Let's Navigate towards Zero-Emission Shipping!

The path towards maritime fuel cell industrialization in the Netherlands

Hybrid & Electric Marine World Expo – RAI Amsterdam - June 2019

Nedstack First

Name	**Nedstack Fuel Cell Technology BV**
Location	Westervoortsedijk 73, Arnhem, the Netherlands
Founded	1999
Ownership	Privately

Website	www.nedstack.com
Industry	PEM Fuel Cells
Logo	Nedstack PEM FUEL CELLS

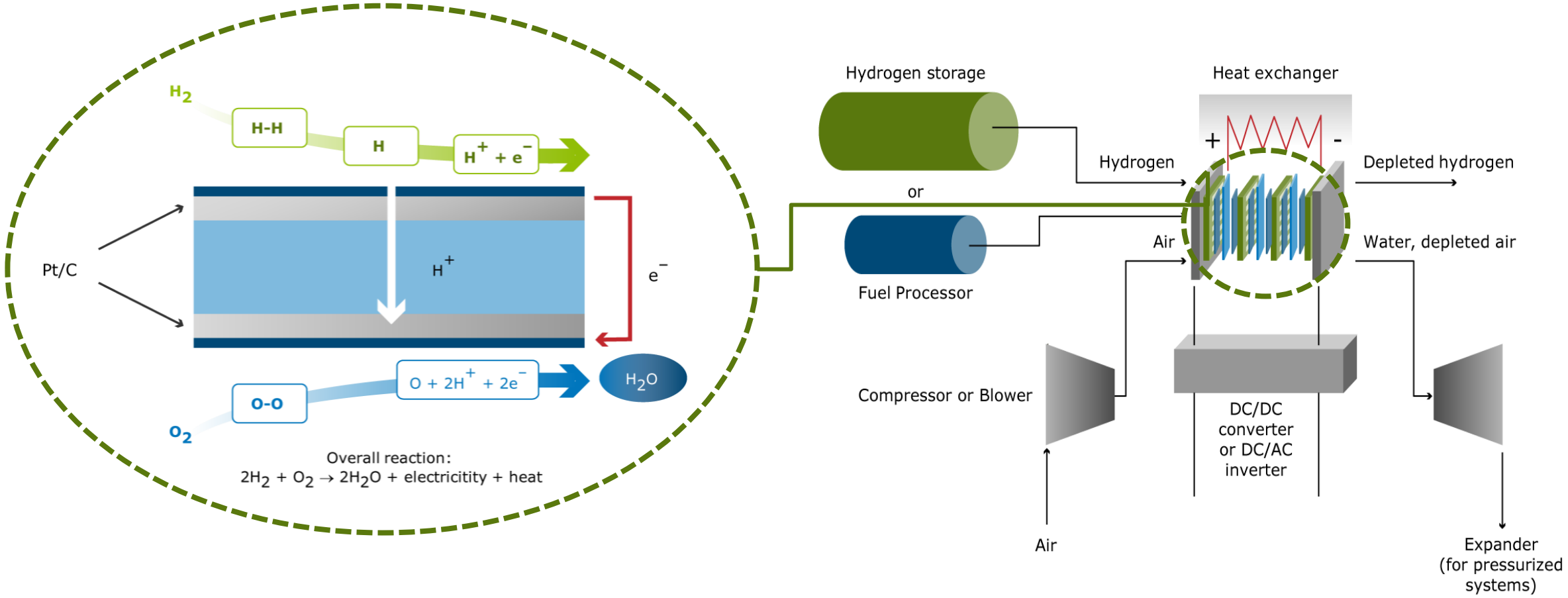
High lights

- Leading Global Player in High Power PEM-FC Technology;
  - Longest PEM Power Plant in Operation > 10 years;
  - First MW Sized PEM Power Plant;
  - Largest PEM Power Plant > 2 / 3.6 Mwe.
- > 700 FC Systems installed-base as per 2017;
- > 23.000 Hours in-use Lifetime demonstrated;
- In-house stack assembly – systems with co-makers on Nedstack IP;

Specialized in Containerized Power Plants

Nedstack main location

PEM Fuel Cells and Fuel Cell Power Installations



A Portfolio of Fuel Cell Power Installations

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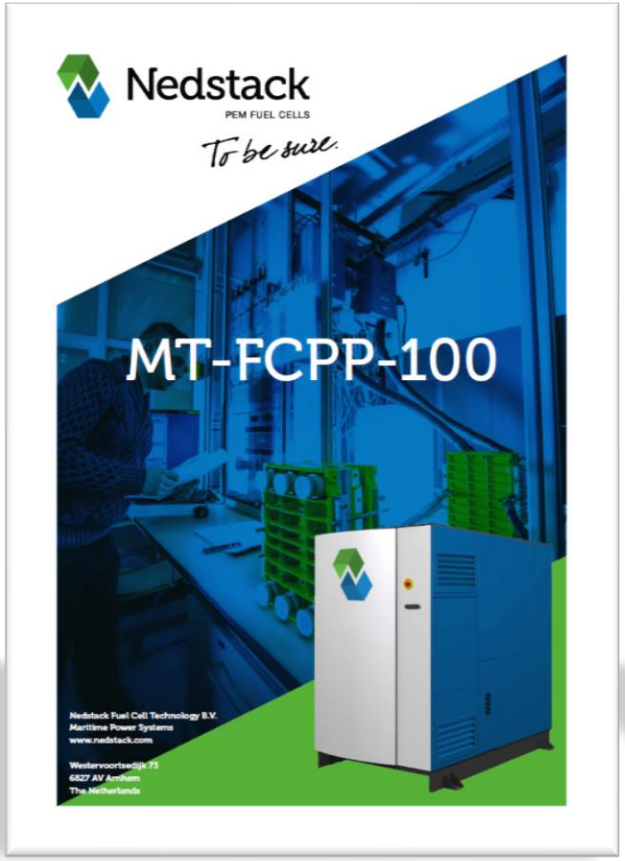
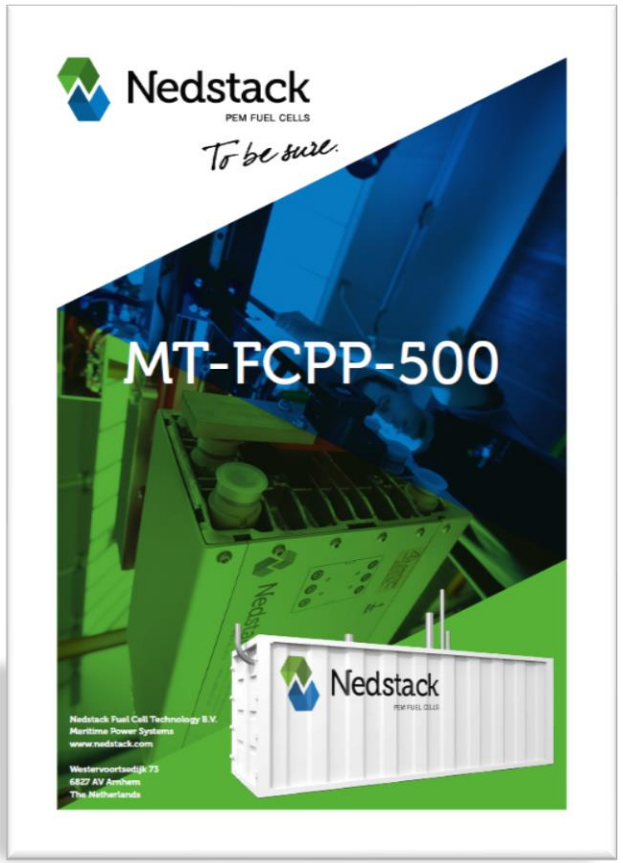
NFCT MT-FCPP-40

