2021 2030 United Nations Decade of Ocean Science for Sustainable Development

U.N. DECADE OF THE OCEAN

TOWARD A SUSTAINABLE MARINE TRANSPORTATION SYSTEM

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U.S. COMMITTEE ON THE MARINE TRANSPORTATION SYSTEM
CMTS

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

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TOWARD A SUSTAINABLE MARINE TRANSPORTATION SYSTEM

· ***Welcome and Introduction:*** Ms. Helen Brohl
Executive Director, U.S. Committee on the Marine Transportation System (CMTS)
· ***Opening Remarks:*** Ms. Lucinda Lessley
Acting Administrator, U.S. Maritime Administration and Chair, CMTS Coordinating Board
· ***Decade of Ocean Science:*** Mr. Julian Barbiére
Head of Marine Policy and Regional Coordination Section, Ocean Decade Focal Point, UNESCO – IOC
· ***Report from IMO & COP26:*** Ms. Monica Medina
Assistant Secretary, Bureau of Oceans and International Environmental and Scientific Affairs
U.S. Dept. of State

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U.S. COMMITTEE ON THE MARINE TRANSPORTATION SYSTEM CMTS

Toward a Sustainable Marine Transportation System

Arne Fredheim
Research Director Energy and transport
SINTEF Ocean

Decarbonisation of maritime transport

- IMO initial strategy to cut GHG by **at least 50%** in 2050
  - Other initiatives set targets for climate neutral in 2050
- Shipping use **3% of worlds energy consumption** (Well-to-Wake)
- Reduction of GHG emission for the **deep-sea shipping** is the main challenge
  - For short sea hydrogen and electricity is realistic solution, including high-speed vessels
- E-fuels in shipping potentially reduce global GHG by 3%
- Studies show that WTW energy consumption will **increase by 75 – 300%**
  - Renewable electricity will be a main constrain for de-carbonization
- Observation: Renewable power is precious, should be used in the most efficient way
- Carbon capture on ship can be interesting, if efficient **CO2 logistical chains** are established

Study on alternative fuels by analyzing the emissions Well-to-Wake, energy use and cost.

- Five main options are discussed
- E-Hydrogen path
- A Pure Diesel path
- Three dual fuel pathways
  - LNG & E-LNG
  - E-Methanol
  - E-Ammonia & E-Methanol & LPG

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Reduction of maritime GHG emissions and the potential role of E-fuels

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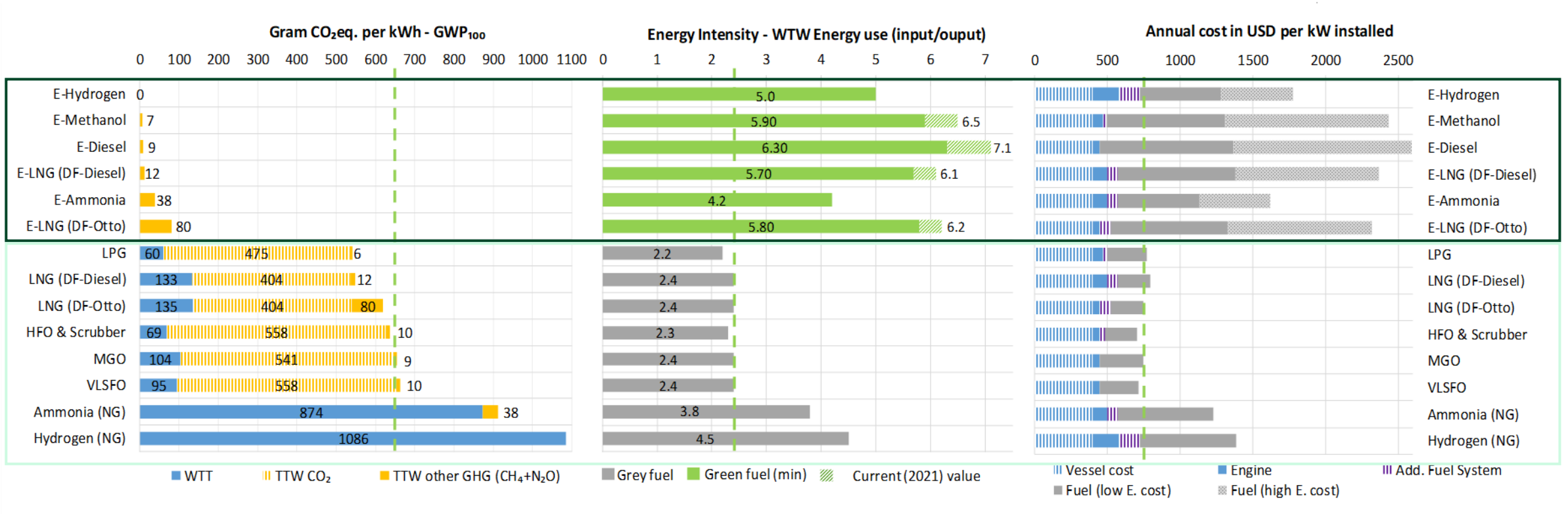
GHG
Abatement cost
Energy efficiency
IMO

ABSTRACT

Maritime transport accounts for around 3% of global anthropogenic Greenhouse gas (GHG) emissions (Well-to-Wake) and these emissions must be reduced with at least 50% in absolute values by 2050, to contribute to the ambitions of the Paris agreement (2015). Zero carbon fuels made from renewable sources (hydro, wind or solar) are by many seen as the most promising option to deliver the desired GHG reductions. For the maritime sector, these fuels come in two forms: First as E-Hydrogen or E-Ammonia; Second as Hydrocarbon E-fuels in the form of E-Diesel, E-LNG, or E-Methanol. We evaluate emissions, energy use and cost for E-fuels and find that the most robust path to these fuels is through dual-fuel engines and systems to ensure flexibility in fuel selection, to prepare for growing supplies and lower risks. The GHG reduction potential of E-fuels depends entirely on abundant renewable electricity.

