On the pathway of non-fossil fuels. A dream or a feasible reality?

Andros Maritime Association
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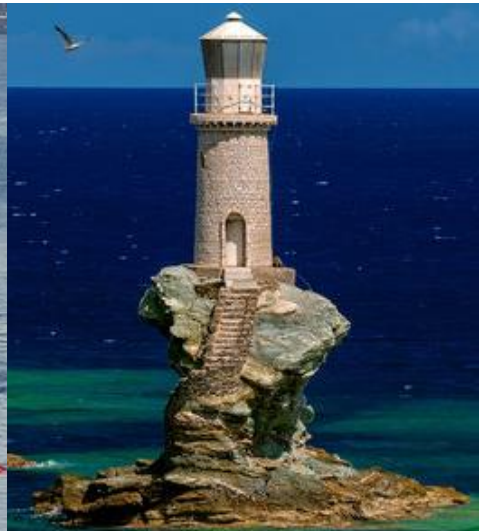


Agenda-Contents

01

Decarbonization

02

IMO GHG Strategy

03

Measures – How to

04

Alternative Fuels

05

Alternative means of propulsion

01

Decarbonization

Decarbonization

- **Decarbonization involves all of the measures and techniques limiting carbon dioxide emissions generated by the production and consumption of energy.**
- **These measures fighting against global warming relate to two main areas.**
- *Search for alternative energy sources which produce fewer greenhouse gases (such as renewable energy and natural gas)*
- *Establish measures to improve energy efficiency.*

The saga of EEDI & EVDI

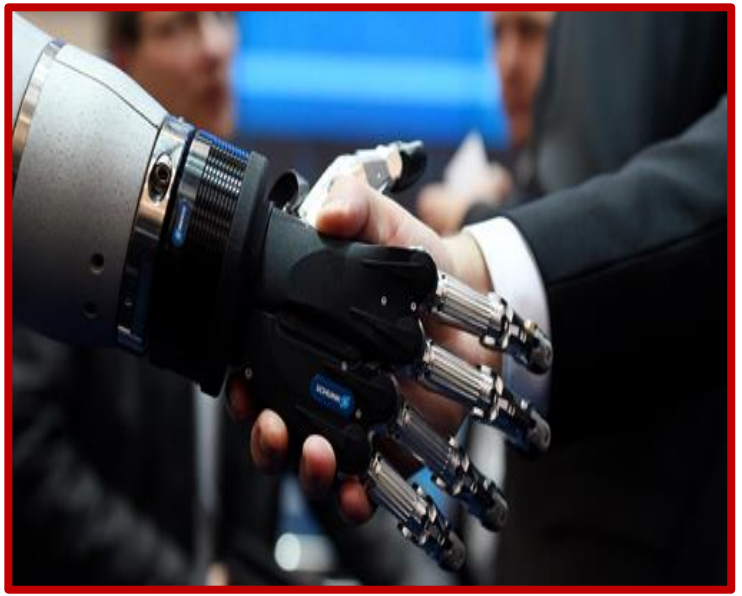
- Today EEDI is the only mandatory instrument to enforce decarbonization.
- Discussion on adoption of Market Based Measures for GHGs was suspended in 2013. An EU ETS may not be a good instrument for reducing GHG emissions
- EEDI regulation is equivalent to imposing an upper bound on the speed. This translates to an upper bound on MCR.
- We may see underpowered unsafe ships. In bad weather they would emit more CO2
- Any bad-inefficient design could be made acceptable by a reduction in "design speed"
- No incentive for more efficient future ship designs. A quantum leap in improving efficiency does not seem likely.

