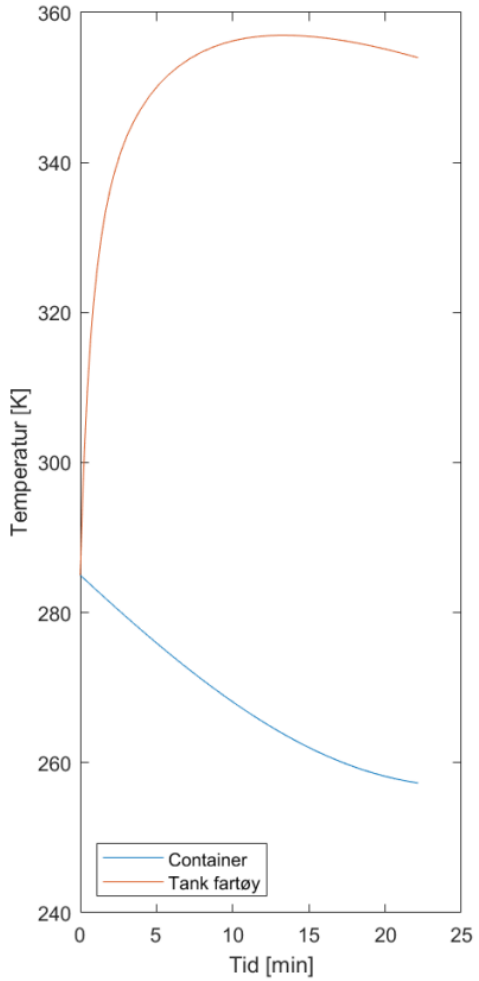
~61,5 kWh/kg

PROJECT | Zero-emissions fish farm vessel

Preferred case







p_{s0} = 350 bar
p_{t0} = 20 bar
T_{s0} = 285 K
L = 20 m
D = 6 mm

Model: SINTEF

PROJECT | Zero-emissions fish farm vessel

RENERGY

Hydrogen infrastructure doesn’t need to be expensive!

H2 Marine and NTE’2 innovative solution includes

- As few components as possible
- Approx. 15–20 % lower CAPEX
- Lower OPEX; approx. 5 % lower power consumption
- Mobile combined storage and bunkering unit
- Flexible and scalable

PROJECT | Zero-emissions fish farm vessel

RENERGY

Project partners

The consortium gathers companies from the whole value chain – from hydrogen production to bunkering and aquaculture. This means that both producers of hydrogen, as well as consumers, are cooperating to develop an economically and environmentally sustainable alternative to fossile fuels.

Project owner and shipbuilder

MOEN

Design and development of the pilot vessel

Moen Marin

Vessel operator and hydrogen end user

SalmoNor

Producer and supplier of hydrogen

H2 MARINE

Producer and supplier of hydrogen

NTE

Hydrogen infrastructure Research & Development

SINTEF

Networking, coordination and communications

RENERGY

RENERGY

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