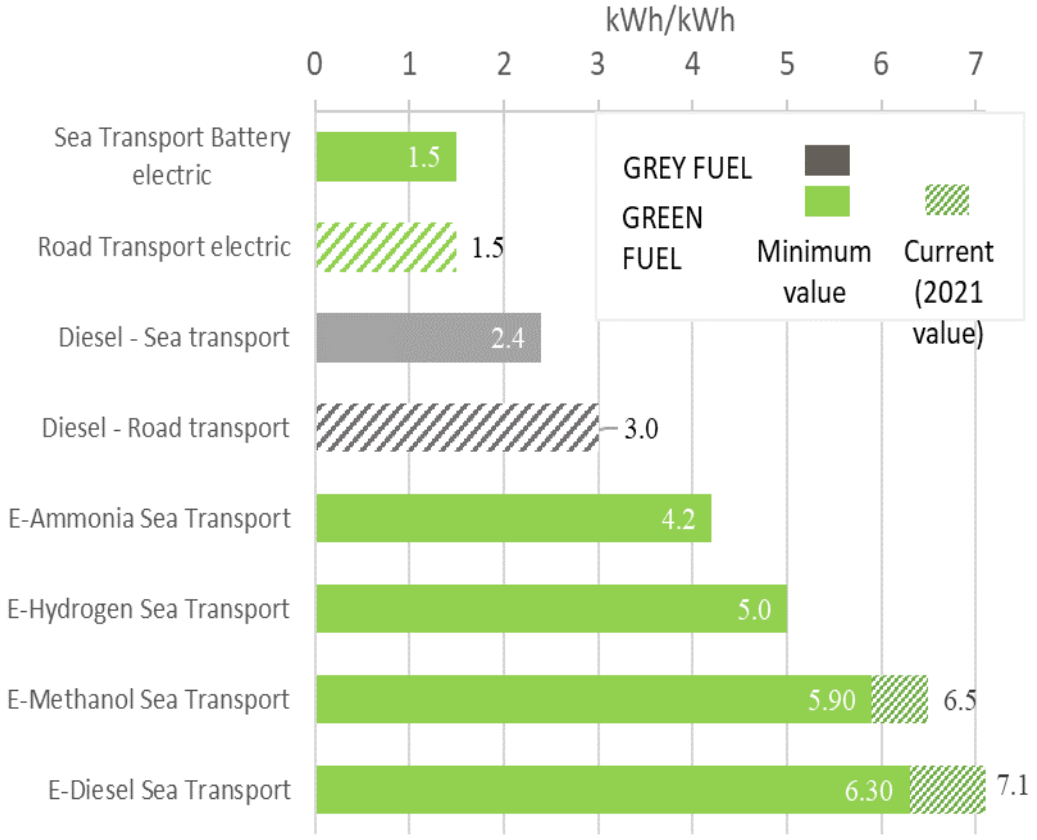
Comparing Well-to-Wake: GHG emissions, energy use and total annual vessel cost



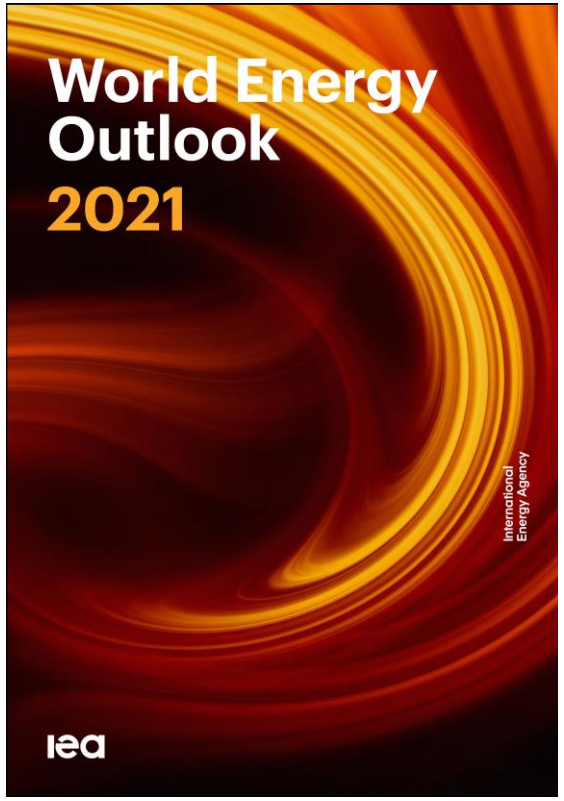
Source: Lindstad, E., Lagemann, B., Rialland, A., Gamlem, G., M., Valland, A. 2021. Reduction of Maritime GHG emissions and the potential role of E-fuels. Accepted for publication in Transportation Research Part D

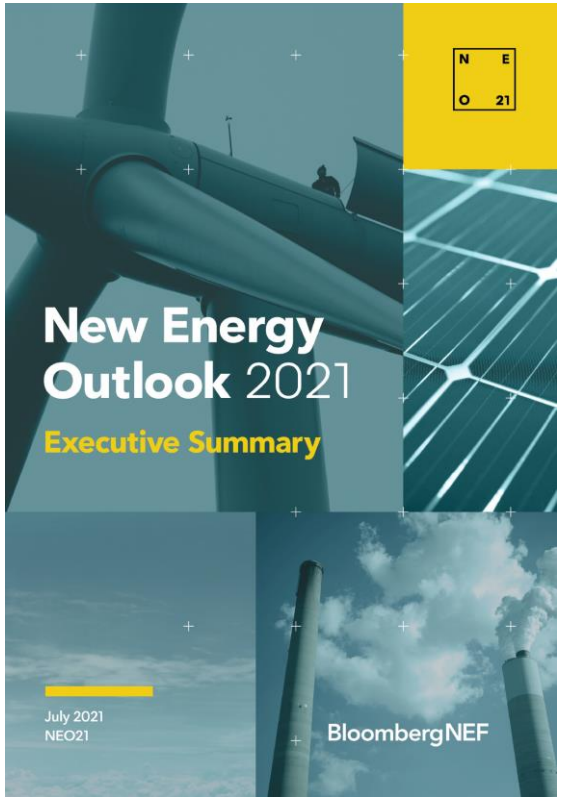
De-carbonization of transport as in the IEA scenario favours road transport due to the high energy use to make E-fuels

- Fuel accounts for around a third of the cost both for sea and road
- **Electrifying road transport cut WTW** energy consumption and cost by 50% and **total transport cost by 15- 20%**
- For sea transport the de-carbonization pathways goes trough E-fuels which in **best case doubles cost and energy consumption**
- The result could be a modal shift with increased road transport and less sea transport



