Nedstack

PEM FUEL CELLS

Let's Navigate towards Zero-Emission Shipping!

H2@Ports Workshop – Marines Memorial Hotel – San Francisco CA - September 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.
- > 750 FC Systems installed-base as per 2019;
- > 23.000 Hours in-use Lifetime demonstrated at stack, 65k at Plant;
- In-house Maritime Application Centre;

Specialized in Containerized Power Plants

Nedstack main location

FCS-XXL LTPEM Stack Label

Nedstack
PEM FUEL CELLS

FCS-XXL
LT-PEM Stacks

Highlights

- Portfolio of LT-PEM Fuel Cell stacks intended for extended long-life and high power applications;
- Designed to provide the lowest possible LCOE within boundaries of absolute reliability, availability and safety.
- Proprietary long-life graphite composite bipolar plate technology and proprietary bulk moulding compounds;
- IEC 62282-2 Compliant design, production and Exit factory inspection.
- Integrated safety system by Nedstack CVM Assembly (TI safety µC) and voltage pick up assembly.

PemGen Label and Signature

Nedstack PEM FUEL CELLS | PEMGEN™ Fuel Cell Power

Highlights

- PemGen defines our portfolio of power systems around our extended long life (XXL) PEM-FCS stack platform.
- Rationalized over the lowest possible levelized cost of energy (LCOE) within boundaries of absolute reliability, availability and safety.
- The PemGen platform is based on the Nedstack Central BoP philosophy for extreme plant life and superior serviceability;
- Configurable to customer requirements;

1) PemGen is a Nedstack European registered trademark. Registered at EUIPO under NO. 018036949

PemGen: A Portfolio of Maritime FC Power Installations

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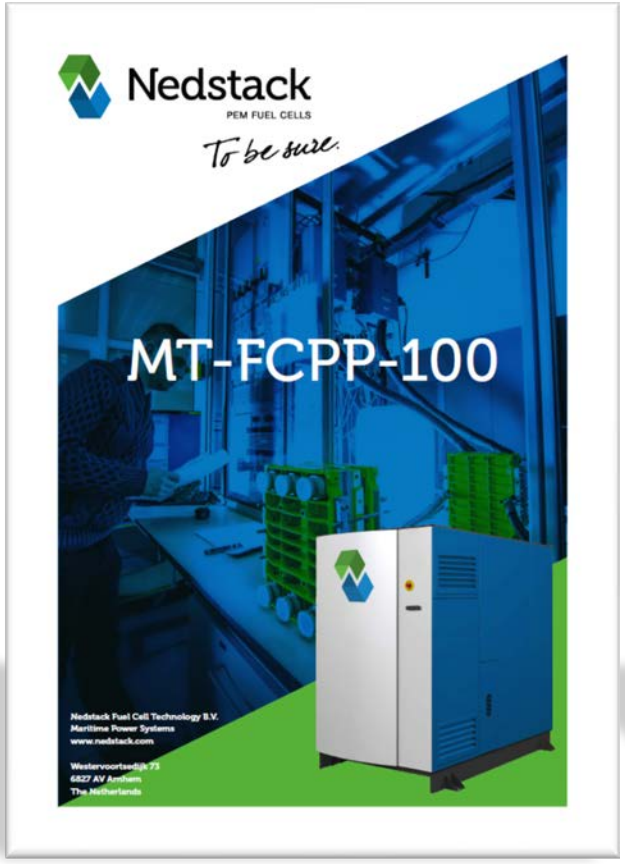
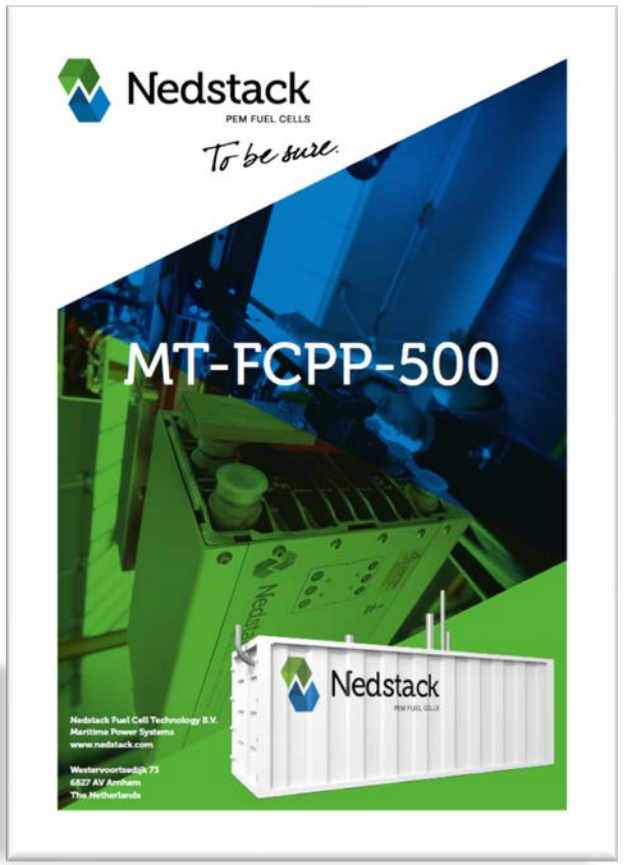
NFCT MT-FCPP-40

