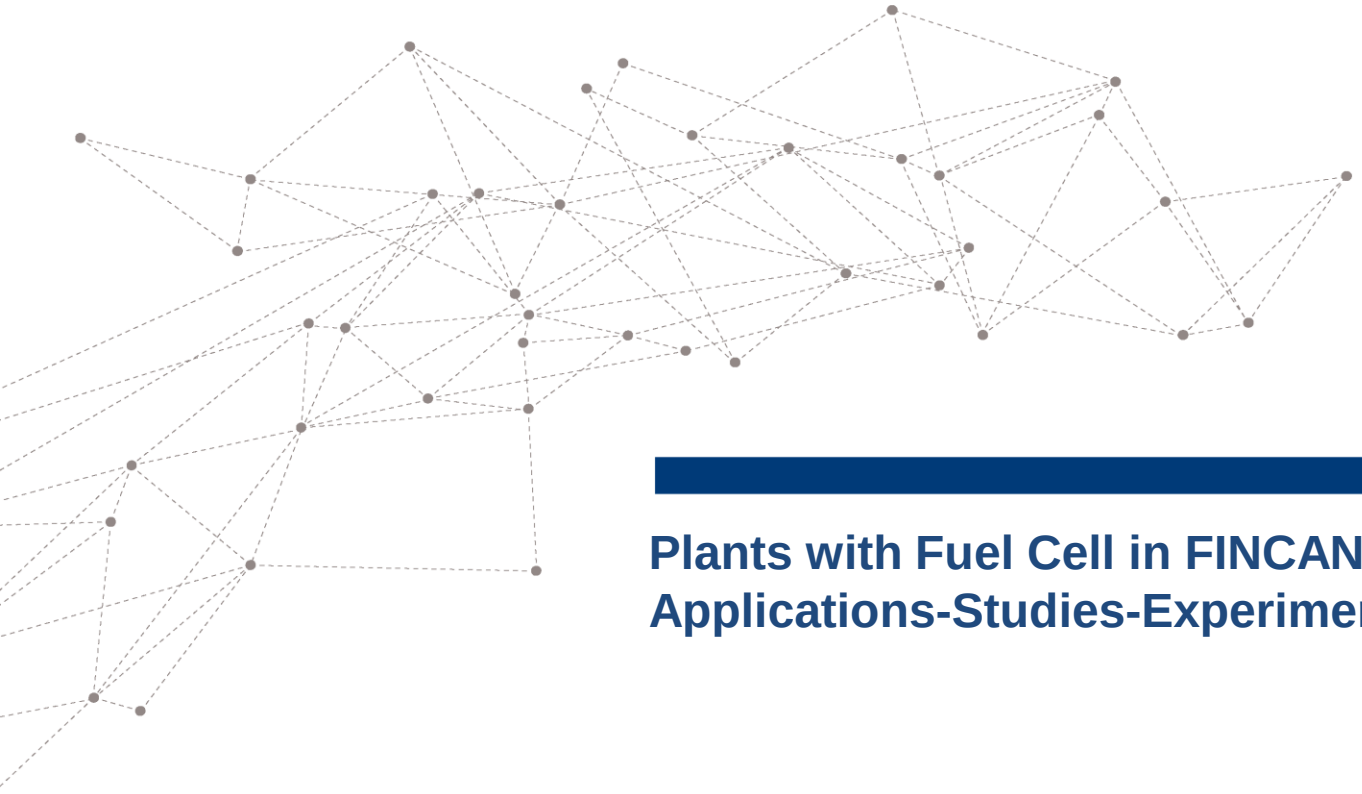


FINCANTIERI
The sea ahead

Plants with Fuel Cell in FINCANTIERI Applications-Studies-Experiments and Future Projects

Gerardo Borgogna

Hydrogen Europe

Valencia 15 June 2017

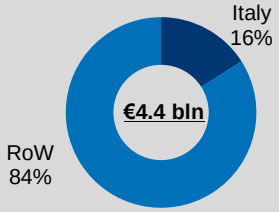
Fincantieri at a glance

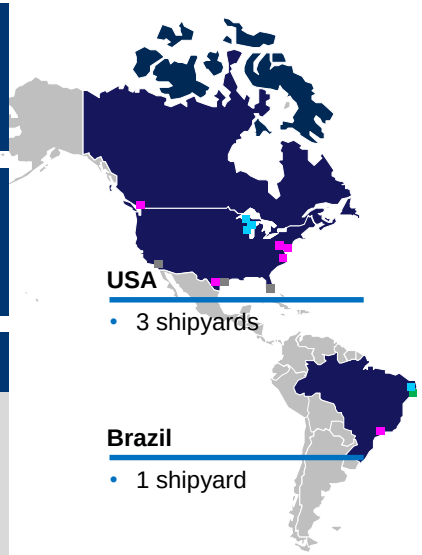
#1 Western designer & shipbuilder(1) with 230 years of history & >7,000 ships built

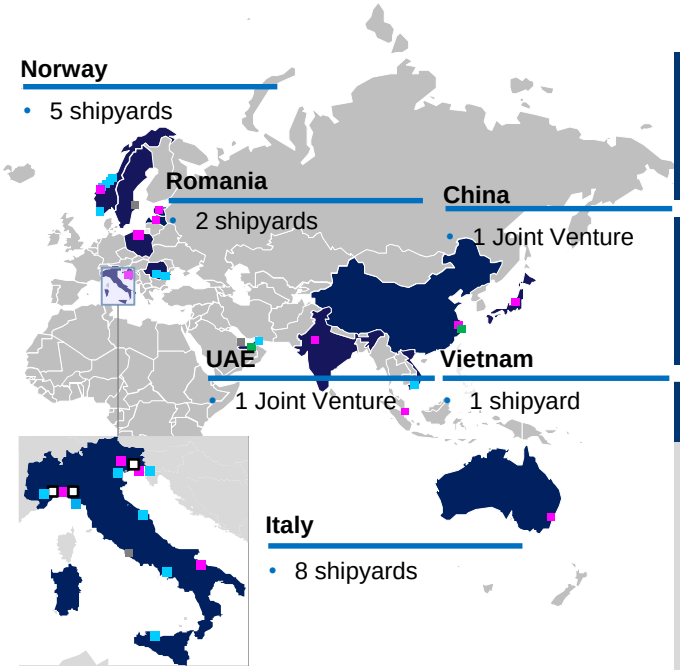
€ 4,429 mln revenues

~ € 24.0 bln total backlog(2)
- **€ 18.2 bln backlog**
- **€ 5.8 bln soft backlog**

Revenues by geography



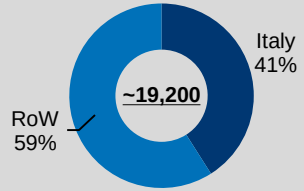




20 shipyards
4 continents

~ 19,200 employees
~ 80,000 subcontractors

Employees by location







Note: all figures reported at December 31, 2016
(1) By revenues, excluding naval contractors in the captive military segment. Based on Fincantieri estimates of shipbuilders' revenues in 2015
(2) Sum of backlog and soft backlog; soft backlog represents the value of existing contract options and letters of intent as well as contracts in advanced negotiation, none of which yet reflected in the order backlog

Corporate/BU headquarters
Shipyard
Joint Venture
Operating subsidiary
Representative / Sales office

