Safety of hydrogen as ship fuel

HFC

Mónica Alvarez Cardozo

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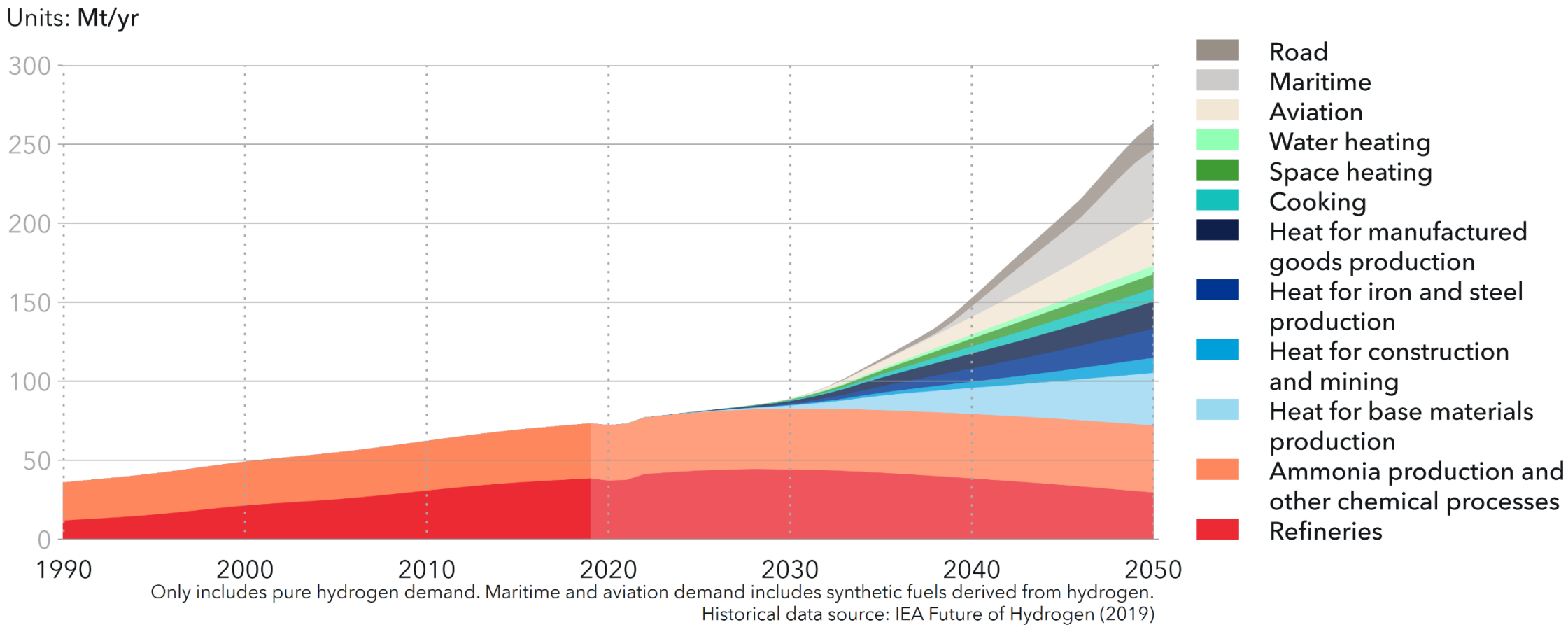
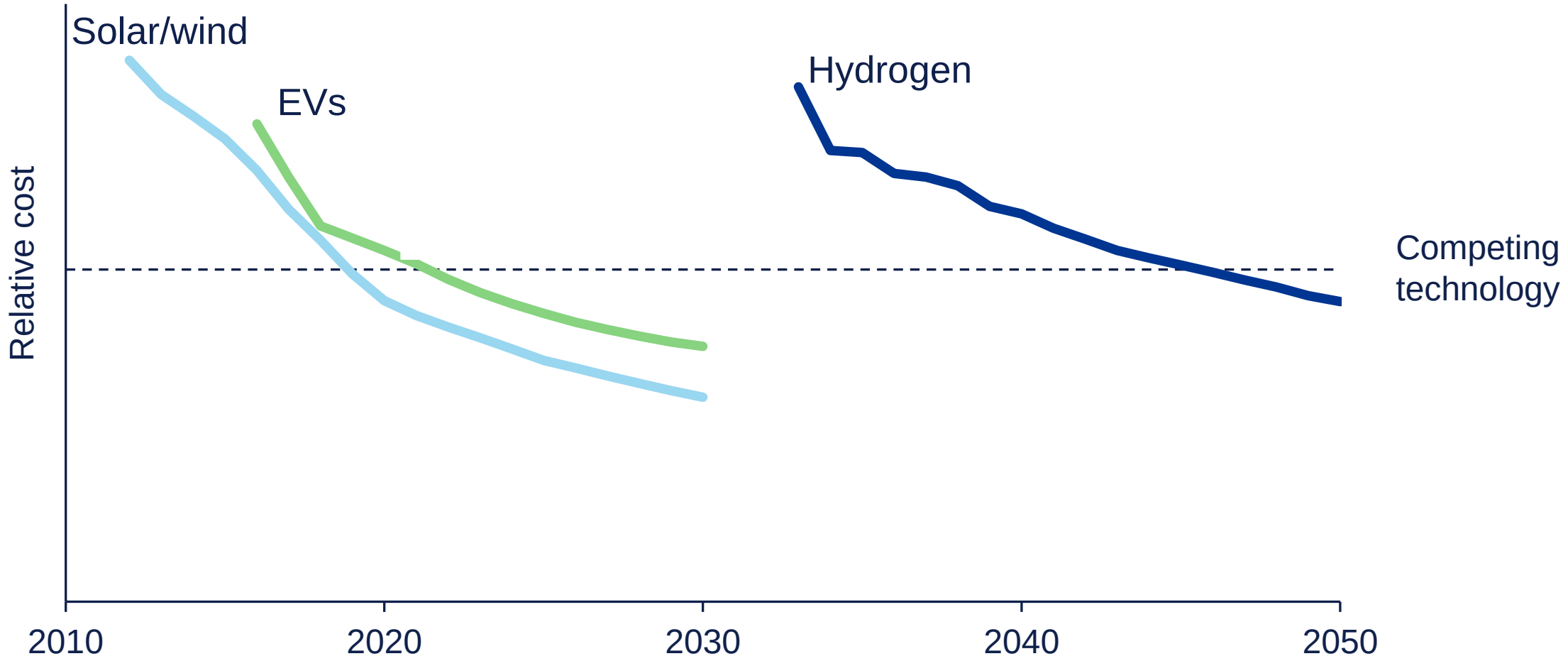
Hydrogen - late but strong growth: 5% of global energy demand in 2050

