ENERGYWEEK.FI

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EnergyWeek

Gas Energy Seminar 2: Using e-fuels to decarbonise ecosystems

By: Pohjanmaan Expo Oy in partnership with Alcea Oy & Novia University of Applied Sciences

14.3.2024

2024 MARCH 11–14 VAASA, FINLAND

EXPO POHJANMAAN ÖSTERBOTTEN

ALCEA

NOVIA UNIVERSITY OF APPLIED SCIENCES

Host

Cynthia Söderbacka

Project Leader, Faculty of Technology & Seafaring-RDI
Novia University of Applied Sciences

What is the marine sector doing to develop carbon free transport?

Aparajit Pandey

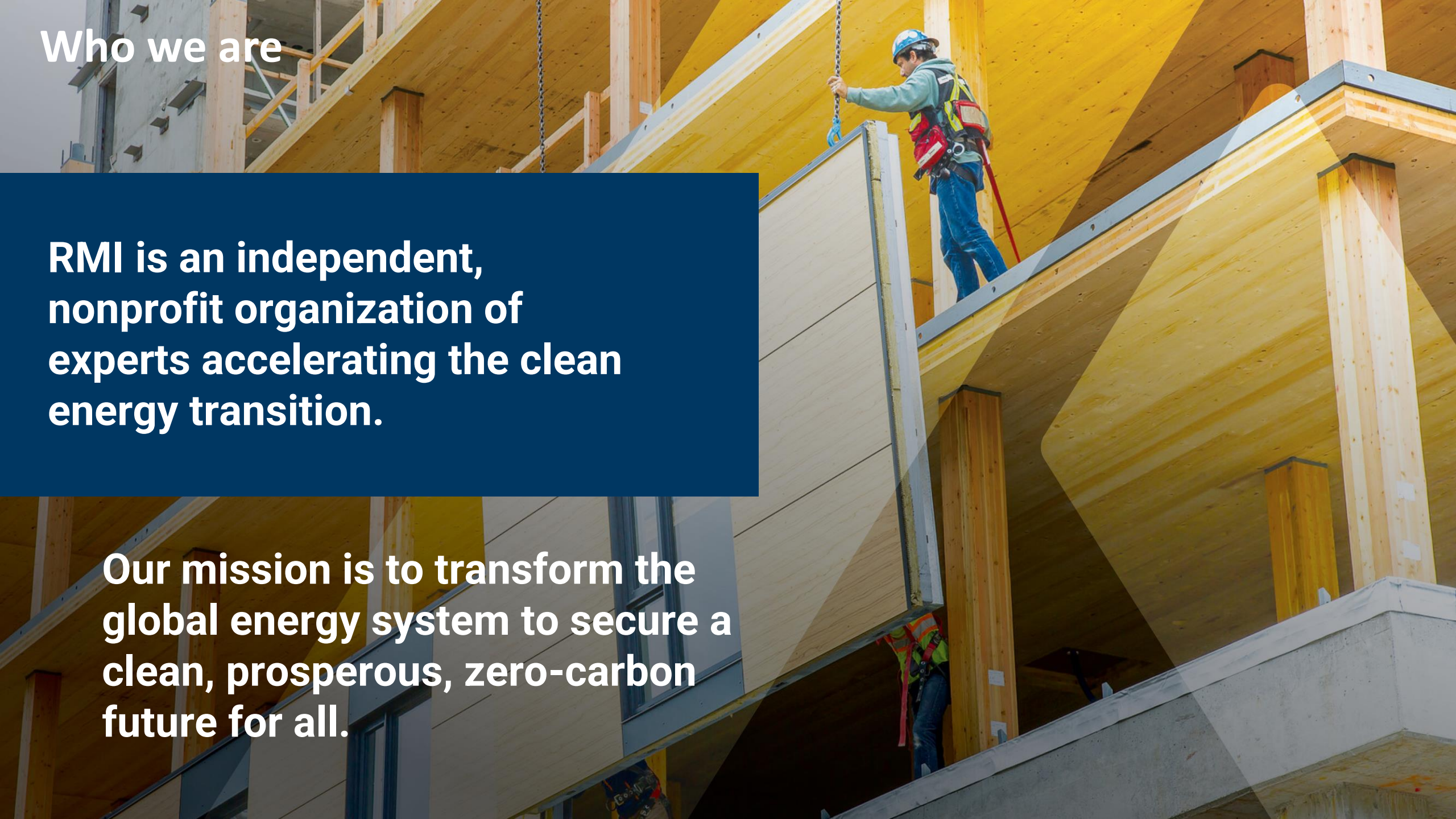
Shipping Decarbonisation lead:
Principal- Climate Aligned Industries
RMI

Energy Week: What is the marine sector doing to develop carbon free transport?

March 14th 2024

RMI
ENERGY. TRANSFORMED.

Who we are



RMI is an independent, nonprofit organization of experts accelerating the clean energy transition.

Our mission is to transform the global energy system to secure a clean, prosperous, zero-carbon future for all.

What we do

Strengthening Market Forces

- Data & Transparency
- Climate Finance
- Technology
- Education & Capacity Building

Advancing Decarbonization

- Carbon-Free Electricity
- Carbon-Free Mobility
- Carbon-Free Buildings
- Climate-Aligned Industry

Working Across Critical Global Geographies

1. Shipping Decarbonization Drivers

2. Zero Emission Fuels

3. Challenges to Implementation

4. Green Shipping Corridors

Introduction

1

At current growth rates, shipping's share of global emissions will grow unless zero and near-zero fuels are adopted at scale

~80%
of world trade today[1]

~2-3%
of current global emissions[2]

>¾
of goods movements by 2050[3]

+ 50%
emissions by 2050 without collective decarbonization efforts

[1] UNCTAD (2020)
[2] ETC (2020)
[3] OECD (2019)
[4] ETC (2019)

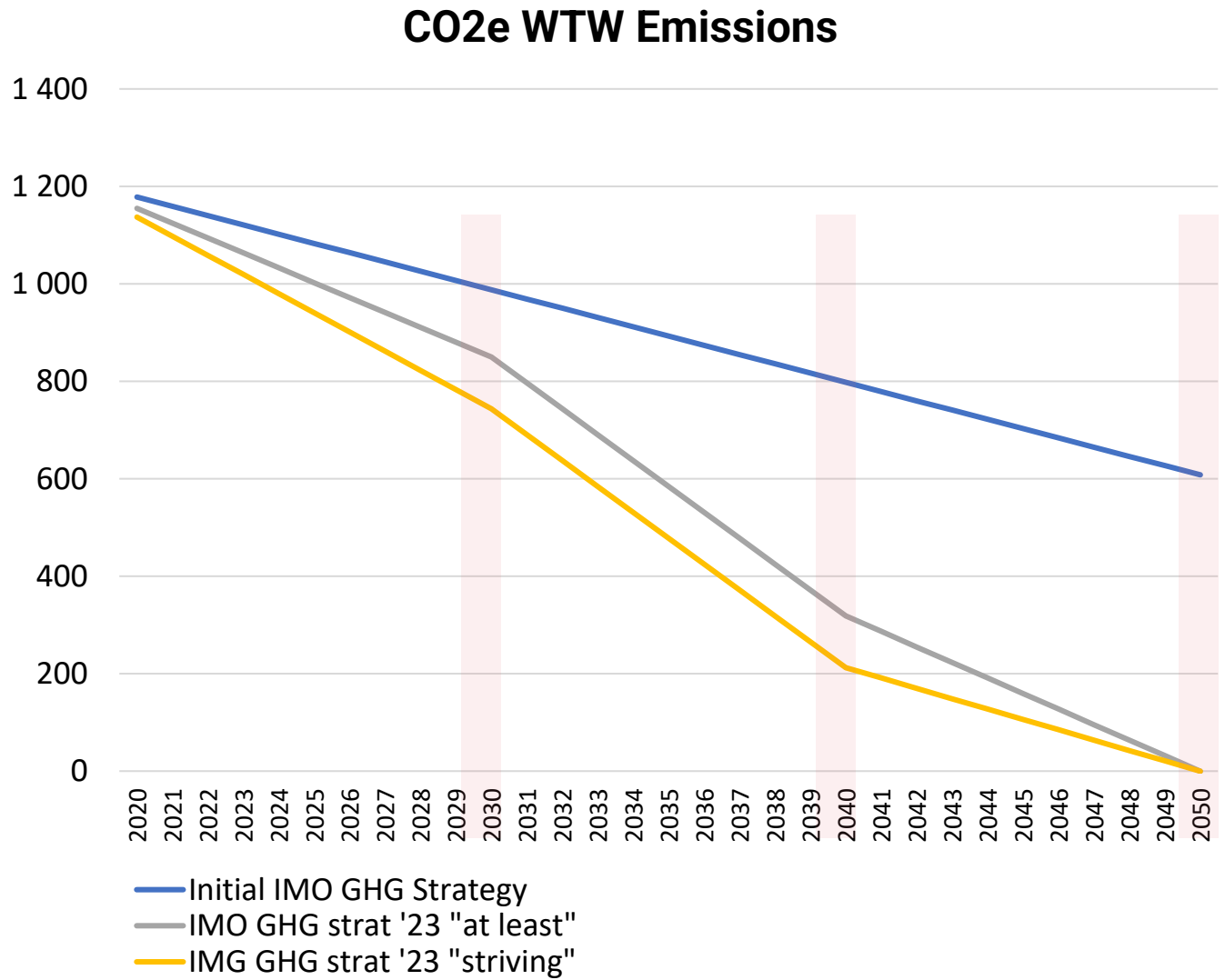
Last year, IMO increased emissions reduction target from 50% to 100% decarbonization by 2050, with interim targets in 2030 and 2040

International regulations with compliance mechanisms to achieve targets currently in development

IMO 2023 GHG strategy:

- ***2030:*** uptake zero or near-zero emission fuels to represent at least 5% of shipping's energy use, striving for 10%;
- **2040:** reduce GHG emissions by 70%-80% *(compared to 2008 levels)*
- ***2050:*** *zero GHG emissions*

Characterized, ultimately, by meeting energy demand safely, through cost reductions, and within global feedstock constraints (e.g. biomass, non-fossil CO2).

