Zero-emission technology for RVs of the future and perspectives:

A Look into the Crystal Ball.

The real and complex reality of DECARBONISATION

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Vigo, 12th June. 2024

RV: The best platforms for alternative fuels testing

The investment of Public Marine institutes has a direct return effect on technological development

56 m RESEARCH VESSEL
(DC GRID+ BATTERIES)

70 m OCEANOGRAPHIC VESSEL
(e-HYBRID | 200 kWh)

84 m OCEANOGRAPHIC VESSEL
(LNG DUAL FUEL)

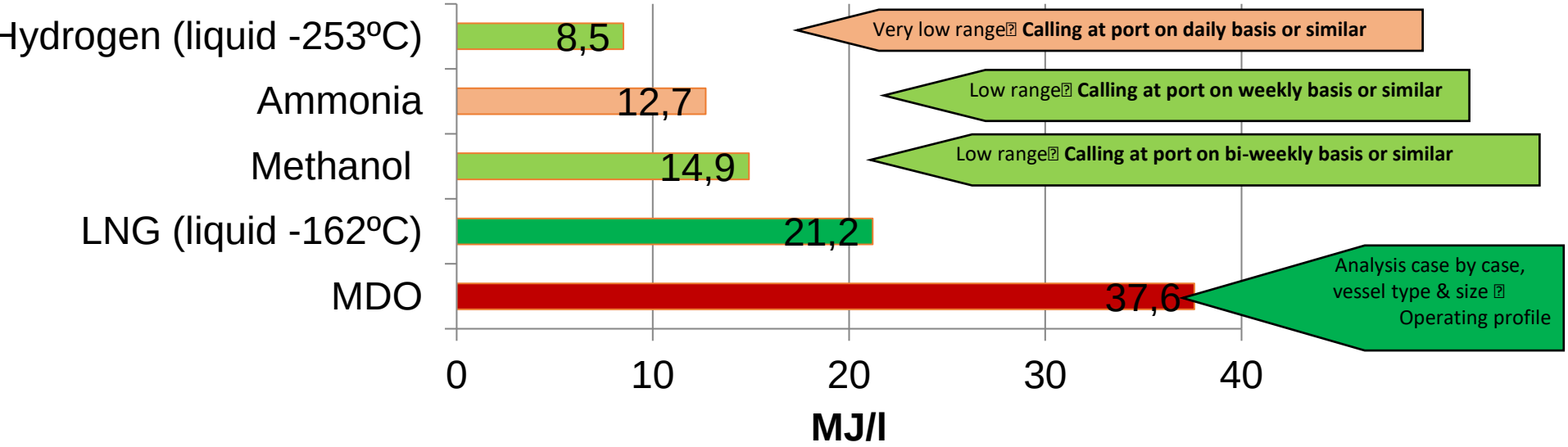
70 m OCEANOGRAPHIC VESSEL
(DC GRID e-SYSTEM)

RV is not a cargo vessel. There is some available EXTRA space

79 m RESEARCH VESSEL
(GAS-OIL METHANOL DUAL FUEL+ batterries)

ENERGY DENSITY

Fuel energy efficiency: Energy per liter content volume



Environmental factors: GAS EMISSIONS BURNING FOSSIL FUELS

- ✓ Local emissions of Sox and Nox and Particulate Matter impacting human health
- ✓ GHG emissions with associated global warming impact