World hydrogen demand by sector

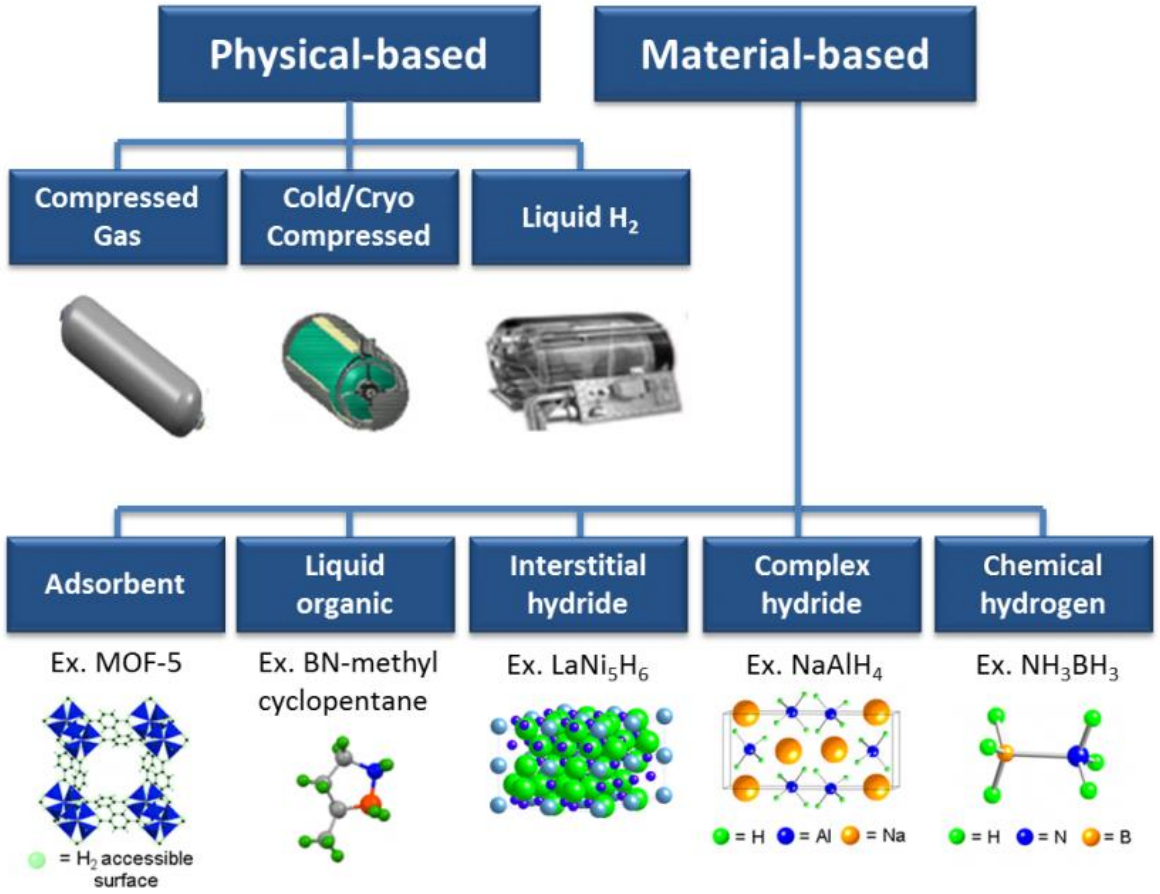


Only includes pure hydrogen demand. Maritime and aviation demand includes synthetic fuels derived from hydrogen.
Historical data source: IEA Future of Hydrogen (2019)