NFCT MT-FCPP-100



NFCT MT-FCPP-500

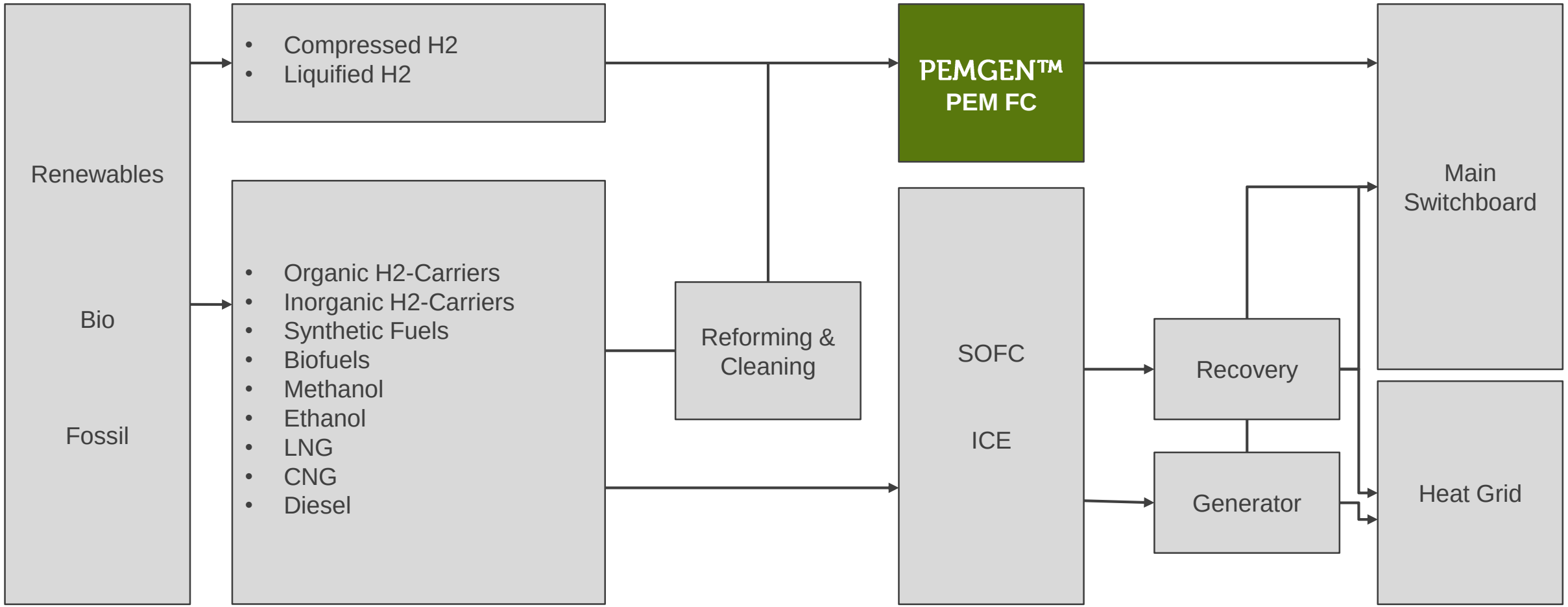


Block Flow Diagram of Pre-Switchboard Flows & Conv.

Nedstack PEM FUEL CELLS

electric & hybrid marine WORLD EXPO 2019

Energy Source → Energy Carrier → Reformer → Conversion → Recovery → Distribution



Why Fuel Cells as a Maritime Power Solution?

Why Fuel Cells ?

HFO + ICE

Negative

- Climate impact;
- Air quality impact;
- Import dependence;

HYDROGEN + PEM FUEL CELL

Positive

- Long range;
- Fast bunkering;
- Low weather sensitivity;

Positive

- Zero Emisssion;
- Efficient;
- Direct Torque;
- Quiet;
- Local Source.

BATTERY

Negative

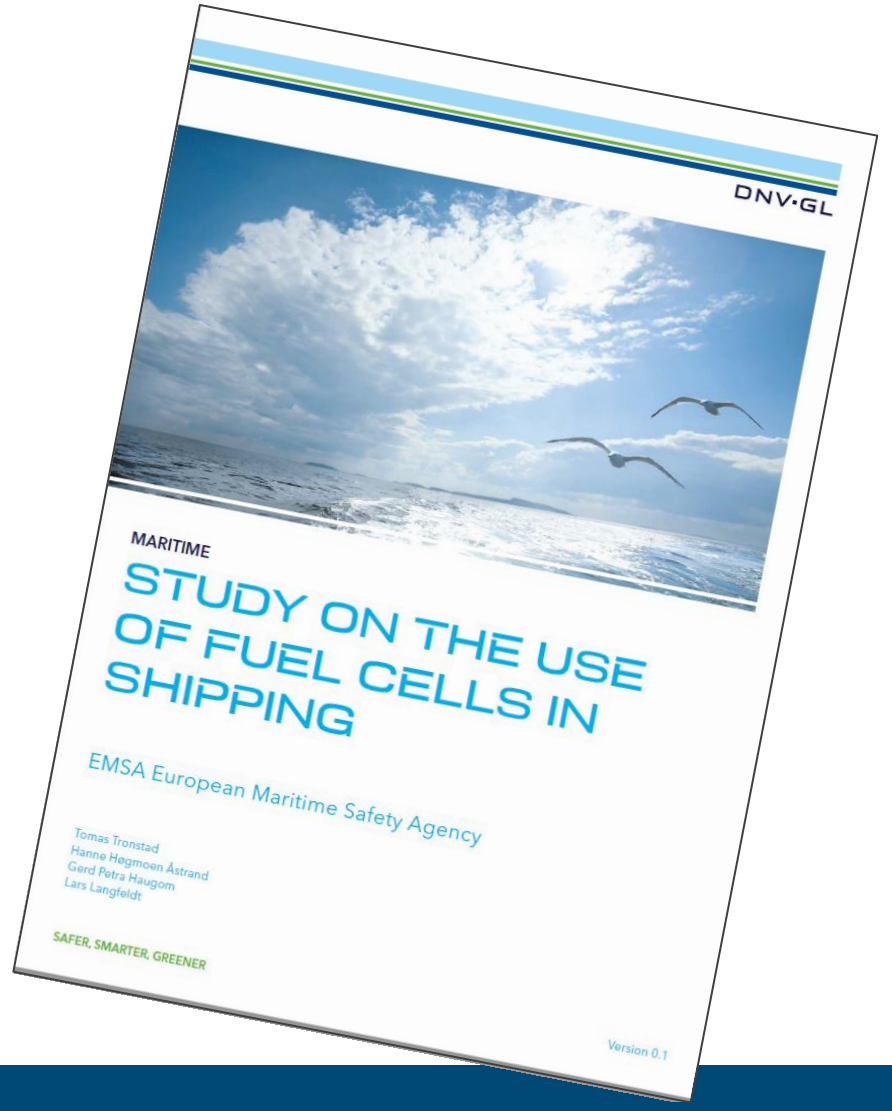
- Limited range;
- Long charging time;
- Low power density;
- Weather sensitive.

PEM FC’s the best option for the maritime domain?