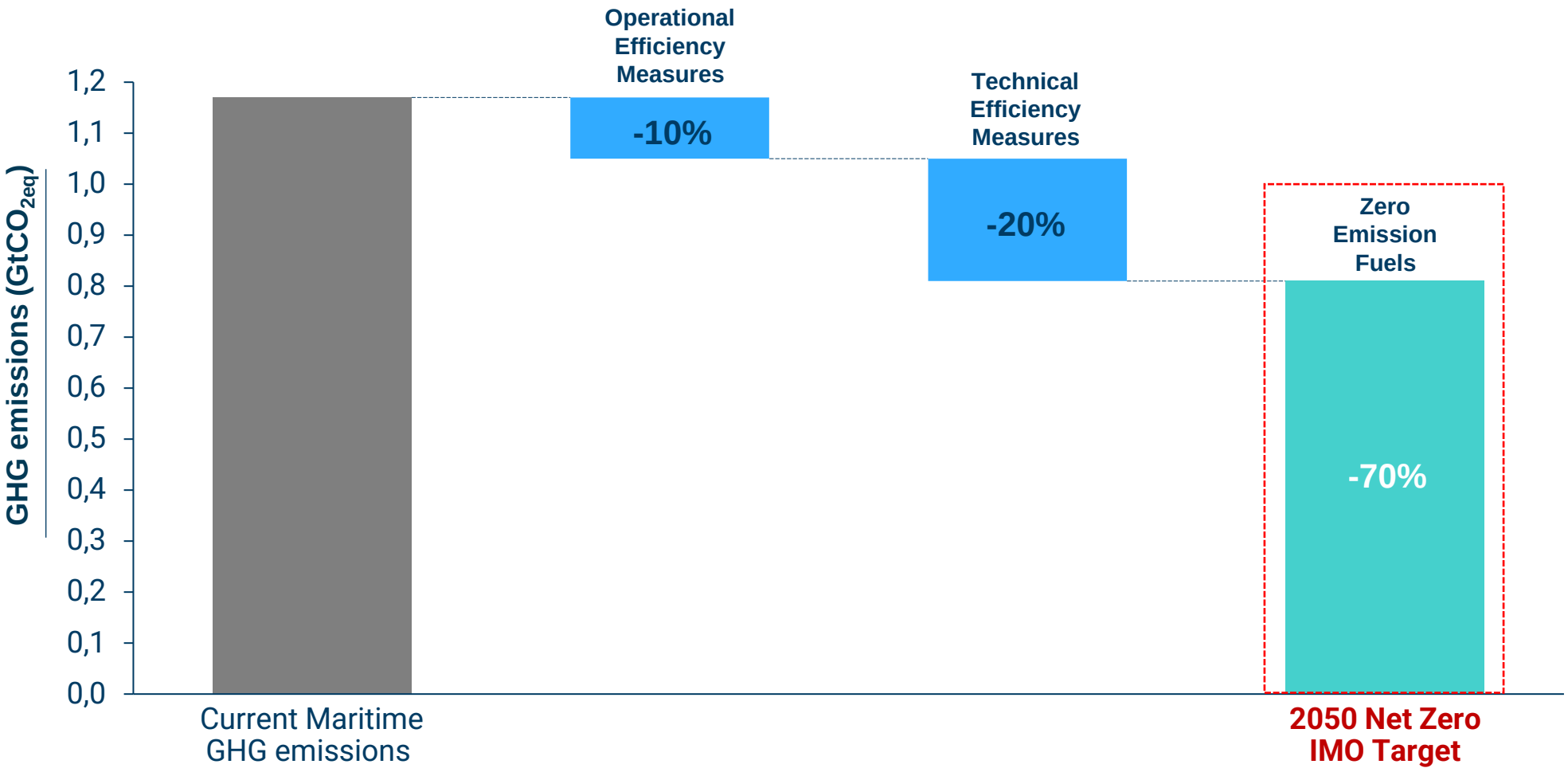


Emission Reduction Options

2

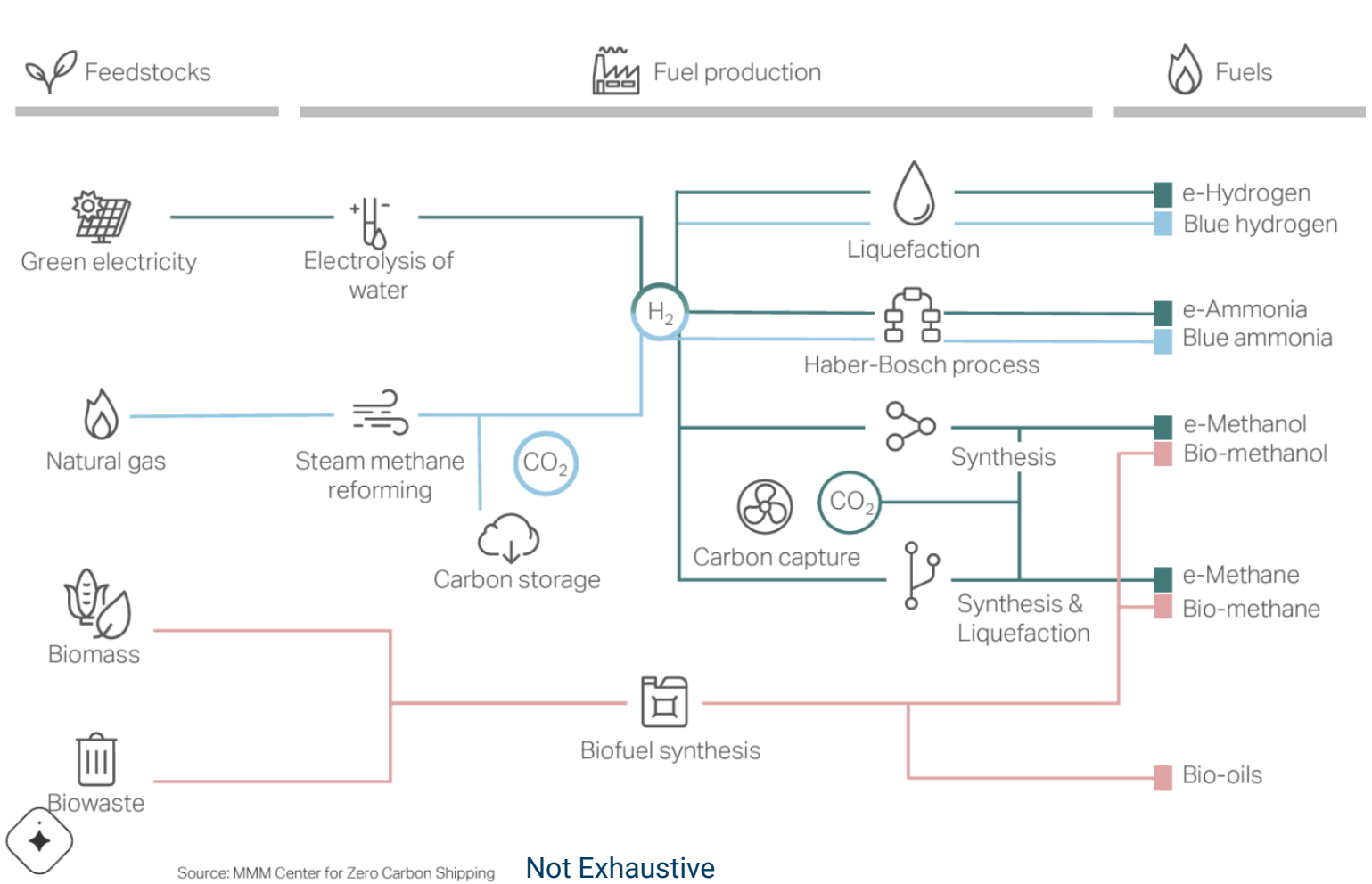
Efficiency measures can help but for true decarbonization the shipping industry will require a revolution in fuels and propulsion technologies

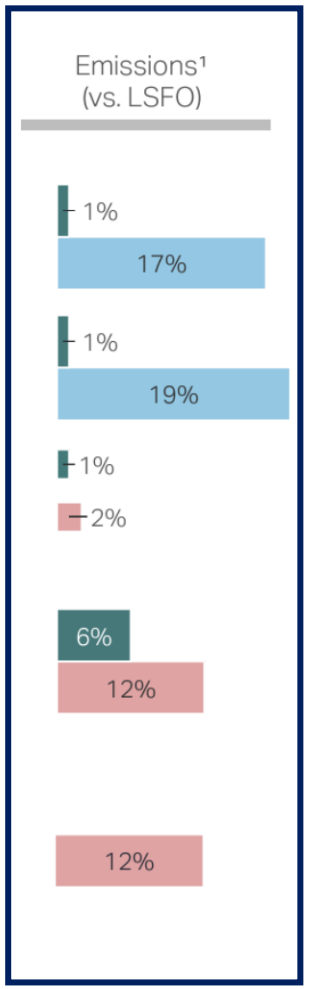
Emission reduction measures for maritime decarbonization



- **Zero-emission fuels** are the **only pathway** to fully decarbonize the maritime sector.
- Transition of the global maritime sector to zero-emission fuels will **require** more than **50 million tonnes of clean hydrogen**
- As we transition to more expensive zero-emission fuels, **payback on efficiency measures will get better**

Zero-Emission Fuels (ZEF) are defined primarily by their well-to-wake GHG emission reduction potential, relative to incumbent fuel oil; >90% emission reduction is a common benchmark for buyers' alliances and green corridor efforts





Source: MMM Center for Zero Carbon Shipping

Not Exhaustive

Representative WtW emissions reductions by fuel type

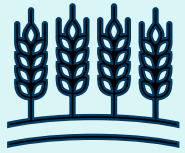
Emissions reductions will vary across production projects due to variations in feedstock, supply chain considerations, leakage rates, and end-use technology (engine type)

Ability of Zero Emission Fuels to scale production to meet ultimate demand of shipping sector is critical characteristic

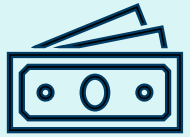
	Zero Emission Fuel	Principal Feedstocks	Supply constraints
E-fuels	e-ammonia	clean hydrogen	Pace of electrolyzer and renewables deployment
E-fuels	e-methanol e-LNG	clean hydrogen and biogenic CO2 *(from pulp & paper, carbon capture on biomass power plants, direct air capture, etc.*	Constrained supply of biogenic CO2 (excluding DAC), and competition for available CO2 with other e-fuel end-uses (aviation, plastics)
Biofuels	bio-oils bio-methanol bio-LNG	Sustainable biomass feedstocks *(MSW, animal manure, forestry and agricultural residues, or energy crops, taking into consideration indirect land use changes)*	Significant concerns around scale of sustainable biomass feedstocks, and competition with other biomass end-uses (pulp & paper, aviation, plastics).

Zero Emission Fuels are now being evaluated rigorously across many essential characteristics by stakeholders across the value chain

Emissions Reduction

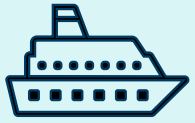


Scalability (Feedstock)



Fuel Cost & TCO

Fuel Storage & Bunkering Logistics



Technology Readiness

Safety (onboard and landside)

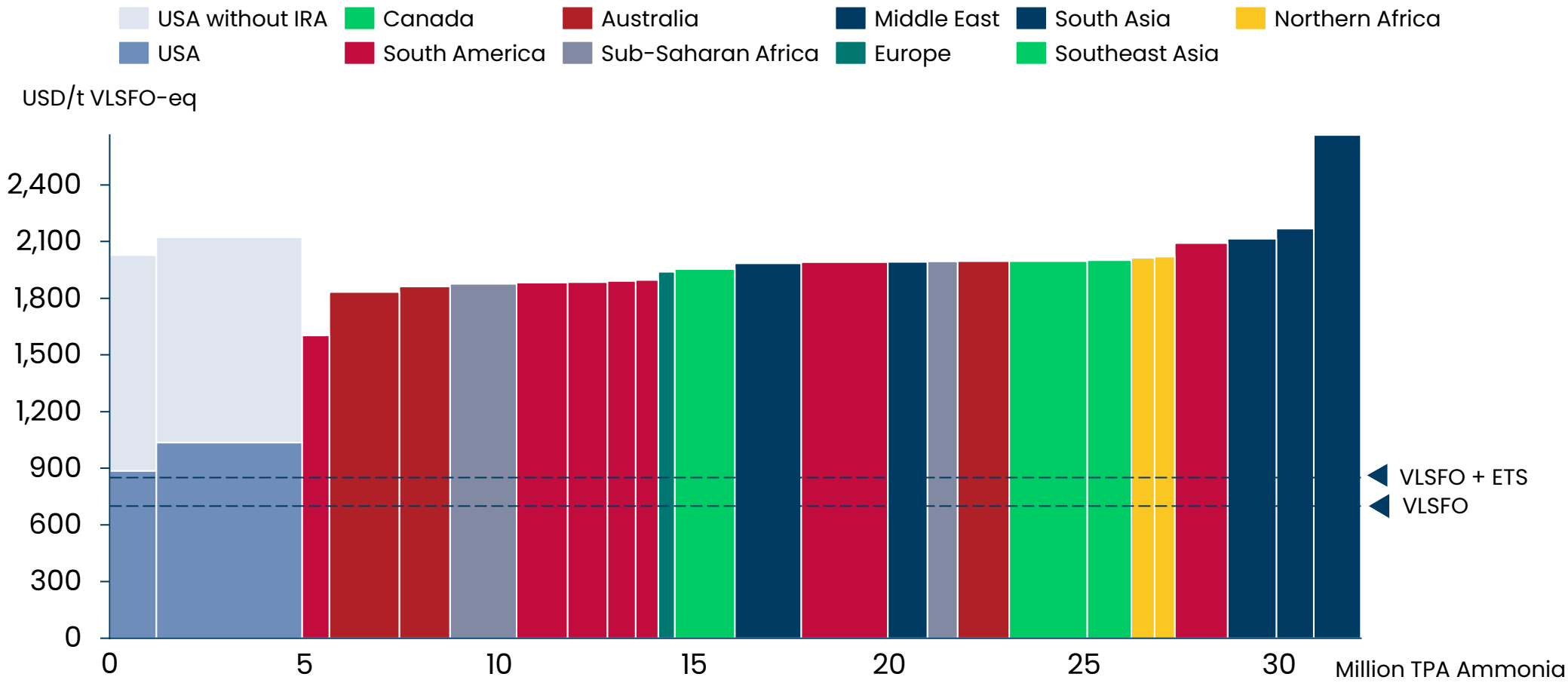
Regulation & Certification

Current State of Shipping Decarbonisation

3

There are more than 30 million tonnes of green ammonia project announcements without a specified "offtake sector"