Energy efficiency



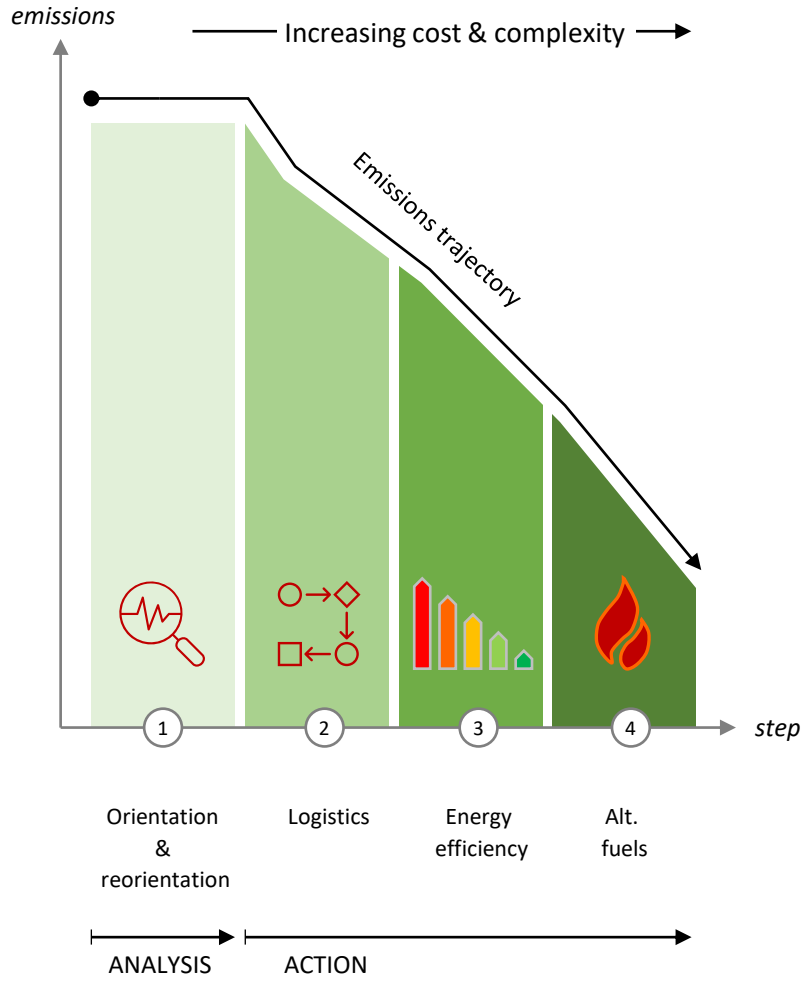


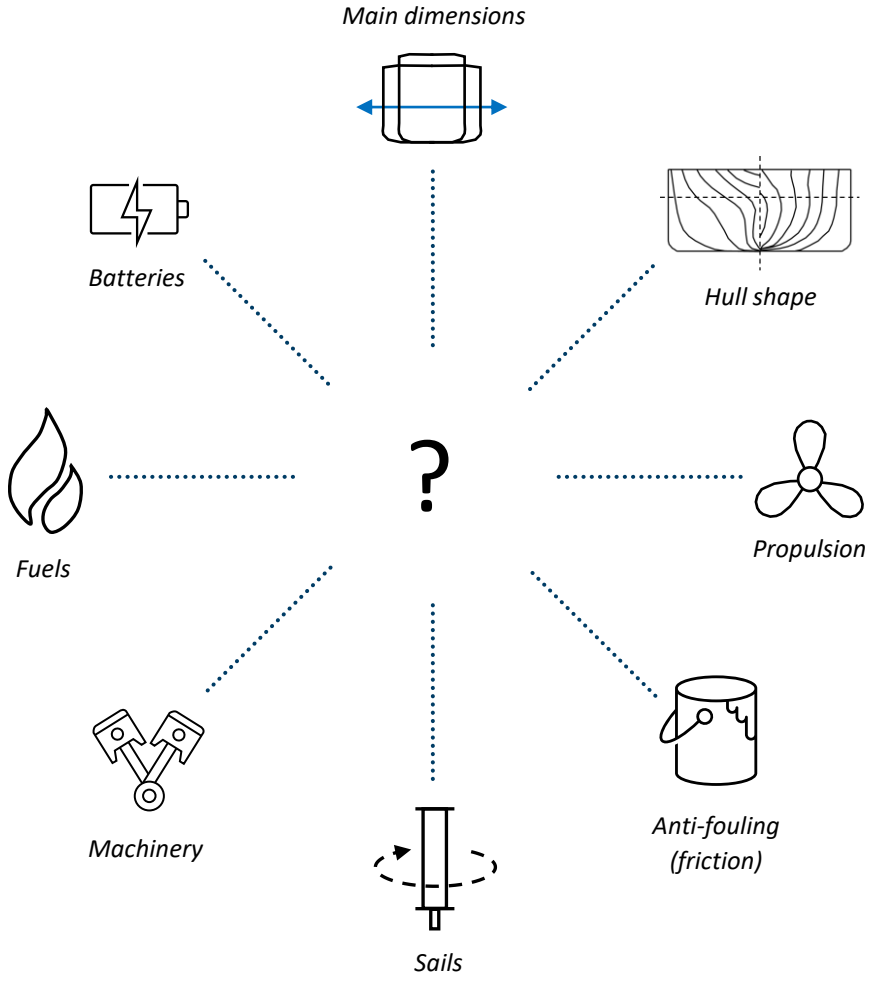
> IEA: **Energy efficiency delivers more than 40%** of the reduction in energy-related GHG over the next 20 years in the IEA's Sustainable Development Scenario.

> Bloomberg: **In shipping, efficiency improvements make up two-thirds of emissions reductions to 2030** in each of our three scenarios, and 2050 it accounts for around 45% of abatement in the sector**.**

IEA on energy efficiency (www.iea.org/topics/energy-efficiency). Dr Timur Gul, IEA, at Forskningsrådet 24 June 2021.
Bloomberg New Energy Outlook, page 8. (https://about.bnef.com/new-energy-outlook/)
Note: BNEF developed three scenarios, i.e. explorations of what is required to reach certain goals, in this case global warming well below 2°C.