PEM FC’s are the highest ranked Fuel Cell solution for shipping

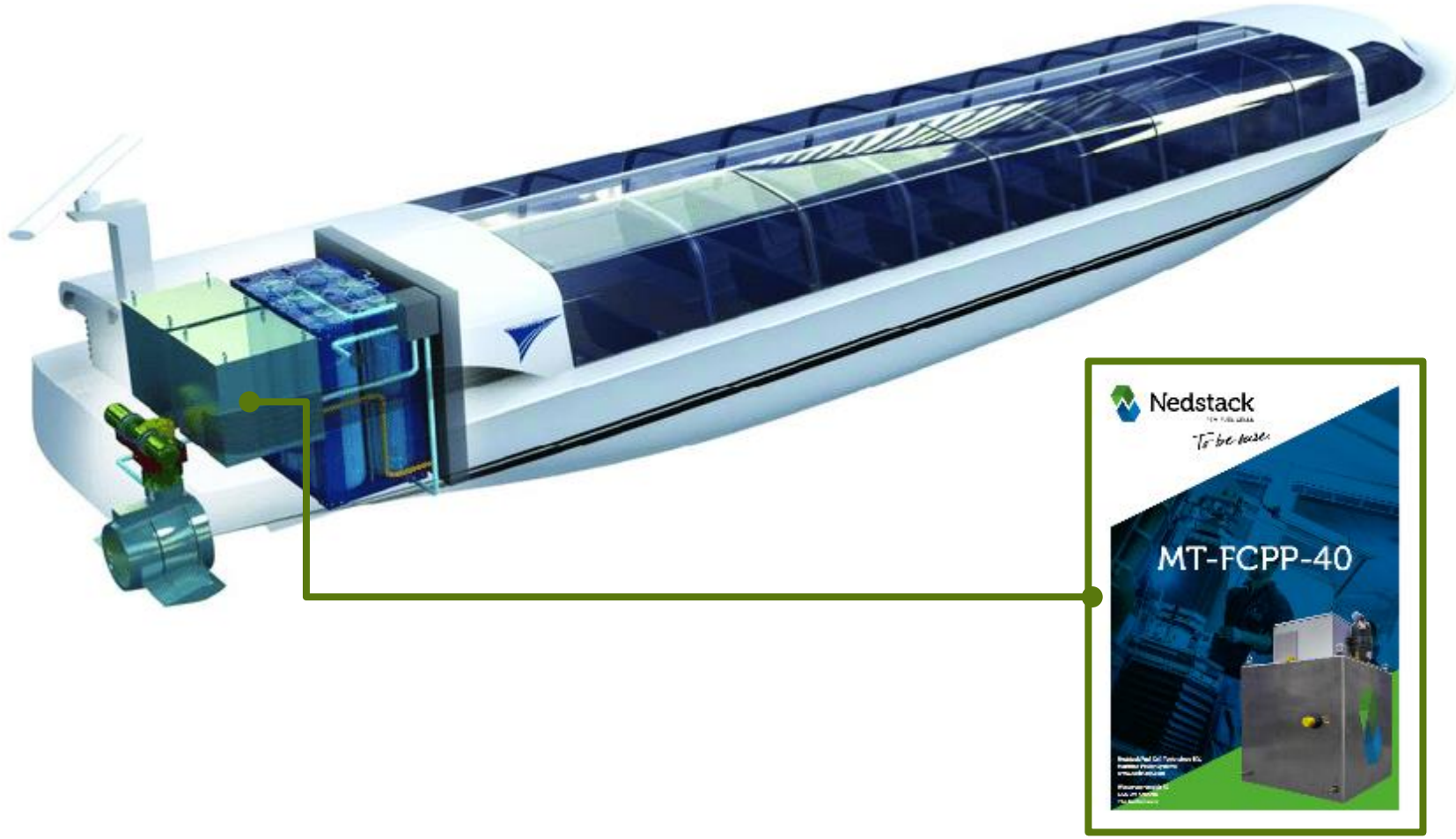
Top ranked on:

- Power Density;
- Resilience;
- Safety;
- Environmental Performance;



Nemo H2 – Second FC pax vessel with Class Appr.

Spec	Value
Length oa	**21,95 m**
Beam oa	**4,25 m**
Draught	**1,1 m**
Displacement	**45 tons**
Payload & Crew	**88**
Mission	**Canal Boat**
Max Speed	**8,5 Kn**
Cruising Speed	**7 kn**
E-Propulsion	**Sern thruster 75 kWe** **Bow thruster 11 kWe**
Battery pack	**70 kWh**
H2 storage	**24 kg @ 35 Mpa**
FC Engine	**2 x 40 kWe**



Contributing to Regulations and Industrialization

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FELMAR First Element Marine Power

- FELMAR – Dutch industry consortium
- Nedstack is project coordinator

FELMAR aims at industrializing and marinzing the current state of fuel cel ltechnology for inland navigation and short-sea applications.

iea International Energy Agency

- IEA-HIA Task 39;
- Nedstack is expert group member

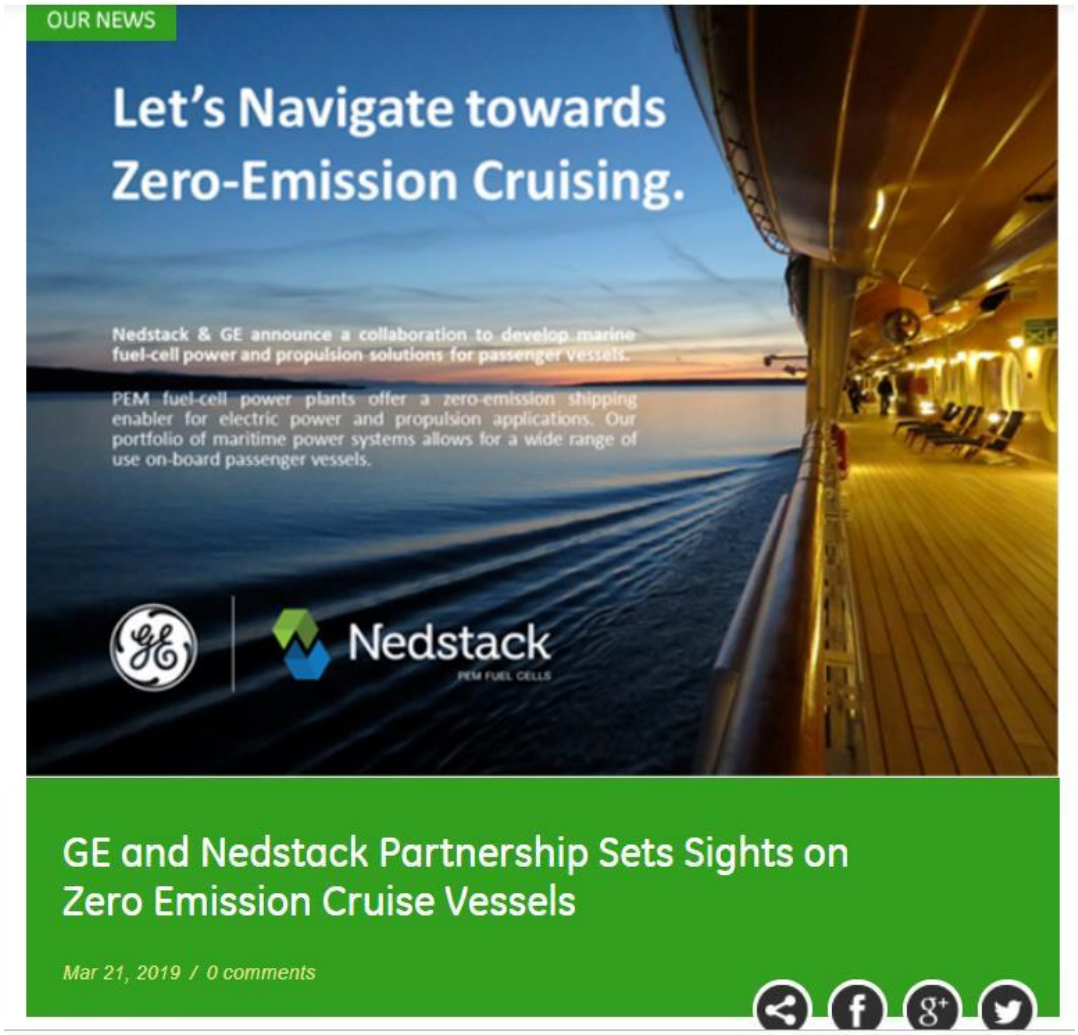
IEA-HIA Task 39 consists of four subtasks: (i) Technology Overview, (ii) New Concepts, (iii) Safety and Regulations, and (iv) Demonstration.

Hydrogen Europe

- HE – Maritime Working Group;
- Nedstack is working group member

The HE-Maritime Working Group pursues to facilitate the adoption of hydrogen and fuel cell technologies in the maritime domain by industry-to-policy coordination.

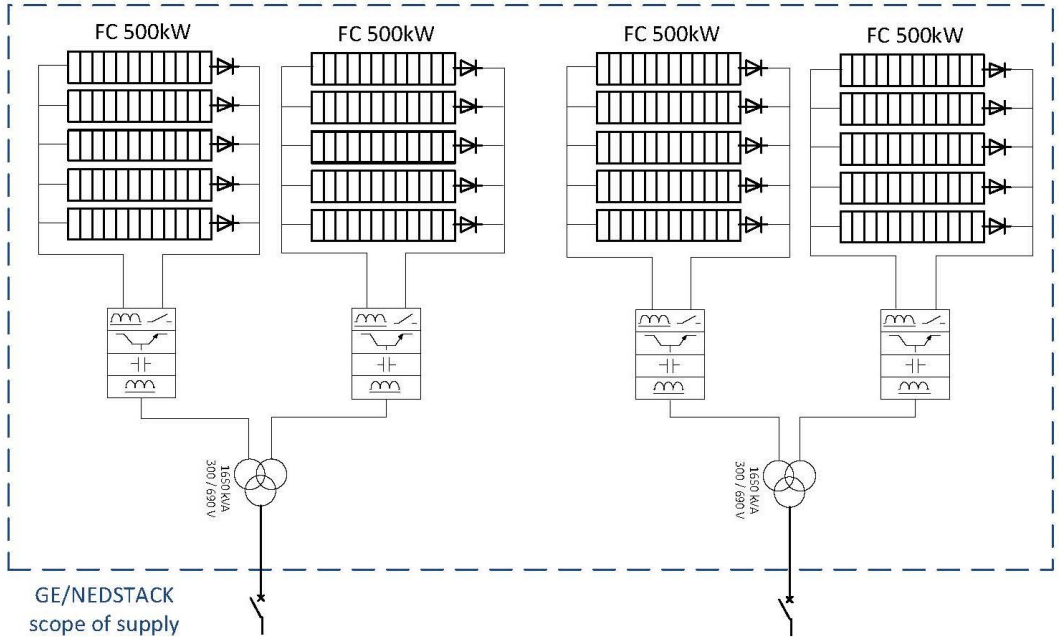
Nedstack / GE Power Partnership (Cruise & Ferry)