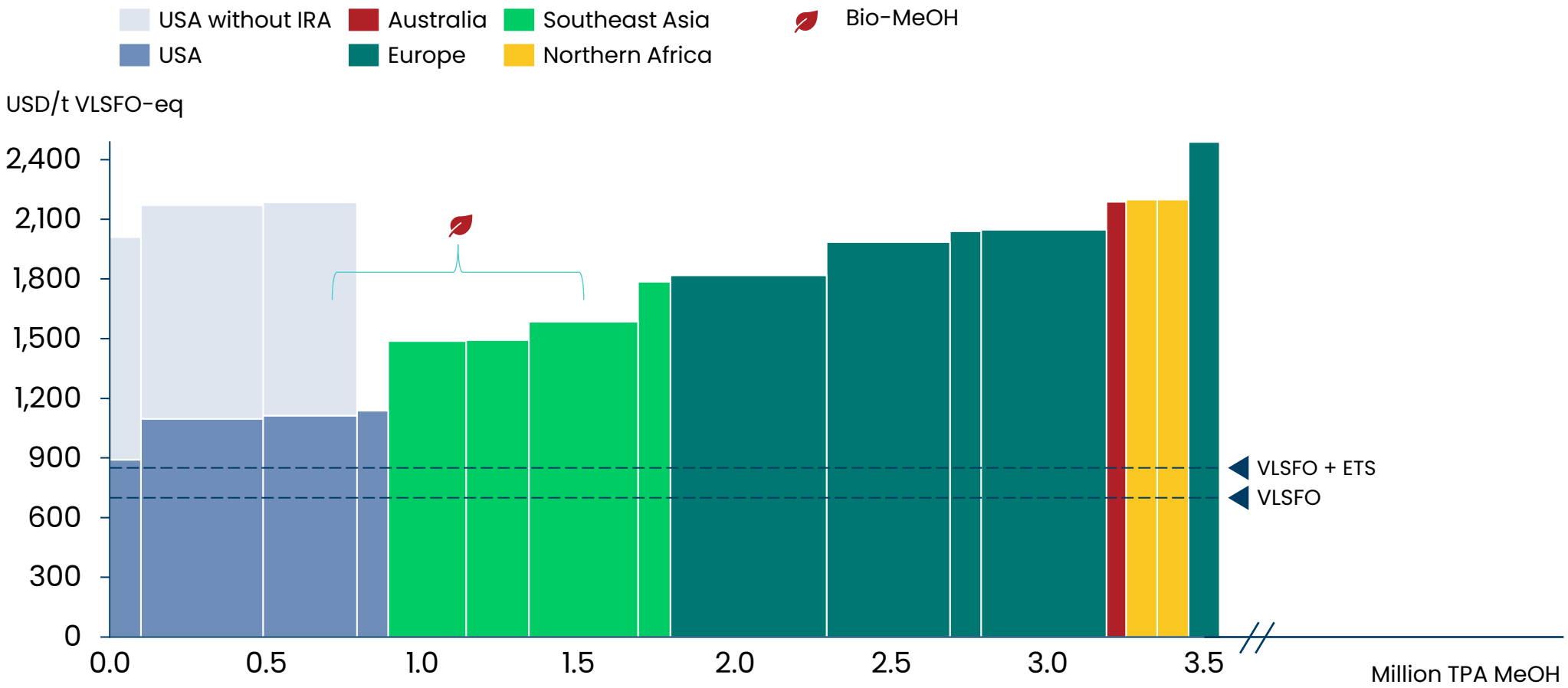
Ammonia 2030 capacity per region by order of production & storage cost[1]
USD/metric ton VLSFO-eq of fuel



Note 1: Incorporating green ammonia projects with est. production of ~100k+ tpa H2 from IEA 2023; Excluding projects that come online after 2030 and projects assigned to other sectors; Supplemented IEA data with Rystad
Note 2: Assuming €100 EU ETS price

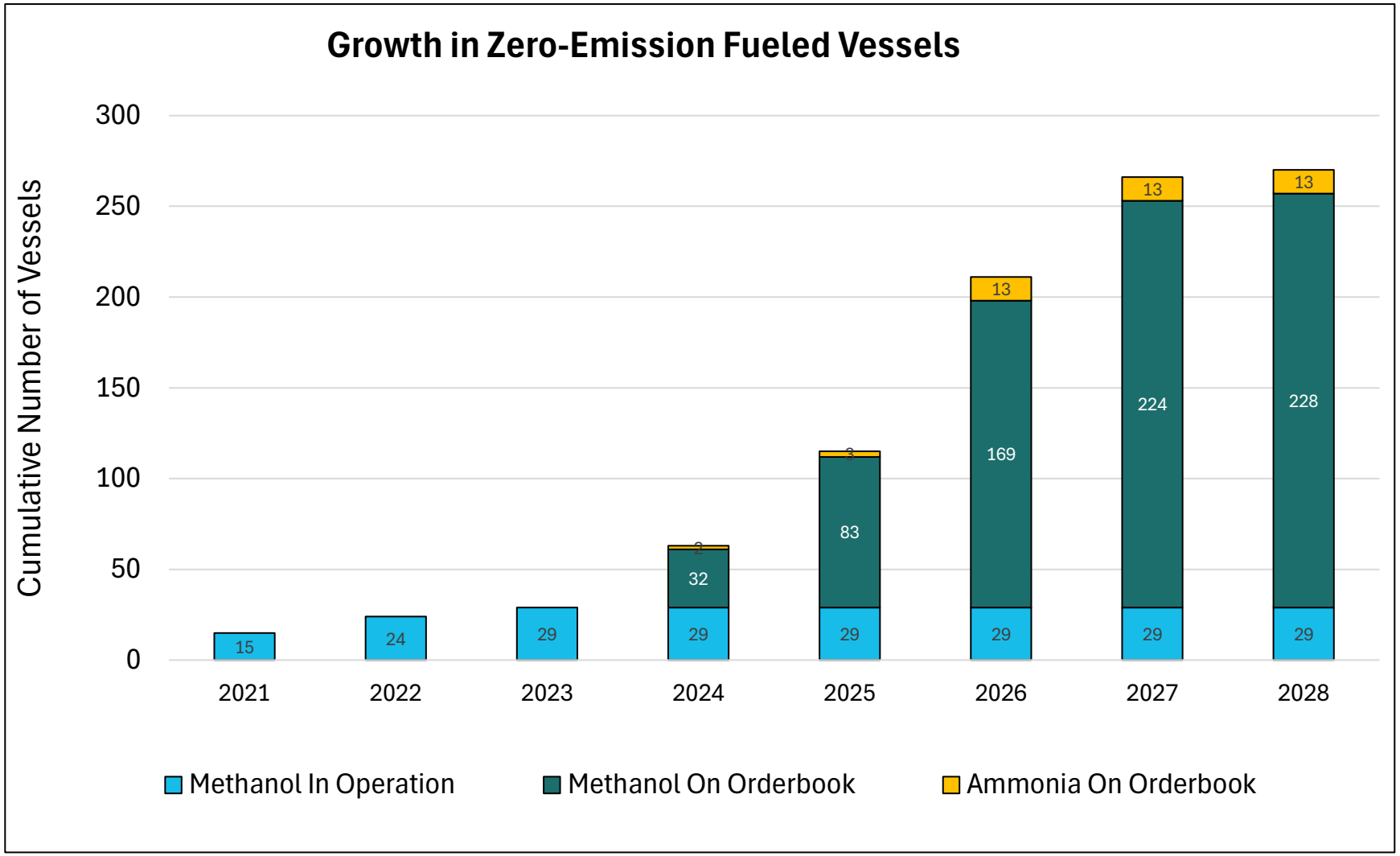
Bio and e-methanol project announcements are much lower compared to ammonia; likely due to difficulties in sourcing biogenic CO2

Bio- & e-methanol 2030 capacity per region by order of cost
USD/tonne VLSFO-eq of fuel



Note 1: Incorporating green methanol projects with est. production of ~15k+ tpa H2 per IEA 2023 and Maersk offtake announcements; Excluding projects that come online after 2030 and projects assigned to other sectors; Cost includes production & storage cost

Orderbook for dual fuel vessels is showing positive momentum; mismatch for methanol fuel availability and demand could be problematic



- To achieve 5% zero-emission fuel demand by 2030 only 600 large containerships required (15,000 TEU)
- Orderbook **does not reflect additional announcements** for ammonia dual-fuel vessel orders from Eastern Pacific, Berge Bulk, Exmar and others due to shipyard classification quirks; **ammonia vessel orders ~40 by 2027**
- Increase in **ammonia and methanol-ready vessels and ability to modify fuel combability** during build allow for **potential to achieve 5% zero-emission fuel demand by 2030**
- **Mismatch** between current methanol demand and supply might be a **cautionary point for overreliance on scarce biomass fuels** to decarbonize shipping

Source: DNV Veracity AFI

Challenges and solutions

4

To make progress towards net zero, a range of barriers and system boundaries will need to be addressed

Cost differential	• **Higher fuel costs for most cases – between 1.5-3x in the near-term (2030)** • Marginal additional cost for shipper from new zero-emission vessels & cargo loss • Significant additional capex in fuel production infrastructure • New fuel and bunkering infrastructure required
Market structure	• **Highly fragmented market and value chain** • Fragmented market requires strategic planning and collaboration across diverse actors, and targeted policy / incentives relative to conventional fuel and/or premium markets
Fuels and Technology	• **Multiple competing fuel pathways with no industry consensus** • Use of hydrogen and ammonia as alternative fuels at early testing phase • Potential limitations on sustainable biofuel feedstock
Regulatory Hurdles	• **Safety standards required for new alternative fuels at ports and on-board vessel** • Regulatory process for safety standards can take up to 3+ years

We believe there are three key measures that can help overcome these challenges and accelerate shipping decarbonization

Implementing green shipping corridors

IMPACT: Bring together actors across maritime value chain to successfully implement commercial scale first mover projects

Enabling zero-emission fuel supply at ports

IMPACT: Accelerate development of zero-emission port fuel infrastructure and catalyze uptake of zero-emission fuels

Developing a maritime Book and Claim system

IMPACT: Create marketplace for consumers to pay ‘green premium’ for decarbonized maritime activity

Towards greener marine transports- R&D cooperation between business and academia

Kaj Portin
General manager- Sustainable Fuels & Decarbonisation
Wärtsilä Finland Oy

Carolin Nuortila,
Senior Reseacher- Fuel Division of Efficient Powertrain Solutions, University of Vaasa

Towards greener marine transports
R&D cooperation between business and Academia

Kaj Portin, Wärtsilä
Carolin Nuortila, University of Vaasa

22.01.2024

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2023 IMO GHG Strategy to reduce GHG emissions to net-zero, by or around 2050

Initial GHG strategy (2018)

EEXI, CII

-40% carbon intensity

-70% carbon intensity
-50% total GHG emissions

Revised GHG strategy (2023)