FINCANTIERI
The sea ahead

Fincantieri market positioning (1/2)

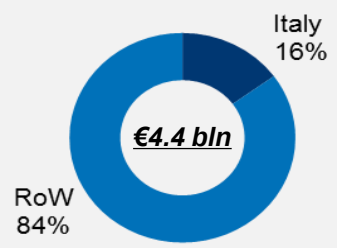
- **World most diversified player** active in **all high value added segments**
- **Balanced exposure** to Cruise, Naval and Offshore
- **Significant share of revenues** coming from **foreign countries**

Business diversification

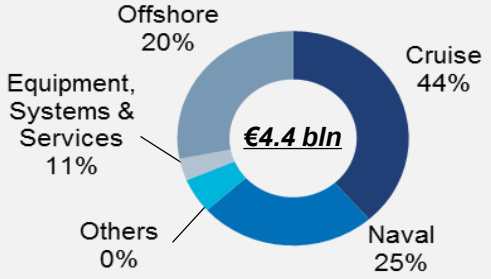
	Fincantieri	Hyundai	DSME	Hanjin	Keppel	Mitsubishi	DCNS	Meyer Werft	IHC	Lürssen	STX France
Cruise	✓							✓			✓
Naval	✓	✓	✓			✓	✓			✓	✓
Ferries	✓	✓	✓	✓				✓			
Mega-Yachts	✓									✓	
Repair & Conversion	✓	✓	✓		✓					✓	✓
Offshore	✓	✓	✓	✓	✓				✓		
Equipment & Systems	✓	✓	✓	✓	✓	✓			✓		
After sales	✓	✓	✓	✓	✓		✓		✓	✓	

2016 revenues breakdown

By client's country



By end market(1)



Source: Company information
(1) Breakdown calculated based on revenues gross of consolidation effects

FINCANTIERI
The sea ahead

Track record, clients and technological leadership

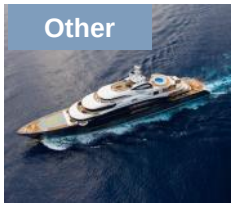
		Track record		Clients	Technological leadership
Shipbuilding	**Cruise** 	**Ship deliveries** • 1990 – 2001: 23 • 2002 – 2016: 52	• **Twofold increase in activity**	Carnival (3), Prestige Cruise Holdings, MSC Crociere, Norwegian Cruise Line, Viking Ocean Cruises, Virgin Cruises, Silversea, Ponant	• *Carnival Vista:* **"ECO Notation" by Lloyd's Register** for exceeding environmental standards • *Royal Princess:* **1st cruise ship fully compliant with new regulations** • *Costa Luminosa & Costa Pacifica:* **Guinness World Record** for joint-christening of 2 ships
	Naval 	**Ship deliveries** • 1990 – 2001: 51(1) • 2002 – 2016: 58(1)	• **Steady, low risk business**	Italian Navy and Coast Guard, United Arab Emirates Navy, US Navy, Qatar Emiri Naval Forces, Algerian Navy, Indian Navy	• *LCS Freedom:* **world's fastest steel frigate** • *Aircraft Carrier Cavour*: **world's most powerful non-nuclear propulsion system** • **More than 20 prototypes developed** over the last fifteen years
Offshore		**Ship deliveries** • 1990 – 2001: 72(2) • 2002 – 2016: 292(2)	• **Acquired VARD in 2013**	Topaz Energy and Marine, Technip, Solstad Offshore ASA, Island Offshore, DCF, Farstad	• *Normand Maximus*: **largest offshore vessel ever built in Norway** • *Skandi Africa*: **"Ship of the Year 2015"**(4) • *AMC Connector*: **world's largest cable layer**(5) • *Far Samson*: **most powerful offshore vessel**(6)
Equipment Systems & Services		• **Strong revenue growth to € 495 mln in 2016**	• **Start-up in 2005**	Italian Navy and Coast Guard, United Arab Emirates Navy, US Navy, Qatar Emiri Naval Forces, MSC Crociere, Carnival	• Innovative and technologically advanced products in terms of **performances**, **lifecycle cost reduction** and **environmental safety** • Full product lifecycle management with unique capacity to support vessels' **maintenance, repair and overhaul all over the world**

(1) Includes other products delivered by Naval business unit. Includes US subsidiaries pre Fincantieri acquisition, excluding 174 RB-M delivered since 2002, of which 28 in 2014 and 3 in 2015
(2) Includes other products delivered by Offshore business unit. Includes VARD and predecessor companies
(3) Parent company of several brands: Carnival Cruise Lines, Costa Crociere, Cunard, Holland America Line, P&O Cruises, Princess Cruise Lines and Seabourn Cruise Lines

(4) Award instituted by the major Nordic shipping magazine Skipsrevyen
(5) In terms of loading capacity (2011)
(6) In terms of bollard pull at the date of construction (423 tons)

FINCANTIERI The sea ahead

Business units, products and positioning

	End markets	Main products	Positioning	Revenues 2016[4]	Backlog
1 Shipbuilding	Cruise 	• All cruise ships *(from contemporary to luxury)*	• #1 worldwide (~45% market share[1])	€ 2,078 mln *(44.2% on total)*	€ 16,372 mln (58 ships)
	Naval 	• All surface vessels *(also stealth)* • Support & Special vessels • Submarines	• Leader: – #1 in Italy[2] – Key supplier for US Navy & Coast Guard[3] – Key supplier for Qatar Emiri Naval Forces	€ 1,156 mln *(24.6% on total)*	
	Other 	• High tech ferries • Large mega-yachts	• Leading player: – High tech ferries – Large mega-yachts	€ 12 mln *(0.3% on total)*	
2 Offshore		• OSV • Drilling units • Fisheries/ aquaculture • Offshore wind • OPV • Expedition cruise • Special vessels	• Leading player in high-end OSVs	€ 960 mln *(20.4% on total)*	€ 1,361mln (41 ships)
3 Equipment Systems & Services		• Marine systems, components & turnkey solutions • Ship interiors • Naval services • Ship repairs & conversions	• Leading player worldwide	€ 495 mln *(10.5% on total)*	€ 1,155 mln

(1) By oceangoing cruise ships > 10,000 gross tons ordered in the 2004 – 2016 period. Source: Fincantieri analysis based on IHS Lloyd's Fairplay – Shippax data and Company press releases
(2) For all the large ships and excluding minesweepers and small ships below 45 m in length
(3) For medium size ships, e.g. patrol vessels and corvettes
(4) Breakdown calculated based on revenues gross of consolidation effects

