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13-15 May 2019
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Italian Navy Staff – Submarine Forces

Hydrogen: a future vision from the underwater domain

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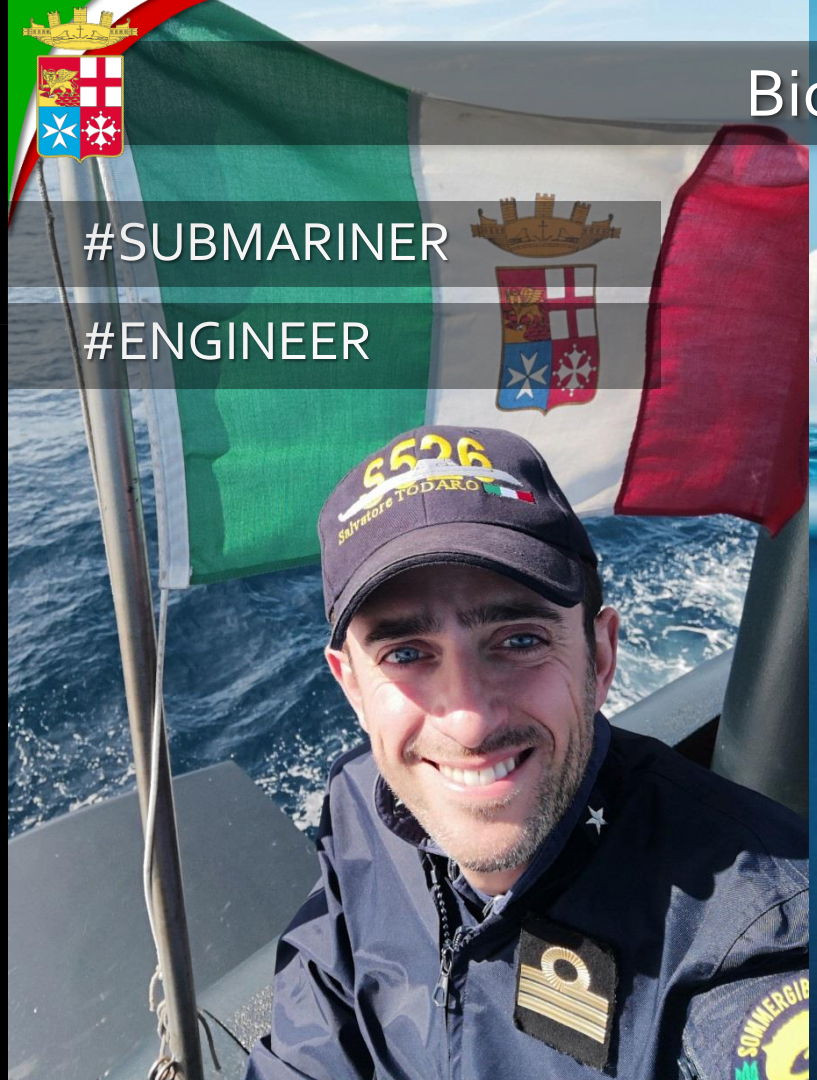
Bio

#SUBMARINER

#ENGINEER



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Agenda

- Energy vector from space to abyss
- Green energy carrier for future applications
- Hydrogen and Italian Submarine Force
- Hydrogen energy storage
- From sea to space
- ITN: leading the change