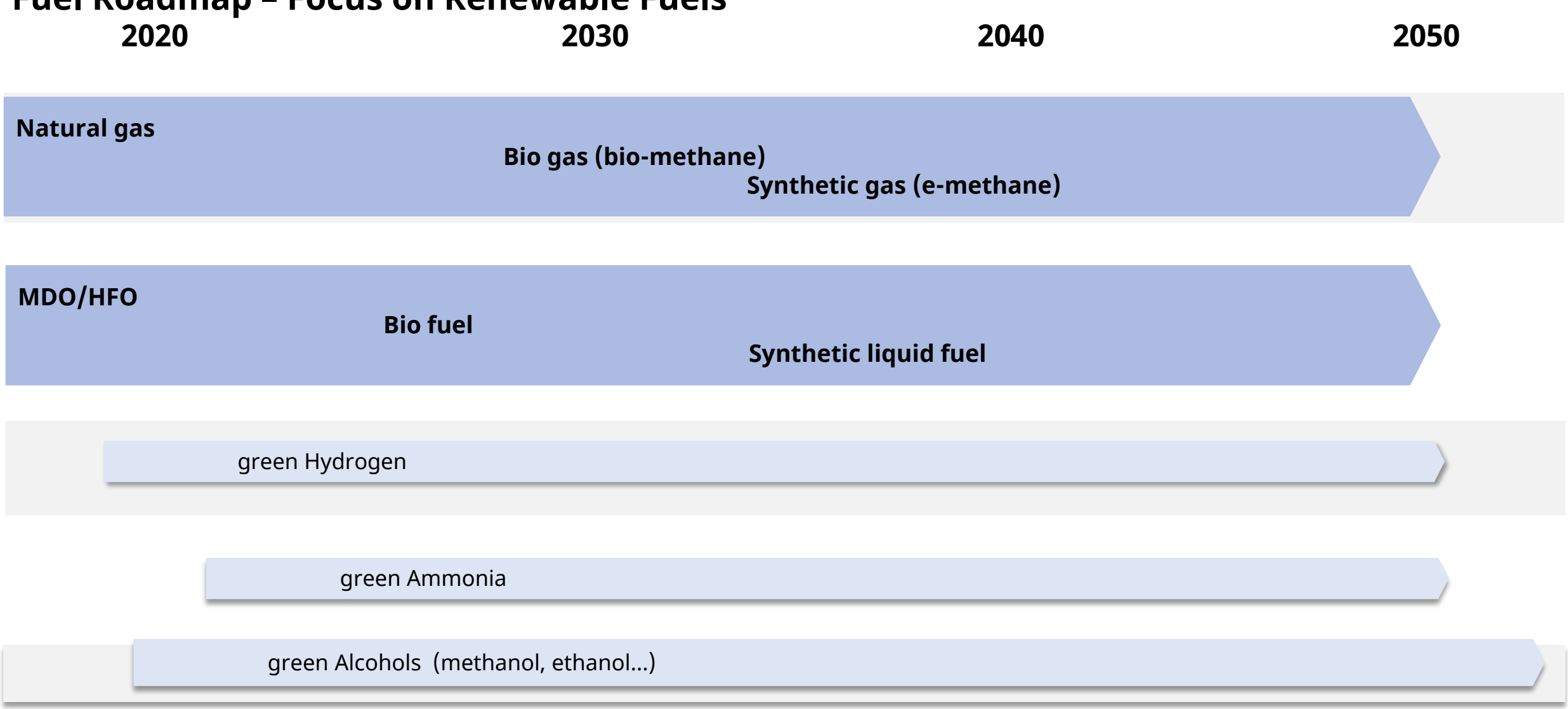
MEPC 80	-40% carbon intensity; 5% uptake of zero or near-zero GHG emission fuels (striving for 10%);		Net-zero GHG by or around 2050, taking into account different national circumstances
Indicative check points	-20% total GHG emissions (striving for -30%[1)])	-70% total GHG emissions (striving for -80%)	

Reduction figures are compared to 2008;

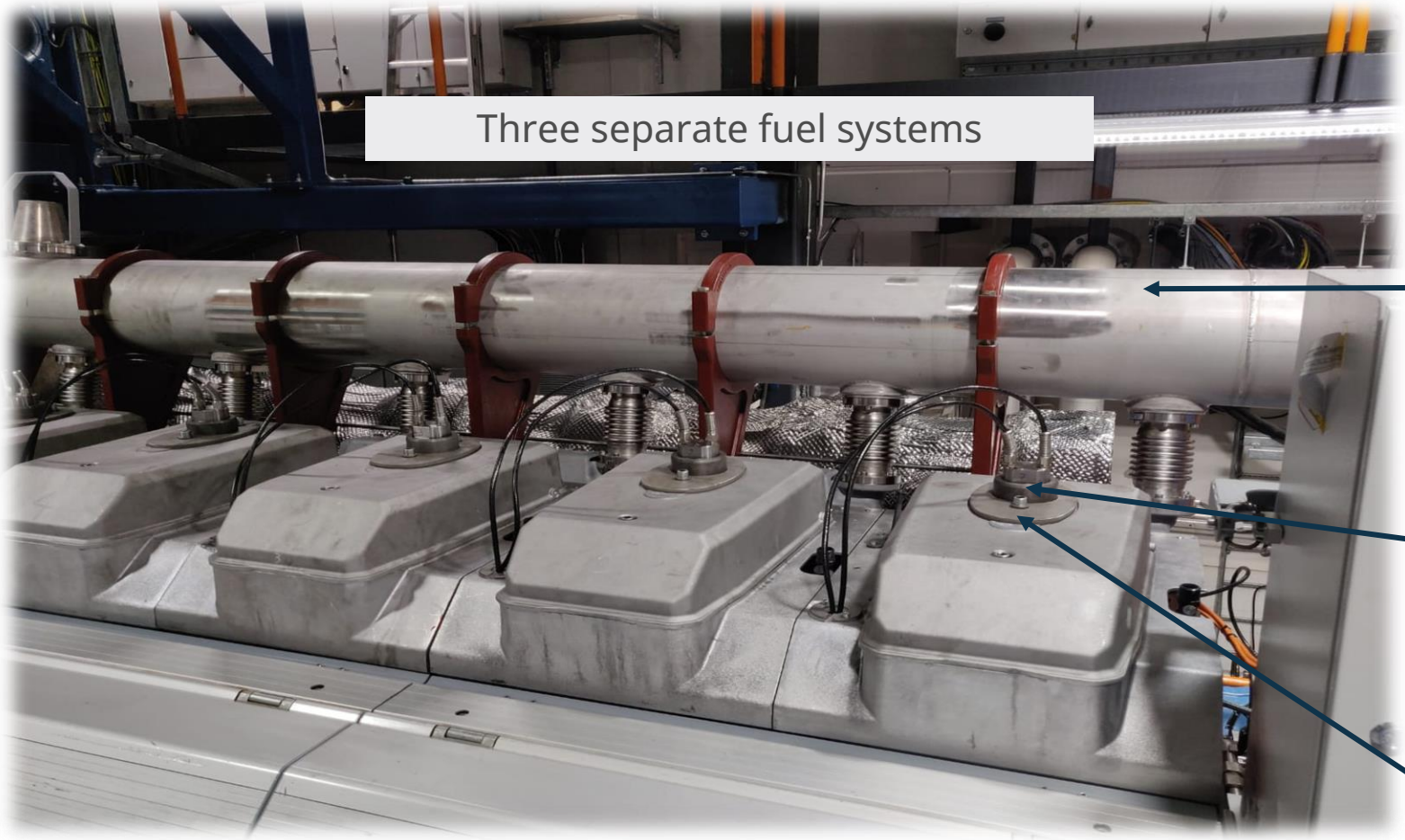
Key takeaways

- IMO MEPC 80 adopted a **revised 2023 IMO GHG Strategy** July 7th 2023.
- Milestones of the new strategy support the Vision to phase out GHG emissions as soon as possible.
- A basket of **mid-term technical and economical measures** should be agreed by 2025 and entry into force 2027. Measures should take into account well-to-wake GHG emissions.
  - Technical element = goal based marine fuel standard regulating the reduction of fuels GHG intensity
  - Economic element = GHG emissions pricing mechanism
- Less ambitious countries have strongly emphasized “a just and equitable transition”, and strategy includes e.g. set of guiding principles to note the different national circumstances, and emphasizes impact assessment and evidence-based decision-making
- The strategy will be subject to a 5-year review period, first due in 2028.
- Some still see it as **insufficiently ambitious**: the deal is not aligned with 1.5°C goal, and the “taking into account different national circumstances” linked to the 2050 target leaves room for developing countries to move at slower pace.

Fuel Roadmap – Focus on Renewable Fuels



The multi-fuel engine



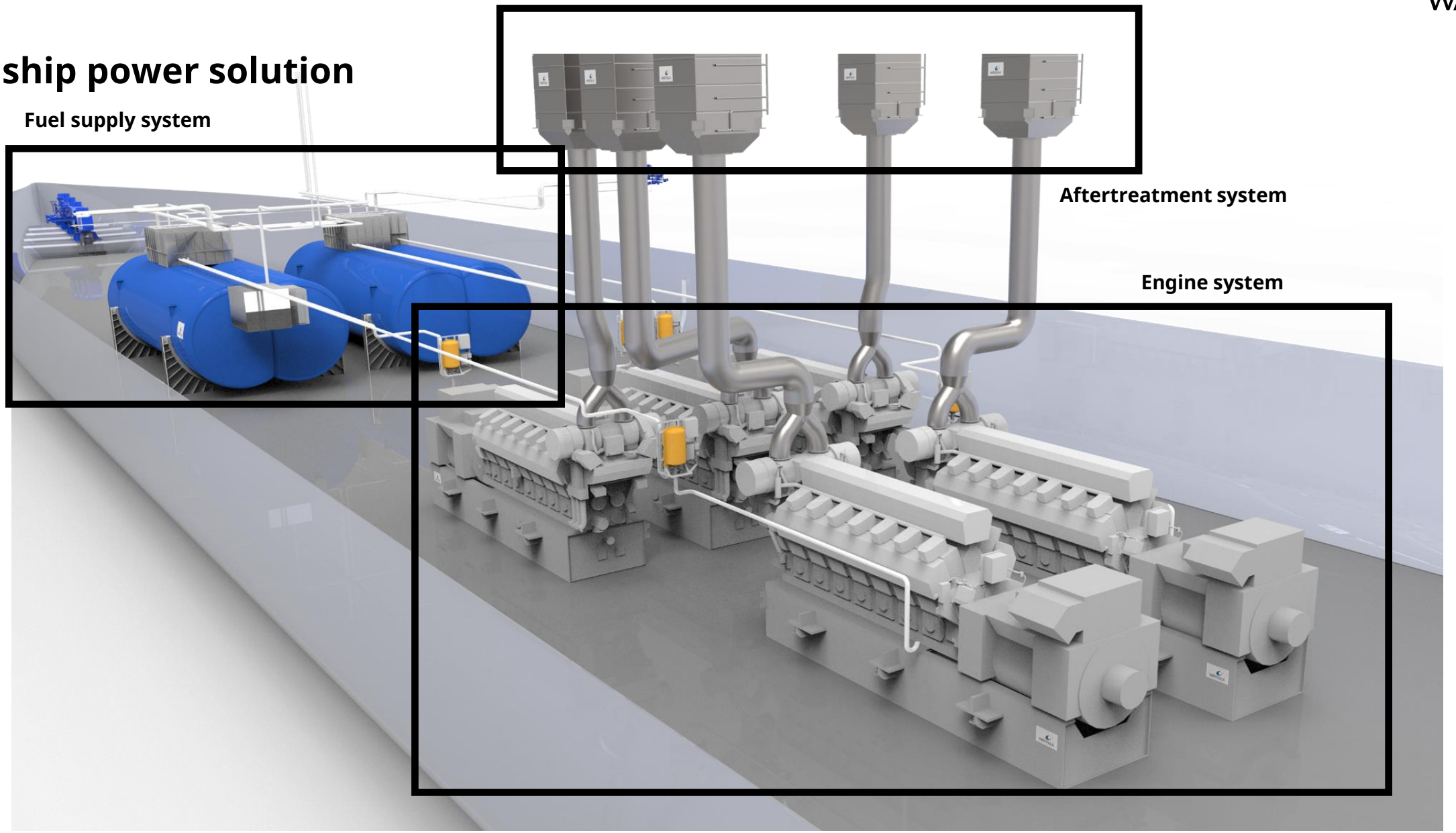
Gaseous fuels*
- LNG
- LPG
- Ammonia
- Hydrogen