Each package of 500kW

Vdc nom=840Vdc

NomP BOL=500kW



Nedstack / HSP Partnership (Inland Navigation)

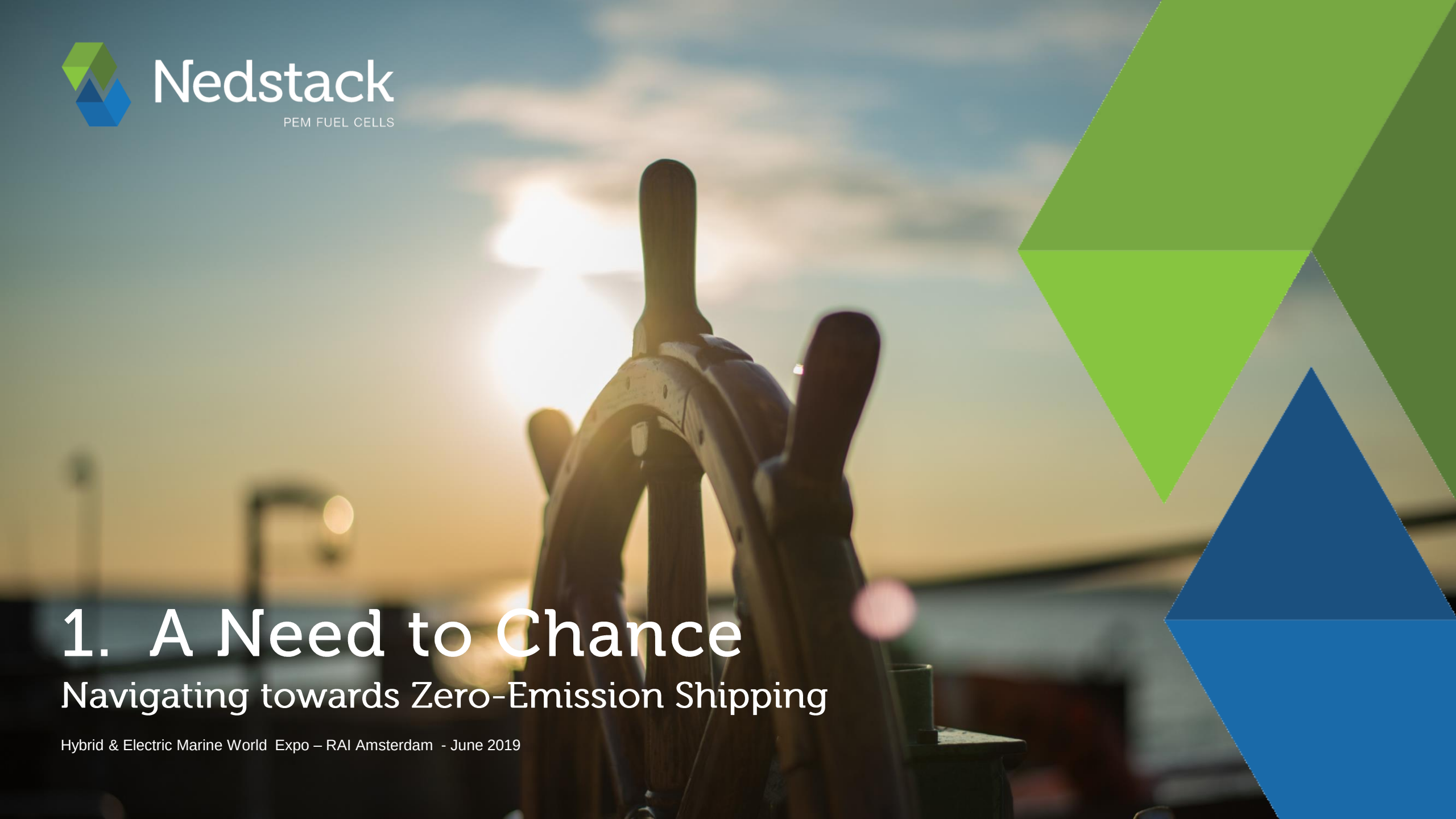
Navigating towards Zero-Emission

1 A NEED TO CHANGE

REALIZING THE CHANGE 4

2 A WILL TO CHANGE

3 A CAPACITY TO CHANGE



1. A Need to Chance

Navigating towards Zero-Emission Shipping

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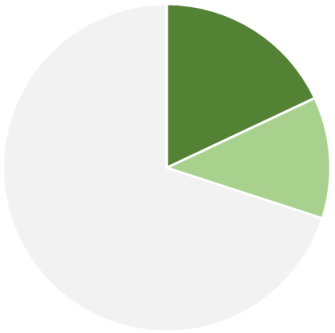
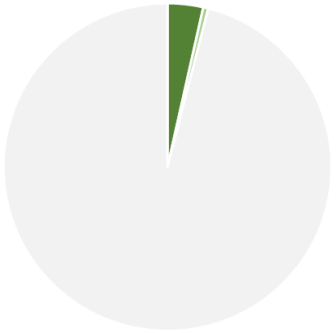
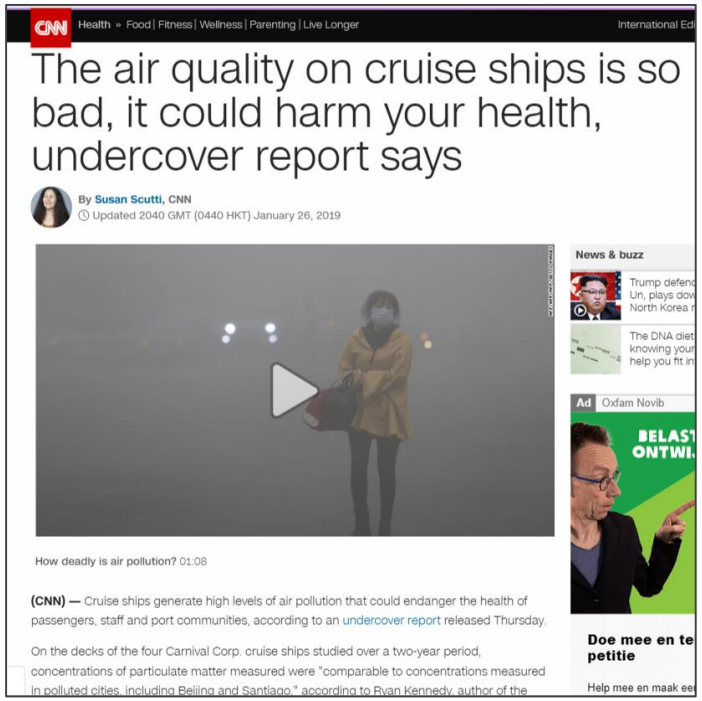
The Global Perspective

18-30%	9%	70%	3.5% to 4%	85%
				
Of all the world's nitrogen oxide **(NOx)**	of the global sulphur oxide **(SOx)** pollution.	of all ship emissions are **within 400 km of land**.	of all **climate change emissions**	of all ship pollution is in the **northern hemisphere.**

1) *The Guardian, 2017*

Why migrate towards zero-emission shipping



CNN Health » Food | Fitness | Wellness | Parenting | Live Longer International Ed

The air quality on cruise ships is so bad, it could harm your health, undercover report says

By Susan Scutti, CNN
Updated 2040 GMT (0440 HKT) January 26, 2019

How deadly is air pollution? 01:08

(CNN) — Cruise ships generate high levels of air pollution that could endanger the health of passengers, staff and port communities, according to an undercover report released Thursday.