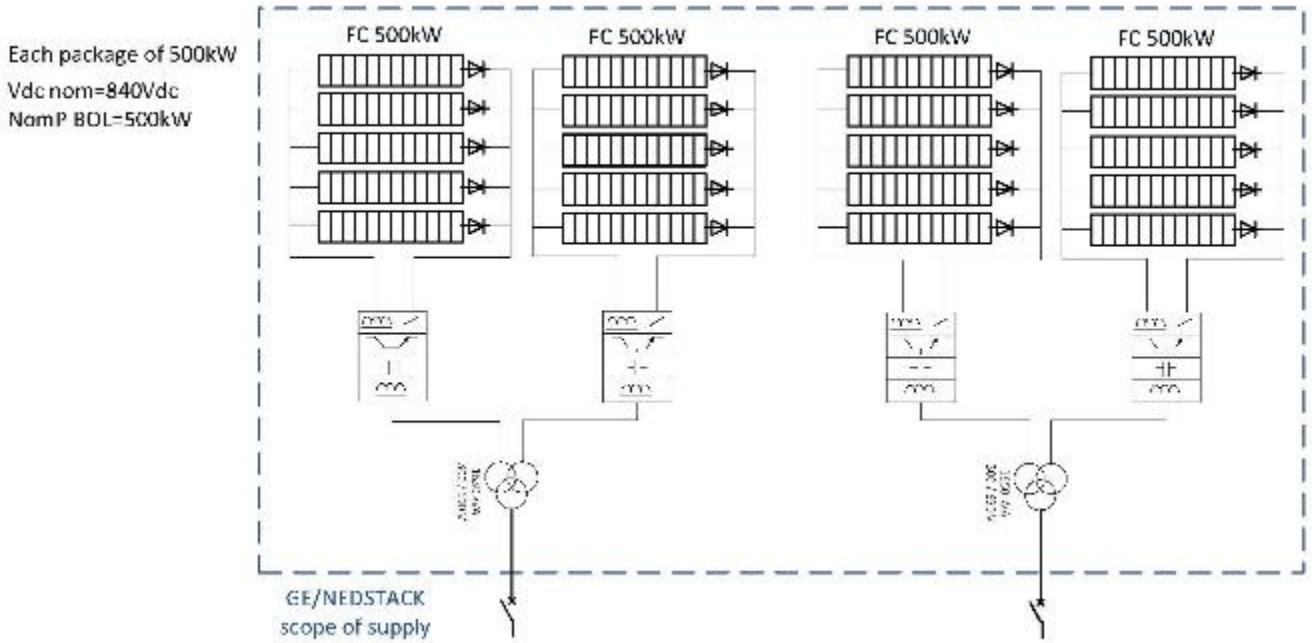
NFCT MT-FCPP-100



NFCT MT-FCPP-500



NFCT/GE Partnership Multi-MWe Partnership



1) https://www.gepowerconversion.com/press-releases/ge-and-nedstack-partnership-sets-sights-zero-emission-cruise-vessels

Nedstack already widely deployed at Ports

1) This work was carried out in the framework of the FP7-FCH-JU project “DEMCOPEM-2MW”, cofounded by the FCH JU under grant agreement n° 621256.

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.

ZESTAs.

- ZE Shipping Technology Association
- Nedstack is a founding member

ZESTAs influences regulators and policy makers to introduce legislation that obligates the uptake of zero-emission shipping technologies.