Liquid fuels*
- HFO
- MDO
- LPG
- Ammonia
- Methanol
- Ethanol

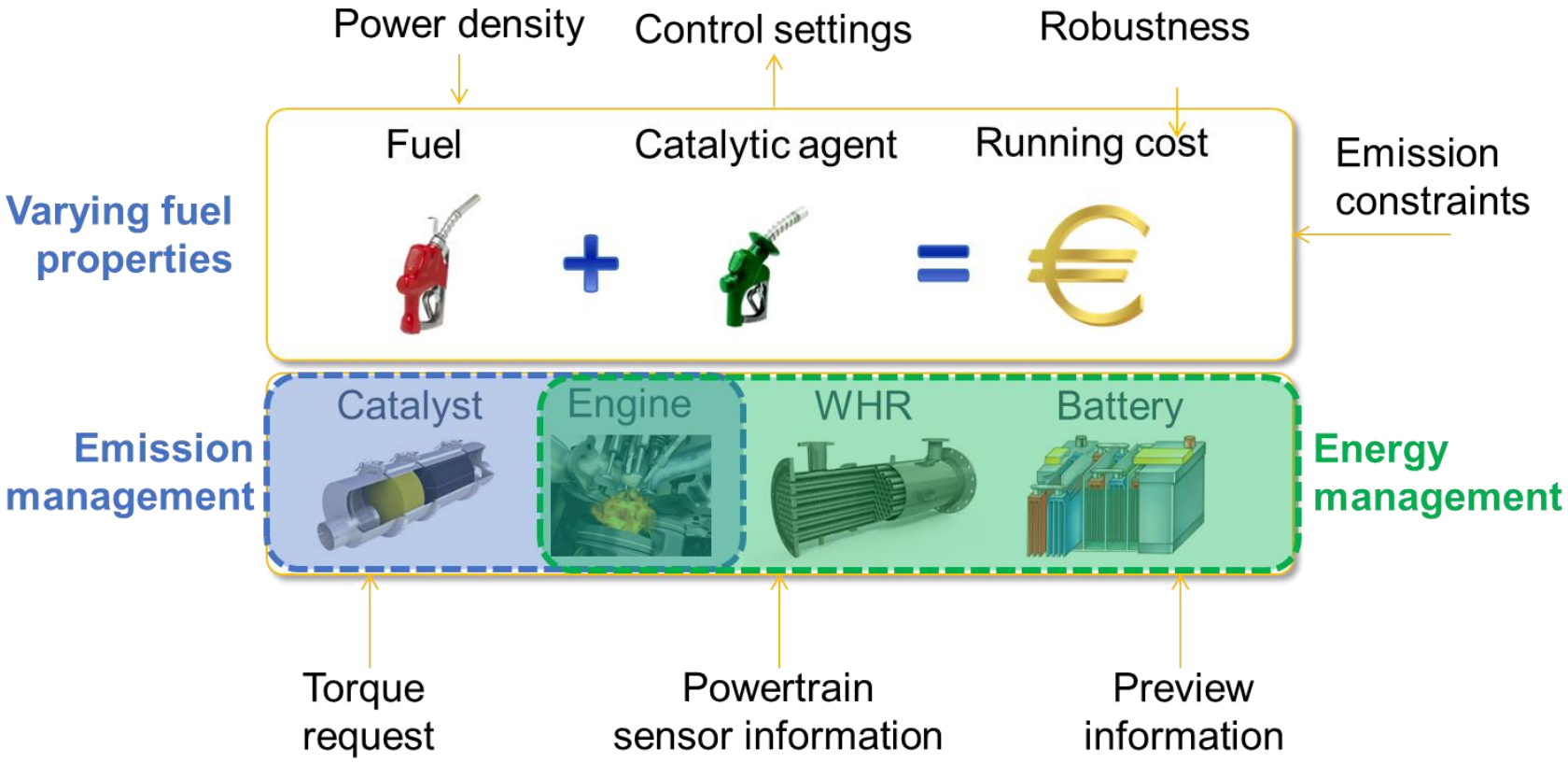
Pilot fuel*
- MDO

* Including corresponding bio and synthetic fuel

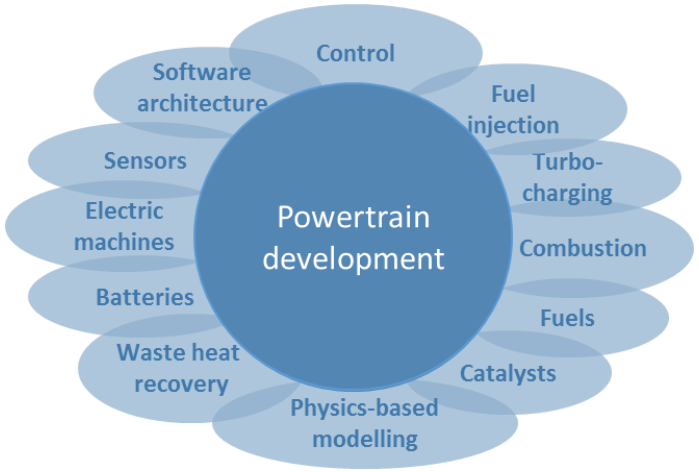
The ship power solution



Team Efficient Powertrain Solutions – Focus area



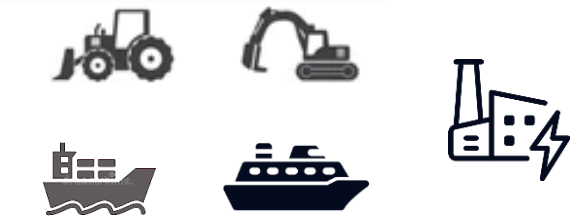
- While focusing on combustion engines we develop complete powertrain solutions



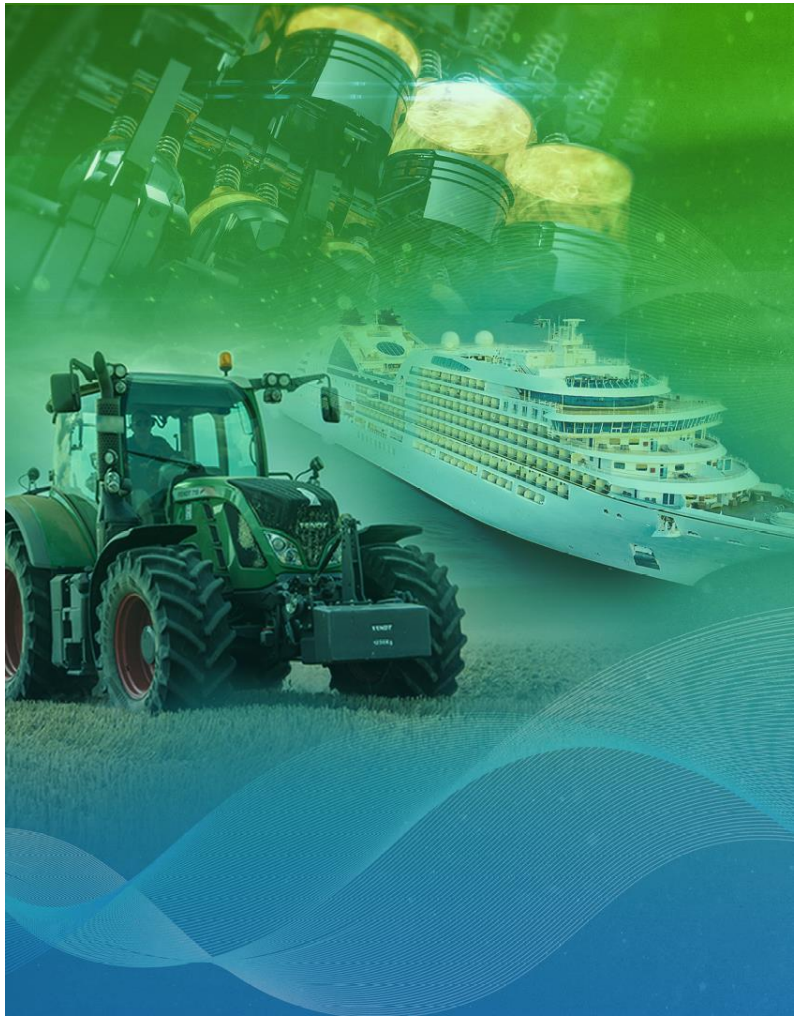
- Internationally unique domain / expertise combination
- Positioned as a strategic partner for Finland's largest Powertrain OEMs and their subcontractor network
- Methodologically focused – we can adapt
- This secures steady Research intake until 2050 +

Efficient Powertrain Solutions - bridges fundamental research and industry application!

	Fundamental research		TRL Level		Applied research
Engine R&D stages	Fundamental process understanding	Influences & sensitivities (system design)	Control development	Control embedding & calibration	Real – world Conformity
Experimental research	Optical engine research	Full-metal single cylinder engine	Multi-cylinder engine tests		Climate chamber and real world tests
(combustion) model type	Physical (2D, 3D)	Phenomenological (0D + quasi-dim)		(semi)-empirical (0D)	



Efficient Powertrain Solutions



MISSION

- Efficient heavy-duty transport and energy sector
- Towards zero/negative emissions impact

VISION

- Maximize overall powertrain energy efficiency
- Integrated powertrain control solutions …
- Innovative tools for design optimization of powertrain configurations and control strategies

Project Portfolio

BF **CPT** (2020 – 2023)

EU **CHEK** (2021 – 2024)

BF **Silent Engine** (2022 – 2025)

BF **CASEMATE** (2022 – 2025)

BF **DAZE** (2023 – 2026)

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deCarbonising sHipping by Enabling Key technology symbiosis on real vessel concept designs

Project CHEK objectives

- Develop and demonstrate at full scale two first-of-a-kind vessel concept designs (Kamsarmax bulk carrier and Meraviglia class cruise)
- Based on real operational profiles
- Equipped with an interdisciplinary combination of innovative technologies working in symbiosis
- Reduce greenhouse gas emissions by 99%, achieve at least 50% energy savings and reduce black carbon emissions by over 95%.

CONSORTIUM

DELTAMARIN

Ship Engineering and designing company

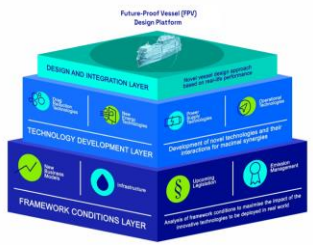
Marine classification society, Risk management, safety assessment

HASYTEC group

CLIMEON

WÄRTSILÄ

Technology providers



MSC

End - Users

Cargill

SILVERSTREAM TECHNOLOGIES

YARA

BAR TECHNOLOGIES

Research, education, capability building

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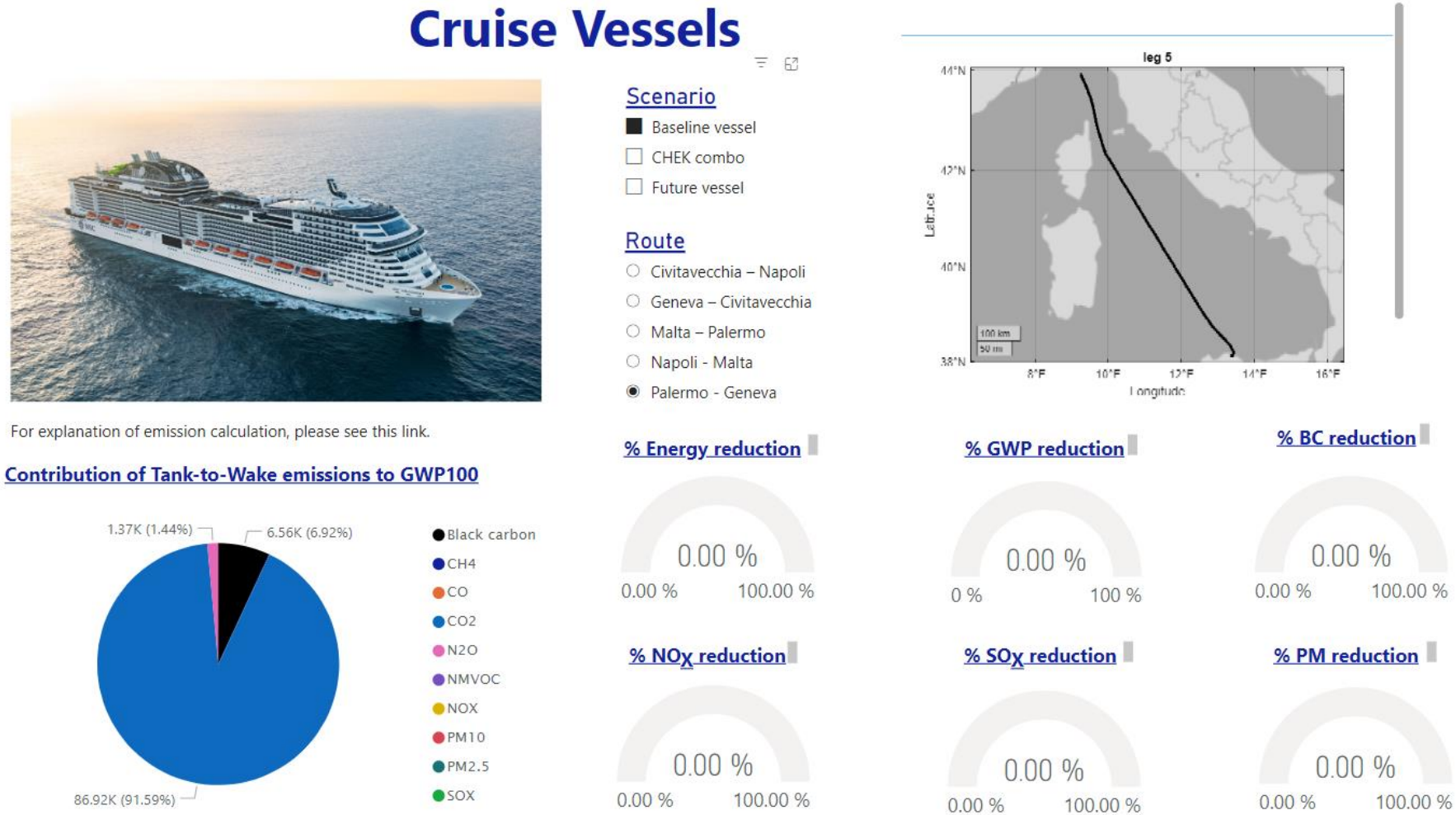
WMU WORLD MARITIME UNIVERSITY

CHEK Emissions simulator

https://www.projectchek.eu/



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Cruise Vessels

For explanation of emission calculation, please see this link.