FINCANTIERI
The sea ahead

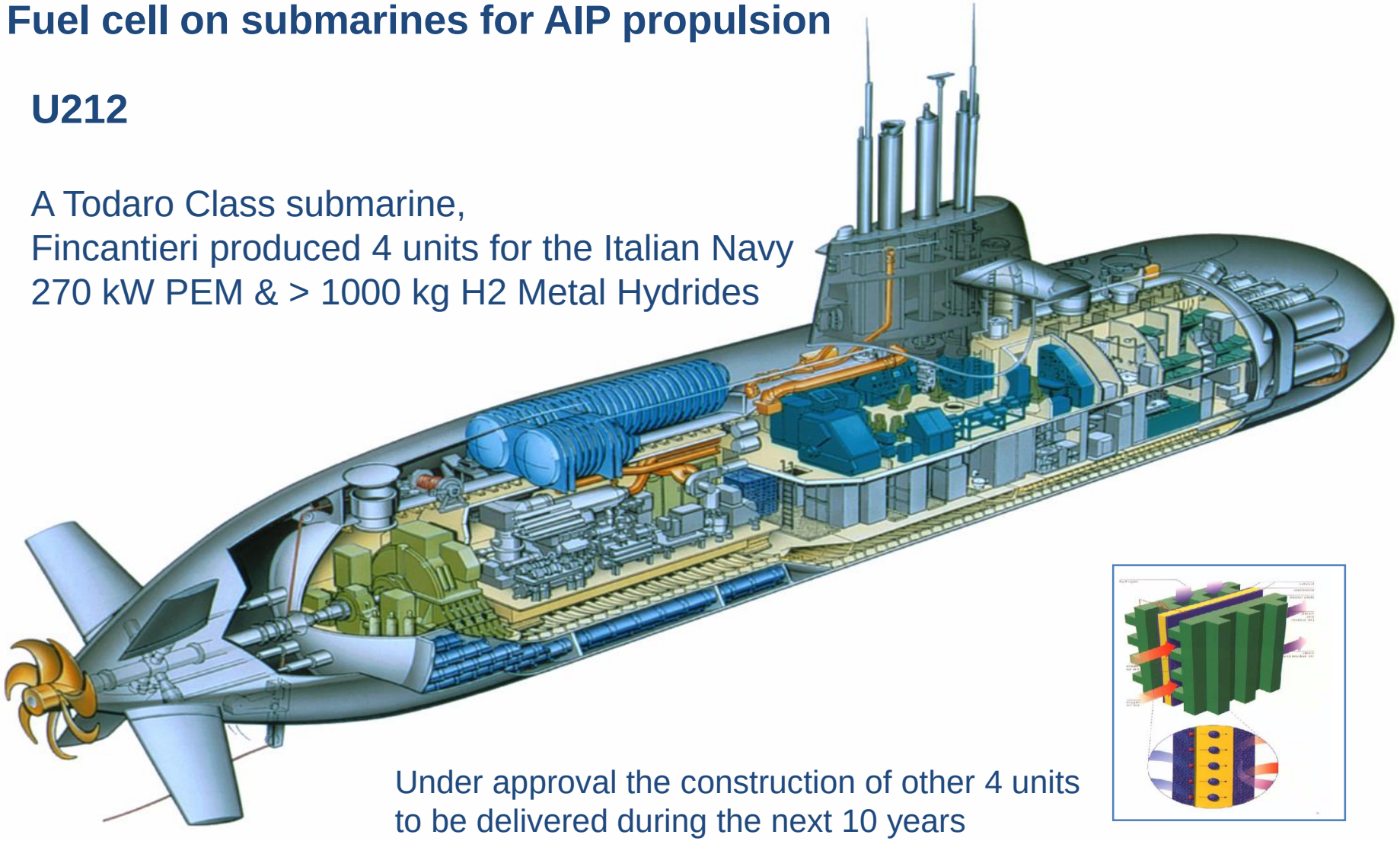
PERSONAL EXPERIENCE

- In Fincantieri since 1978, I have followed all the development of project coordination activities for a wide range of both military and merchant ships, even in positions of major responsibility. Involved highly complex projects such as submarines, logistical support ships, Ferries, gas tankers, tanks, etc. for a large part of my job life.
- Research activities have been coordinated for several years, performing studies for the hydrodynamic optimization of the Ferry, hull structure of submarines and, in the last six years, studies on innovative propulsion systems *Zero Emission*.
- Use of Hydrogen and Fuel Cells for propulsion systems and Auxiliary Power Units
- Lithium Batteries and special metal hydrides for H2 Storage for an high performance of energy storage system.
- Today I‘ m the Fincantieri delegate inside the FCHJU and the responsible for the development of hydrogen technologies for Fincantieri and the HI-SEA Joint Lab activities (Hydrogen Initiative for Sustainable Energy Applications).

Fuel cell on submarines for AIP propulsion

U212

A Todaro Class submarine,
Fincantieri produced 4 units for the Italian Navy
270 kW PEM & > 1000 kg H2 Metal Hydrides



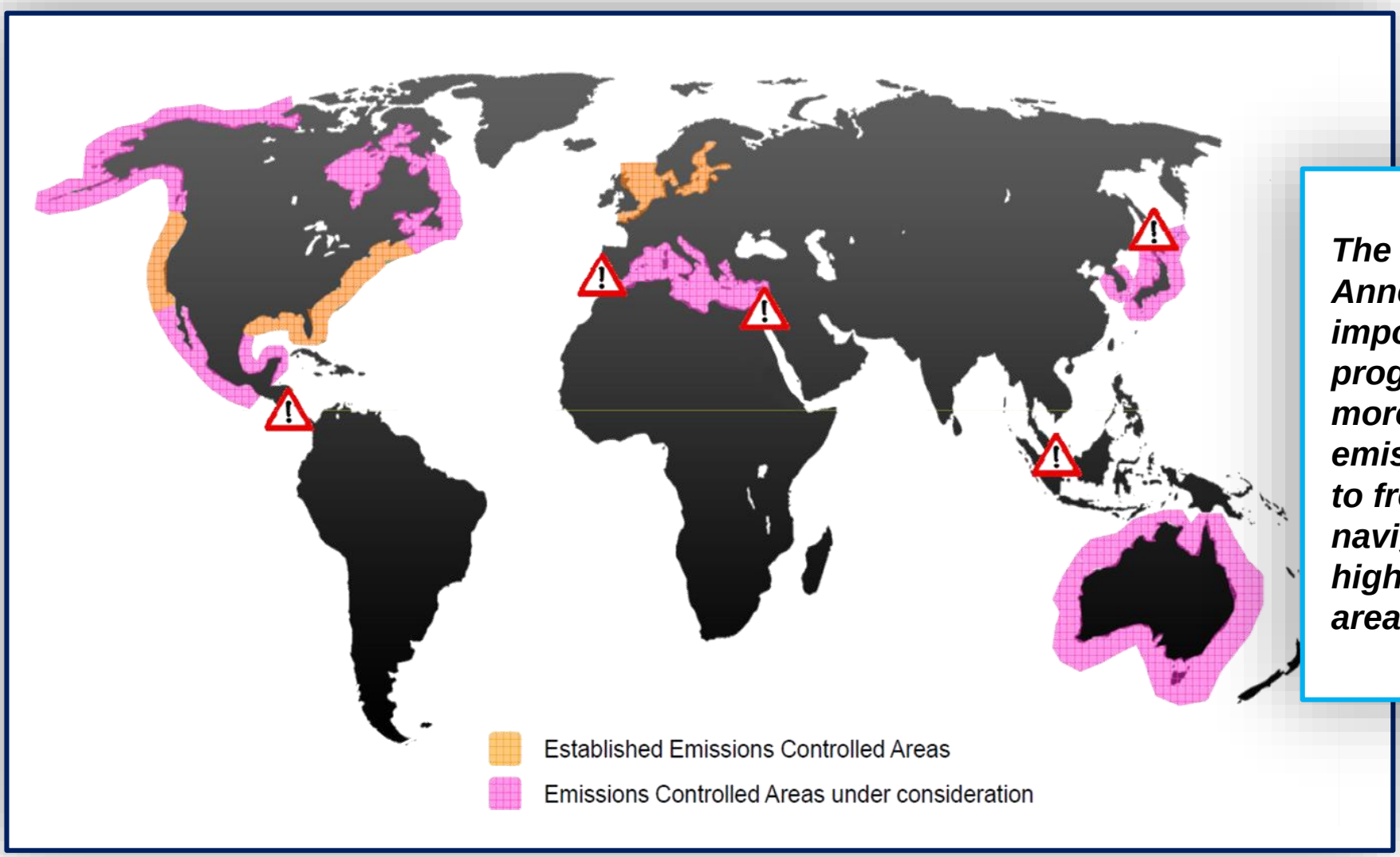
Under approval the construction of other 4 units
to be delivered during the next 10 years