- The formula for EVDI is the same as that of EEDI but valid for existing ships too.
- Design speed generates inaccuracies and differences even between sister ships.
- IMO strategy will be guided by actual emission figures gathered through the IMO's fuel data collection system with an implementation plan by 2023.
- A bunker levy would lead to slow steaming and induce technological changes and logistical measures.
- There is no serious incentive to build or use fuel efficient ships if fuel prices are low

The two D's of modern power

→ Digitalization and decarbonization will shape the power generation industry for years to come

- The world is becoming ever more digitally dependent.
- **Digitalization enables new manufacturing technologies, opening up new possibilities and altering how electricity is used, how power is generated and supplied.**
- New manufacturing technologies, such as 3D printing, is far more flexible. It allows easier production changing consumption of electricity.
- Decarbonization is about climate, but also about fuel supplies and electrification.
- In an era of geopolitical uncertainty, with limited fossil fuel resources, decarbonization is in the hands of digitization. Everything digital is electric. The future of energy is going to be about electricity.



The one billion dollar question

→ Would decarbonization and the shift to alternative fuels discourage the refineries to produce more low sulfur fuel?

INTERNATIONAL
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ORGANIZATION

02

IMO GHG Strategy

IMO GHG Strategy

→ Levels of ambition are as follows:

- Carbon intensity of the ship to decline through implementation of further phases of the energy efficiency design index (EEDI) for new ships (Only Regulation at the moment)
- Carbon intensity of international shipping to decline, through reducing CO2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008
- GHG emissions from international shipping to peak and decline as soon as possible and reduction of the total annual GHG emissions by at least 50% (taking into account an increase of sea transportation) by 2050 compared to 2008

IMO GHG Strategy

→ Possible short-term measures could be finalized and agreed by the MEPC between 2018 and 2023 (no measures until 2023)

- Improvement of the existing energy efficiency framework with a focus on EEDI and SEEMP, taking into account the outcome of the review of EEDI regulations
- Technical and operational energy efficiency measures for both new and existing ships, including consideration of various KPIs to assess the energy efficiency performance of shipping.
- Establishment of an Existing Fleet Improvement Program
- Use of speed optimization and speed reduction
- Research and development on marine propulsion, alternative low-carbon and zero-carbon fuels, and innovative technologies coordinated by an International Maritime Research Board.

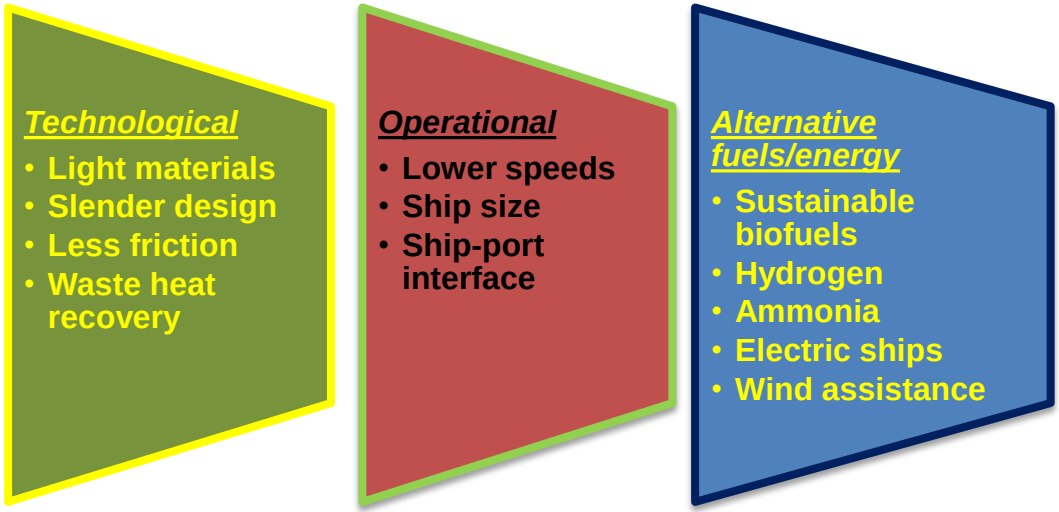
Short term measures

- Energy efficiency improvement focus on EEDI and SEEMP
- Technical and operational energy efficiency measures for both new and existing ships
- Initiate R&D to address marine propulsion and innovative technologies
- Additional GHG emission studies
- Encourage port developments and activities globally to facilitate reduction of GHG emissions
- Consider and analyze the use of speed reduction as a measure
- Consider and analyze measures to address emissions of methane and volatile organic compounds

Mid-term measures

→ Possible mid-term measures could be finalized and agreed by the MEPC between 2023 and 2030, long term ones beyond 2030.