On the decks of the four Carnival Corp. cruise ships studied over a two-year period, concentrations of particulate matter measured were "comparable to concentrations measured in polluted cities, including Beijing and Santiago," according to Ryan Kennedy, author of the

News & buzz

Trump defend Un, plays dow North Korea r

The DNA diet knowing your help you fit in

Ad Oxfam Novib

BELAS ONTWI

Doe mee en te petitie

Help mee en maak ee

1) Content by CNN (online) / Picture by Aadt1

Shipping no longer the clean alternative?

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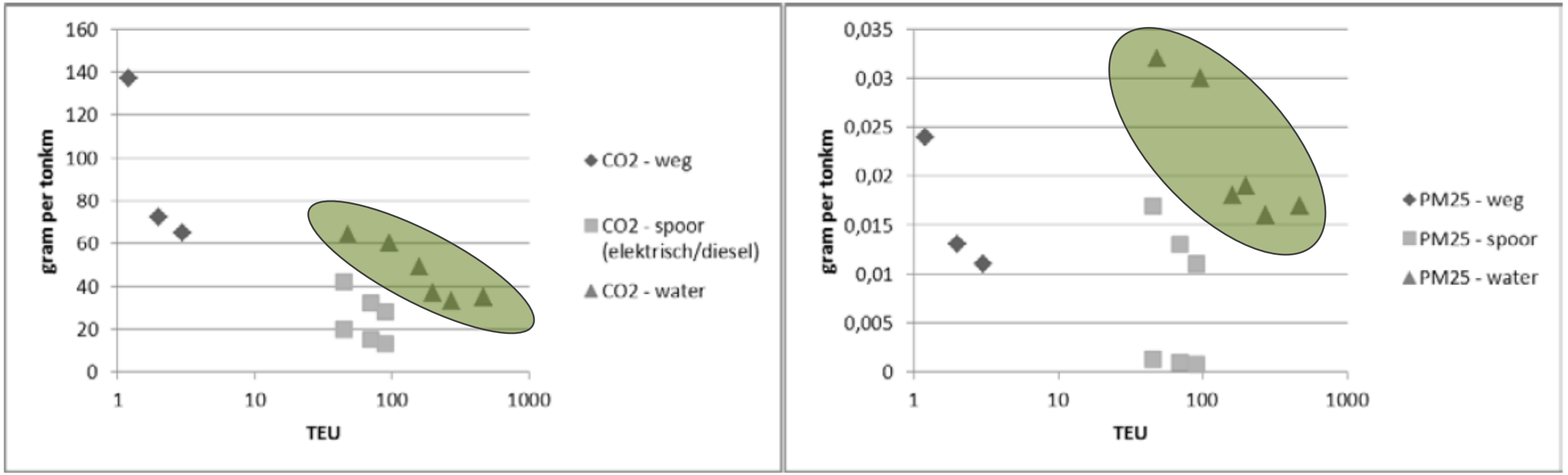
CO_2

PM



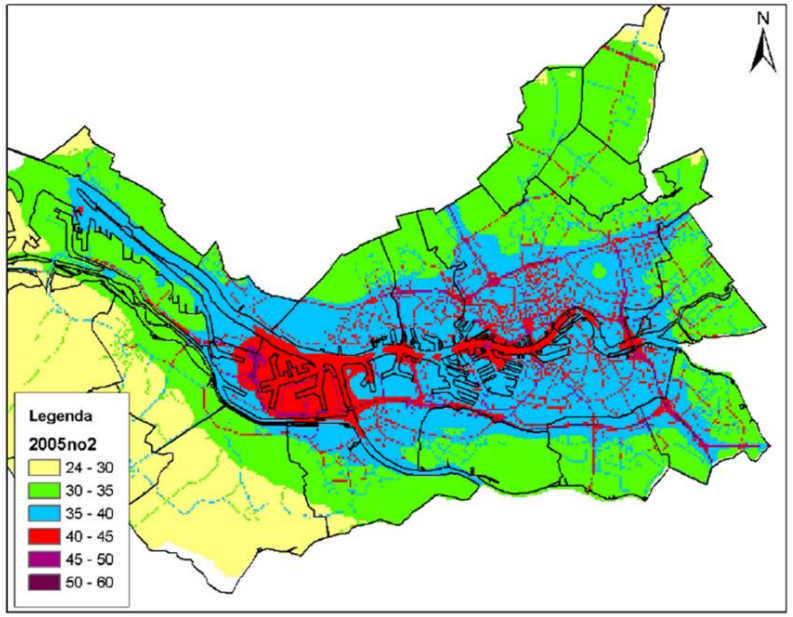
Figuur 5 Illustratie verlies voorsprong binnenvaart als 'groene alternatief'[6]

The Ports perspective

Ports are Climate Change Engines

• **Rotterdam**	**29.8**	**tCO2e/capita**
• Denver	21.5	
• Minneapolis	18,3	
• Houston	14.1	
• Los Angeles	13.0	
• Chicago	12.0	
• Portland	12.4	
• Shanghai	11.7	
• Cape Town	11.6	
• New York City	10.5	
• Hamburg	9.7	
• London	9.6	
• Singapore	7.9	
• Barcelona	4.2	

Ports are Air Quality Issue Zone



European Ports are Urban Ports

ESPO

90% *of European ports are urban ports*

1) GHG emissions (tCO2e/capita) Source: Hoornweg et al (2011)

2. A Will to Change

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The global perspective IMO

IMO is at the UN climate change conference (COP 24) in Poland, highlighting key elements of the Initial IMO Strategy on reduction of GHG emissions from ships.

The strategy sets out a vision to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, while, at the same time, pursuing efforts towards phasing them out entirely. This sets a pathway of CO2 emissions reduction consistent with the Paris Agreement temperature goals.

IMO INTERNATIONAL MARITIME ORGANIZATION

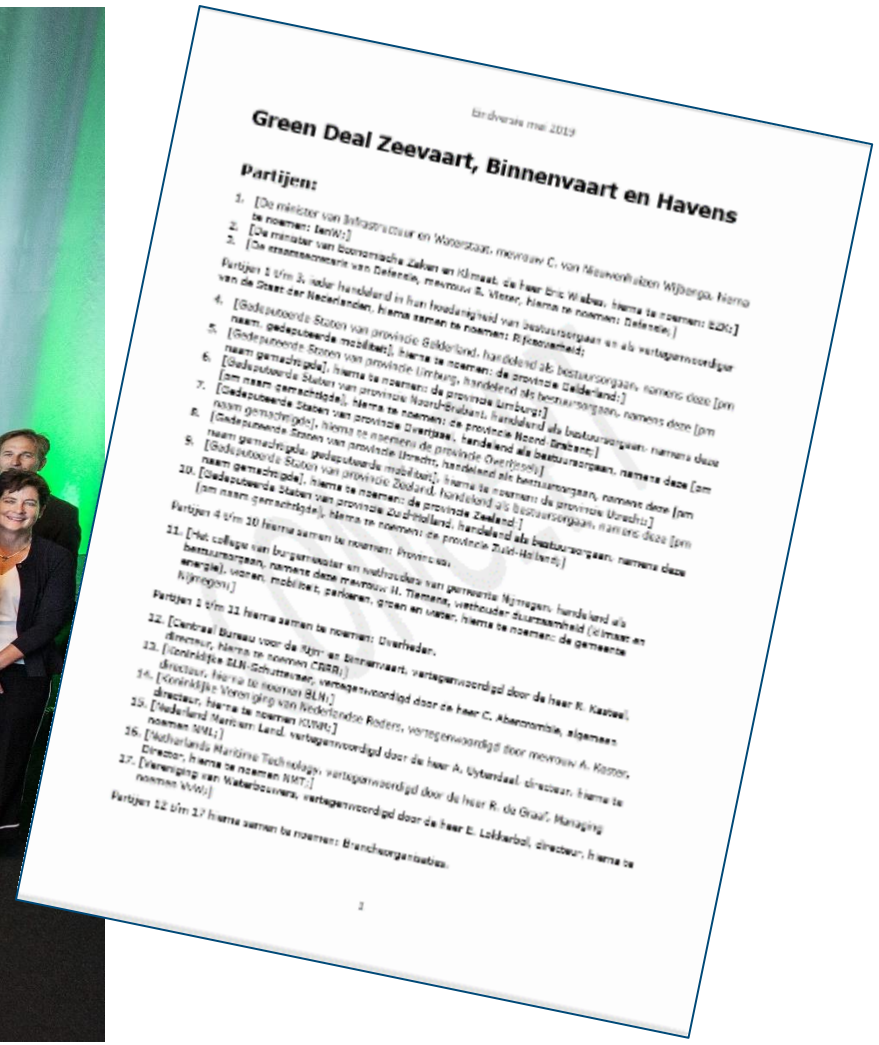
International Shipping News 07/12/2018

The Rhine perspective CCR

The Central Committee for the Navigation of the Rhine (CCR) has adopted her zero-emission strategy on December 7th 2017 with an aim of having realized zero-emission rhine navigation as per 2050.