U212A Italian Navy submarines

Displacement standard	1500 t
Displacement submerged	1700 t
Lenght	58 m
Max surface speed	11 Kn
Submerged speed	> 16 Kn
Crew	27 people

Upcoming changes in regulation

Need to produce energy without polluting the surrounding environment…



The new Marpol Annex VI, impose progressively more stringent emission limits to free navigation in high-value areas (e.g., US)

Ultra-tech, ultra-luxury for very special owners

Ultra-tech: fundamental elements

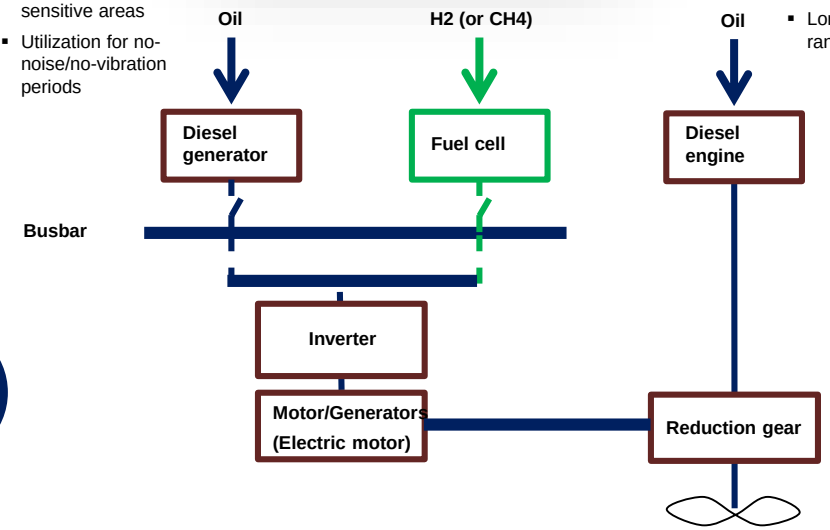
SWATH

- A look-like port, everywhere the owner is, to enjoy luxury lifestyle
- Best sea-keeping (and comfort) and “no sea-sickness” thanks to the limited TPC, The 24 meter large beam and the submerged bulbs
- “Zero” noise and vibrations
- Space for safe return to port equipment

+

FUEL CELL

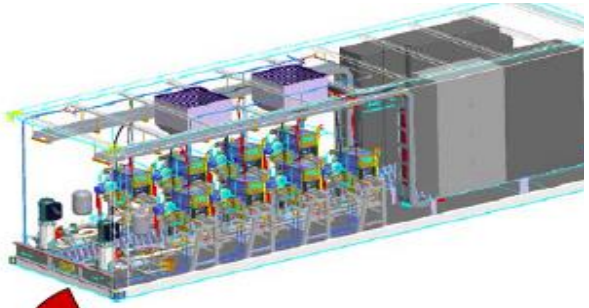
- Exploration of environmentally sensitive areas
- Utilization for no-noise/no-vibration periods



- Regular cruising
- Long ranges

3 different operation mode:

- **Diesel mechanical** propulsion feed by Diesel engine
- **Zero-emission** Electric propulsion feed by Fuel Cells system for full respect of the environment
- Fuel cells system or Diesel generators combined to Diesel engine used as a booster



FINCANTIERI

Laboratory Specifications

- 4+4 Stacks
- Power 130 kW + 130 kW
- Two DC/DC converter 350-600 V
- Automation and Control

Fincantieri and UNIGE developed the “Teseo Project” together. The collaboration between the parties is going on through the Joint Laboratory for the development of Hydrogen Technology for Marine Application.

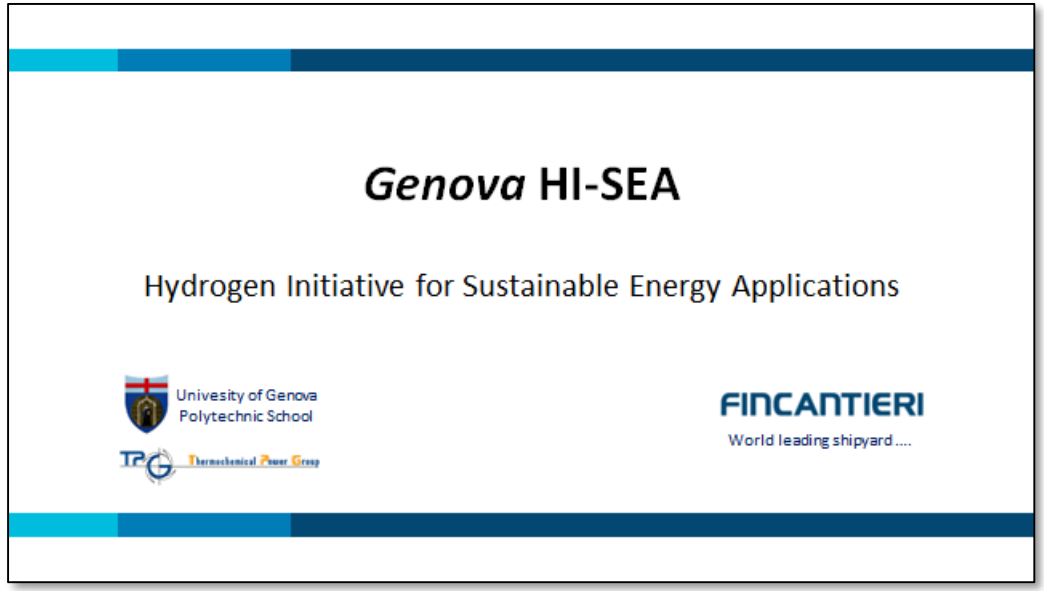
The Laboratory will be used for the study of Fuel Cells, Hydrogen Storage Systems, Hydrogen Refueling Systems, Marine applications as also for the assessment of large PEMFC system for various applications.