Respiratory

Carcinogen

Ozone

SOX
NOX
PARTICULATE MATTER

THE REDUCTION OF THESE EMISSIONS WILL HAVE A CLEAR **LOCAL** IMPACT

GREENHOUSE GAS	GLOBAL WARMING POTENTIAL (GWP)
CARBON DIOXIDE (CO_2)	1
METHANE (CH_4)	29,8
NITROUS OXIDE (N_2O)	273

THE REDUCTION OF THESE EMISSIONS WILL HAVE A GLOBAL WARMING REDUCTION IMPACT

OPERATIONAL PROFILE

RESISTANCE CURVE

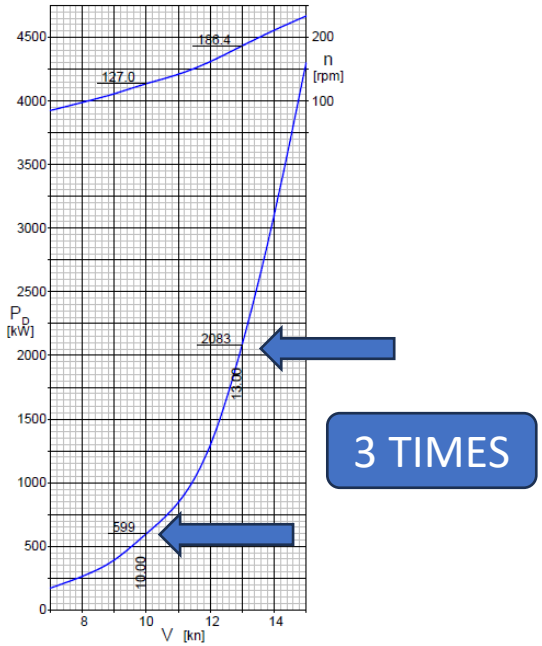
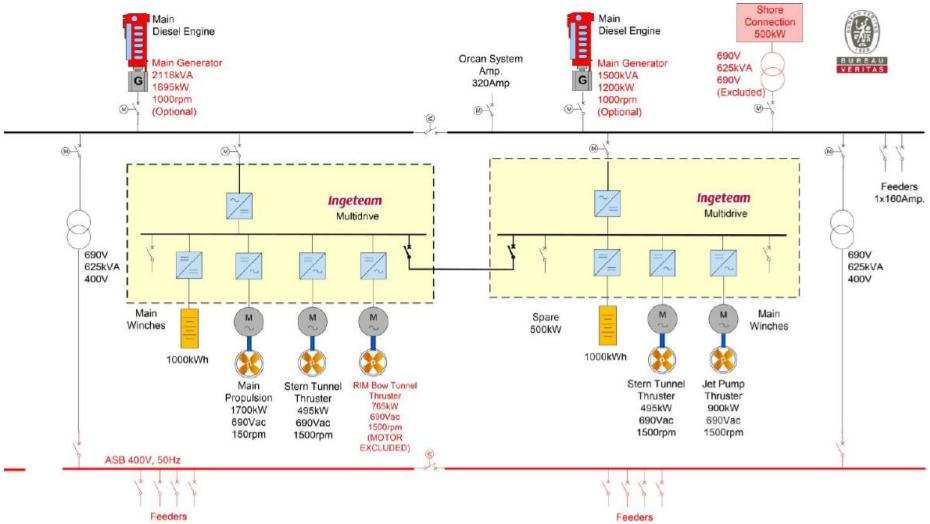


Fig. 48. Propulsion prediction – hull version with the long drop keel

3 TIMES

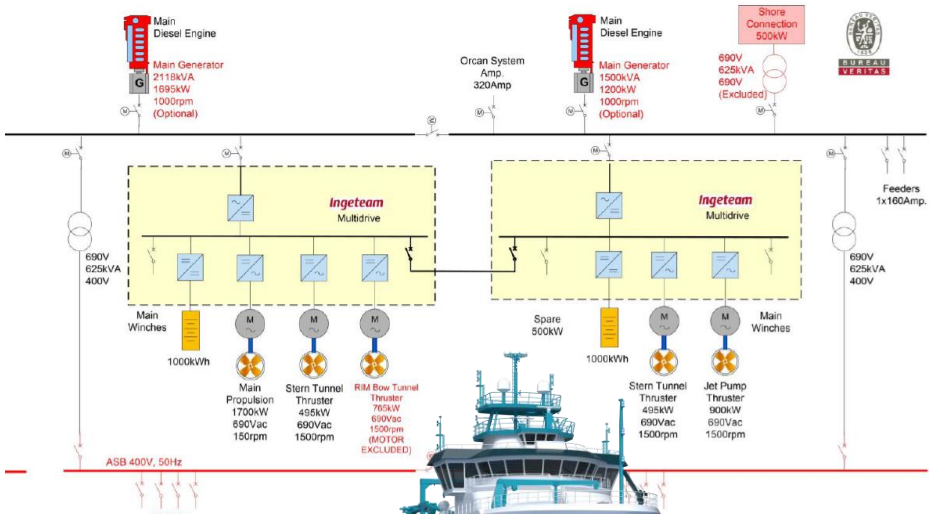


THE KEY:

AS FEW GENERATORS AS POSSIBLE STARTED AT THE HIGHEST POSSIBLE LOAD

OPERATIONAL PROFILE

THE NEW TREND: DC GRID CONNECTED TO BATTERY SYSTEMS



BATTERIES IN WORLD-CLASS RVS?: YES, HOWEVER… ONLY FOR….