- Further continue and enhance technical cooperation and capacity-building activities such as under the ITCP (Integrated Technical Cooperation Program)
- Implementation program for effective uptake of alternative low carbon and zero-carbon fuels
- Development of a feedback mechanism to enable lessons learned on implementation of measures to be collated and shared through a possible information exchange on best practice
- New/innovative emission reduction mechanism(s), possibly including market-based measures, to incentivize GHG emission reduction



Long-term Measures

→ The final touch of MEPC 72 last April

- Pursue the development and provision of zero-carbon or fossil-free fuels to enable the shipping sector to assess and consider decarbonization in the second half of the century
- Establish new/innovative emission reduction mechanism(s).

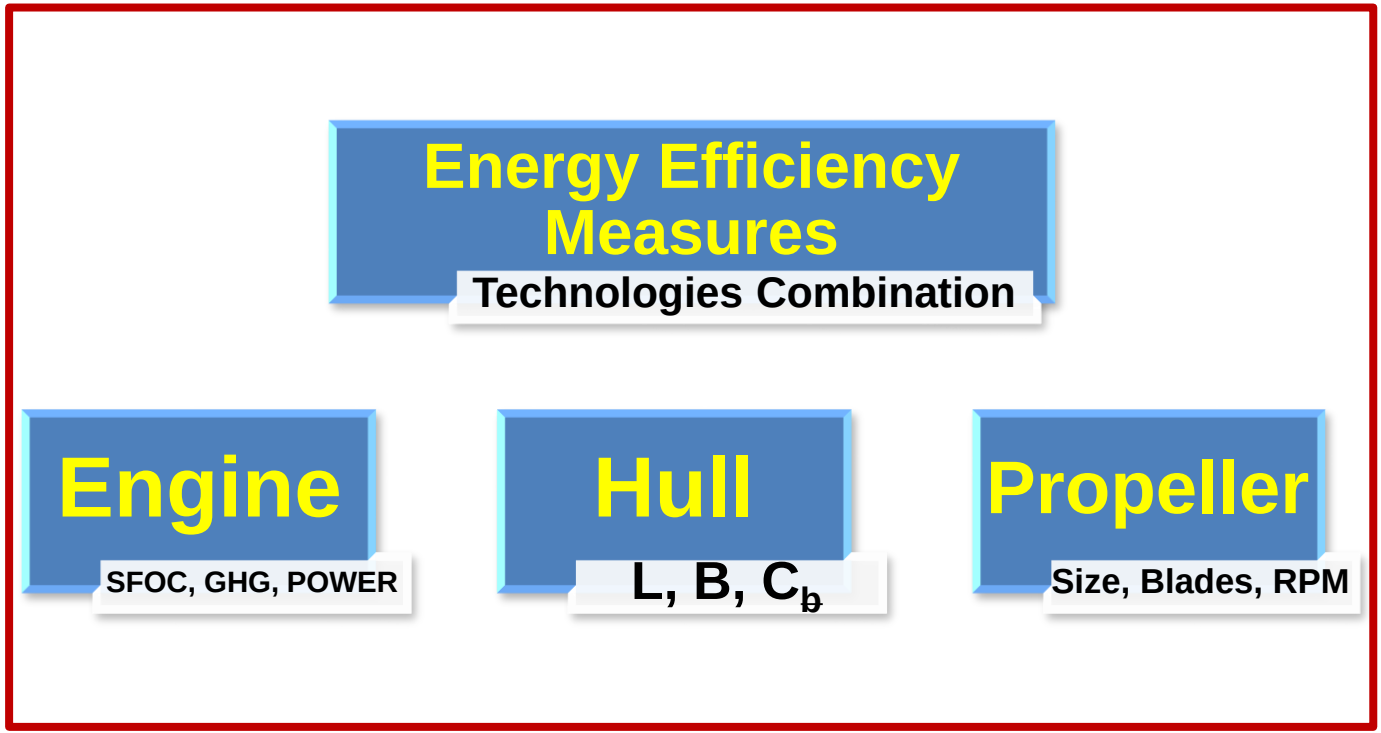
- MEPC 72 agreed on the titles to a series of columns on a spreadsheet, leaving to the next meeting the onerous task of filling in the blanks.
- EU and Pacific nations are pressuring the IMO to fix its gaze on a carbon target in line with temperature rises well below 2 C; emerging economies want financial support to do that.
- Countries are also acutely aware that shipping carries 80 percent of global trade, so any new regulations that affect the freight-carrying fleet must have long lead times.