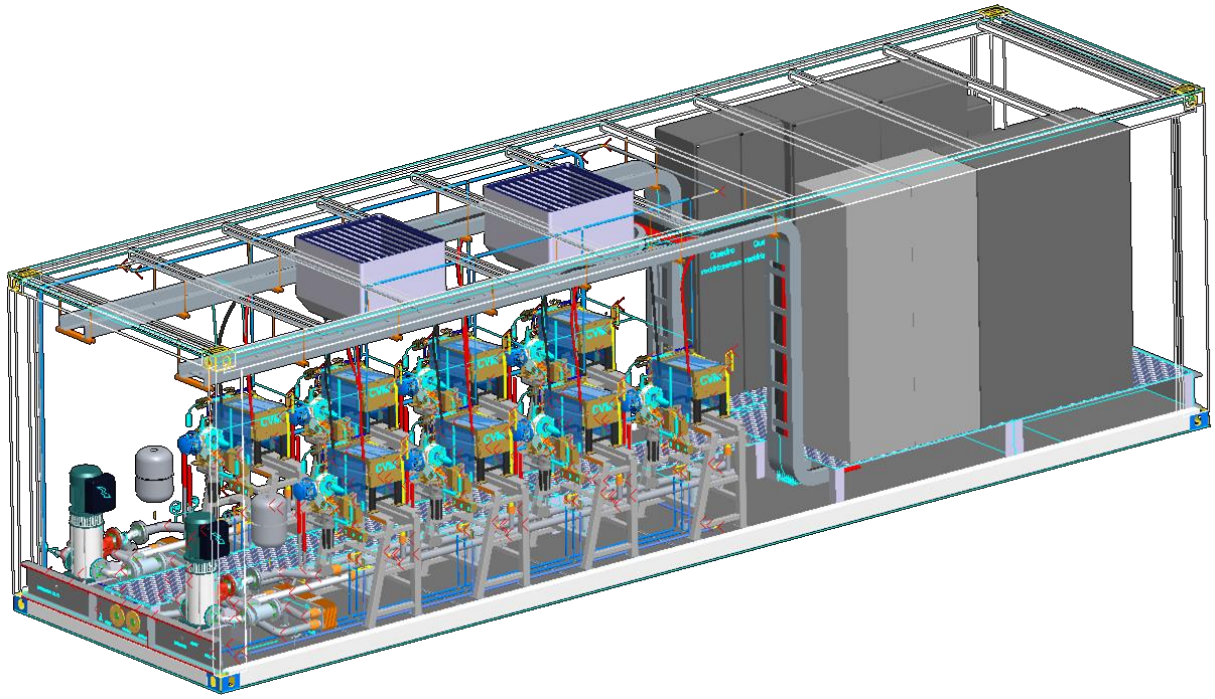
HI-SEA Joint Laboratory

The system has been designed to study:

- Fuel Cell/Batteries hybrid systems
- System control analysis
- Marine systems design
- System modeling and validation
- Marine condition tests

The HI-SEA Joint laboratory will further develop the assessment of Fuel Cell systems for ship applications.

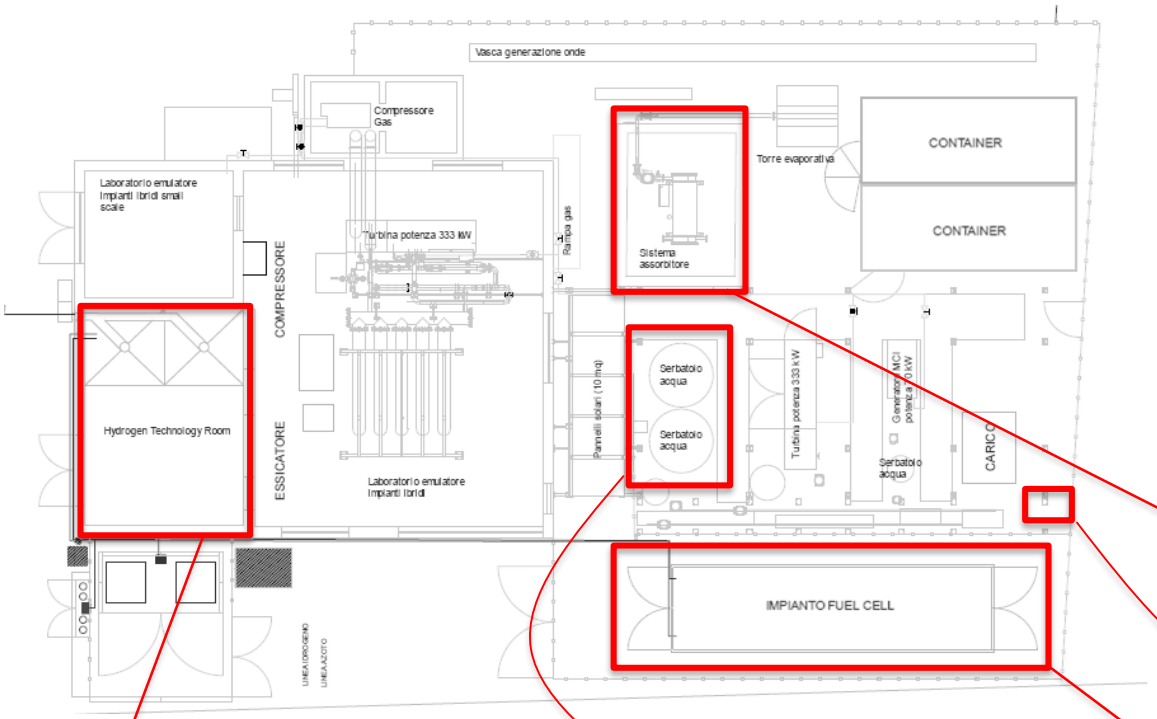




System Specification

- 8 PEM stacks Nuvera Orion
- 264 kW Max Power
- 4+4 configuration with two independent branch
- Controllable DC/DC for each branch
- 60 kW AC/DC system to simulate batteries
- ATEX compliant with forced ventilation
- Cathode recirculation mechanical configuration
- 300-600 VDC bus
- 250-500 A bus
  Liquid cooling system

HI-SEA Joint Laboratory



The HI-SEA Joint Laboratory will exploit the potential of PEM fuel cell systems for ship applications through the assessment of:

- Fuel Cell/Batteries hybrid systems
- Cogeneration analysis
- Trigeneration analysis
- Smart Grid coupling
- Simulation validated models

- 100 kW absorber chiller for the study of trigeneration systems

- Dedicated space for the analysis of single modules performance
- Cogeneration and heat storage analysis
- 260 kW PEM system
- Campus grid connection (Heat and Electricity)