Spinning Reserve operation mode:

In the event of a sudden load demand the required Energy is instantly supplied by the batteries. There is no need to start an additional Genset .

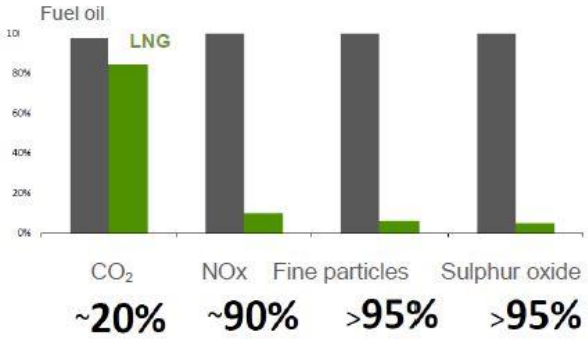
Dynamic Performance operation mode :

EMS ensures that the load ramps are performed softly, always keeping the Engines within their most efficient operating margins

UTM
UNIDAD DE TECNOLOGÍA MARINA

CSIC

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA 1914



LNG: THE TRANSITION FUEL FOR DECARBONIZING

New Spanish research vessel: a diesel-LNG hybrid approach

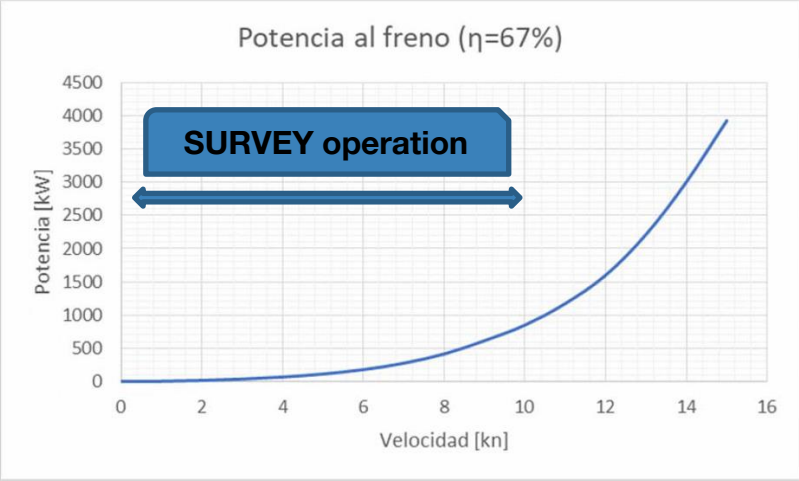
e Buen

LNG: WELL PROVEN AND EXTENDED TECHNOLOGY

LNG: OPERATIONAL PROFILE

OPERATING PROFILE WITH LNG

STATE OF THE ART Global Research Vessel with a range over 45 days



Decision making, the use of Dual fuel gen-sets:

1.- MDO for transit, higher speeds and areas far away from the coast

2.- Lower emissions fuel for:

a.- Approach to port

b.- At least 10 days of operation with speeds below 10 kn. Environmentally sensible areas like Antartida or Mediterraneum sea

Research

LNG: 10 DAYS AT MAX. 10KN

LNG: SPACE AVAILABILITY

LOCATION OF LNG TANKS TO AVOID INTERFERENCE WITH OCEANOGRAPHIC OPERATIONS

AREA FOR RESEARCH OPERATION

2x 56 m3 LNG IMO C tanks

LNG PROS AND CONS

¿WHY the use of LNG as dual-fuel in RVs?