The Maritime 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.**

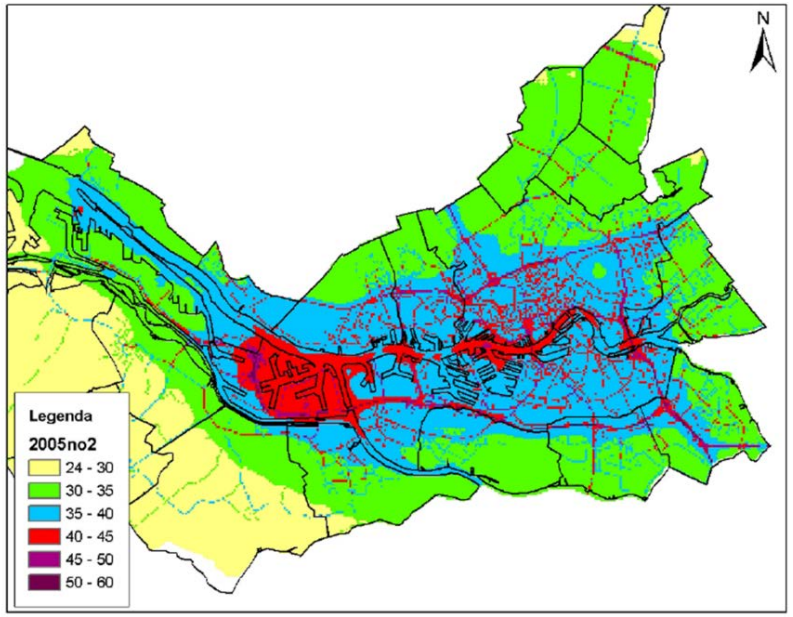
1) *The Guardian, 2017*

H2@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



Most Ports are Urban Ports

ESPO

90% *of European ports are urban ports*

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

NemoH2 – 2nd FC pax. vessel with Class Approval

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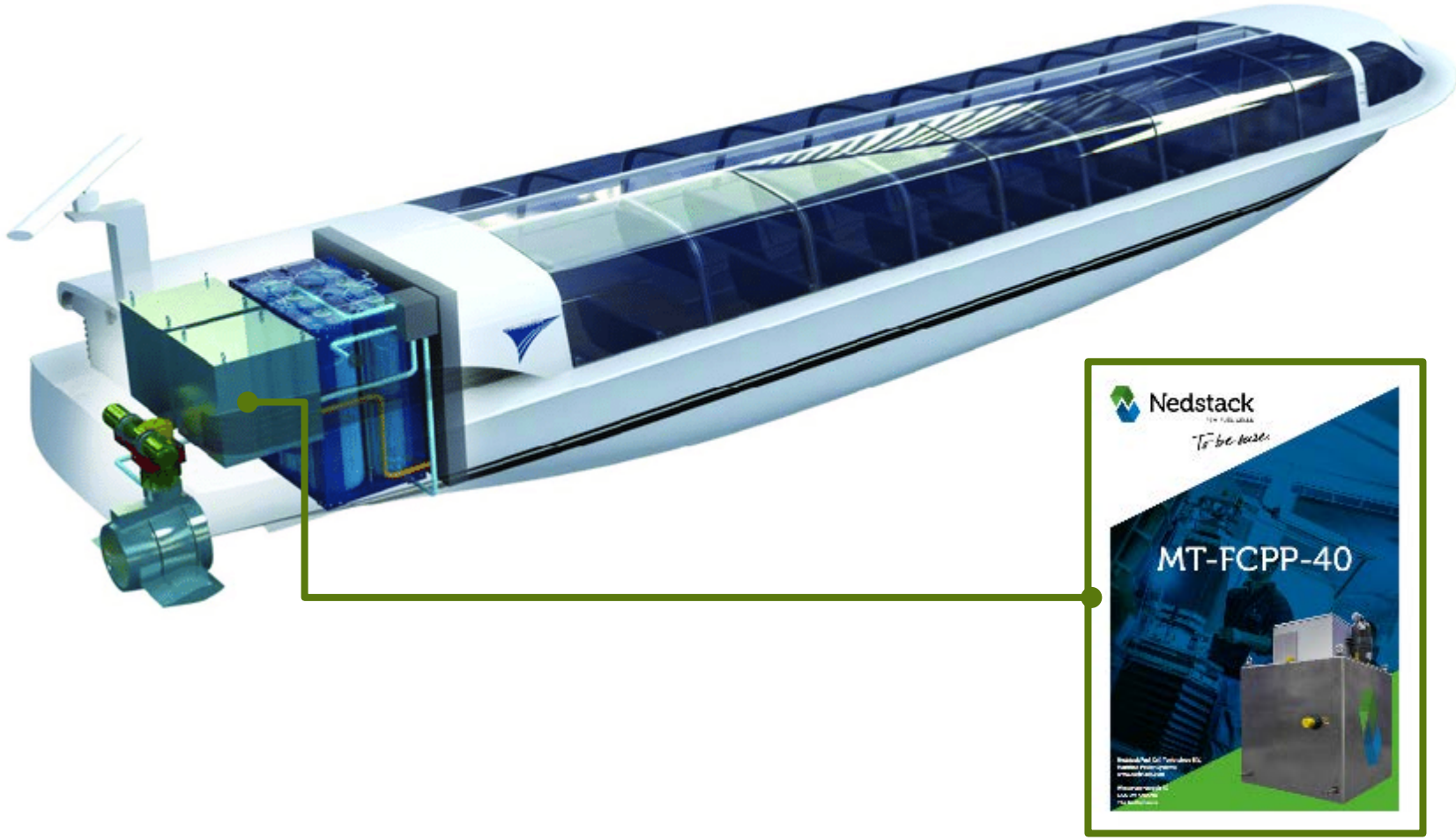
Spec	Value
Length oa	**21,95 m**
Beam oa	**4,25 m**
Draught	**1,1 m**
Displacement	**45 tons**
Payload & Crew	**88**
Mission	**Canal Boat**
Max Speed	**8,5 Kn**
Cruising Speed	**7 kn**
E-Propulsion	**Sern thruster 75 kWe Bow thruster 11 kWe**
Battery pack	**70 kWh**
H2 storage	**24 kg @ 35 Mpa**
FC Engine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