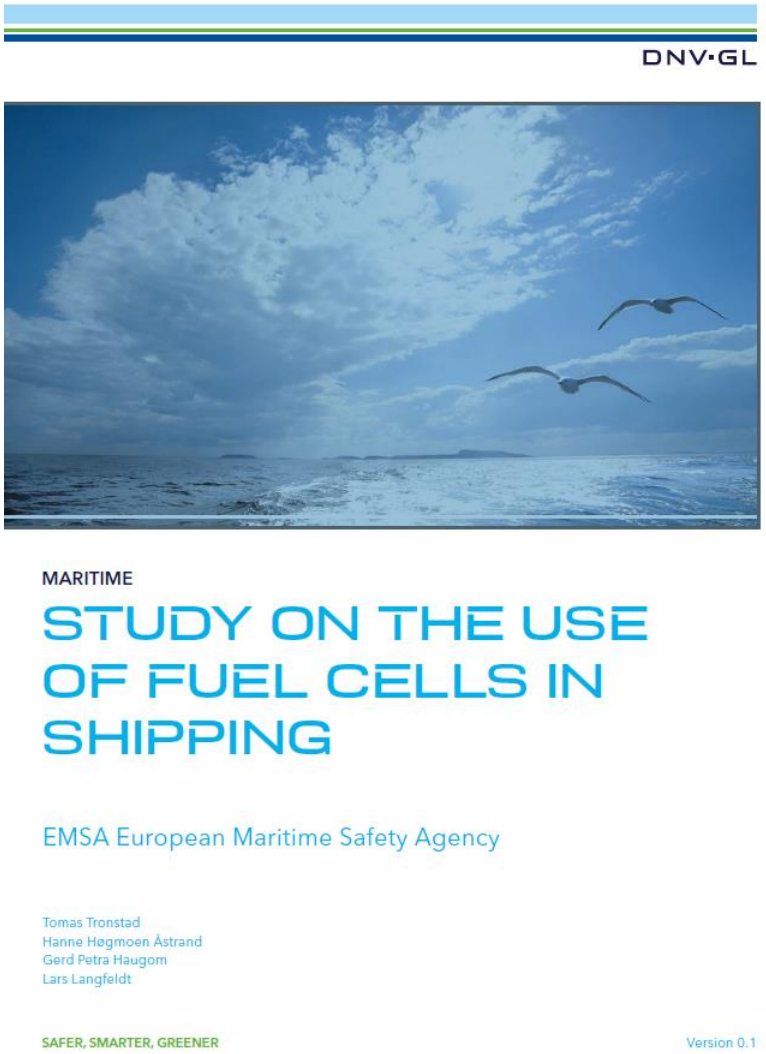
h2boat hydrogen to boat

SME third party dedicated to the laboratory management and to small scale technical study and prototyping of:

- Metal Hydrides hydrogen storage systems
- Fuel Cell+Metal Hydrides coupled systems
- Water Electrolysis+RES coupled systems

FINCANTIERI

STUDY ON THE USE OF FUEL CELLS IN SHIPPING



STUDY ON THE USE OF FUEL CELLS IN SHIPPING

The study was launched to provide the European Maritime Safety Agency (**EMSA**) with a technical assessment of the use of fuel cells in the naval sector. *(January 2017)*
The study is divided into three main sections:-

A - Technology: analysis of major naval research projects and description of the technologies studied

B - Regulations: overview of the main bunkering, storage, distribution and installation basics

C - Safety assessment: The conclusions of the FMEA Workshop held in Hamburg in October 2016 are reported

CONSIDERATIONS

In the following slides some consideration on the three main Fuel Cell technologies identified by DNV are given, from the Fincantieri prospective.

FINCANTIERI

Fonte: www.emsa.europa.eu/news-a-press-centre/external-news/item/2921-emsa-study-on-the-use-of-fuel-cells-in-shipping.html

Proton Exchange Membrane Fuel Cell (PEM-FC)

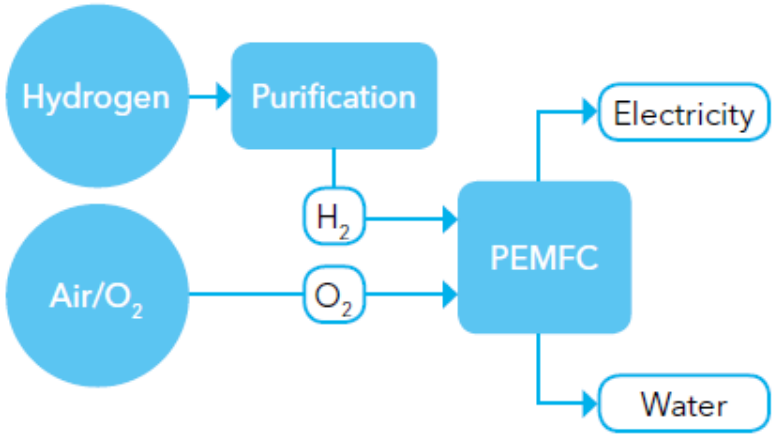


Figure A.22: Flow chart for PEM fuel cell system.

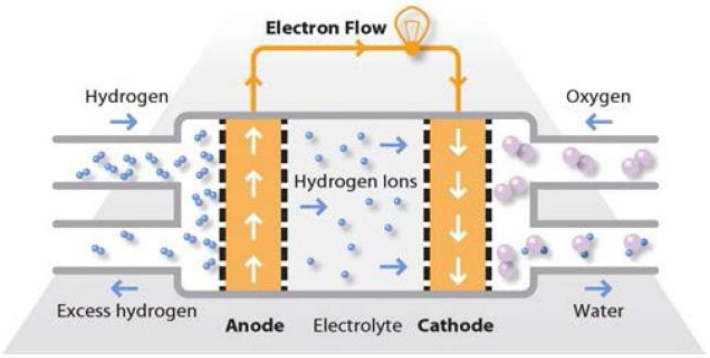


Figure A.21: Schematic of a proton exchange membrane fuel cell (PEMFC) .

The PEM-FC is, in the present study, the technology that has received the highest score in the ranking

- *mature technology*
- *modules size of up to 120kW*
- *a relatively low cost*
- *moderate lifetime*
- *efficiency is 50-60%*

- *water as the only emission and low quality heat (for cogeneration)*
- *extremely pure hydrogen*
- *<u>storage of hydrogen on a vessel (reformer is difficult)</u>*

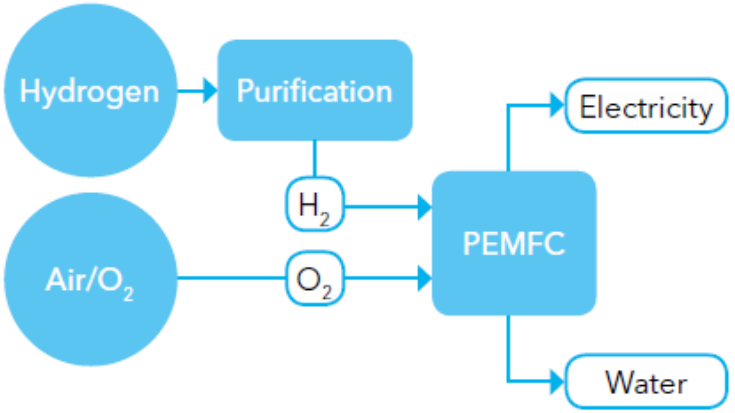


Figure A.22: Flow chart for PEM fuel cell system.

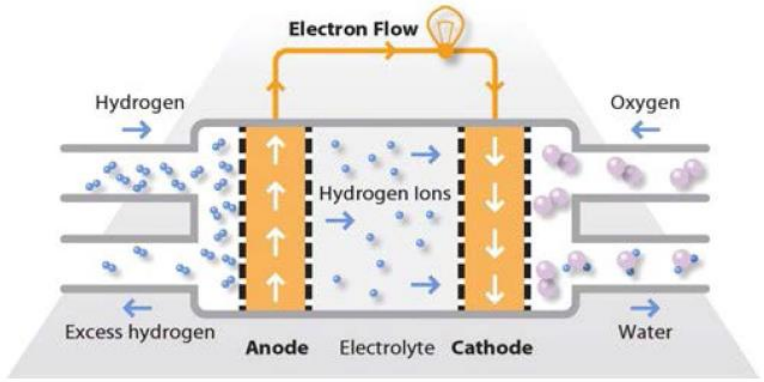


Figure A.21: Schematic of a proton exchange membrane fuel cell (PEMFC) .