"Sea-map" towards green shipping
Four stepped approach to green shipping

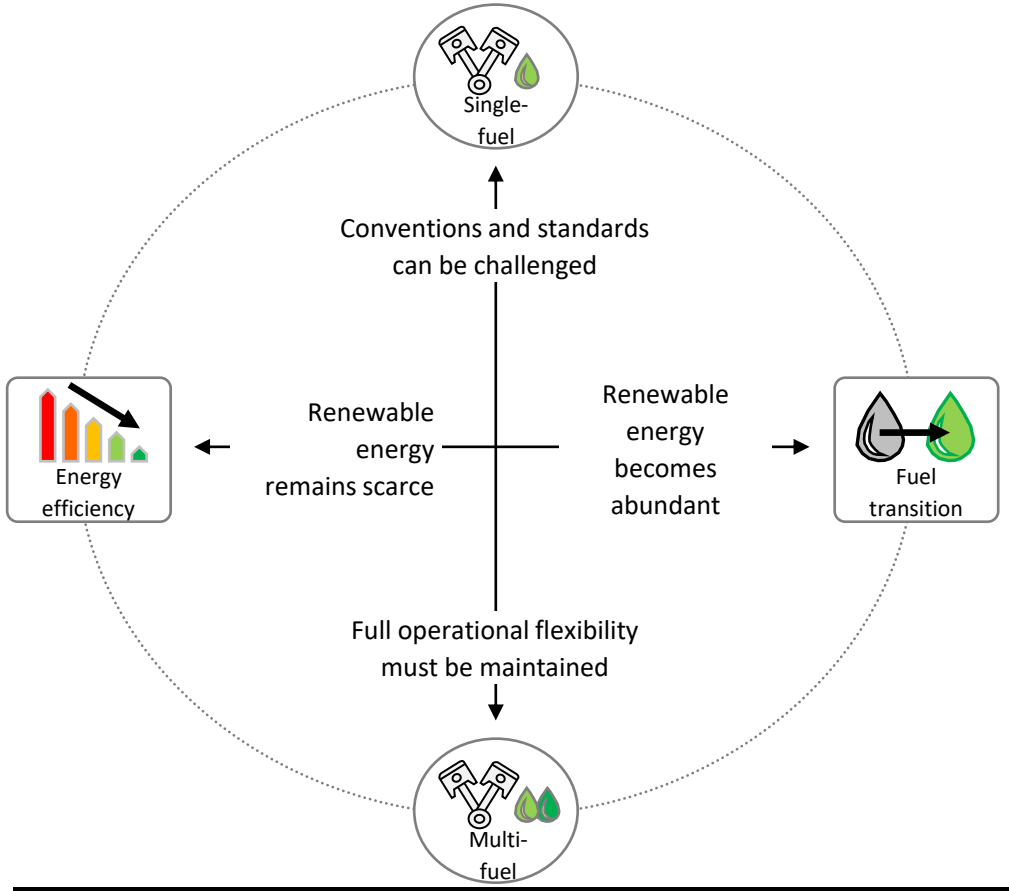


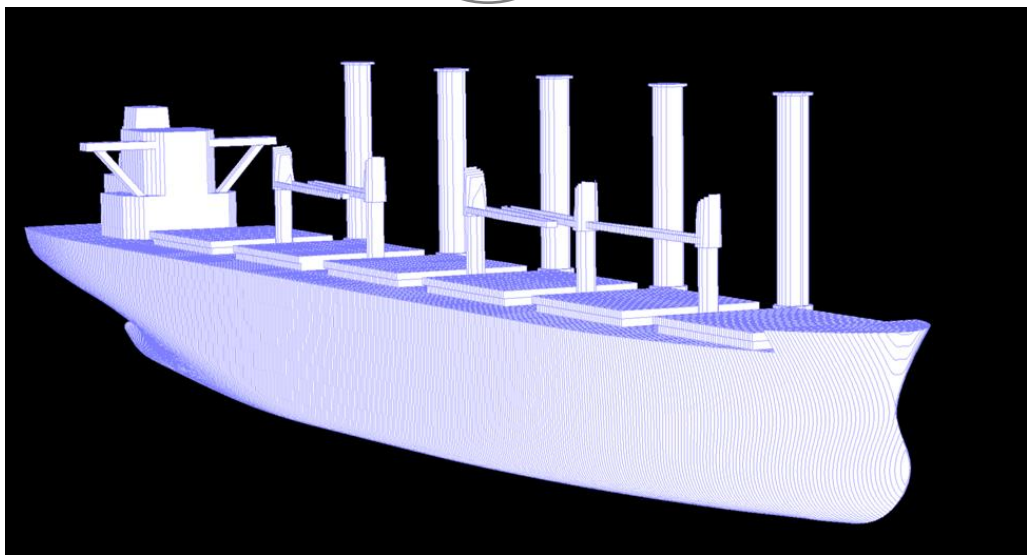


Note: From the forthcoming sea map to green shipping

Decarbonization strategy

- Availability of renewable energy will impact **decarbonization strategy**
- Single focus on fuel transition can only be justified if renewable energy will become abundant.
- Need to **increase energy efficiency**
  - Propulsion assistance (wind sails, wave foils etc.)
  - Hull design
  - Speed
  - Energy efficiency control systems
- Start small, but **start now**
  - Need to use available solutions – 2030 target
  - Blend in now and gradual fuel transition
- Dual-fuel engines to **ensure flexibility** in fuel selection in long term
  - LNG or LPG in short term which can reduce GHG WTW with 15 – 20% (CO_2 eq.)