Challenge Identification

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1

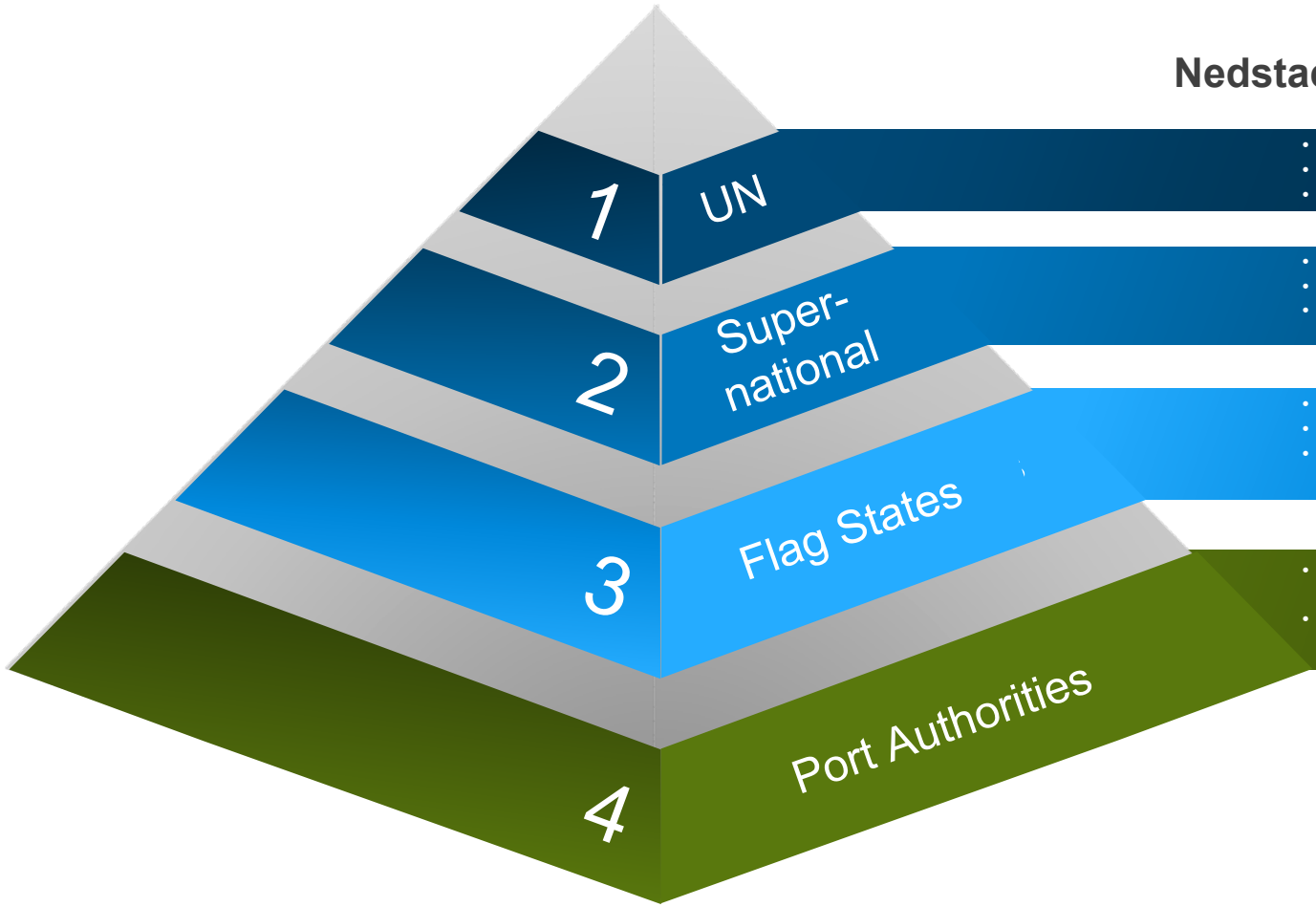
Challenge 1: SUPPLY CHAIN GAP

Maritime is not automotive.

Automotive components and supply chains are not compatible with the maritime domain. Not with their duty cycles and not with their environmental conditions and safety requirements.

Maritime fuel cell power installations require more robust, longer lasting and Class approved hydrogen related components.

Regulatory Development Summary (in scope)



Nedstack Regulatory Status Assessments

IMO
- All Current vessels approved under alternative design process.
- IGF Code on Low Flashpoint Fuels Chapter E. Ready in Concept.
- Class rules to be established after Chapter E approval.

Regional
- CCR (Rhine States) have no hydrogen rules;
- Current demonstrators based on ROSR waivers;
- Hydrogen rules being formulated (no release date)

National
- Awaiting IMO level approval;
- Currently most flags provide waivers under class approval (RBD) only;
- Additional Health and Safety codes and documentation requirements apply;

Port
- Port Management Bye-laws are not in favor of hydrogen and fuel cell demonstrators as far as we know them.
- Waiver programs are depending on personal motivation and support of administrators and are more depending on personality rather then policy.

Challenge Identification

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Challenge 2: THE REGULATORY GAP

Port Authorities are law makers.

Any maritime fuel cell project should also aim at creating institutional freedom to act.

Such institutional engineering involves obtaining Port Management Byelaw waivers, Class approval (by alternative design) and commitment from the flag state.