The HT-PEMFC is a technology that is less mature than conventional low temperature PEM

Address some of the problems with the low temperature of the PEM with the same efficiency of traditional PEMFCs

- *reduces the sensitivity towards impurities*
- *simpler, lighter and cheaper reformers*
- *operational temperature of up to 200˚C*
- *heat that can be used for ship internal heating purposes*

- *demonstrated aboard the MS Mariella in Pa-X-ell project 30 kW*
- *lifetime problem*
- *high costs*

Solid oxide fuel cell

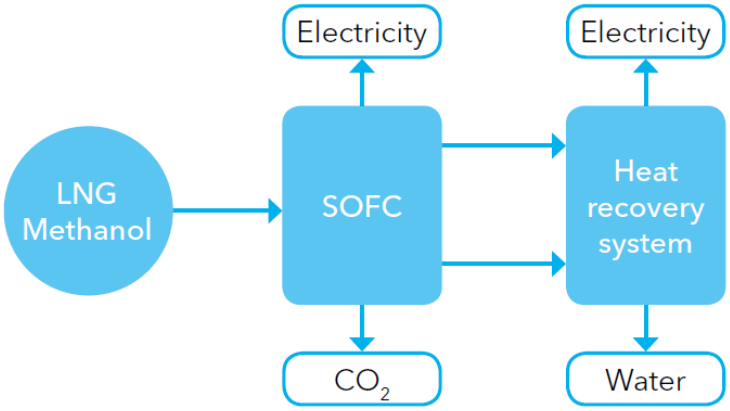


Figure A.30: Flow chart for a solid oxide fuel cell system.

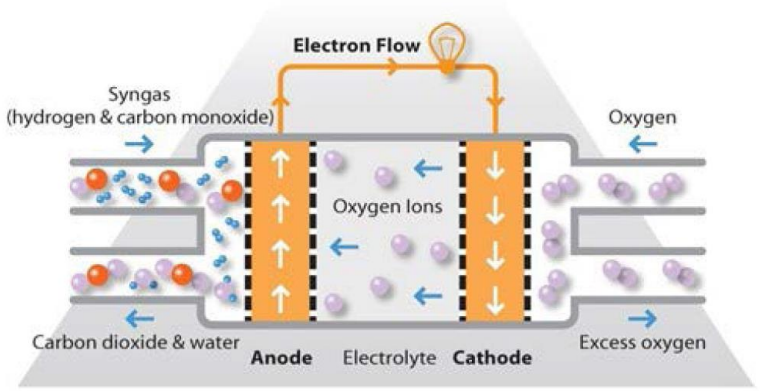


Figure A.29: Schematic of a solid oxide fuel cell (SOFC) .

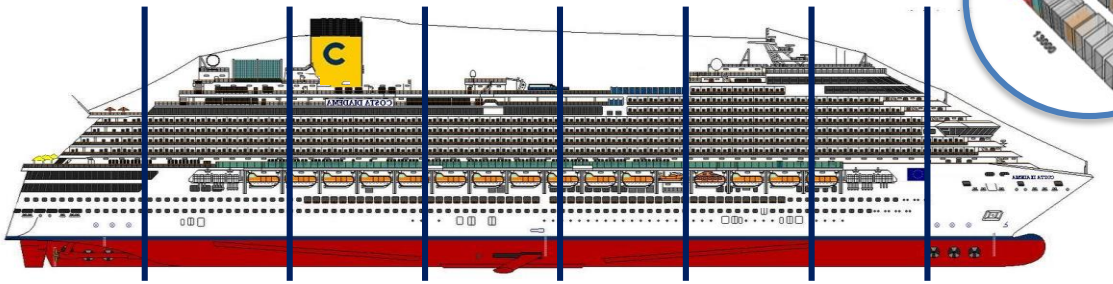
The SOFC is a highly efficient, moderately sized fuel cell but at a early stage of development

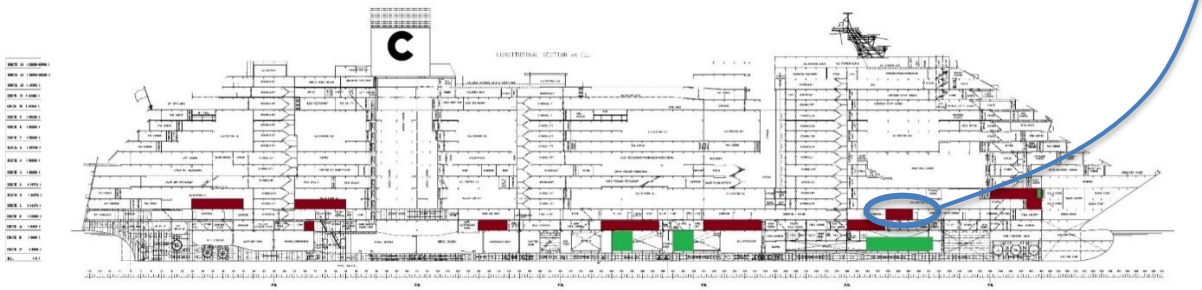
- *with heat recovery the total fuel efficiency can reach about 85%*
- *flexible towards different fuels*
- *hybrid systems*

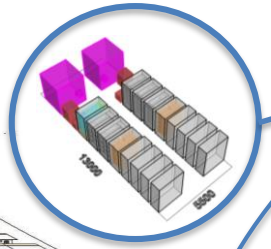
- *high temperature can be considered a safety concern*
- *short life cycle*
- *high costs*
- *start-up times*

Onboard Distributed Generation

Distributed energy generation for ship application:
Energy analysis and Feasibility study for Passenger ships





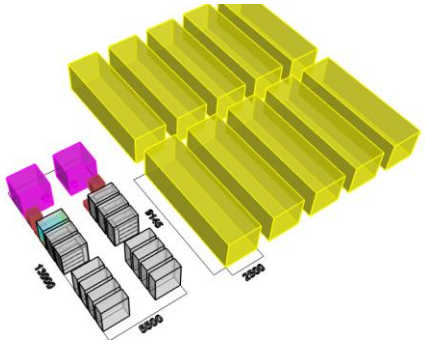


Example of PEM Machinery Room
2x600 kW power
BOP considered

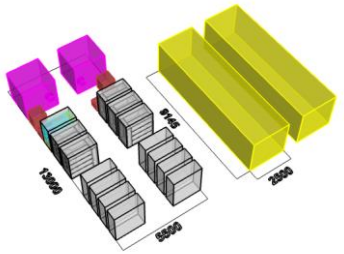
HYDROGEN STORAGE IS THE KEY CHALLENGE

Compressed H2?
Metal Hydrides?
LNG reformers?