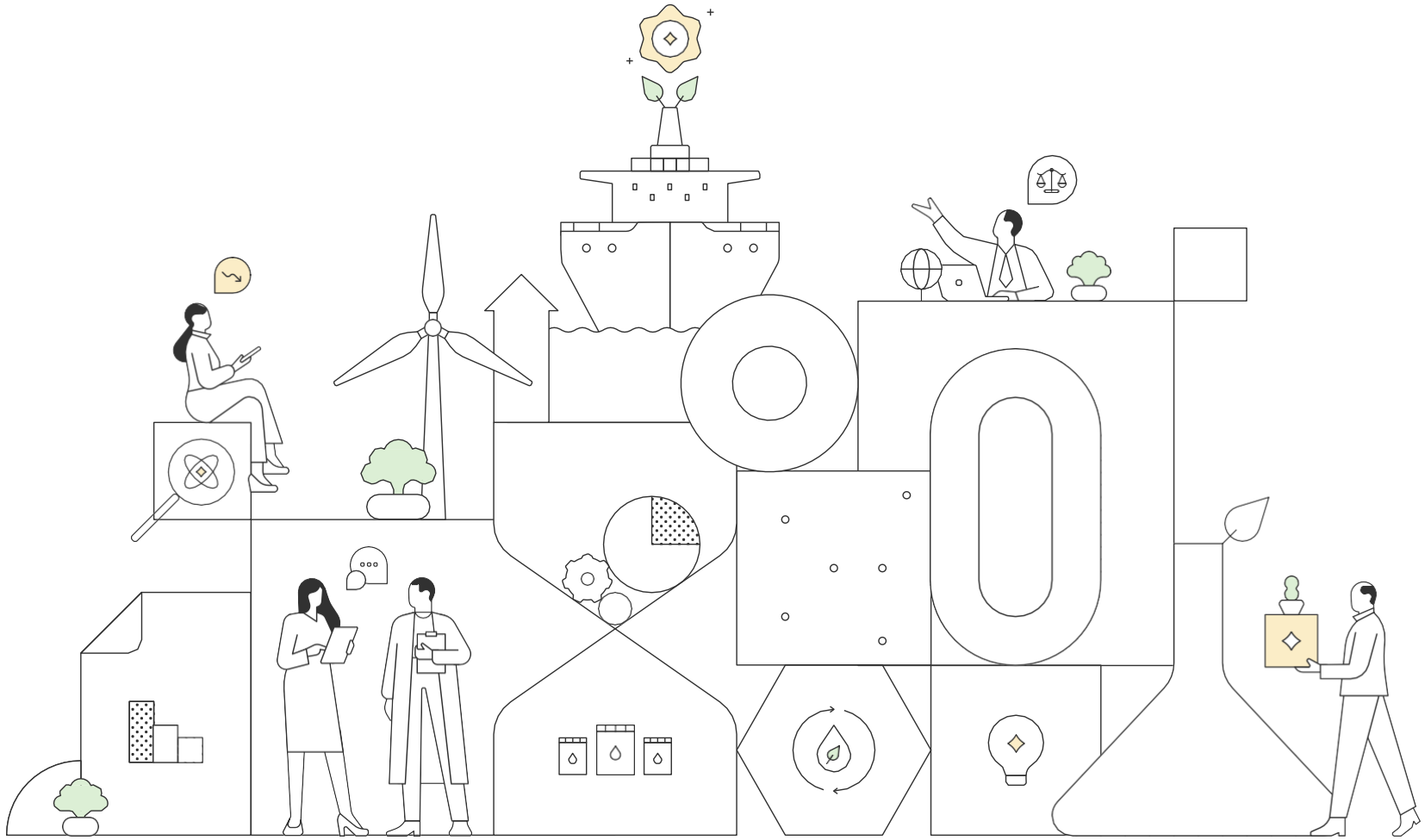
SINTEF

Technology for a better society

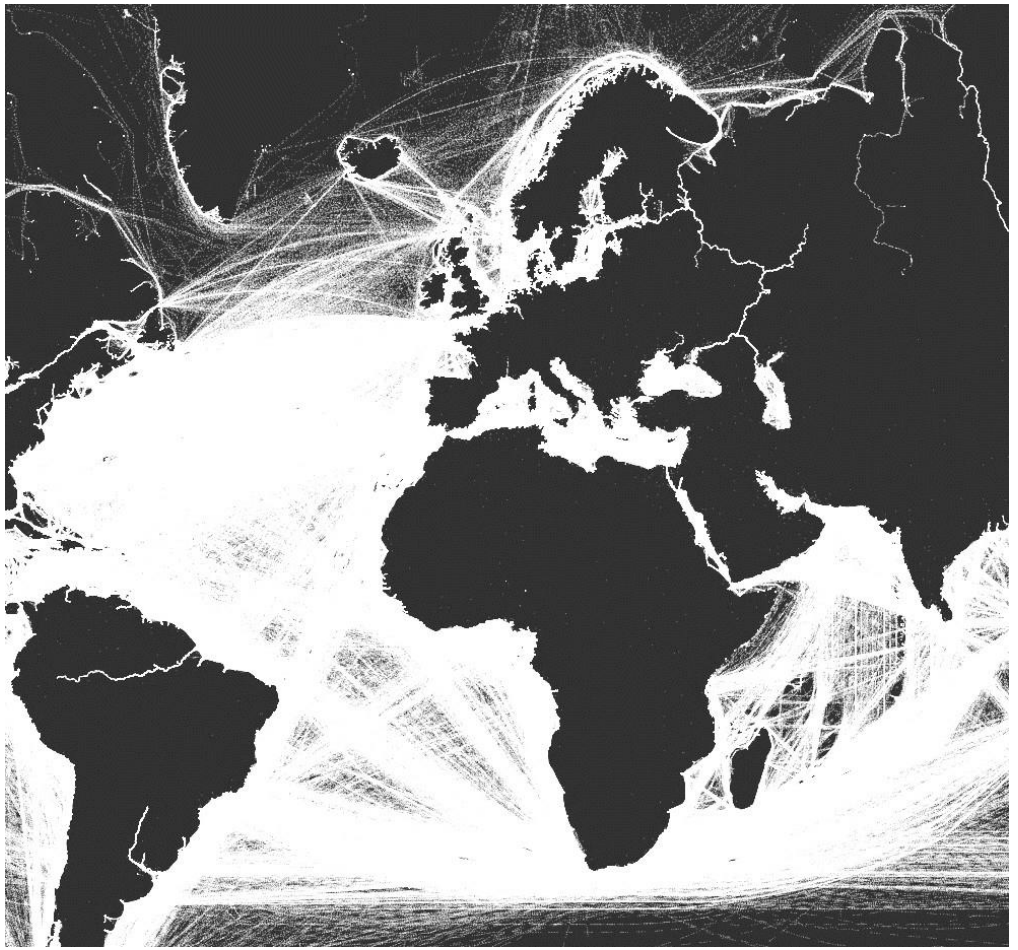
We show the world it is possible

Claus Winter Graugaard
Head of Onboard Vessel Solutions

UN Decade of the Ocean Toward a Sustainable Marine Transportation System
14 Dec 2021



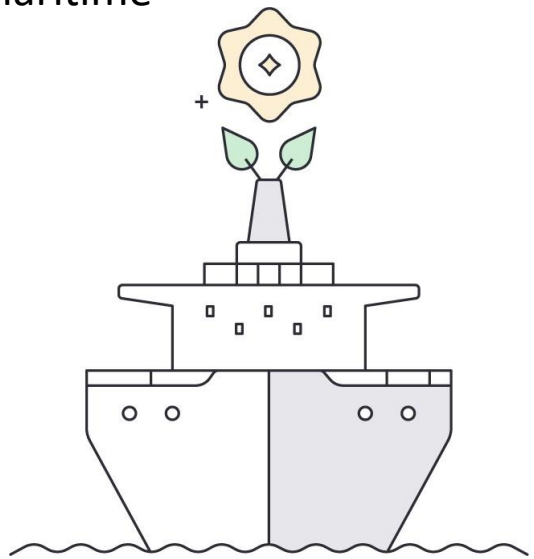
With 100.000 commercial vessels globally consuming m300Tons fuel p.a. the shipping-sector accounts for around 3% of global CO_2 emissions.



The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping - we show the world it is possible

Our vision
A decarbonization of the global maritime industry by 2050

Our mission
To be a visible and significant driving force in the global maritime decarbonization journey