CCNR
COMMISSION CENTRALE
POUR LA NAVIGATION DU RHIN

The Dutch National Perspective Green Deal



Eindversie mei 2019

Green Deal Zeevaart, Binnenvaart en Havens

Partijen:

1. [De minister van Infrastructuur en Waterstaat, mevrouw C. van Nieuwenhuizen Wijbenga, hierna te noemen: IenW;]
2. [De minister van Economische Zaken en Klimaat, de heer Eric Wiebes, hierna te noemen: EZK;]
3. [De staatssecretaris van Defensie, mevrouw B. Visser, hierna te noemen: Defensie;]

Partijen 1 t/m 3, ieder handelend in hun hoedanigheid van bestuursorganen en als vertegenwoordiger van de Staat der Nederlanden, hierna samen te noemen: Rijkspartijen;

4. [Gedeputeerde Staten van provincie Gelderland, handelend als bestuursorganen, namens deze [en namens gedeputeerde mobiliteit], hierna te noemen: de provincie Gelderland;]
5. [Gedeputeerde Staten van provincie Limburg, handelend als bestuursorganen, namens deze [en namens gemachtigde], hierna te noemen: de provincie Limburg;]
6. [Gedeputeerde Staten van provincie Noord-Brabant, handelend als bestuursorganen, namens deze [en namens gemachtigde], hierna te noemen: de provincie Noord-Brabant;]
7. [Gedeputeerde Staten van provincie Overijssel, handelend als bestuursorganen, namens deze [en namens gemachtigde], hierna te noemen: de provincie Overijssel;]
8. [Gedeputeerde Staten van provincie Utrecht, handelend als bestuursorganen, namens deze [en namens gemachtigde], hierna te noemen: de provincie Utrecht;]
9. [Gedeputeerde Staten van provincie Zeeland, handelend als bestuursorganen, namens deze [en namens gemachtigde], hierna te noemen: de provincie Zeeland;]
10. [Gedeputeerde Staten van provincie Zuid-Holland, handelend als bestuursorganen, namens deze [en namens gemachtigde], hierna te noemen: de provincie Zuid-Holland;]

Partijen 4 t/m 10 hierna samen te noemen: Provincies;

11. [Het college van burgemeester en wethouders van gemeente Nijmegen, handelend als bestuursorganen, namens deze mevrouw H. Tiemens, wethouder duurzaamheid (klimaat en energie), wonen, mobiliteit, parkeren, groen en water, hierna te noemen: de gemeente Nijmegen;]

Partijen 1 t/m 11 hierna samen te noemen: Overheden.

12. [Centraal Bureau voor de Rijn- en Binnenvaart, vertegenwoordigd door de heer R. Kastelein, directeur, hierna te noemen CBRB;]
13. [Koninklijke ELN-Schuttevaer, vertegenwoordigd door de heer C. Abercrombie, algemeen directeur, hierna te noemen ELN;]
14. [Koninklijke Vereniging van Nederlandse Reders, vertegenwoordigd door mevrouw A. Kramer, directeur, hierna te noemen KVNR;]
15. [Nederland Maritiem Land, vertegenwoordigd door de heer A. Uytendaal, directeur, hierna te noemen NML;]
16. [Netherlands Maritime Technology, vertegenwoordigd door de heer R. de Graaf, Managing Director, hierna te noemen NMT;]
17. [Vereniging van Waterbouwers, vertegenwoordigd door de heer E. Lokkerbol, directeur, hierna te noemen VvW;]

Partijen 12 t/m 17 hierna samen te noemen: Brancheorganisaties.

1

3. A Capacity to Change

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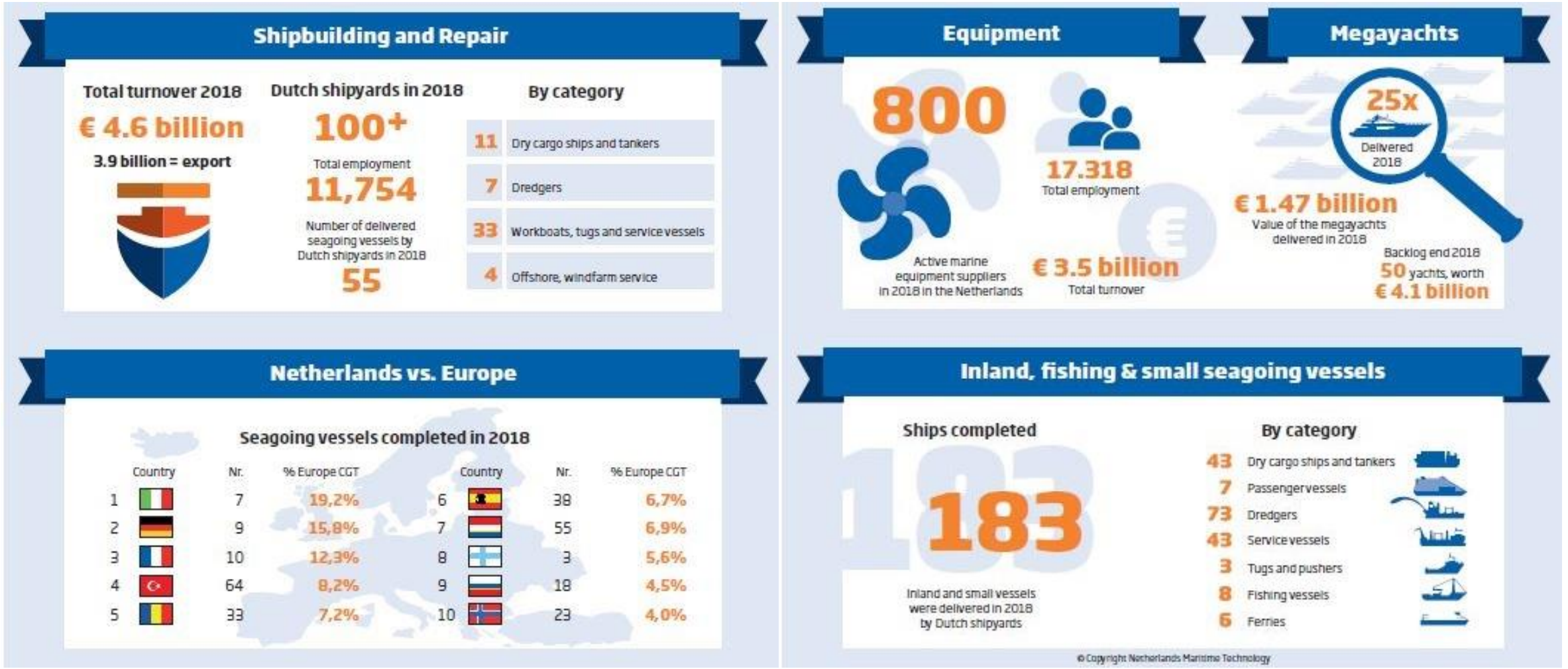
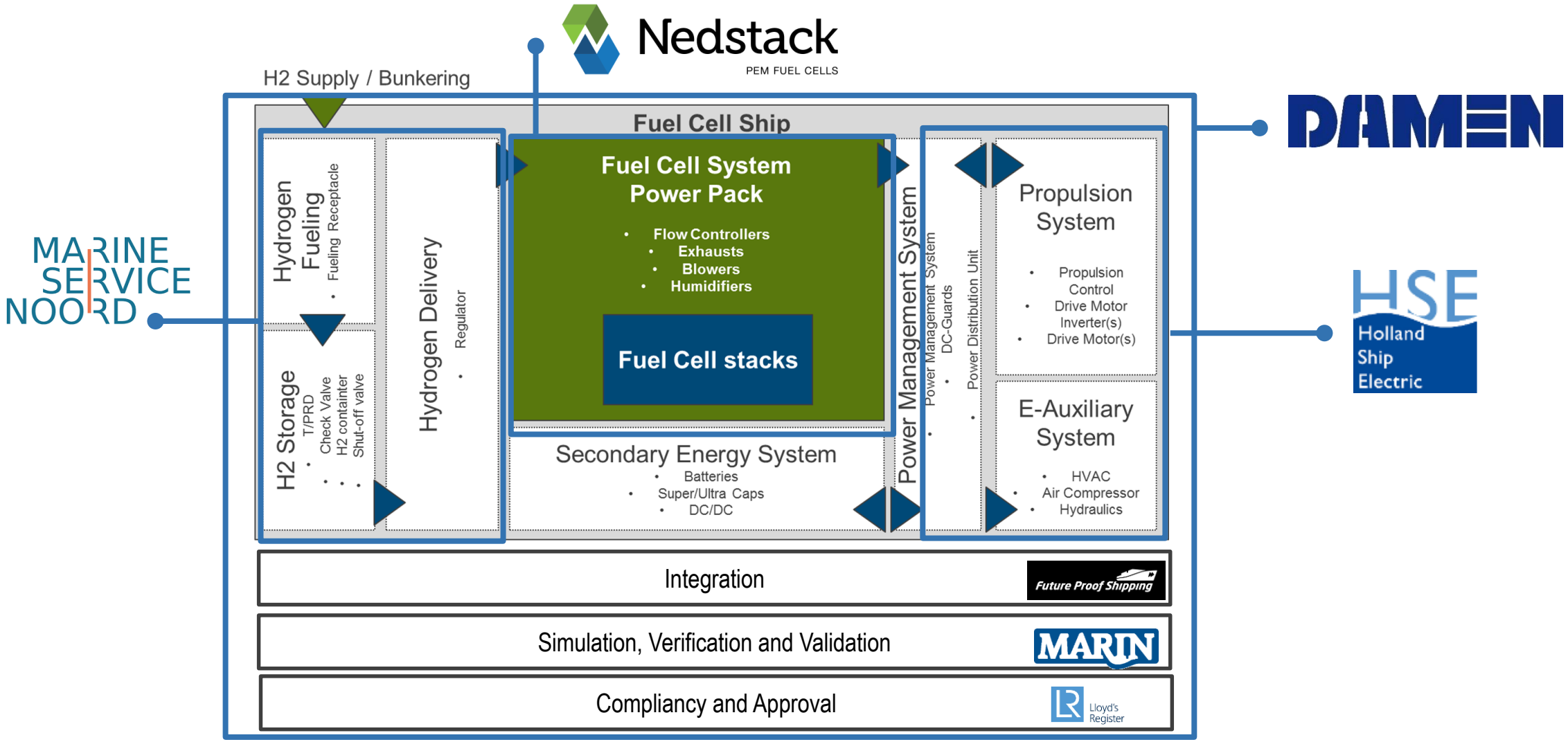
The Dutch Maritime Industry (2018)