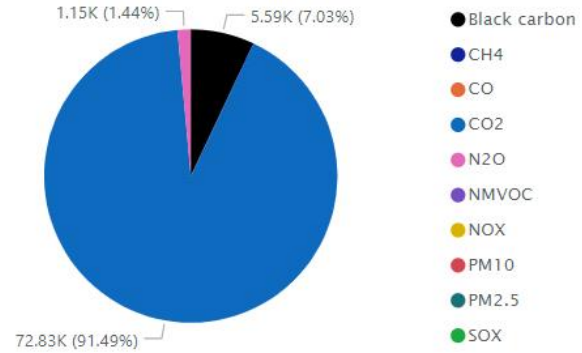
Scenario

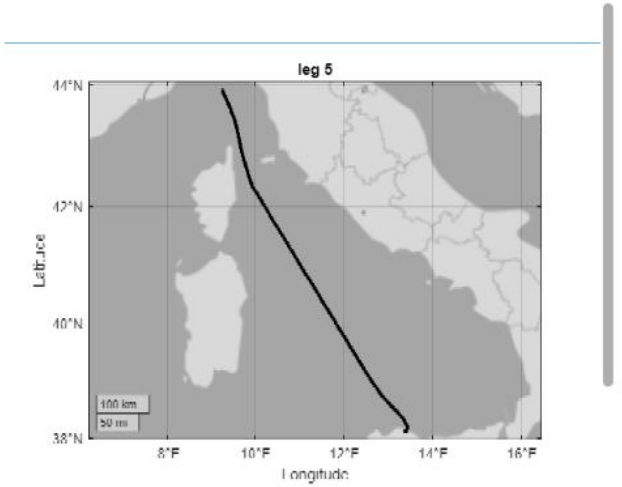
- ☐ Baseline vessel
- ■ CHEK combo
- ☐ Future vessel

Route

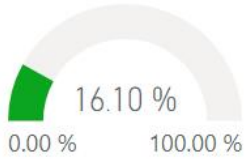
- ○ Civitavecchia – Napoli
- ○ Geneva – Civitavecchia
- ○ Malta – Palermo
- ○ Napoli - Malta
- ◉ Palermo - Geneva

Contribution of Tank-to-Wake emissions to GWP100



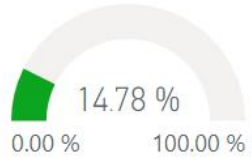


% Energy reduction

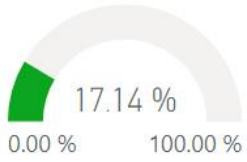


% GWP reduction

% BC reduction

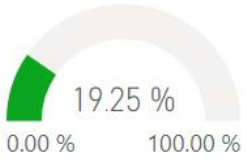


% NOx reduction



% SOx reduction

% PM reduction



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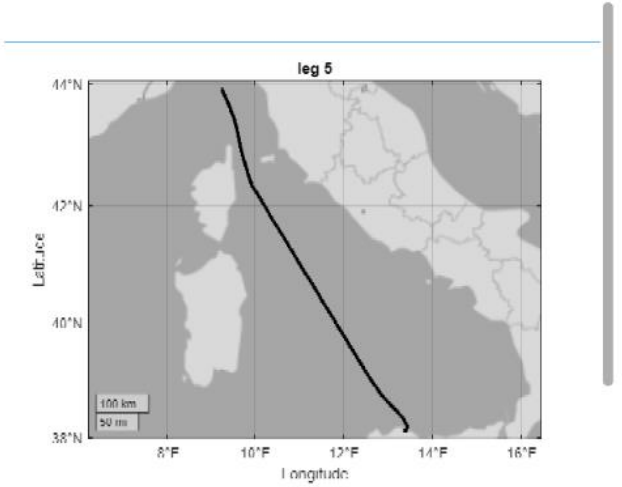

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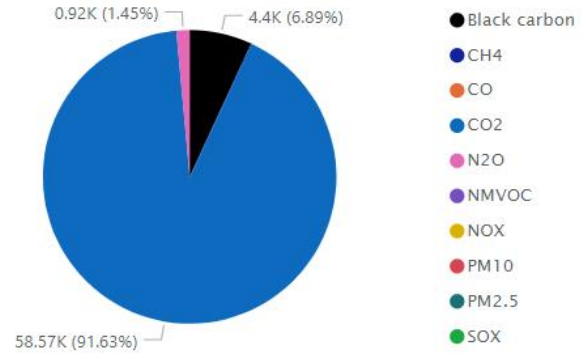
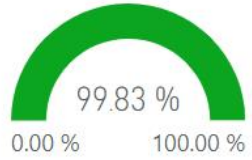


% Energy reduction

% GWP reduction

% BC reduction



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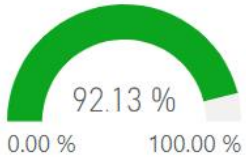

% SOx reduction

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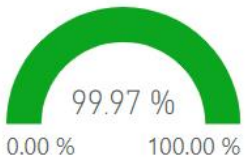

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Areas for cooperation and development

- **Legislation**
- **Systems**
  - Tank system, fuel handling, engine, exhaust and after treatment, etc.
- **Training and PPE**
- **Robust and safe operation on vessels and power plants**
- **Fuel availability and cost operation**

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Summary

- Decarbonising of the marine sector is urgent and requires a wide range of measures
- Fuel flexibility secures a future proofed solution
- Concepts for ICE operation on the future fuels like Ammonia, Hydrogen, and Methanol are already being developed and demonstrated.
- A successful development requires expertise and actions from many contributors
- Great opportunity for Academia and Industry to collaborate and lead the way
- With the support from authorities and countries the development can be accelerated

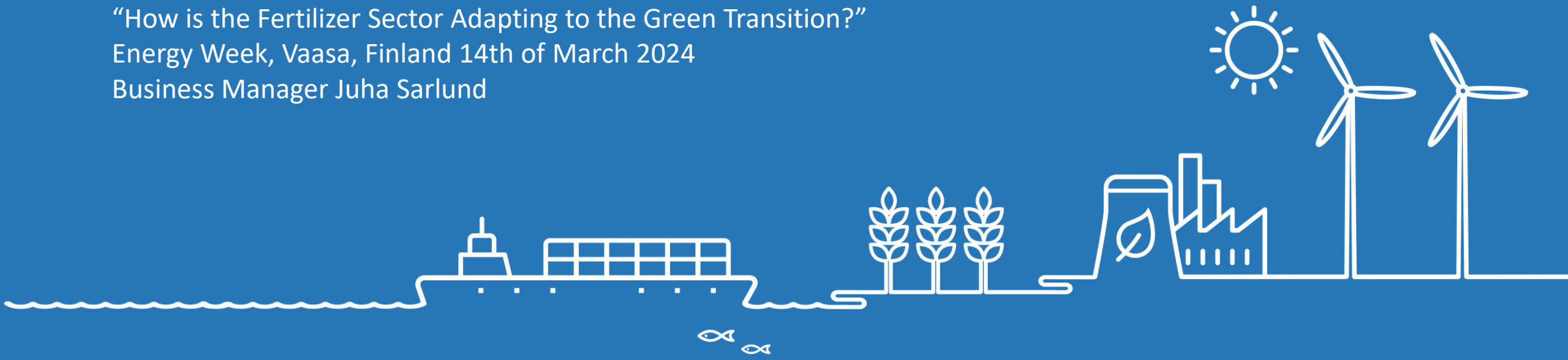
How is the fertilizer sector adapting to the green transition?

Juha Sarlund

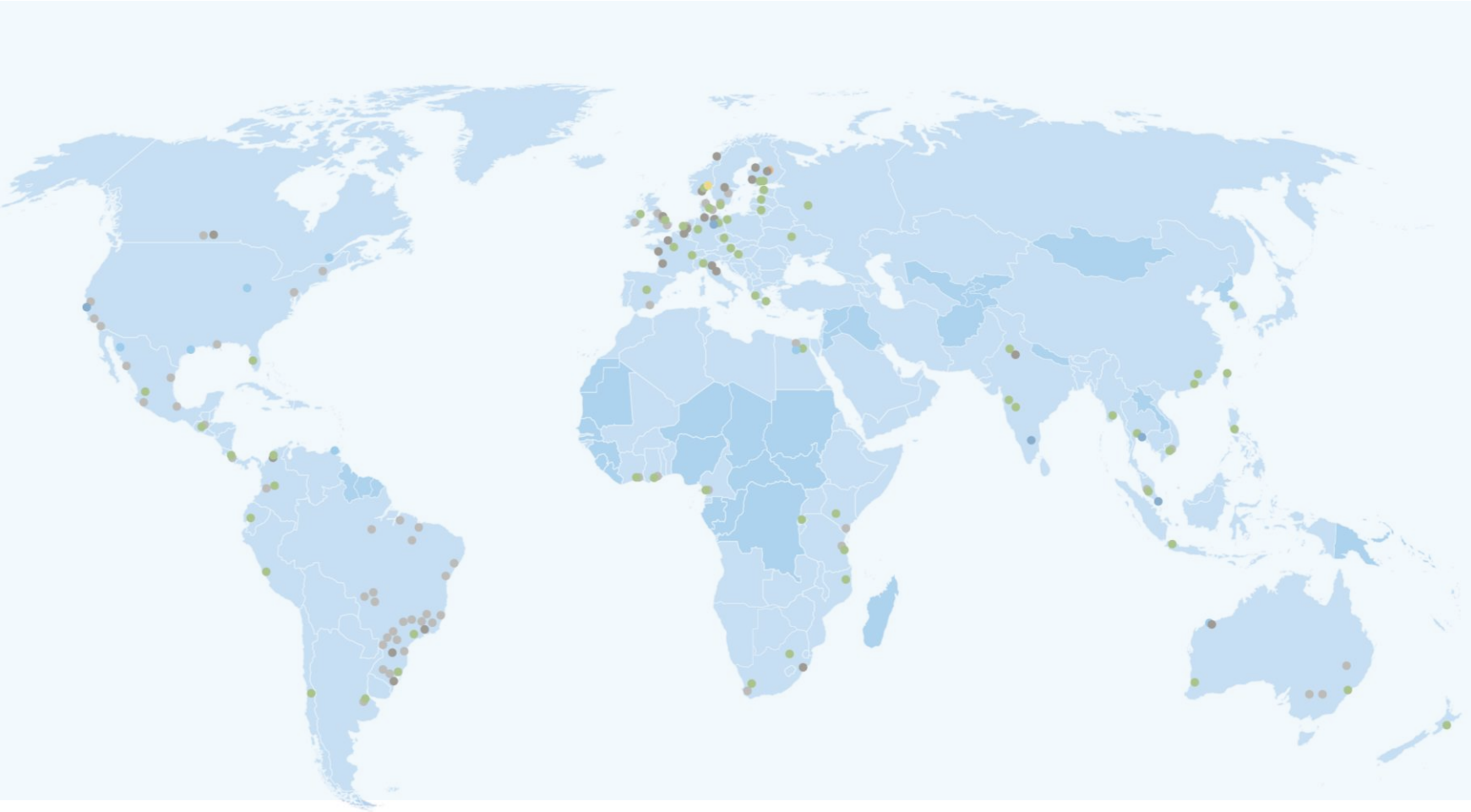
Business manager & Yara Industrial Solutions
Country representative
Yara