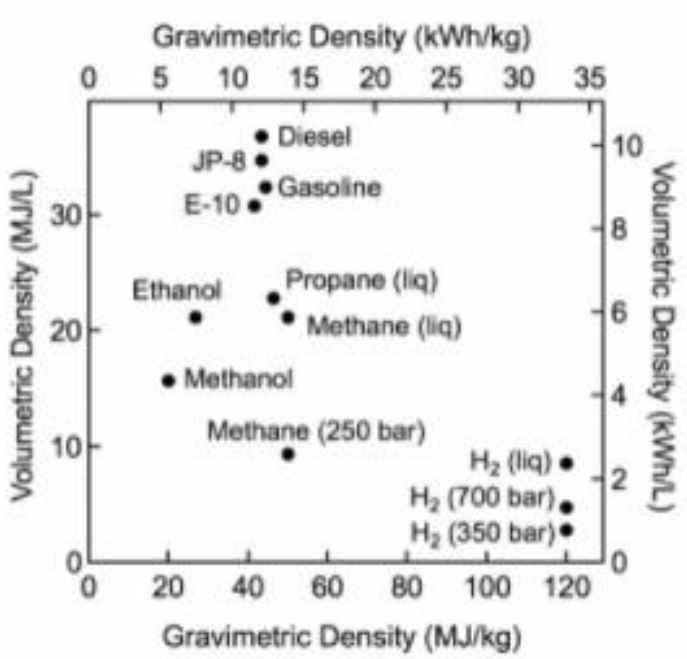
Hydrogen scaling too late



H_2 Storage



Source: US DOE

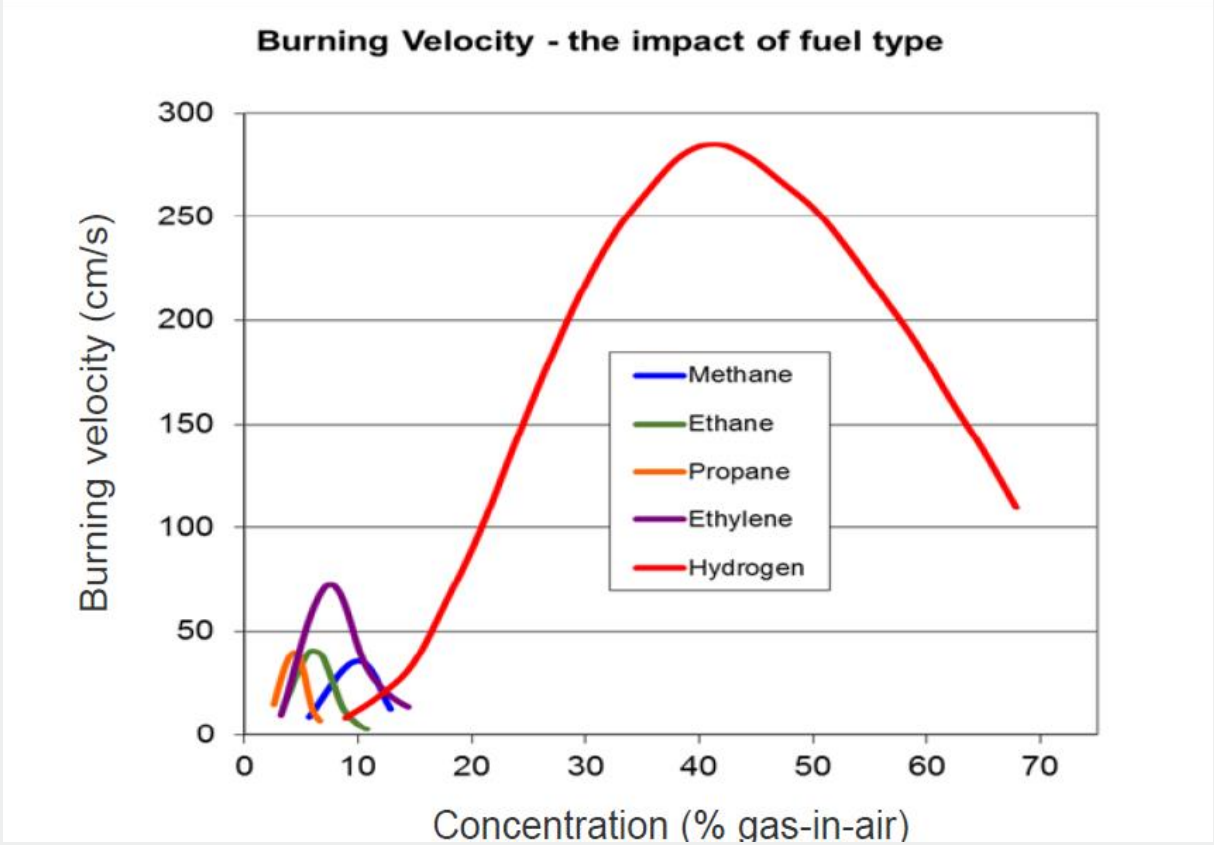


Source: US DOE

Loss of containment

Ignition and explosion potential is largely worse

- Flammability & ignition energy
- High flame speeds at a wider range
- Pool /Jet Fires, BLEVE
- Liquid and solid oxygen formation
- Spontaneous ignition autoignition (shockwave)
- Deflagration to Detonation Transition (DDT)
- Risk of detonation with hydrogen is larger than for hydrocarbons