Summarazing:

- ✓ Clear **advantages for the ENVIRONMENT**
- ✓ Fuel gas **BETTER PRICE** (expected)
- ✓ And the **NECESSARY TECHNOLOGY IS AVAILABLE** and has been well proven for many years in methane tankers (which transport LNG and also use it as fuel) with a very **favorable safety records.**

OUR EXPERIENCE WITH LNG

CHALLENGES

- ✓ Higher CAPEX higher initial investment
- ✓ Loss of cargo space: LNG capacity
- ✓ Bunkering infrastructure is still in the early stages
- ✓ Competence / Training
- ✓ Slight methane slip from engine when running on low load

BIOFUELS: TRANSITION FUEL FOR DECARBONIZING

BIO-FUELS: HVO

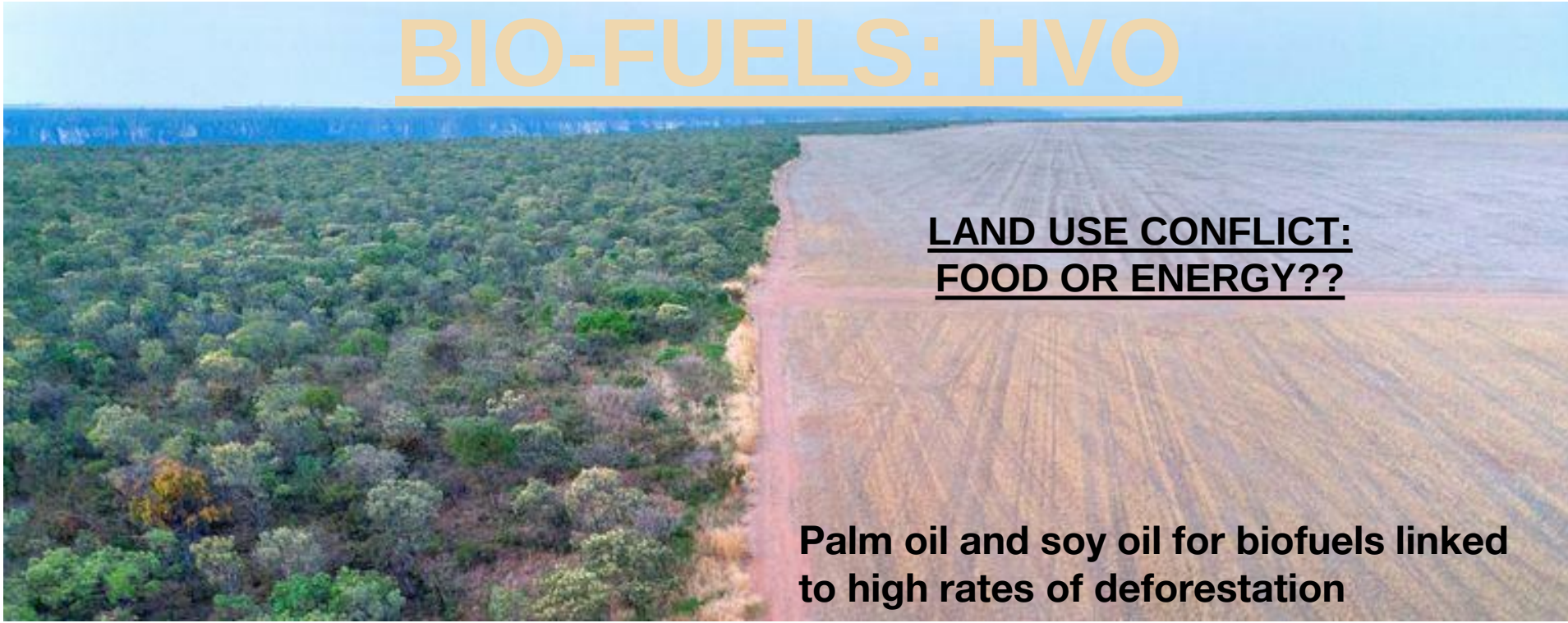
FEWER EMISSIONS/ GOOD PERFORMANCE/ USER-FRIENDLY FOR HUMANS

- ✓ **LIMITED RAW MATERIALS CONTRIBUTING TO THE DEFORESTATION OF THE PLANET.**
- ✓ **MANUFACTURING BIO-FUELS REQUIRE HIGH ENERGY CONSUMPTION.**
- ✓ **ALTHOUGH CO2 AND SOOT EMISSIONS ARE GREATLY REDUCED, NITROGEN AND PARTICULATE EMISSIONS REMAIN ALMOST THE SAME.**