Not-for-profit

Money earned by or donated to the Center is used in pursuing our mission

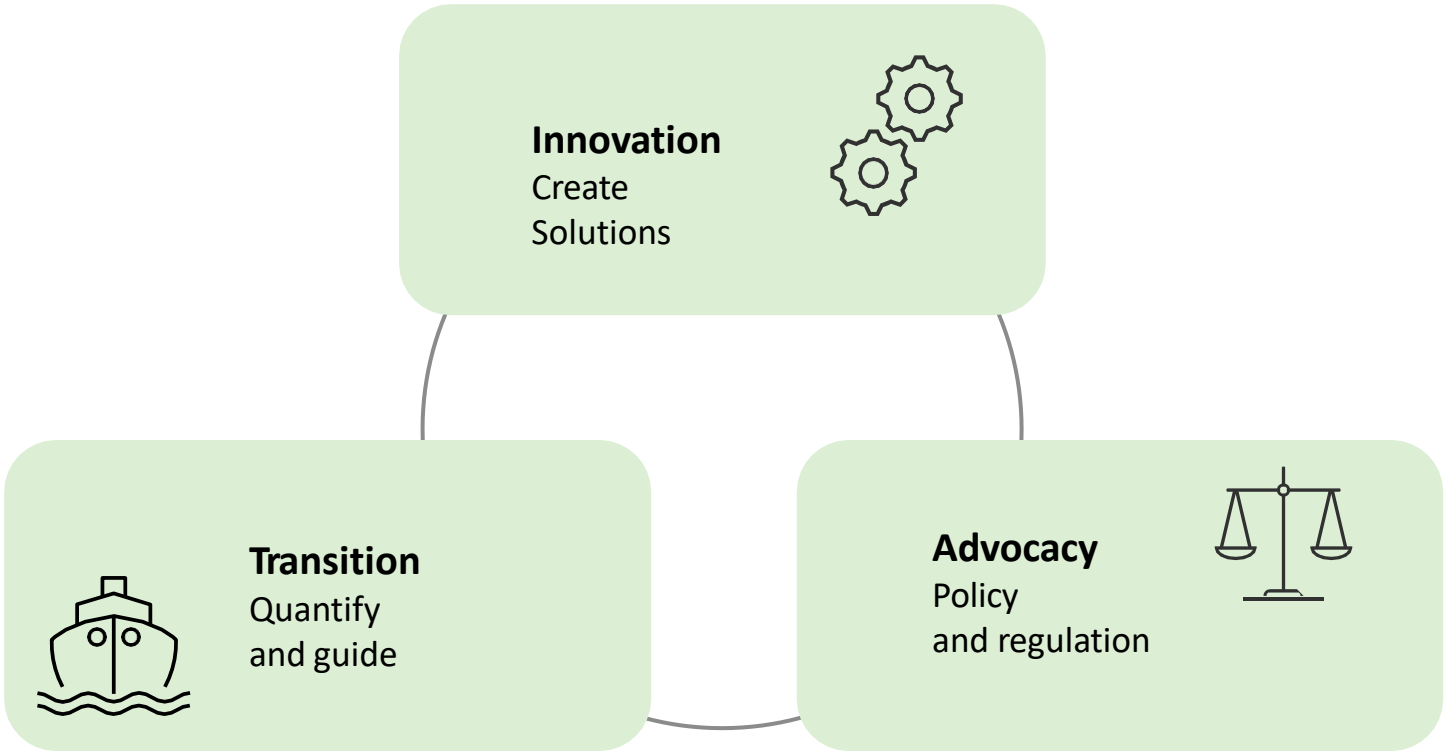
Independent

We operate in a pre-competitive environment bringing together key players across the value chain

Science-based

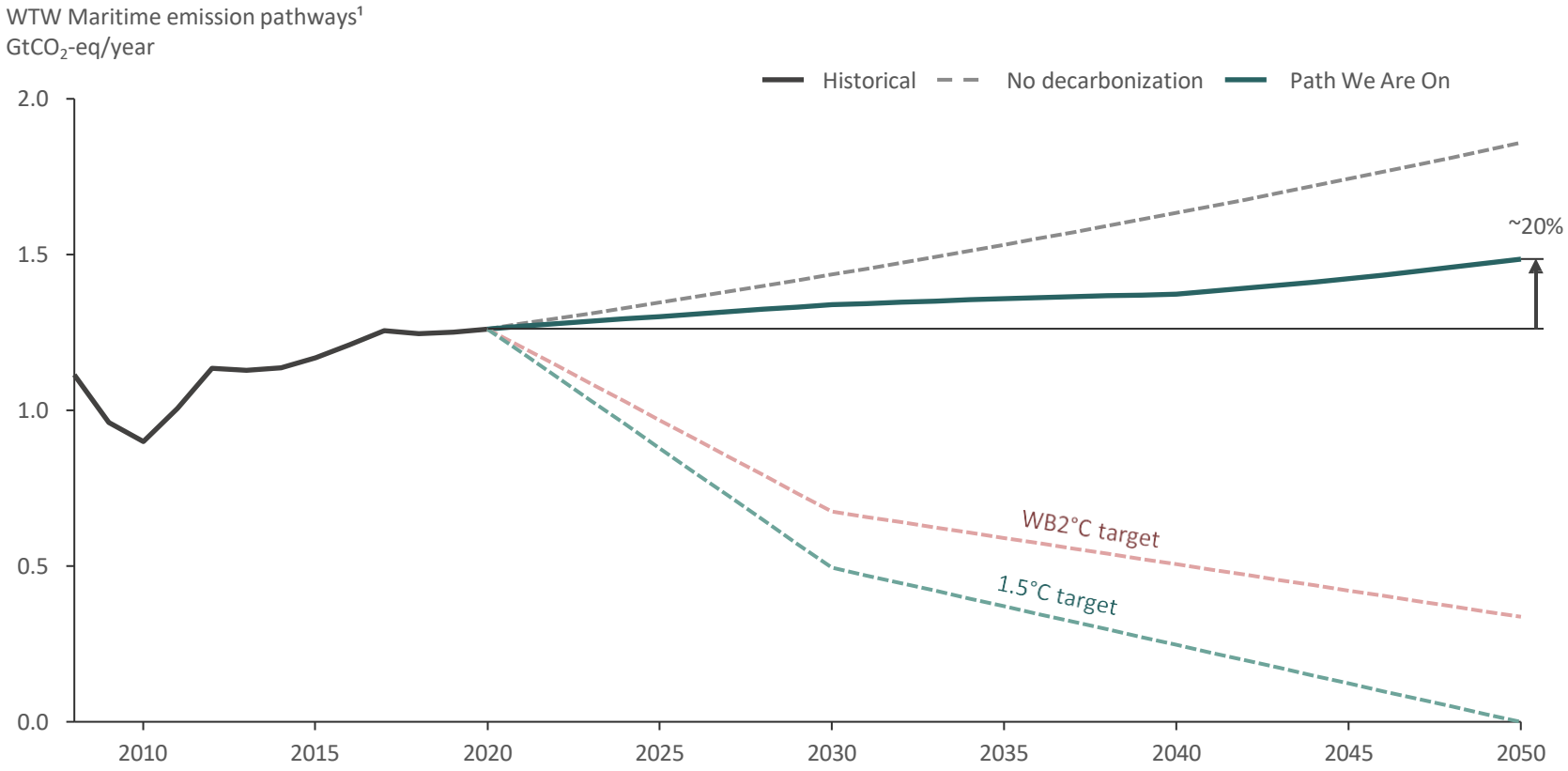
We explore viable decarbonization pathways by assessing available data and developing own energy and technology solutions

The Center addresses the challenge end to end - from the highest level to the smallest molecule



Did you know
That 98% percent of the global fleet runs on fossil fuels today?

The path we are on leads to increased GHG emissions



- The path we are on may lead to more GHG emissions in 2050 compared to today
- Industry leadership on its own cannot drive the transition and must be supported by regulation

Sources: IMO, IEA, Clarksons and Techno-economic model MMM Center for Zero Carbon Shipping
1 WTW = well to wake.
.