Yara Clean Ammonia

"How is the Fertilizer Sector Adapting to the Green Transition?"
Energy Week, Vaasa, Finland 14th of March 2024
Business Manager Juha Sarlund



Yara - Global mission, global presence



17,500
Employees worldwide

24.1
Billion USD revenue

26
Production plants

140
Countries with sales

10,000+
Yara-branded retail outlets globally

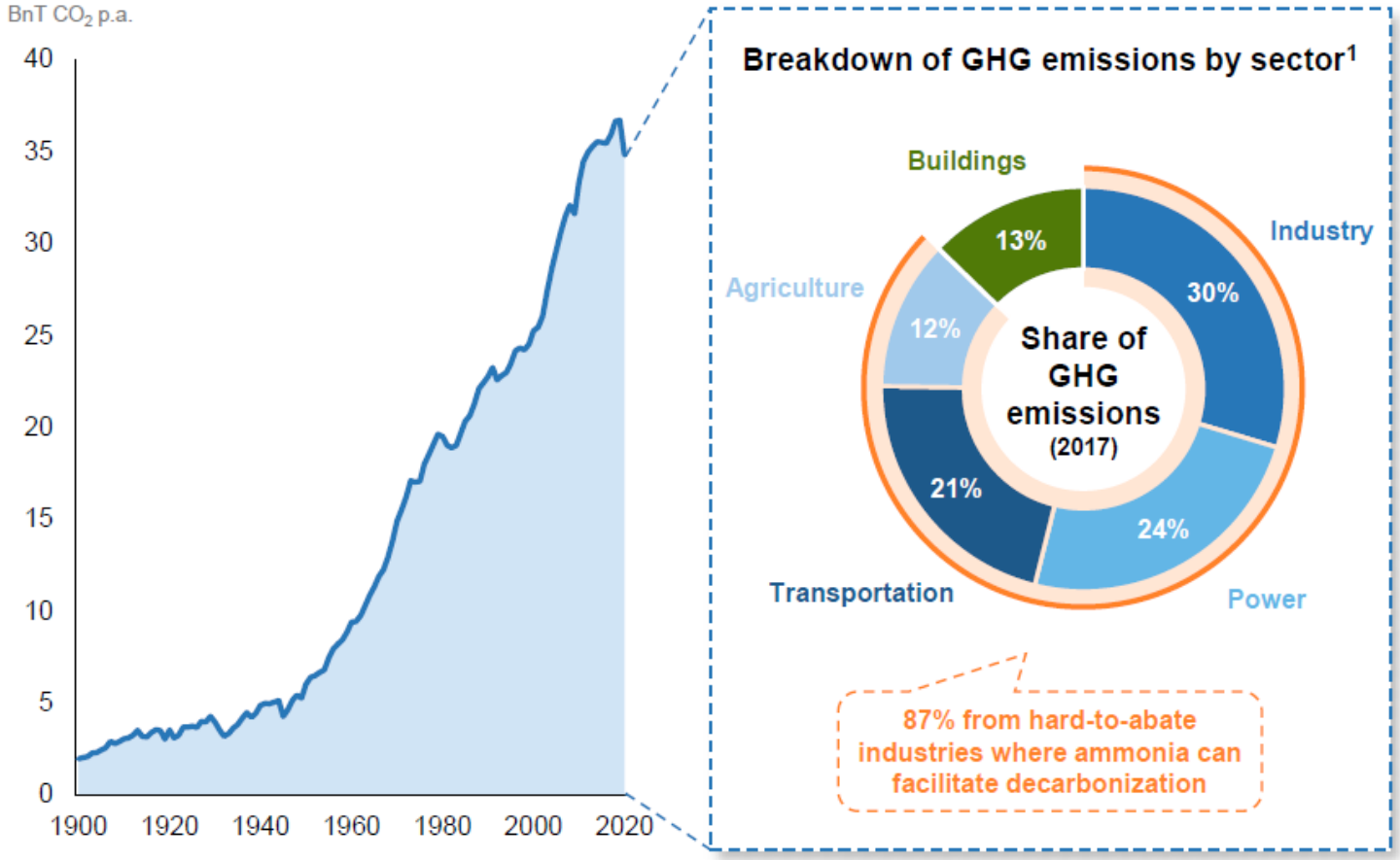
Yara's solutions for tomorrow

Yara is moving ahead at full speed on many ambitious initiatives to grow a nature-positive food future.

agoro™ CARBON ALLIANCE | Yara Clean Ammonia

Clean ammonia offers a solution to the decarbonization challenge…

Rapid growth in GHG emissions from hard-to-abate industries

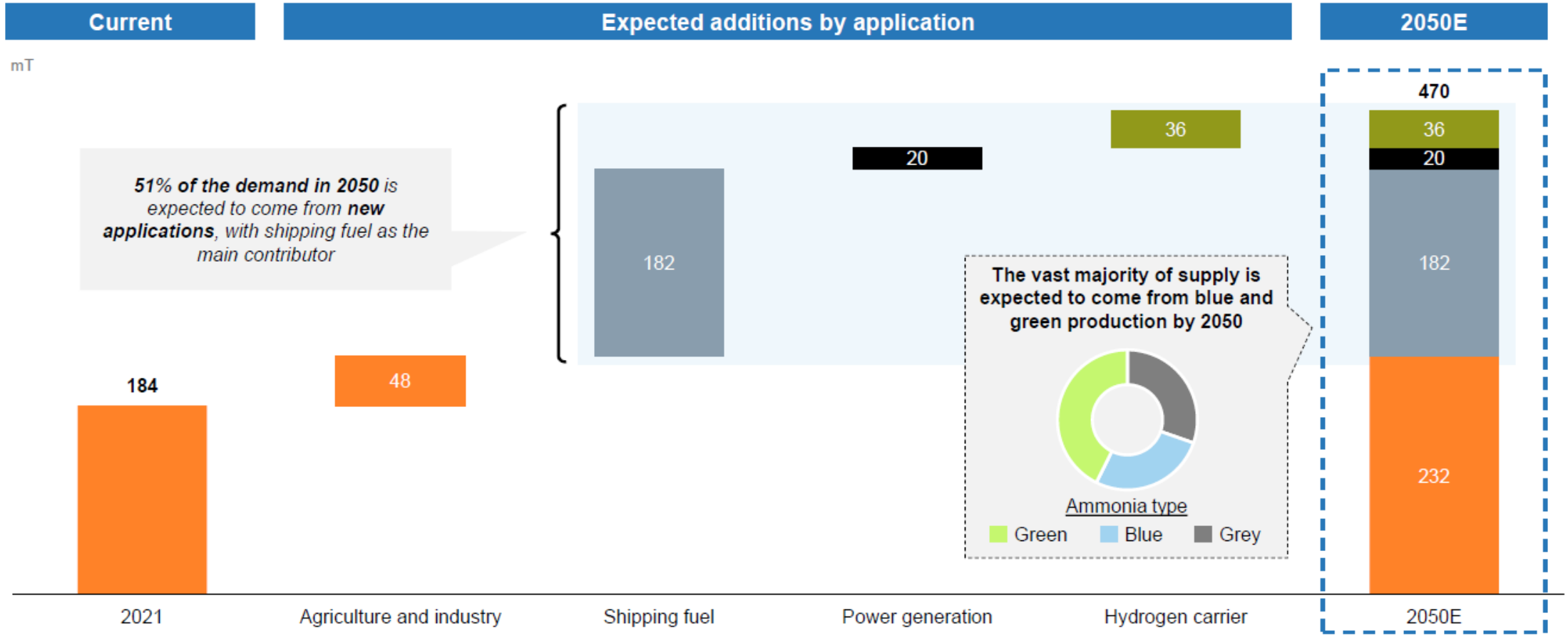


Ammonia is an attractive solution

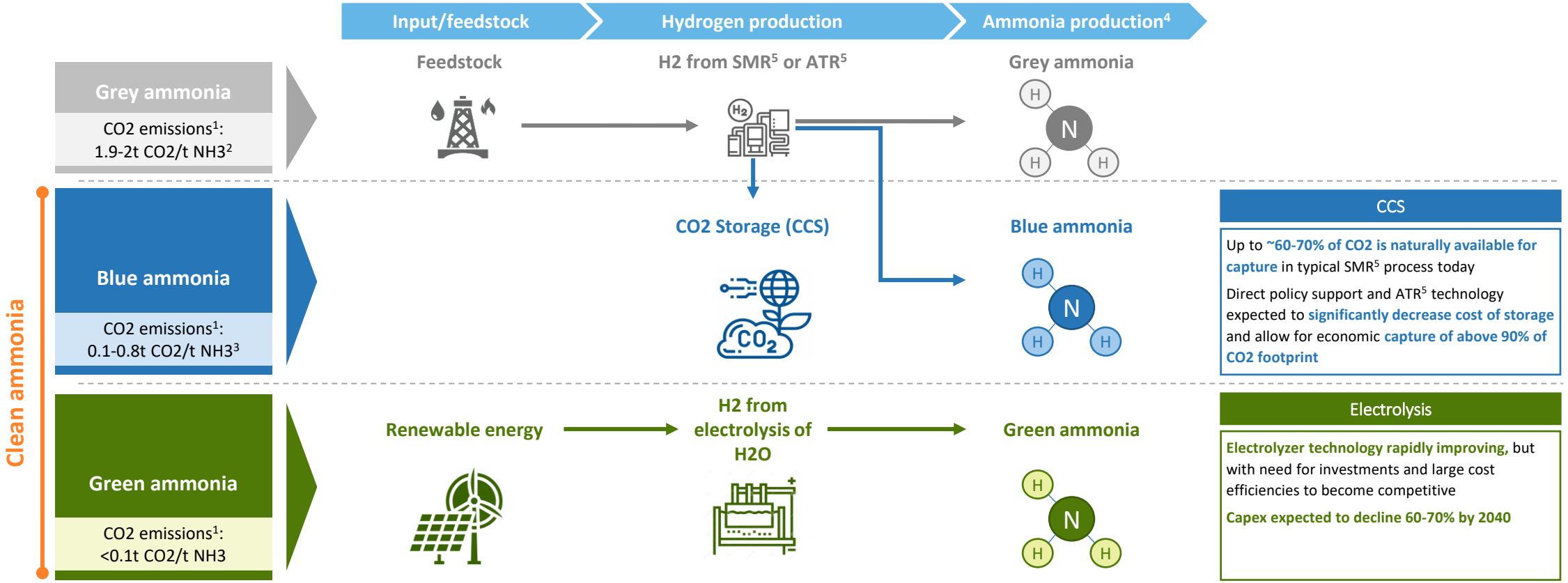
- Clean ammonia available through existing blue and green production methods
- Highly versatile with multiple direct applications
- Ideal energy carrier with favorable performance across clean fuel KPIs[2]
- Well-established global infrastructure and storage network

Significant growth potential driven by adoption of clean ammonia in new applications

Global ammonia demand expected to grow significantly in volume from 2021 to 2050, adding close to 300mT to the market



Different “colors” indicate different production processes for hydrogen and related carbon intensity



The Haber-Bosch process is used to synthesize ammonia from hydrogen[1], producing an identical ammonia molecule regardless of “color”

Source: Company information; Arkwright market study 2021

1) Indirect emissions (Scope 3) from natural gas and embedded assets are not included in the values
2) Fertilizers Europe Carbon footprint calculator
3) IRENA Innovation outlook: renewable ammonia
4) Combining hydrogen with nitrogen from the air
5) SMR = Steam Methane Reforming, ATR = Autothermal Reforming

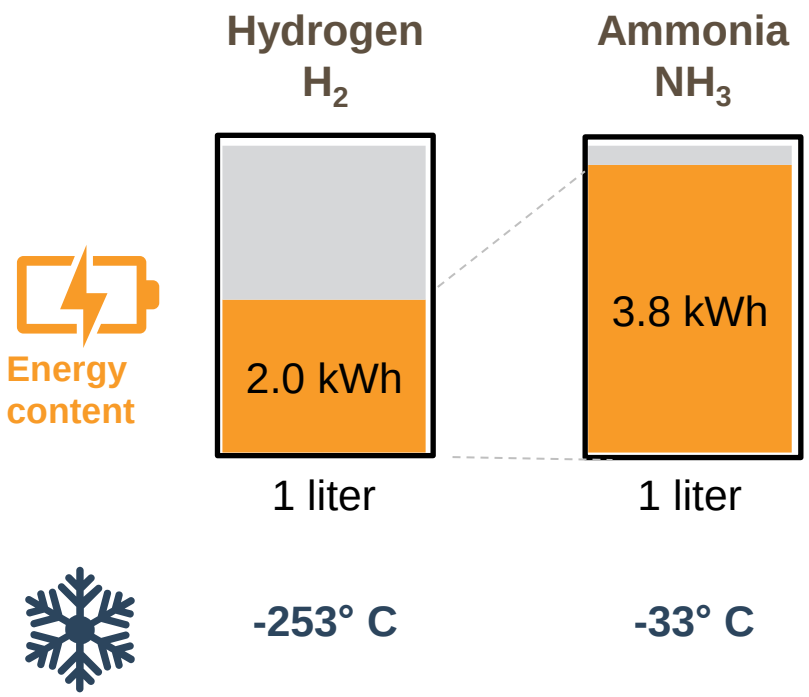
Several building blocks needed to fit together for the clean ammonia opportunity to reach its full potential