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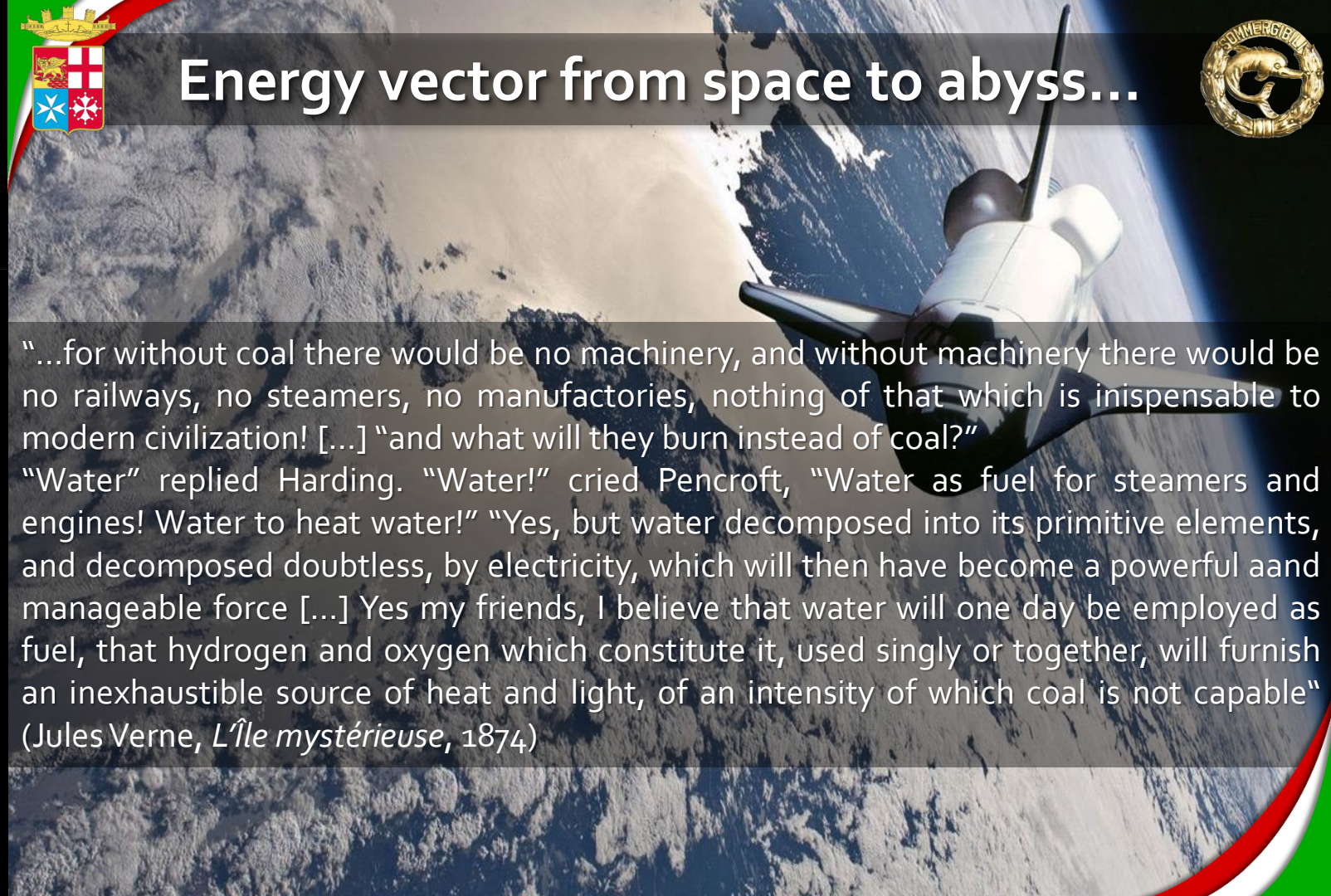
Energy vector from space to abyss…



"…for without coal there would be no machinery, and without machinery there would be no railways, no steamers, no manufactories, nothing of that which is inispensable to modern civilization! […] "and what will they burn instead of coal?"
"Water" replied Harding. "Water!" cried Pencroft, "Water as fuel for steamers and engines! Water to heat water!" "Yes, but water decomposed into its primitive elements, and decomposed doubtless, by electricity, which will then have become a powerful aand manageable force […] Yes my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable"
(Jules Verne, *L'Île mystérieuse*, 1874)

Green energy carrier for future applications

- Completely green and unlimited worldwide
- Highest energy density per mass
- Low energy density per unit volume
- Hydrides hydrogen storage
- High pressure hydrogen storage
- Hybrid pressure-hydride storage