Hydrogen Explosions in Practice – comparison with Methane

Hydrogen (20%vol layer)

Methane (10%vol layer)

Innovative inherently safe solutions are needed

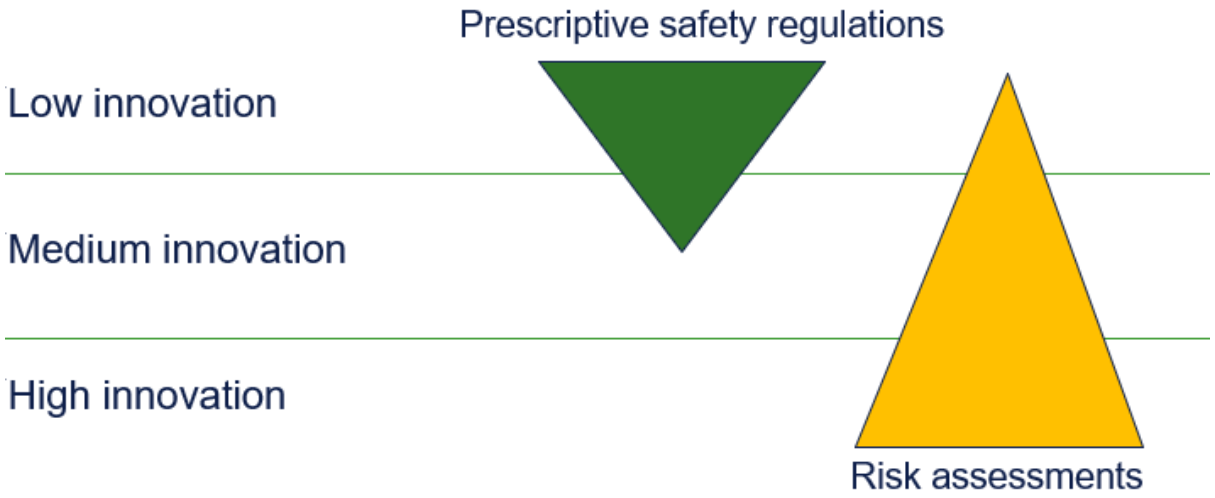
Lack of maritime experience	Enclosed & semi-enclosed spaces	No double barriers e.g., CH_2
New players and increased number of projects	H_2 quantities	Both frequency and consequence increases
Crew competence/ human factor	Limited possibility to use distance as a safety barrier	Containerized swappable solutions

IGF Code

- ✓Goal and functional requirements
- ✓Interim guidelines for fuel cells
- ✓Safety equivalency
- ✓Alternative design

"*For other low-flash point fuel, compliance with the functional requirements of this code must be demonstrated trough alternative design*"