Dutch Zero-Emission-Shipping consortium



Zero-Emission Lab @ MARIN

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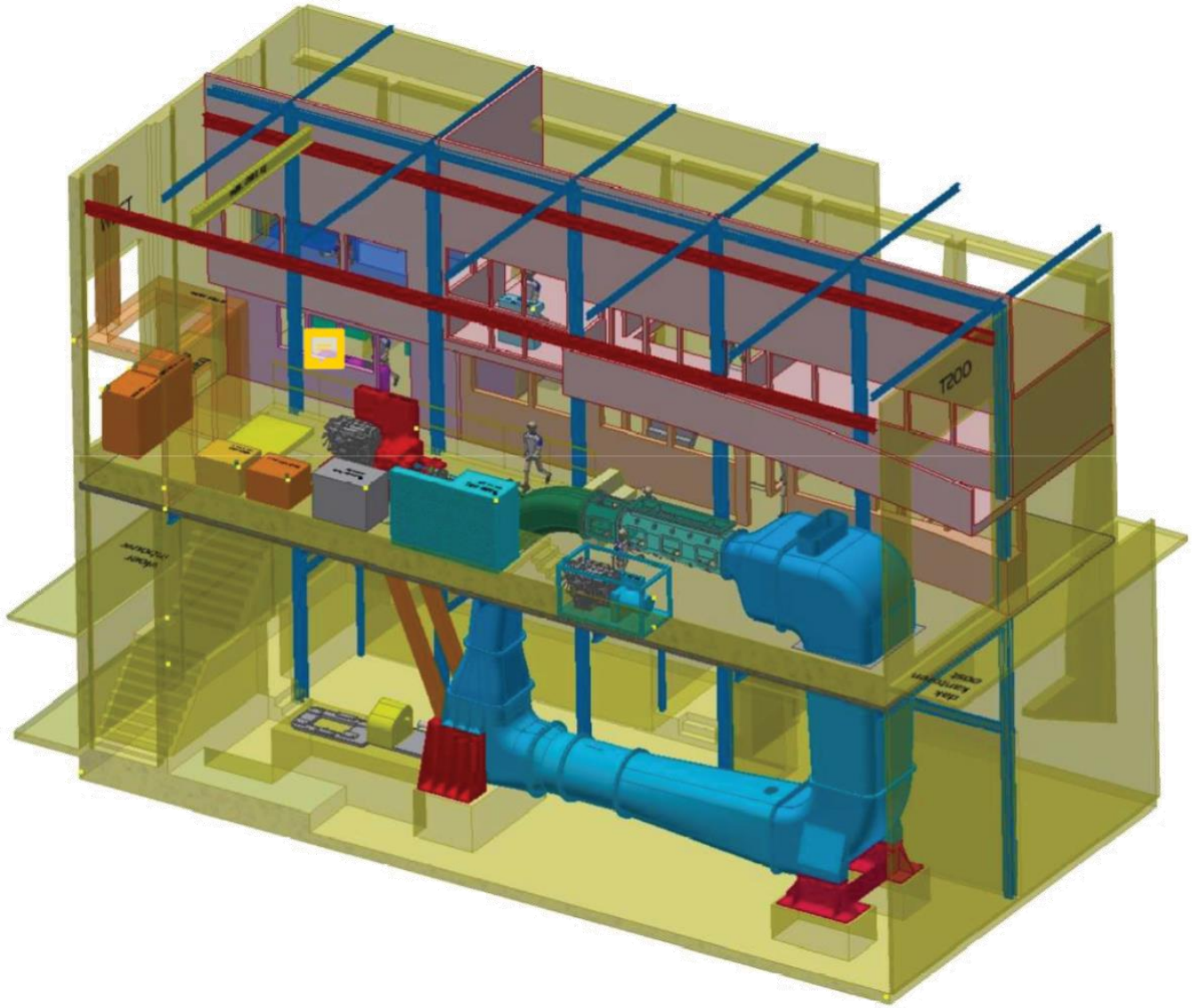
Test Capabilities for Zero-Emission Shipping:

World wide unique test-bed for zero-emission shipping technology.

- Cavitation effects resilience;
- Duty cycle simulation;
- Dynamic response tests;
- Power Split optimization;
- Advanced Control Functionalities;
- ...