Example of LNG reformer for 1.2 MW size PEM system



LNG SR using SOA land technology (10x30ft)



LNG ATR using SOA automotive technology (prototypes, 2x30ft)

FINCANTIERI

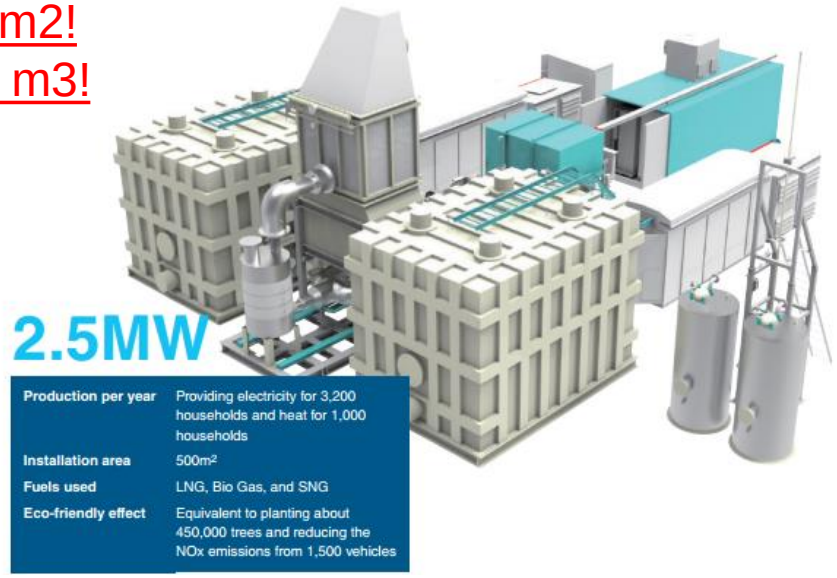
Fuel Cell ship application - vision

Gyeonggi Green Energy
(Hwaseong, Gyeonggi-do)
December 2013 / **58.8 MW**

Based on POSCO Energy MCFC fuel cell systems

It mean that the technology is ready and that fuel cells are on the verge to be installed onboard ships?
NO

500 m2!
3500 m3!



Many characteristic have to be considered for marine application of fuel cells:

- **H2 Storage**
- **Weights**
- **Volumes**
- **System and BOP onboard distribution**
- **IMO Rules and National Rules**
- **Electric distribution**

These are only technical aspects,
COST will be the most important driver

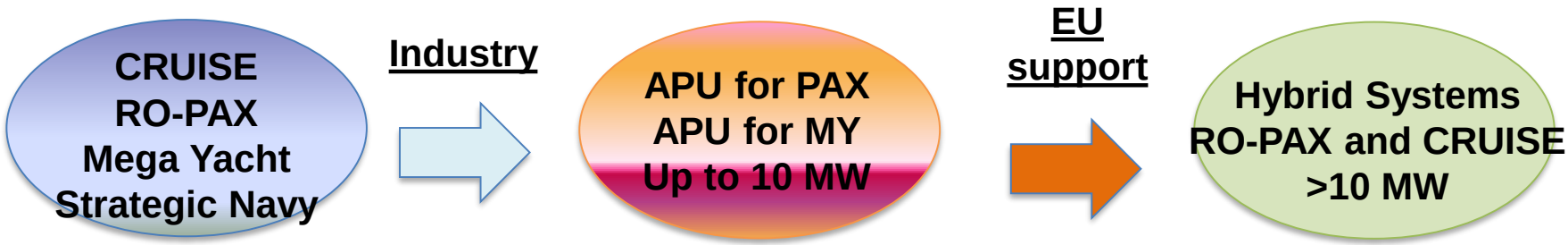
FINCANTIERI

Is possible to power a Full Electric Ship only by Fuel Cells?

NO

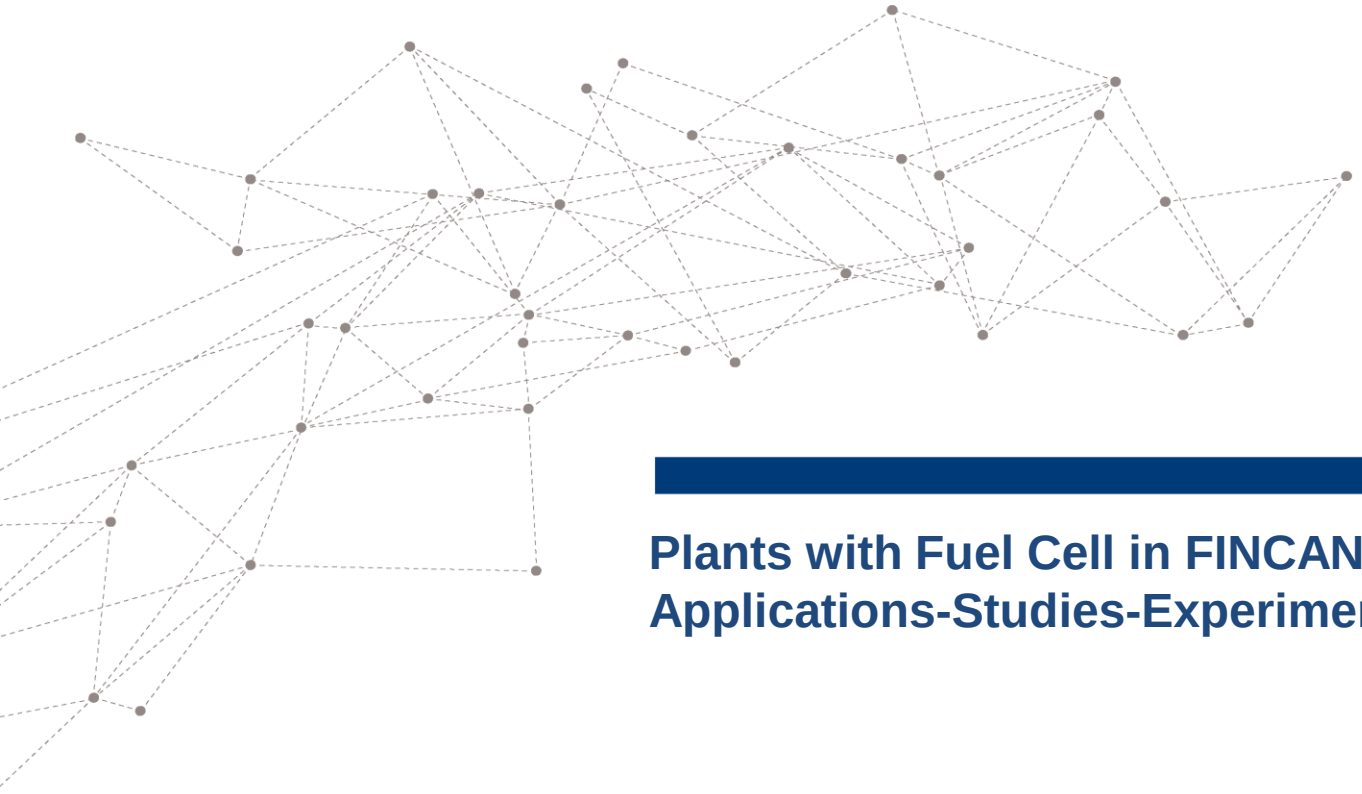
It is not possible to have a modern design ship (e.g. Ferry or PAX ship)
with the same performance in terms of payload, # passenger, speed and so on..

Traditional ships IMO emission control High impact in ports CO_2 Emission control	Few users, Local H_2 production, Limited impact on emission	Large number of users, Port infrastructure required, Local grid connection, High impact on emission
Diesel Electric ships (Prototype and studies)	**FC AUX system for particular Operational Profile and particular ship types** (Zero Emission, Protected Area)	**Hybrid system FC /Batt/ ICE for Propulsion and AUX** (ECA Zones, Port/Harbor Motorway of the Sea,…)



FINCANTIERI

Thank you for the attention



FINCANTIERI
The sea ahead

Plants with Fuel Cell in FINCANTIERI
Applications-Studies-Experiments and Future Projects

Gerardo Borgogna

Hydrogen Europe

Valencia 15 June 2017