EU Hydrogen Ports Conference Main Sponsor

Nedstack Main Sponsor of European Hydrogen Ports and Maritime Conference 2018 and 2019

Challenge identification

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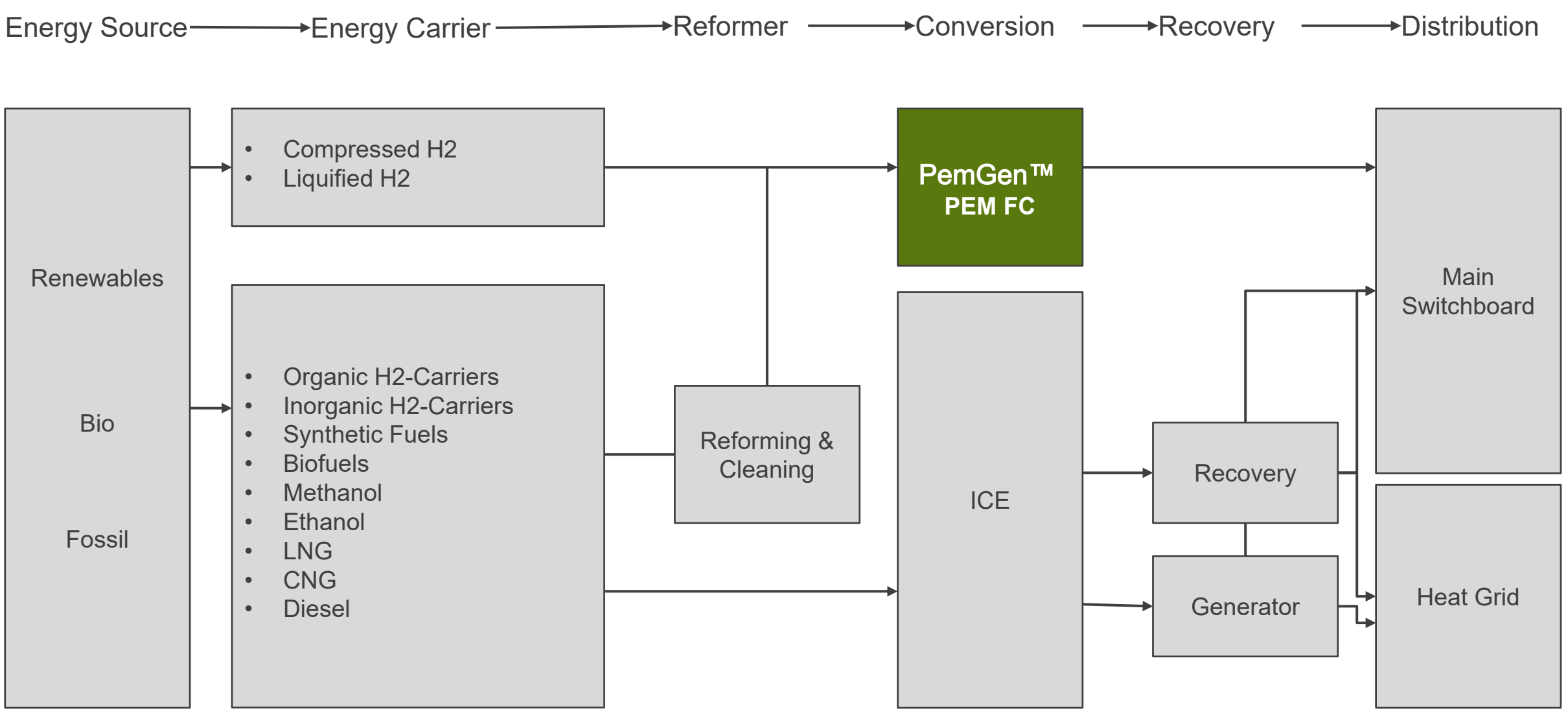
Challenge 3: THE WAITING GAME

There is a strong need to change, but hydrogen fuel cell technology is widely considered to be experimental, to be unregulated and uncertain.

Shipowners are waiting for ports to provide infrastructure and the other way around. There is a waiting game at play where the imperative to act is being passed around from ship to shore and back.

For any demo to emerge a coordinating mechanism is needed to align the ecosystem and coordinate action.

Block Flow Diagram of Pre-Switchboard Flows & Conv.



Challenge Identification

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Challenge 4: THE ENERGY VECTOR & INFRA CHALLENGE

There are a diversity of routes from the energy source to the main switchboard, each requiring their own infrastructures and technology solutions.

Automotive grade hydrogen quality and by extension automotive stacks are not feasible.

However there is no clear view on what energy source / energy carrier route is most promising.

Fuel Cell Power Installations or Systems?

E

IMO INTERNATIONAL MARITIME ORGANIZATION

SUB-COMMITTEE ON CARRIAGE OF CARGOES AND CONTAINERS
6th session
Agenda item 3

CCC 6/3
7 June 2019
Original: ENGLISH
Pre-session public release: ☒

AMENDMENTS TO THE IGF CODE AND DEVELOPMENT OF GUIDELINES FOR LOW FLASHPOINT FUELS

Report of the Correspondence Group

Submitted by Germany

SUMMARY

Executive summary: This document contains the report of the Correspondence Group on Development of Technical Provisions for the Safety of Ships using Low-flashpoint Fuels.