03

Measures
How to achieve Decarbonization

Energy efficiency improvements

- Engine types & loading
- Fuels
- Sea & engine margins
- Power take-off and its efficiency
- Light running factor



Measures and their potential impact on CO_2 reduction

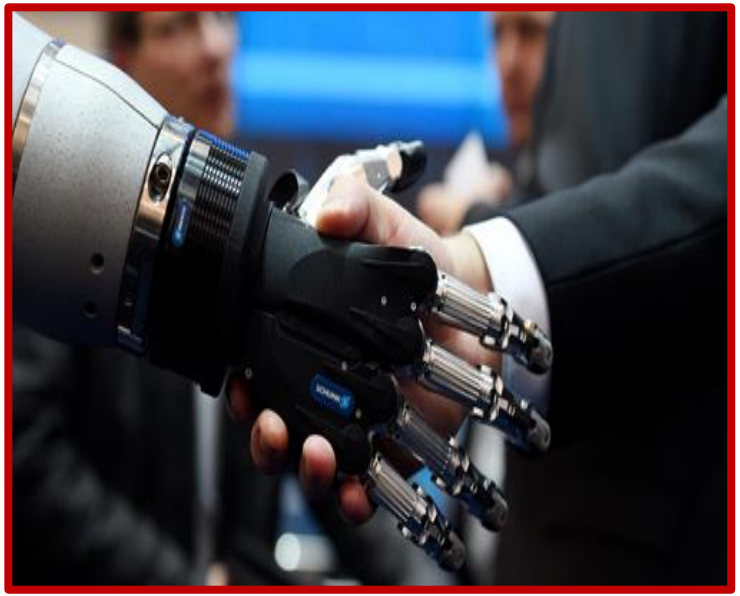
Type of measure	Main measures reviewed	Short description	CO2 reduction
Hull design	Vessel size	Economy of scale	4-83%
	Hull shape	Hydro-optimization	2-30%
	Lightweight materials	High strength steel, composite	0.1-22%
	Air lubrication	Hull air cavity lubrication	1-15%
	Resistance	Resistance reducing devices	2-15%
	Ballast water	Reduce ballast quantity	0-10%
	Hull coating	Distinct types of coating	1-10%
Power & propulsion	Hybrid propulsion	Hybrid electric power	2-45%
	Power system	Variable speed electric power	1-35%
	Propulsion efficiency devices		1-25%
	Waste heat recovery		1-20%
	On board power demand	Auxilliary power (lighting)	0.1-3%

Type of measure	Main measures reviewed	Short description	CO2 reduction
Alternative fuels	Biofuels		25-84%
	LNG		5-30%
Alternative energies	Wind power	Kite, sails/wings	1-50%
	Fuel cells		2-20%
	Cold ironing	Electricity from shore	3-10%
	Solar power	Solar panels on deck	0.2-12%
Operation	Speed optimization	Operational speed,reduced speed	1-60%
	Capacity utilization	Fleet management	5-50%
	Voyage optimization	Weather routing	0.1-48%
	Other operational measures	Trim optimization, RBM	1-10%

Eco-efficient technologies

→ Advanced digital assistance and control of shipping

- New digital navigation equipment and systems
- Better integration of navigation information
- New non-fossil propulsion systems
- Automatic anti-collision systems
- Cyber Internet – Big data – Performance
- Automatic docking and sail away
- Shore based control and operation
- Navigation by computers – autonomous ships