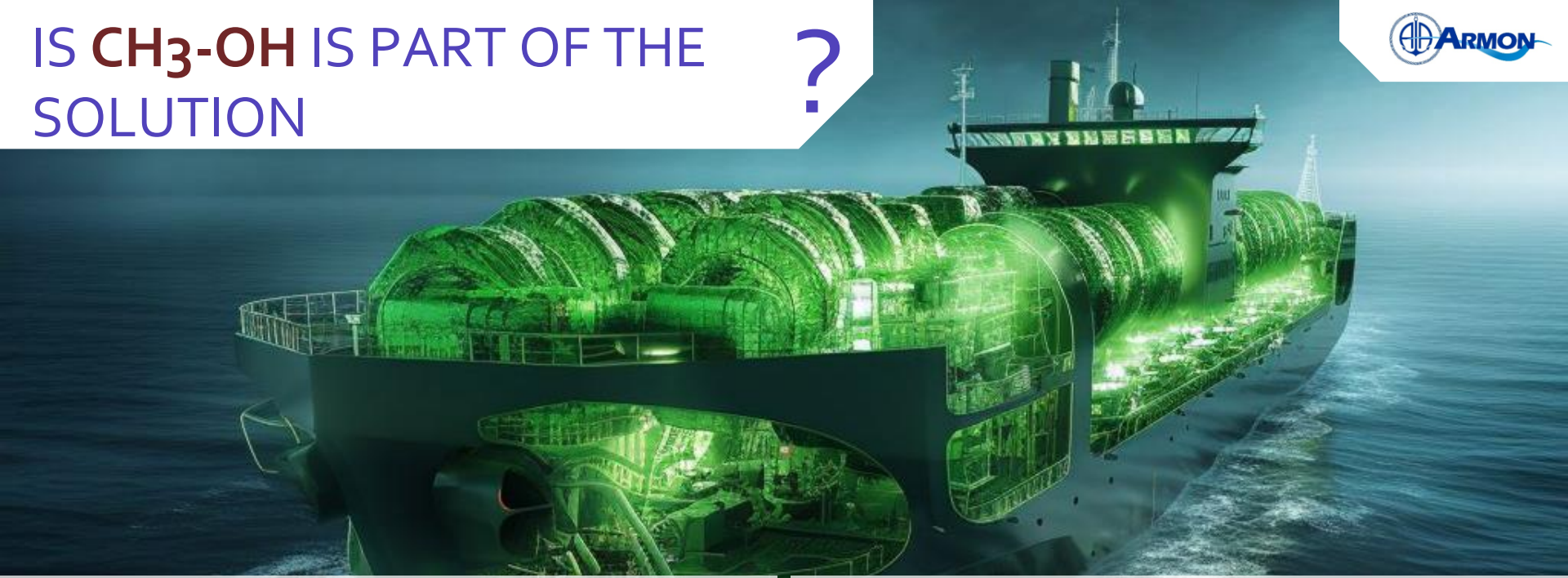
HVO IS A BIOFUEL MADE FROM HYDROGEN-TREATED OILS AND FATS FROM VEGETABLE AND ANIMAL SOURCES

DERIVA DE LA BIOMASA, MATERIA ORGÁNICA EN PROCESO BIOLÓGICO

BIOFUELS: TRANSITION FUEL FOR DECARBONIZING



IS CH_3-OH IS PART OF THE SOLUTION ?



OVERVIEW OF METHANOL AS FUEL

- Methanol is a promising alternative fuel for the shipping industry

- It is safe, cost-competitive, and can meet more restrictive emissions regulations

BENEFITS ? DECARBONISATION

- Methanol is sulfur-free, making it an attractive alternative to traditional fuels