Strategic direction, if applicable: 2

Output: 2.3

Action to be taken: Paragraph 41

Related documents: CCC 4/3/5, CCC 5/3, CCC 5/3/3, CCC5/3/4, CCC 5/3/6, CCC 5/8/10, CCC 4/INF.11

Background

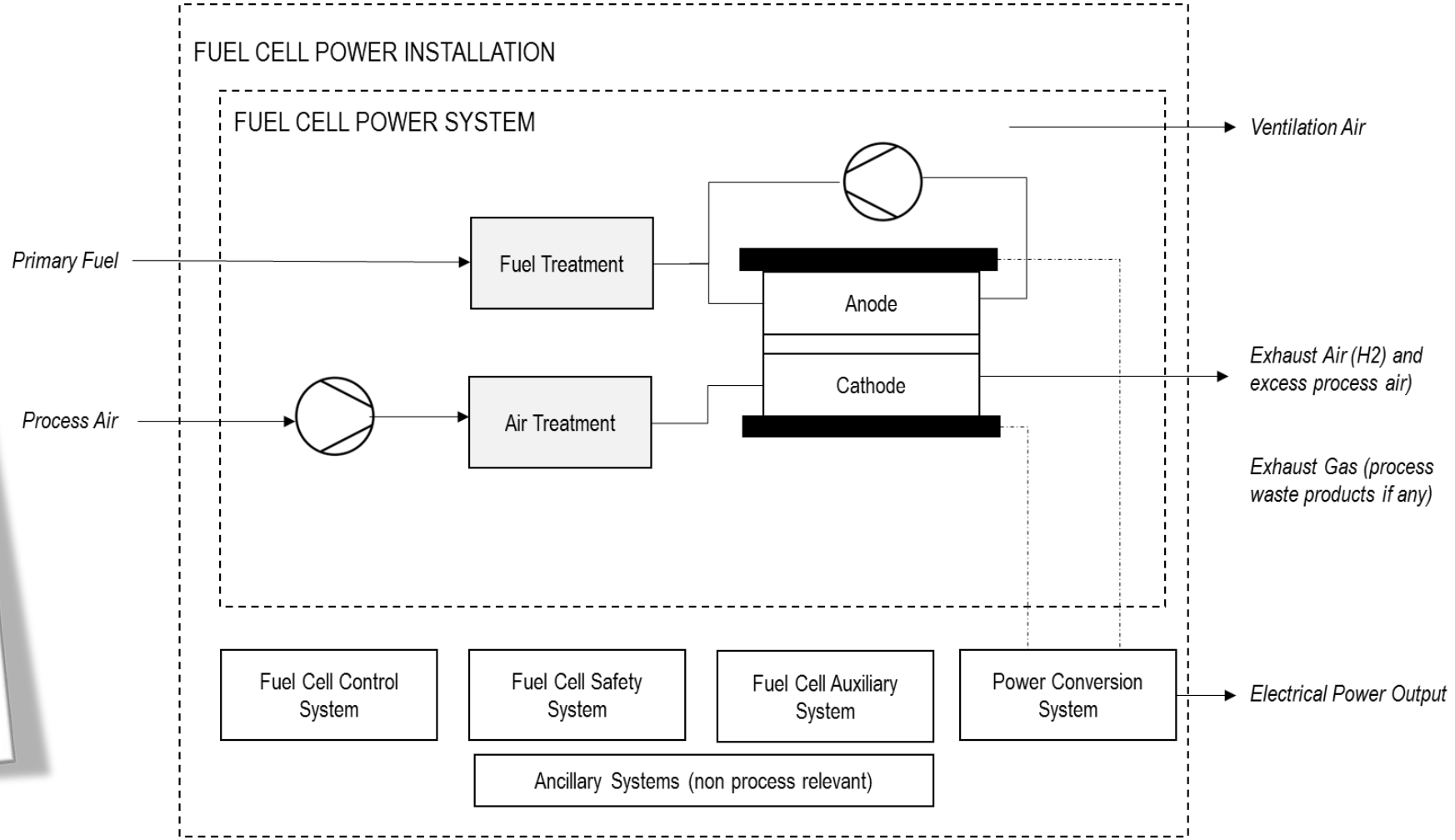
1 The Sub-Committee on Carriage of Cargoes and Containers (CCC), at its fifth session, in order to progress the work intersessionally, agreed to re-establish the Correspondence Group on Development of Technical Provisions for the Safety of Ships using Low-flashpoint Fuels, under the coordination of Germany. This document reports on the outcome of the work of this Group.