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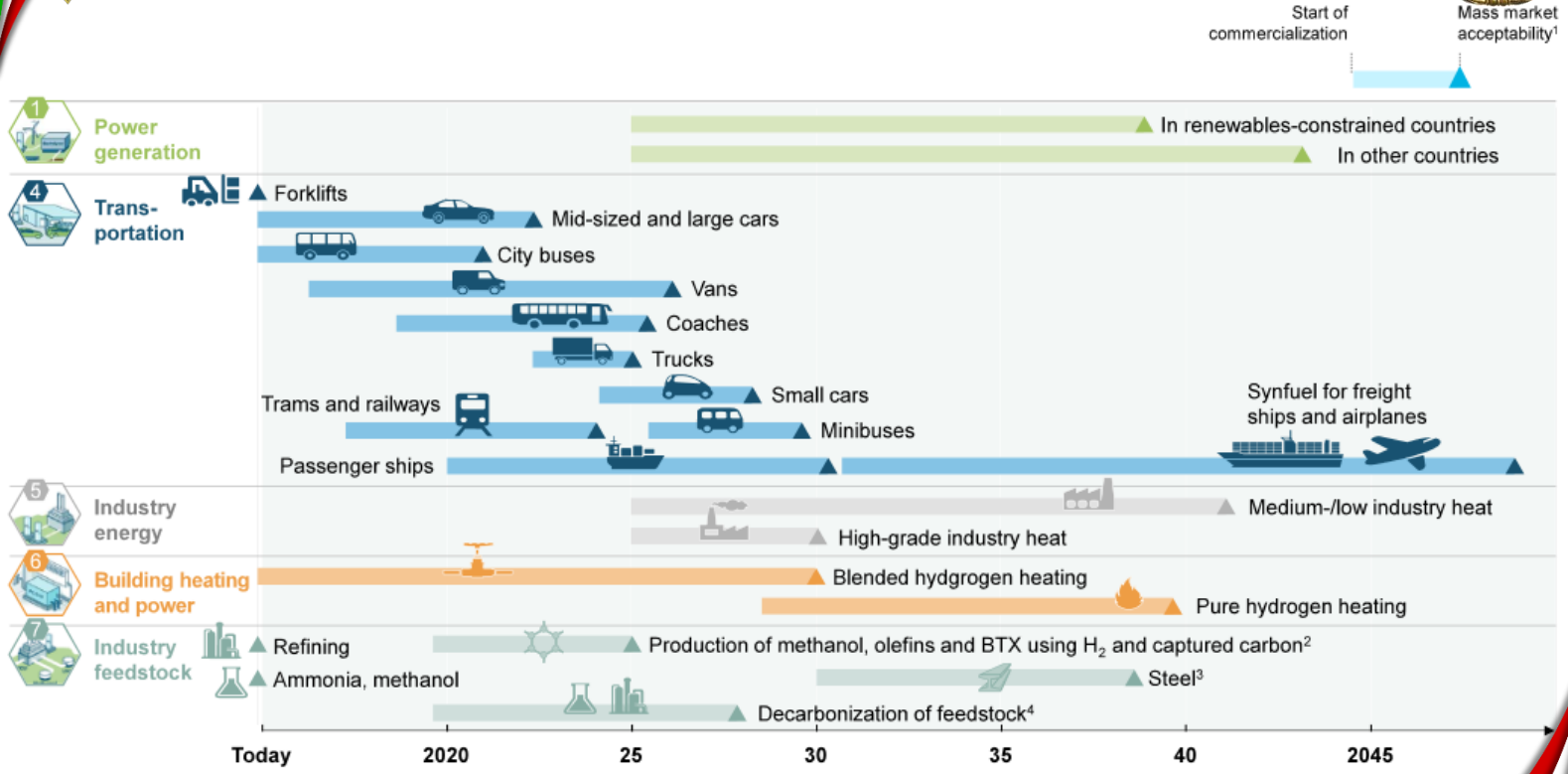
Green energy carrier for future applications



1 Mass market acceptability defined as sales >1% within segment in priority markets
2 Market share refers to the amount of production that uses hydrogen and captured carbon to replace feedstock
3 DRI with green H_2, iron reduction in blast furnaces and other low-carbon steel making processes using H2
4 Market share refers to the amount of feedstock that is produced from low-carbon sources
SOURCE: Hydrogen Council
McKinsey & C

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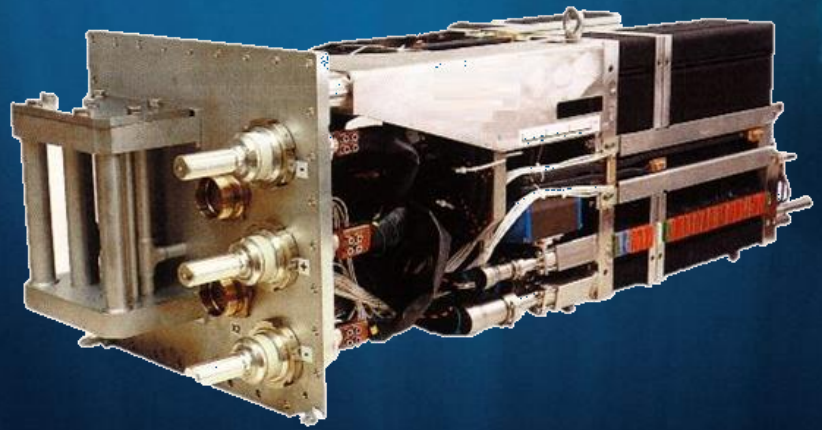
Hydrogen and Italian Submarine Force