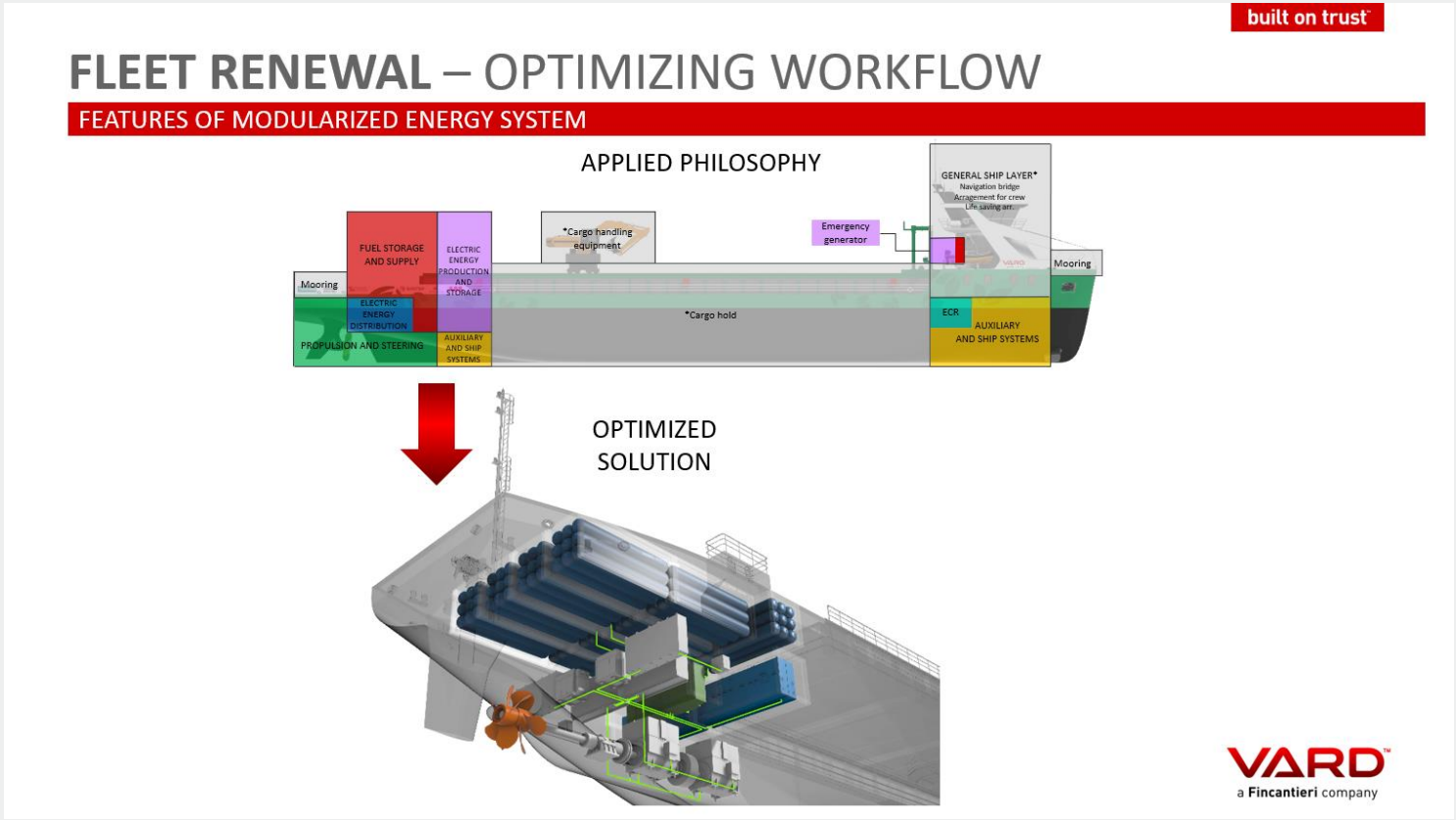
Alternative design approach



DNV UK Spadeadam

Liquefied hydrogen release phenomena for model development and validation

DNV JDP / Green Shipping Program



- Vard Engineering Brevik AS
- Statkraft AS
- Trosvik Maritime AS
- HK Shipping Group AS
- Hexagon Purus ASA
- Flowchange AS
- Sintef Ocean AS
- ABB AS
- DNV AS

HySHIP

MarHySafe Phase 2

Dealing with the knowledge gaps for LH_2 and CH_2

Planned activities:

- validate the Handbook based on practical user experience, including partners and ongoing demonstration projects
- enhance and validate risk modelling tools for hydrogen as ship fuel based on test results and Phase 1 conclusions
- pre-calculate risks
- asses hydrogen bunkering safety
- evaluate approaches/methods for safety distances and hazardous zones
- propose guidance and training material for first users

Summary

Hydrogen safety is on a critical path for decarbonization of shipping.

Cost-effective, inherently safe designs need to be developed to allow commercialization and standardization

New designs need to be assessed with fire and explosion safety studies at an early phase

Industrial cooperation, research and large experiments are needed to validate models and safety measures

Decarbonization is urgent and important, but we must take time to do it safely

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monica.alvarez@dnv.com
+47 91515522

www.dnv.com