- Interest in methanol as a fuel has grown in the shipping industry

New Dutch RV: a diesel-methanol- battery hybrid approach

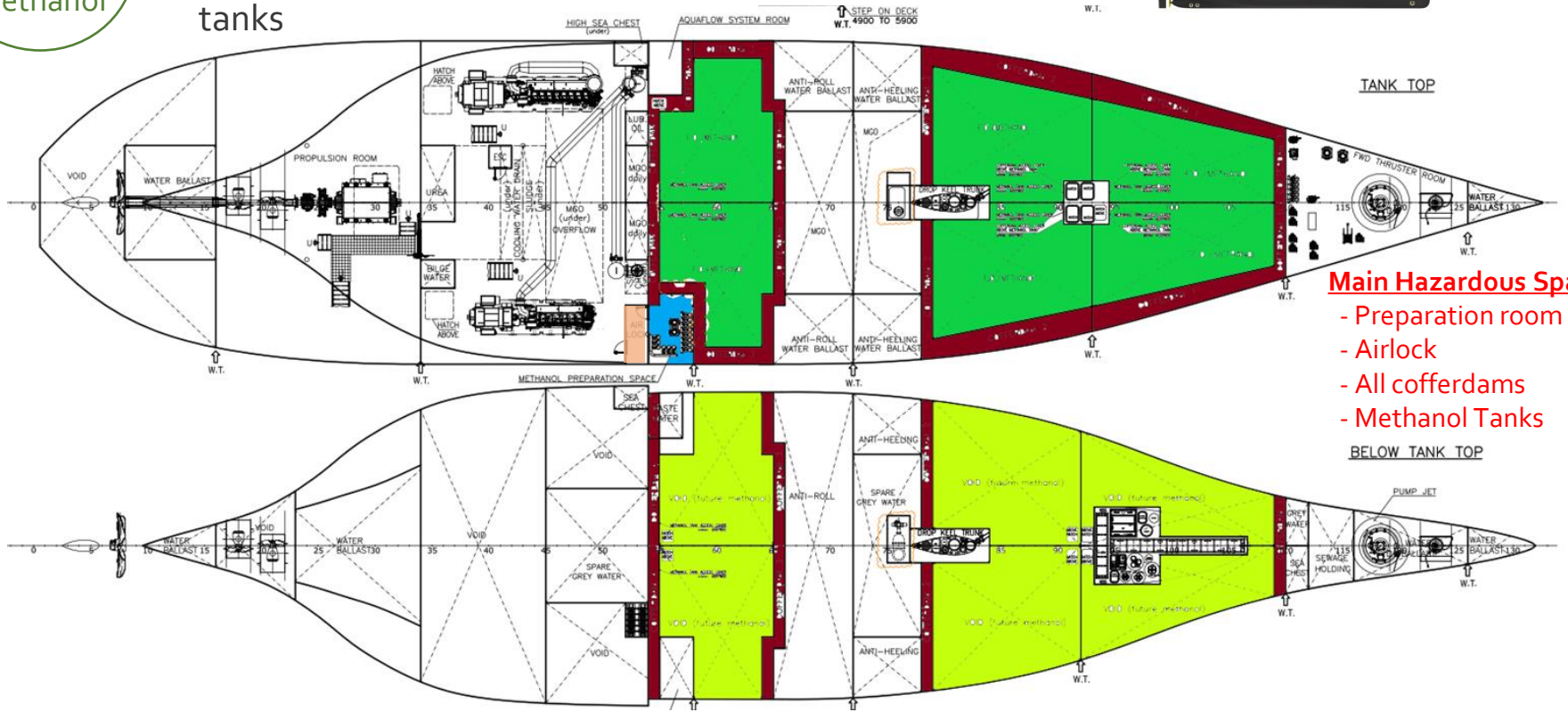
State of the art RV:

- LOA _____ 79,97 m
- B moulded _____ _____ 17,00m
- Speed _____ 12,00 knots
- POB _____ 47 persons
- Diesel-Methanol Electric Propulsion (2x ABC 1,200 ekW + 1.695 ekW)
- Other particulars:
  - ✓ The ship is prepared to use methanol as a carbon-neutral fuel METHANOL READY: 225 m3
  - ✓ 2x Battery packs of 1,000 kWh each)

CH3-OH
Methanol

TANK LAYOUT

Liquid at Environment Temperature □ estructural tanks



Main Hazardous Spaces:
- Preparation room
- Airlock
- All cofferdams
- Methanol Tanks

MGO = 224 m³ | FO & METHANOL = 388 m³ | FUTURE METHANOL = 240 m³ (TOTAL = 852 m³)