List of participants

2 Representatives from the following Member States participated in the Group:

ARGENTINA
AUSTRALIA
BELGIUM
MARSHALL ISLANDS
MALAYSIA
NETHERLANDS

Document2



1) IMO CCC-5-3 ANNEX 4 – relevant to the Pending IMO IGF Code on Low Flashpoint Fuels - Chapter E

Challenge Identification

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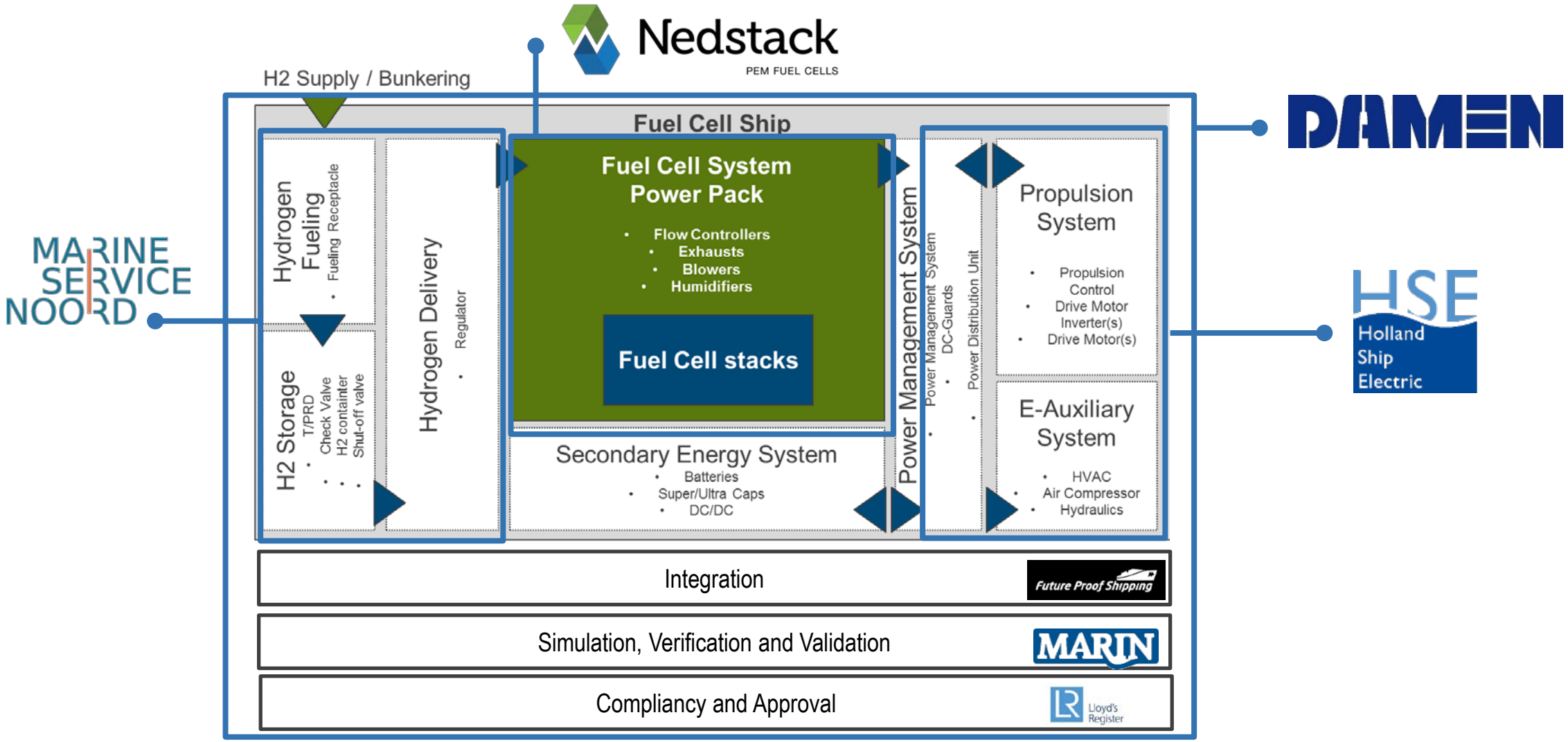
Challenge 5: THE DEFINITION CHALLENGE

IMO and by extension the maritime industry administer different system definitions than we are used to in the IEC 62282 series of international standards.

There is a definition problem on how we define scope, power ratings and so on. Supplier solutions are not cross-comparable and maritime industry actors have difficulties understanding the different BoP strategies and built levels.

Dutch Zero-Emission-Shipping consortium



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Challenge 6: THE INTERFACE AND SAFETY GOAL ATTRIBUTION CHALLENGE

Ongoing demonstrators and engineering programs bring to light a challenge on the exact attribution of safety goals and interfaces between the gas storage, gas distribution and fuel cell power installation system.

A standardized safety concept with attributed safety goals to sub systems would be highly preferable.