Activating critical levers across five categories can drive reduction of maritime emissions

1 Policy and regulation

National and regional regulation is of great importance, but we need global regulation. IMO can level the playing field by introducing maritime **CO_2 pricing and tighter energy efficiency regulations**

2 Tech advancements on ship

Existing efficiency technologies are technically mature but not universally adopted. We need better sharing of operational best practices, and **new efficiency solutions**

3 Energy & fuel advancements

Accessibility and availability of alternative fuels will **be largely dependent on scaling** of known, but not yet commercially scaled, technologies

4 Customer demand/pull

End-product-buyers are willing to change purchasing habits to show climate action. The pace of maritime decarbonization will increase if more consumers **demand zero-carbon transportation and are willing to pay a premium**

5 Finance sector mobilization

Green financing is already widely used by other industries and is now gaining momentum in the maritime industry as well. **Lower finance cost** can support and accelerate decarbonization

Source: MMM Center for Zero Carbon Shipping

Alternative fuels have varying maturity levels and challenges in the early years of transition

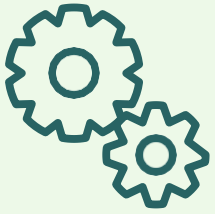
				Mature and proven	Solutions identified	Major challenges remain
Alternative fuels for decarbonization	Energy Carrier	Feedstock availability	Fuel production	Fuel storage, logistics, bunkering	Onboard fuel conversion[1]	Onboard safety and fuel management[2]	Regulation[3]
	Fossil fuels						
	e-hydrogen						
	Blue hydrogen						
	e-ammonia						
	Blue ammonia						
	e-methanol						
	Bio-methanol						
	e-methane						
	Bio-methane						
	Bio-oils						

- The future fuel pathways will include more options than we know today
- Each pathway has different challenges in terms of scalability, cost and technology maturity and safety
- Alternative fuels will be in competition, when the sectors and nations progress through the green transformation.

Accelerated progress is needed in four areas during the next decade to make the 2050 target

A level playing field
with global regulation

Alternative fuels
available at scale



Energy efficiency support
across the value chain

Support to first movers

The full strategy document including detailed deep dives on each priority can be found on

www.zerocarbonshipping.com

Source: MMM Center for Zero Carbon Shipping

How Hydrogen and Fuel Cell Technology Supports a Sustainable Marine Industry

Dr. Joseph Pratt, CEO & CTO

UN Decade of the Ocean Toward a Sustainable Marine Transportation System

U.S. Committee on the Marine Transportation System

December 14, 2021

ZERO EMISSION INDUSTRIES

Previously known as:

GOLDEN GATE ZERO EMISSION MARINE

Hydrogen is the only real option for marine electrification

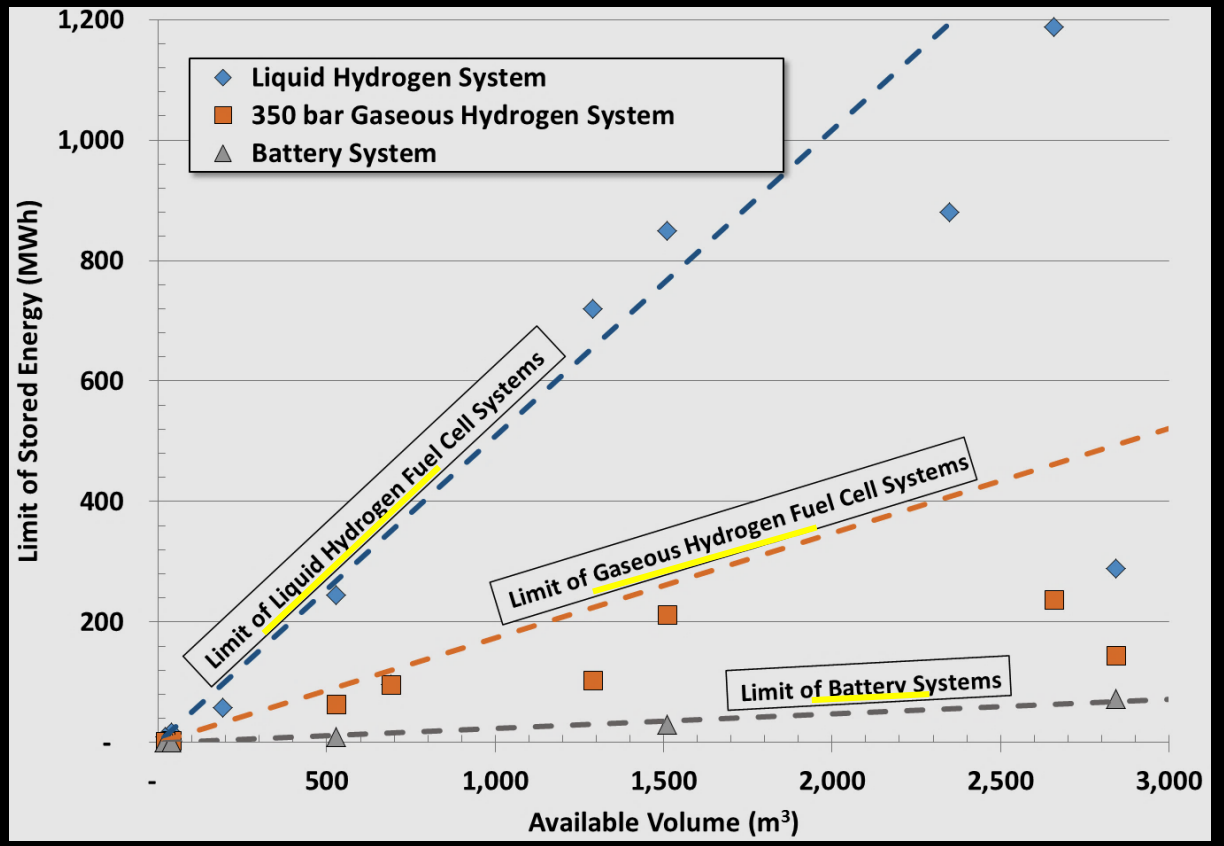
Hydrogen Fuel Cell

- **Energy costs**: Decrease with scale
- **Usage**: Long range, high flexibility
- **Fueling method**: Flexible, no infrastructure required

Battery

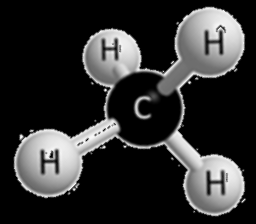
- **Energy costs**: Increases with scale (demand charges, infrastructure, grid upgrades)
- **Usage**: Limited to locations with charging, limited range
- **Charging method**: Shore based equipment needed at each charging dock