Methanol: possibility of application in the decarbonization of RV fleet

✓ **CHALLENGES**

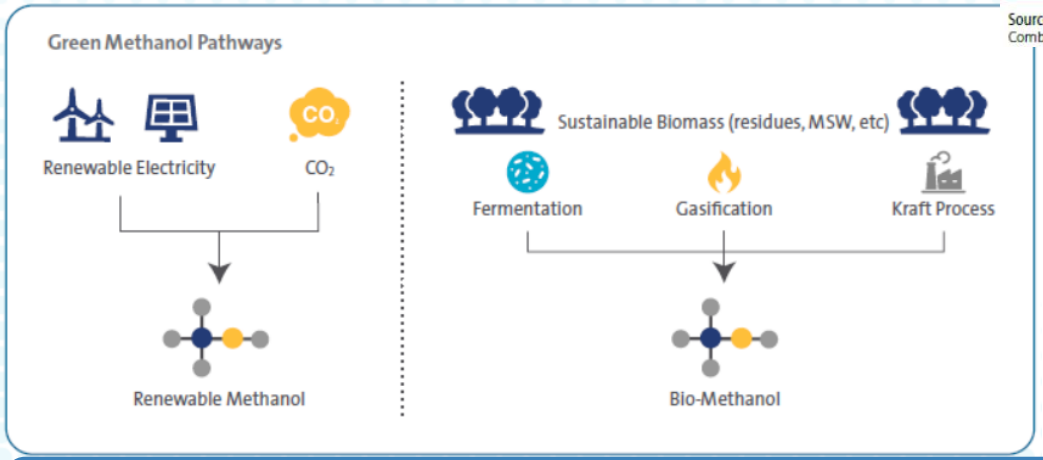
- **Higher CAPEX** □ higher initial investment
- **Loss of cargo space: COFFERDAMS SURROUNDING**
- Bunkering infrastructure is still in the early stages
- Fuel costs, still some uncertain
- Competence / Training
- Very low flash-point: 11ºC. High flammability.
- Invisible flames when burns
- Toxic and poisonous

The price of synthetic methanol must compete at competitive levels as studies show methanol prices will be higher in comparison with other synthetic fuels.

Green methanol production and Bunkering

Green methanol is one of the most promising carbon neutral fuels for the long-term in a decarbonization scenario

Source: Stena Lines, MAN
Combustion emission reductions when compared to heavy fuel oil



Negligible and expensive production

LOGISTIC PROBLEM:
Where shall we bunker in an Indian Ocean Research Campaign????

BETTING ON THE MEDIUM TERM:
MIXED USE OF GAS-OIL- METHANOL TANKS FOR A FUTURE COMPLETE INTEGRATION OF METHANOL

World's first hydrogen-powered tugboat:

Tractor - Type TUG (< 500 GT):

- LOA _____ 30,20 m
- $B_{moulded}$ _____ _____ 12,50m
- Bollard Pull _____ > 65 TBP
- Speed _____ 12,50 knots
- **H_2** Capacity _____ **405 kg at 350 bar**
- **Dual fuel engines:**
  - 2x ABC-BEHYDRO 12V DZD
  - 2000 KW/engine at 1000 rpm

Expected range (running on H_2):

- **8-9 hours**

(at transit speed of 7-8 knots, > 100 km)

ARMON's Tug in-house design (& CMB for H_2 equipment)

ARMON EXPERIENCE: "hydrogen in compressed form is only applicable to small ships operating in very short ranges that can refuel frecuently"

✓ **CHALLENGES**

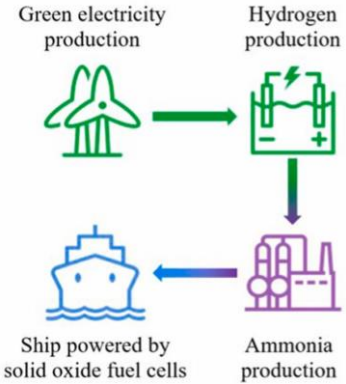
- **HYDROGEN IS DANGEROUS.**
- **HYDROGEN 25% of energy per liter compared to gas-oil.**
- **HYDROGEN: very low range.**
- **High trained crews.**
- **Bunkering logistics virtually non-existent**

DANGEROUS → LOW ENERGY PER LITER → VERY LOW RANGE → COMPLEX USE

Ammonia: possibility of application in the decarbonization of RV fleet

- **Ammonia (NH_3)** as a future potential fuel for shipping .