Regulatory environment	Market	Technology	Infrastructure
			
A **global adoption of "fair" CO2 prices or subsidies** supporting low-carbon fuels; **"true" carbon pricing or forceful regulation** required to sufficiently incentivize the transition	**Users in key end-markets will shift towards ammonia** – or be "pulled" by their final customers	The **technologies required** to support the green "hydrogen economy" will be **efficiently developed and scaled to make green cost competitive**	The **required infrastructure and operational support will be developed** in line with market growth

Source: Arkwright market study 2021

YCA will develop clean ammonia as a decarbonized energy carrier and industry feedstock

Attractive storage & transport properties



Multiple growth drivers

- Carbon-free fertilizer and industrial application
- Zero-carbon fuel for the maritime sector
- Preferred baseload solution as substitute for renewable energy constrained countries
- Best suited long-distance hydrogen carrier

Yara is executing a 4-way strategy towards securing clean ammonia supply around the world

RETROFITTING
existing capacity

BUILDING
new capacity

DEVELOPING
partnerships

ESTABLISHING
offtake agreements

Current pipeline of green and blue ammonia pilots/demo laying the foundation for full scale plants

Norway

- **Pilot scale** of 20 kilotons of green ammonia / 24 MW
- First electrolyzer project of industrial scale with system integration into an existing ammonia plant
- ***Full electrification*** *of the total plant ~500 kt ammonia unit would remove 800 kt* CO_2

Netherlands

- "**Blue" or low-carbon** Capture and liquefaction of CO2 for transport and permanent storage
- Saving 800 000 tons of CO2 emissions from the plant
- ***Green –*** *sourcing hydrogen based on renewable wind power*

Australia

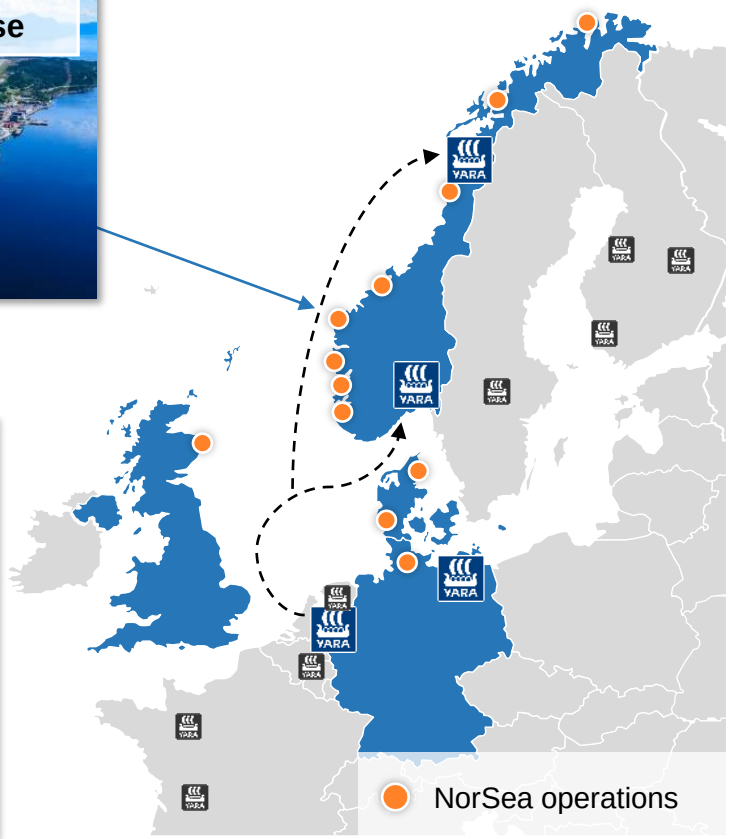
- **Pilot scale** of up to 3 kilotons of green ammonia / 10 MW
- First industrial scale carbon neutral ammonia produced from solar power
- Targeting energy and materials value chain in Australia/Japan

MoU with NorSea to establish a new, secure supply chain for ammonia bunkering

Overview of the NorSea network

NorSea | Wilhelmsen

- Founded in 1965
- 4.5m sqm base area
- >10,000 port calls



Key highlights

- NorSea and YCA have signed an MOU for to **establish ammonia bunkering infrastructure for the North Sea**
- **NorSea is the largest logistics operator for North Sea activities**, with over 10,000 landings per year, including all large oil and gas players in the region
- The first green ammonia bunkering is **targeted to start in 2024**
- At the outset, **the scope includes all NorSea bases in the North Sea**

NorSea involvement

- **NorSea will operate** the bunkering terminals
- *Commercial and ownership strategy to be defined*

YCA invovlement

- **YCA will supply clean ammonia** to terminals and handle **safety aspects**
- YCA will, in close cooperation with partners, **develop and scale the logistics** to ensure sufficient supply

NorSea | YARA YCA + AZANE Fuel Solutions

- *Operations*
- *Commercial*

- *Technology*
- *Construction*

Source: Company information; NorSea

Yara Eyde

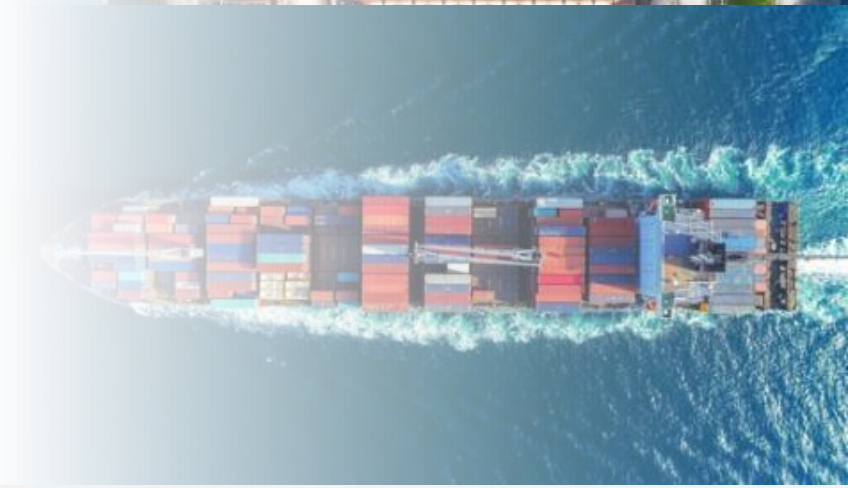
- The world's first ammonia-powered container ship
- Collaboration between North Sea Container Lines and Yara Clean Ammonia.
- Yara Clean Ammonia supplies pure ammonia for fuel, and Yara signs a 15-year freight contract.
- This means that Yara's fertilizer production at Herøya can be delivered emission-free to Europe, which cuts Yara's scope 3 emissions by 11,000 tonnes of CO2.

Yara and REMA1000 for Low Carbon Oat Bread

- Aim reducing emissions from Norwegian food production, from fertilizer production to finished food products.
- The companies will use mineral fertilizers produced using electrolysis and renewable energy, adopt better agronomic practices, and leverage precision farming tools.
- The green oats will have 25-30 percent lower carbon footprint than regular oats.
- The intention is to produce an oat-based bread, to be made available in REMA 1000’s stores in 2025.

Key highlights

1. Blue and Green Ammonia represent a **massive opportunity to reduce the global GHG emissions**
2. **The Ammonia market** is expected to **more than double by 2050**
3. **The energy transition** requires seamless efforts on **Infrastructure, Regulation, Technology, and Markets**
4. Yara has **three own production projects** being developed as the heart of the green transition
5. We have several **Flagship Initiatives, Programs, and Projects** to enhance the **Green Transition**
6. **In Yara Clean Ammonia Yara has the #1 global ammonia midstream platform**[1] to reach for the future



Source: Company information
1) Based on volumes of traded ammonia in 2021 - Argus market study (2022)

Yara Clean Ammonia

Moderator

Cynthia Söderback

Project Leader, Faculty of Technology & Seafaring-RDI,

Novia University of Applied Sciences

Panel topic: Using e-fuels to decarbonise ecosystems

Aparajit Pandey
Shipping Decarbonisation Lead;Principal-Climate Aligned Industries, RMI

Kaj Portin
General manager, Sustainable Fuels & Decarbonisation, Wärtsilä Finland Oy

Carolin Nuortila
Snr. Researcher-Fuel Division & EPS, University of Vaasa

Juha Sarlund
Business Manager & Yara Industrial Solutions Country Representative, Yara

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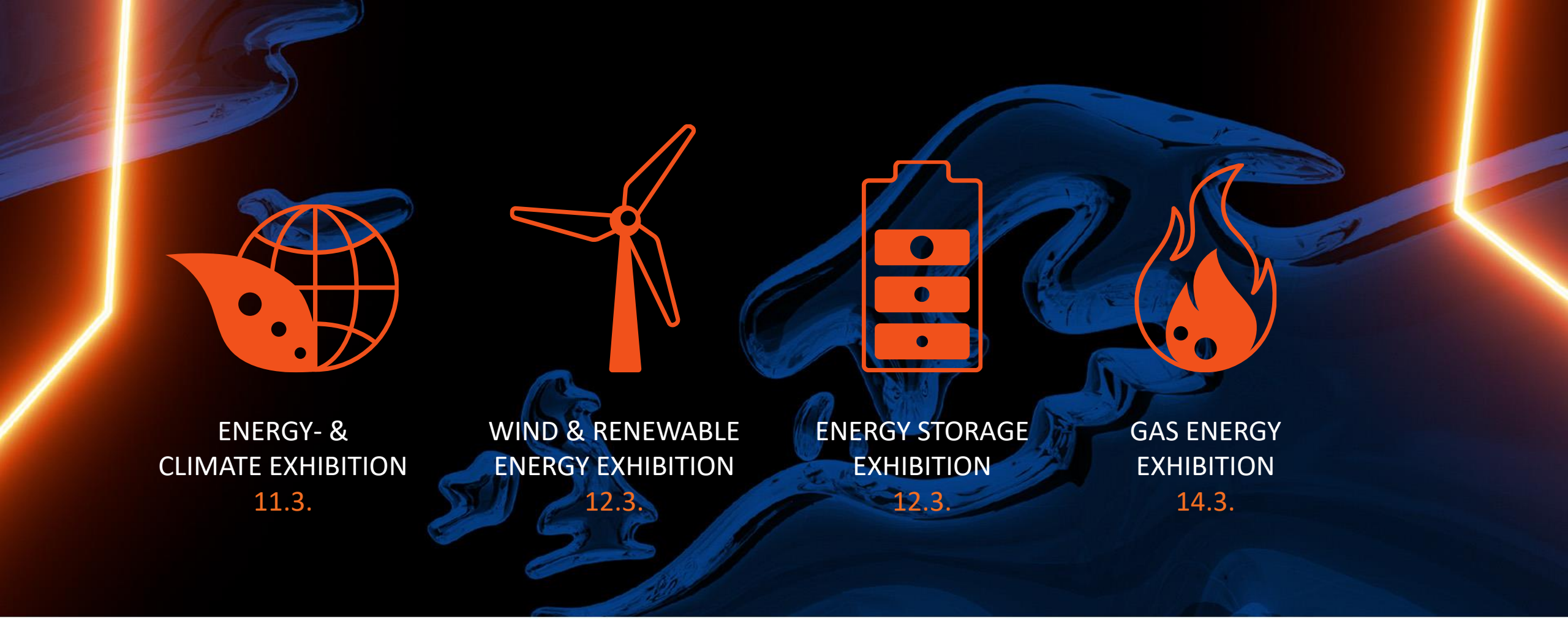

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