MARIN

Previous Maritime Fuel Cell Applications in NL

4. Realizing the Change

Navigating towards Zero-Emission Shipping

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Already widely deployed in Port Environments

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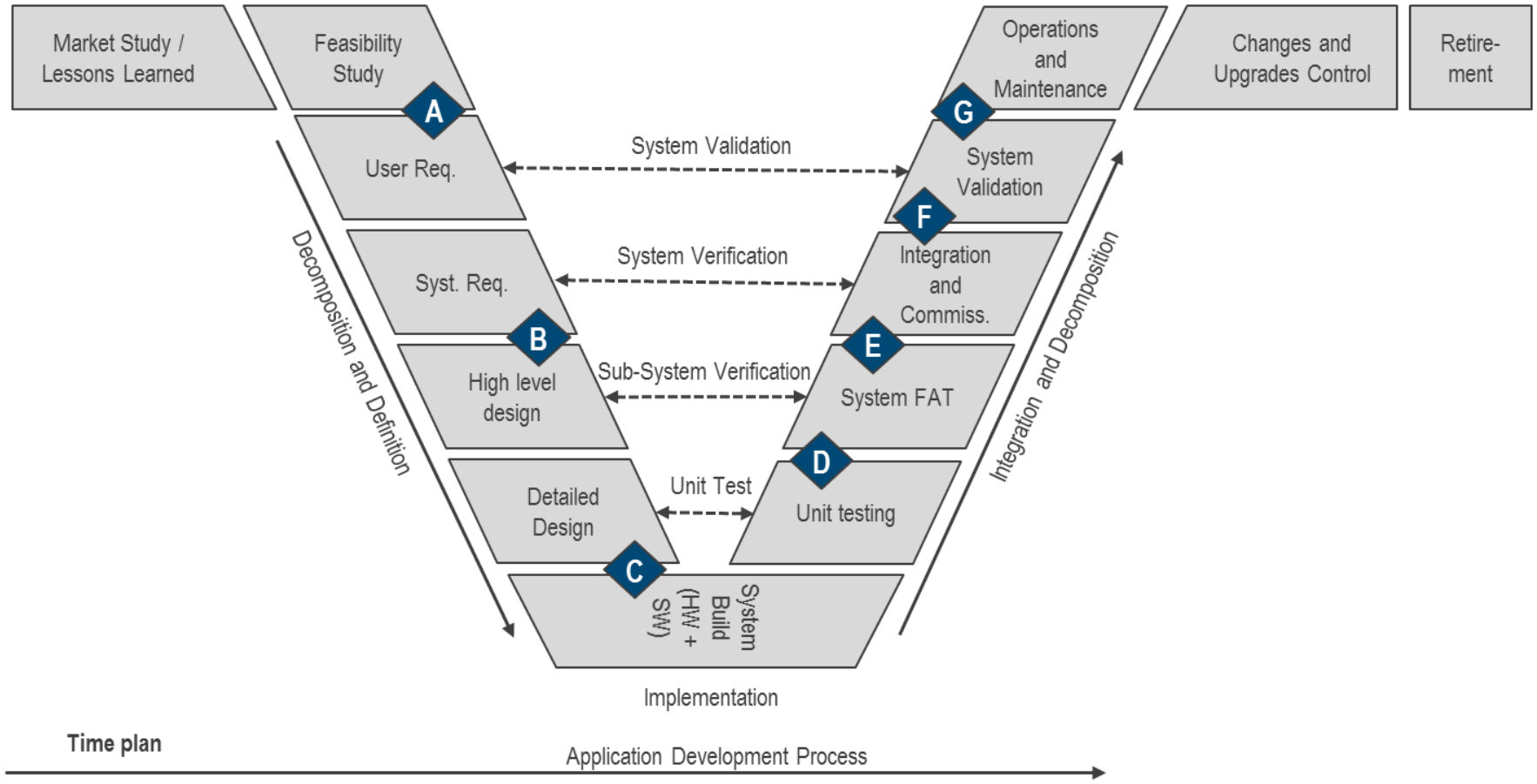
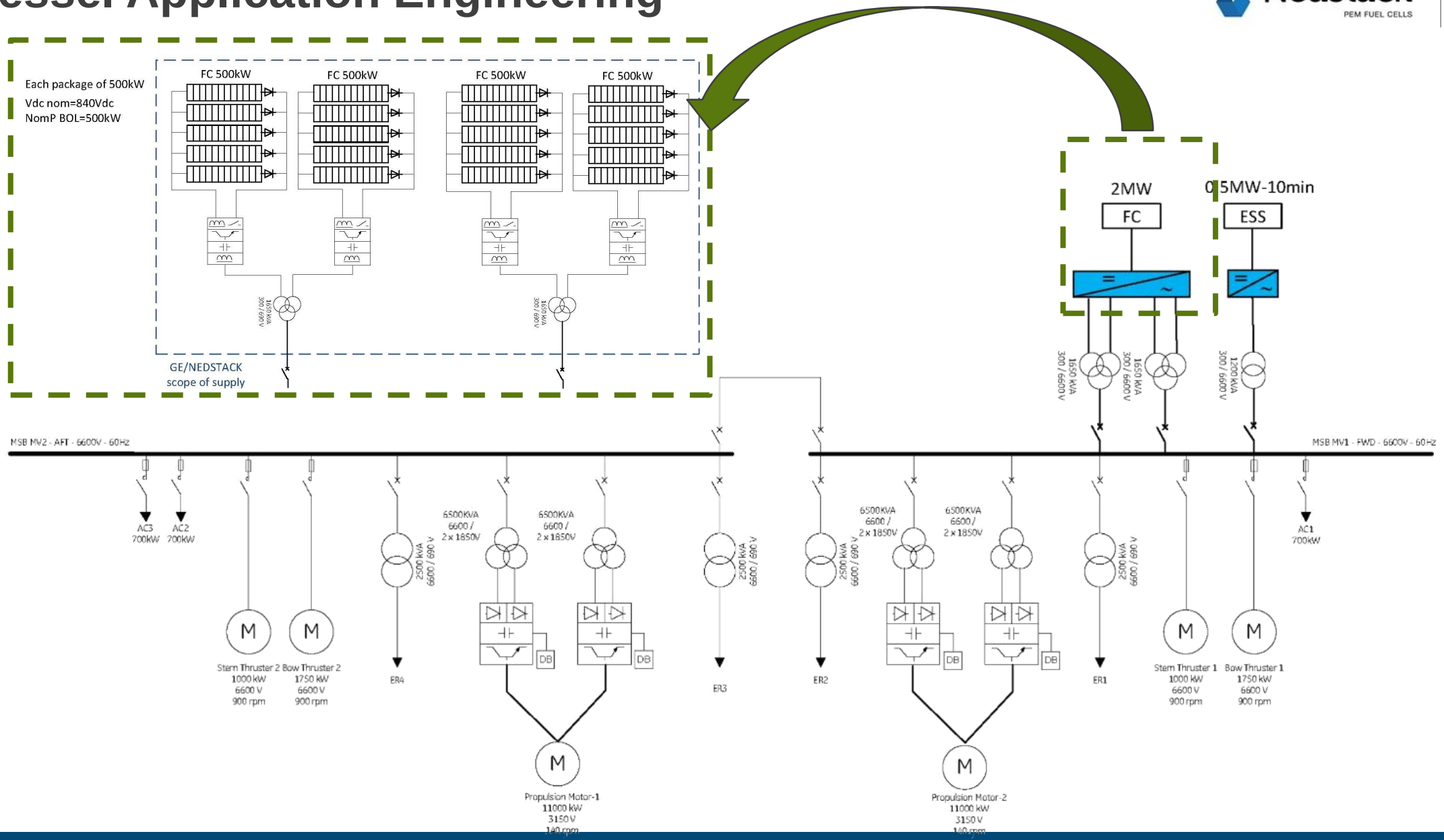
Nedstack Maritime Application Centre



Vessel Application Engineering



Built & Class Approval

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NEDSTACK MARINE MARKET TECHNOLOGY VERIFICATION PLAN

Basic Standardization & Class Approval		Fundamental Marine Verification & Improvement	
IEC Standardization	Class Approval	Vessel Profile Optimiz.	Marine Environment
kiwa	GL Germanischer Lloyd	MARIN	MARIN
			
COMPLETED	COMPLETED Initial	In Progress - Q4 2019	In Progress - Q4 2019

Journey Summary

1 A NEED TO CHANGE

2 A WILL TO CHANGE

3 A CAPACITY TO CHANGE

4 REALIZING THE CHANGE

Journey Summary

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1

A NEED TO CHANGE

The Netherlands has a **unique ports & maritime industry** both on the supply and demand side.

By extension the Netherlands is **strongly subjected to related emissions**;

2

A WILL TO CHANGE

Supported by both global (IMO) and regional (CNRC) policies, the Netherlands has installed a unique public private partnership (**Green Deal Ports & Shipping**) to facilitate a change to zero-emission shipping.

3

A CAPACITY TO CHANGE

The Netherlands has a **supply chain with incredible innovation strength** and past experience with fuel cell shipping.

MARIN is installing a **Zero-Emission-Lab** to facilitate the transition**.**

4

REALIZING THE CHANGE

The Netherlands has a system of subsidy policies in place to support the transition.

Nedstack has installed **a Maritime Application Group** to serve projects end-to-end.

Let’s Stay in Touch !

Nedstack
PEM FUEL CELLS

www.Nedstack.com

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