Batteries physically cannot work for the majority of marine vessels



Reference: *Practical Application Limits of Fuel Cells and Batteries for Zero Emission Vessels* (download from: maritime.sandia.gov)

Hydrogen is similar to natural gas, but does not contain carbon
Fuel cells electrochemically convert hydrogen to power



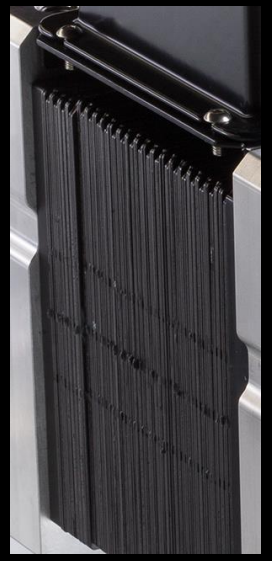
Natural gas / LNG

→ energy
water
CO
CO_2
CH_4
NOx (smog)

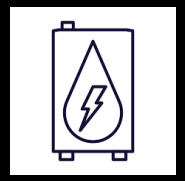
→ energy
water

Hydrogen / LH_2

- Does not contain carbon
- Non-toxic
- No possible water contamination if spilled

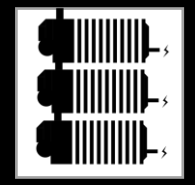


The advantages of fuel cells goes far beyond environmental



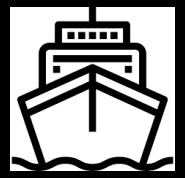
Reliable

Fuel Cells are solid state, and the rest of the powertrain has few moving parts



Scalable

Power can be scaled up/down depending on vessel type and operating needs



Modular

No more "engine room", power train can be distributed across the vessel

Flexible

Maintain current operational flexibility

Low Maintenance

Reduce operation and maintenance cost by 20% to 50%

Connected

Remote monitoring and real time operational intelligence.

Marine Applications of Hydrogen

Each of these vessels can be powered by fuel cells and hydrogen.

Hydrogen enables zero carbon and zero pollution operation.

Reference: *Practical Application Limits of Fuel Cells and Batteries for Zero Emission Vessels* (download from: maritime.sandia.gov)

The *Sea Change* Hydrogen Fuel Cell Ferry

Nov. 18, 2021 (Bellingham WA): First Fueling

- Aluminum catamaran
- 72’-7” (22 m) LOA
- 24’-6” (7.5 m) beam
- 78 passengers + 2 crew
- 22 knot top speed
- 2x 300 kW electric motors
- 100 kWh Li-ion battery
- **360 kW PEM fuel cell**
- **H_2: 242 kg @ 3,600 psi (250 bar)**
- **No infrastructure required to fuel**

Technology Summary

Diesel and LNG	Battery Electric	Fuel Cell *Best of Both*
✓ Flexible	✗ Flexible	✓ Flexible
✗ Zero Emission	✓ Zero Emission	✓ Zero Emission
✗ Simple Maintenance	✓ Simple Maintenance	✓ Simple Maintenance

For further information please contact:

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ZERO EMISSION INDUSTRIES

Hydrogen Simplified.

Out of the Blue Comes Green

maritime cleantech

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EQUIPMENT AND SERVICE SUPPLIERS
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AF GRUPPEN
AeronMollier
ABB
eta energi
GAC
LMG MARIN
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MARLINK
THE SWITCH
VIS
ZEM
YXNEY MARITIME
BRUNVOLL
Corvus Energy
HYON
Hydro
LOS
MDC
massterly
HEINZMANN
Mecmar AS
TEKNOTHERM MARINE
DALSEIDE SHIPPING SERVICES AS
GREENSTAT
zeabuz
AQUAPRO
Bertel O. Steen Power Solutions
BLOM Maritime
BALLARD
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SEAM
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hafenstrom
CFD marine
SPEAR POWER SYSTEMS
Smart
COWI
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evoy
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FUTURE ENERGY SOLUTIONS
airseas
BEYONDER
Hardanger cruise
NGP
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BREMNES SEASHORE
Kystrederiene
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Wilhelmsen
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Østensjø Rederi
HØEGH LNG
NORTH SEA SHIPPING
NAPIER
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SinOceanic SHIPPING
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STAVANGER
FAGSKOLEN I HORDALAND
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NHH
UNIVERSITAS BERGENSIS
IFE
Høgskulen på Vestlandet
cmr Prototech
SINTEF
PUBLIC SECTOR
Vestland fylkeskommune
ROGALAND FYLKESKOMMUNE
KVINNHERAD KOMMUNE
STORD KOMMUNE
BERGEN KOMMUNE
Haugesund kommune
CLASS SOCIETY – REGULATORS
Sjøfartsdirektoratet
Norwegian Maritime Authority
Lloyd's Register
DNV·GL
RINA
FINANCE & LAW
CMS law·tax·future
SparebankenVest
DNB

Ampere

AN ELECTRIC REVOLUTION IN NORWEGIAN FJORDS

2015

ALL FERRIES IN NEW TENDERS MUST BE LOW /ZERO EMISSION

2021

70 ELECTRICAL FERRIES IN OPERATION

CO2

REDUCTION IN CO2 EMISSION: EQUIVALENT TO 350.000 CARS

MAJOR REDUCTIONS IN FUEL COSTS

CRUISE

FLAGSHIPS
CH2 BARGE VESSEL

H2-CRUISESHIP
VIKING CRUISES

LH2-FERRY

ShipFC
WORLD´S FIRST
ON AMMONIA

40%
IMO: REDUCTION IN
CARBON INTENSITY

2020 · 21 · 22 · 23 · 24 · 25 · 26 · 27 · 28 · 29 · 2030

TrAM
ELECTRIC
FAST FERRY

AUTONOMOUS
CONTAINERSHIP
YARA BIRKELAND

ZERO EMISSION
FAST FERRIES IN COUNTY
MUNICIPALITIES

50%
REDUCTION IN
CO2-EMISSIONS

H2&BATTERIES
HAVILA KYSTRUTEN

HyShip
ConRo SHIP
ON HYDROGEN

55
ELECTRIC FERRIES
OPERATING IN NORWAY

PILOT-E
VALUECHAIN FOR HYDROGEN

maritime cleantech

Global Trends

We are committed to becoming climate positive by 2030 by reducing more greenhouse gas emissions than the IKEA value chain emits

IKEA

REGULATIONS AND POLITICS

Shipping must cut carbon emissions by 50% by 2050 and improve efficiency

IMO

EXPECTATIONS OF CARGO OWNERS AND CONSUMERS

ACCESS TO INVESTORS AND CAPITAL

Why do we need an EU Taxonomy?
We need reliable tools to support companies in the transition to climate neutrality and a sustainable economy.

maritime cleantech

How will we succeed

- Drive testing and piloting
- Shipping contract incentives
- Infrastructure

maritime cleantech