Zero-Emission Lab @ MARIN

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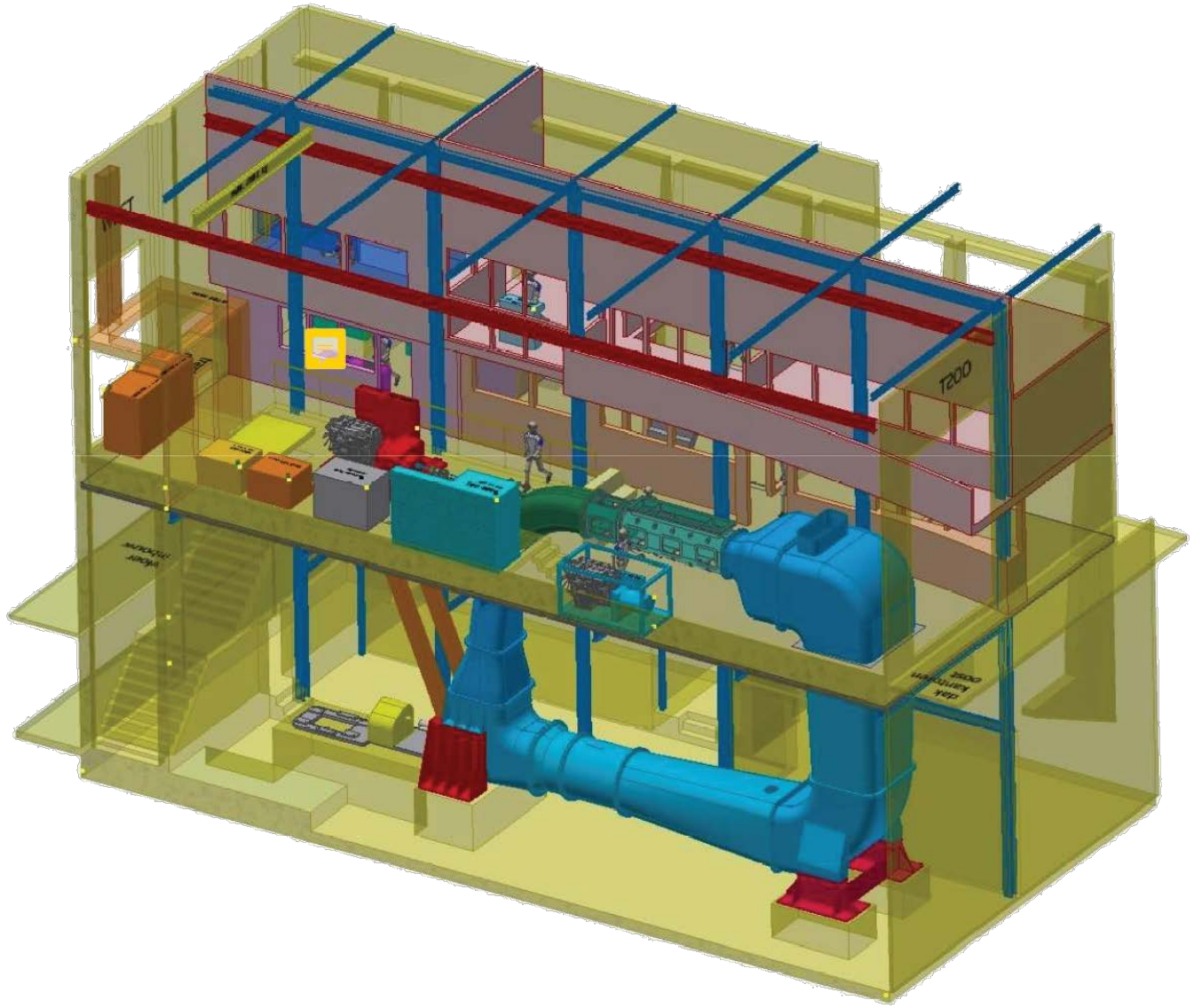
Test Capabilities for Zero-Emission Shipping:

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



Challenge Identification

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Challenge 7: THE VERIFICATION CHALLENGE

Already published Class Rules assume the IEC 62282-3 as a reference for technology verification and requires complementary verification for ‘Maritime use’.

However, no convention for sea-worthiness verification has been codified so far, leaving shipowners in doubt whether FCPI’s can withstand cavitation effects, rough sea dynamics and so on.

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Coopetition Opportunities

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Coopetition Opportunity. We Should Jointly….

1	**The Supply Chain Gap**	• Quantify the maritime hydrogen and fuel cell market potential to move suppliers; • Communicate the opportunity widely in the maritime technology market.
2	**The Regulatory Gap**	• Continue lobbying at IMO level; • Develop a Flag state recommended policy for hydrogen / fuel cell waivers; • Develop a Port Management Byelaw kit for creating an innovation space;
3	**The Waiting Game**	• Install a Ship-to-Shore coordination mechanism for aligning all actors in the eco system to facilitate the transition;
4	**The Energy Vector and Infra Challenge**	• Develop a joint view on promising and less promising maritime energy vector and bunkering routes to facilitate port authority decision making and infra planning;
5	**The Definition Challenge**	• Define our maritime solutions as Fuel Cell Power Installations and specify at End-of-Life rates at system level (or jointly embrace a different convention).
6	**The Challenge of Interfacing and Safety Goal Attribution**	• Establish an industry benchmark as a safety concept or at least an attribution of safety goals to sub systems. Such pro-forma safety concept would be the base case for any shipowner or shipyard looking for an off the shelf solution.
7	**The Verification Challenge**	• Establish a set of sea-worthiness test cases and scenario's for maritime fuel cell power installations that compliment the IEC test requirements.

Let’s Stay in Touch !

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www.Nedstack.com

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