- Ammonia, sometimes called "the other hydrogen", **is carbon-free.**
- **E-METANO (CO_2+4H_2 → CH_4+2H_2O)**



- Still **some challenges:**
  - The GHG emissions from production of ammonia depends on the production method. Most of the ammonia produced today derives from natural gas, generating larger CO_2 emissions per energy unit.

  - 25% less energy vol. density than methanol

The price of synthetic methanol must compete at competitive levels as studies show methanol prices will be higher in comparison with other synthetic fuels.

Ammonia: possibility of application in the decarbonization of RV fleet

Numerous studies have shown that the increased formation of nitrous oxide (N2O) may offset ammonia's carbon-free advantages, leading to a higher greenhouse gas potential than fossil fuels

Combustion of ammonia in engines can also cause higher nitrous oxide (NOx) emissions

The toxicity of ammonia is a major concern

REMEMBER:

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Ammonia is nowadays dismissed due to the lack of proven technological maturity

Don't waste your efforts by painting chimneys green.

Sustainable changes must be accompanied by **appropriate decisions** on a case-by-case, project-by-project basis.

ANALYSE YOUR OPERATIONAL PROFILE YOUR LOGISTICS AND LIFECYCLE : well-to-tank fuel emissions, close the circle

GET ADVICE FROM ENGINEERS NOT

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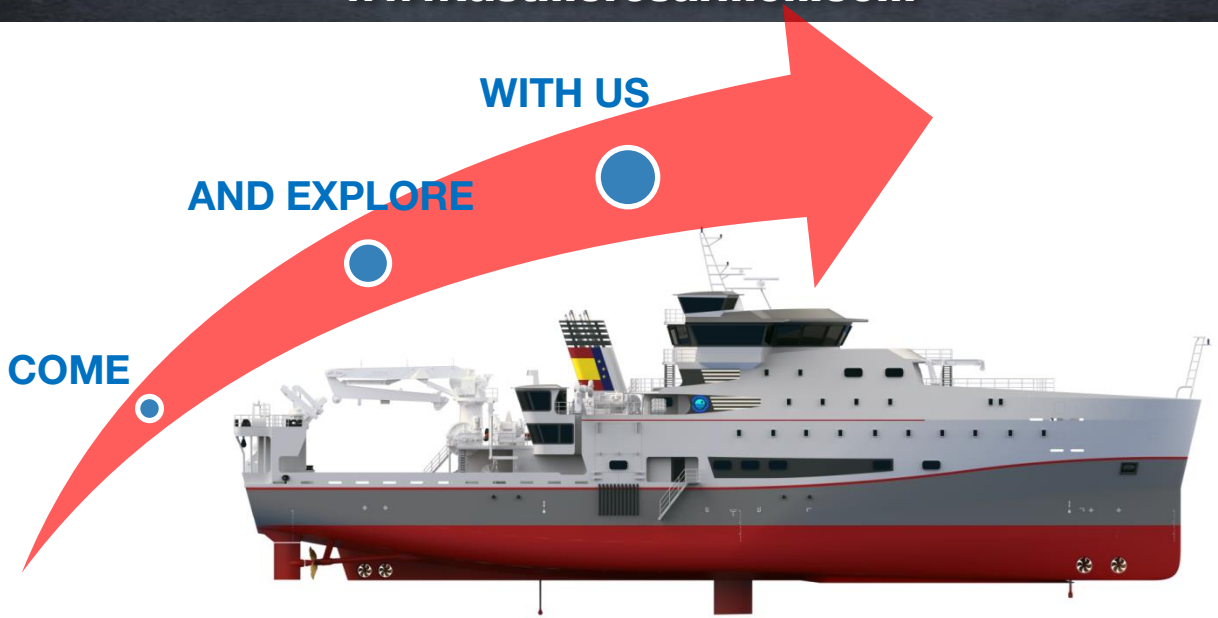

ARMON is also able to provide ALTERNATIVE solutions for:
Ferries, Fishing Boats, Tugs, Offshore, Patrols, Ro-Pax, Merchant, Dredgers,…

THANK YOU!