80.000 Kg H2

100 refillings

100.000 hrs FC

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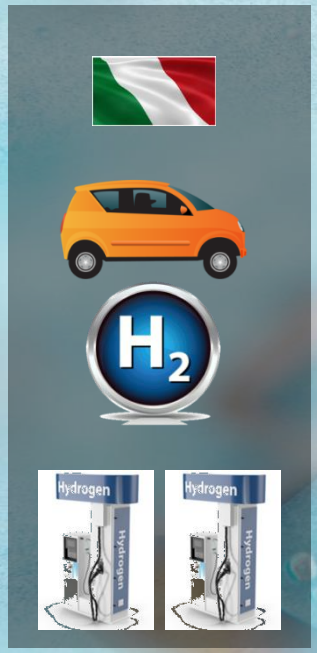
Hydrogen and Italian Submarine Force



Leading the national hydrogenization process

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Hydrogen and Italian Submarine Force

Capability to garantee the logistic support worldwide

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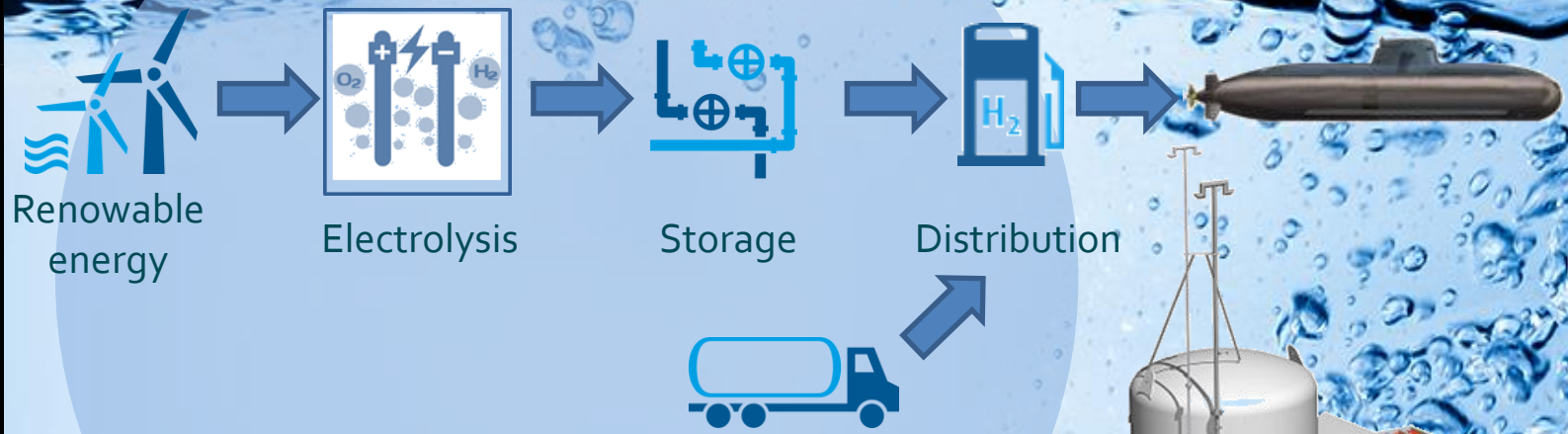
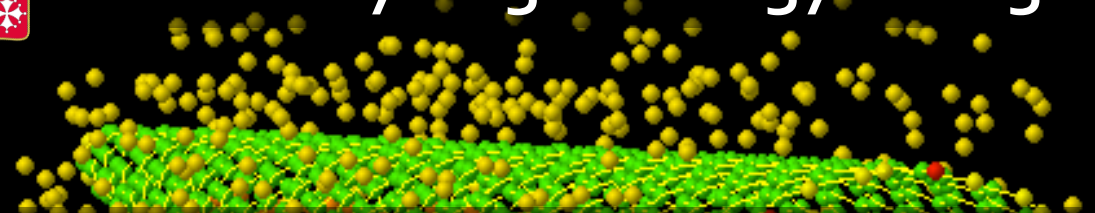
Hydrogen and Italian Submarine Force



Green H2

Circular economy of hydrogen

Hydrogen energy storage



Metal hydride (MH) storage:

- Simplicity and safety
- Low equilibrium pressure (potential for > 8 wt. % H_2 and > 90 kg/m3 H_2 -storage capacities at 10-60 bar)
- High weight
- Temperature depending (absorbtion/desorption)
- Aging of metal hydride (lifetime) and costs
- Contamination

Hydrogen energy storage

High pressure storage:

- High volume needed
- High pressure container
- Large amount of energy needed for the compression
- Material, design and safety concern
- Embrittlement and diffusion
- Certification required

Possible future development:

hybrid pressure-hydride storage

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...from Sea to Space

Submariners in Space

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ITN: leading the change

- Confident about hydrogen as energy vector for the future
- Regulations required
- R&D activity iot promote new feasible solutions

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Thank you for the attention

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