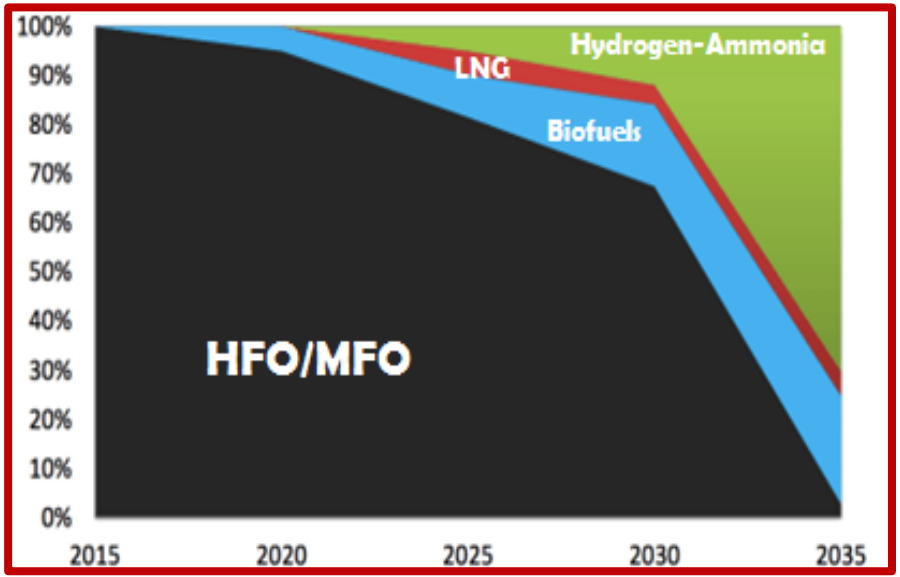


04 Alternative Fuels

Studies nominate ammonia fuel enabling carbon-free shipping by 2035

→ Fuel mix evolution between 2015-2036 for 80% carbon reduction: 70% ammonia / hydrogen, 3% heavy fuel oil biofuels (22%) and LNG (5%),

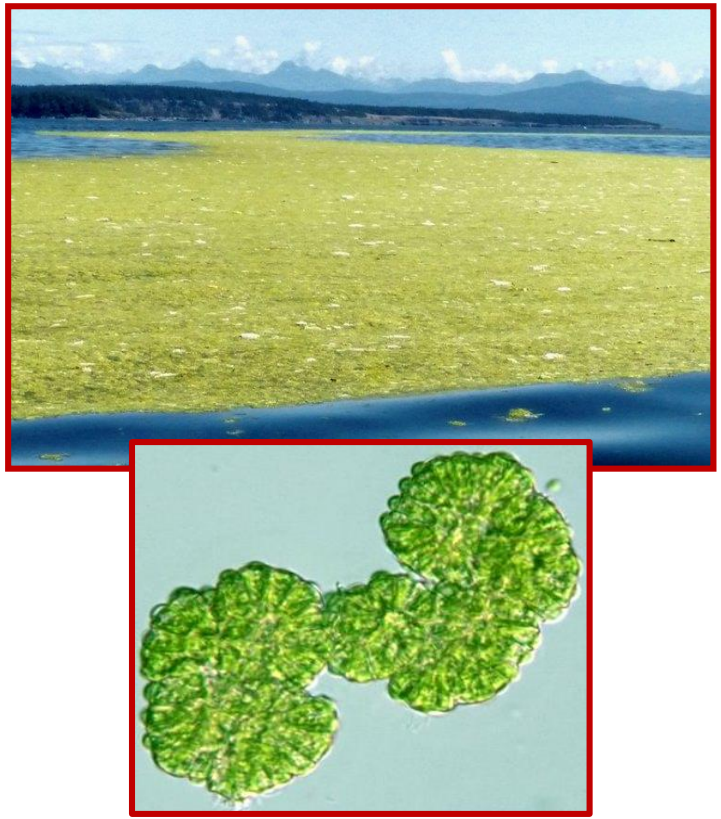
- ‘Green’ production of ammonia could hence easily develop where renewable energy sources are abundant.”
- Technical and operational measures would also be needed to achieve full decarbonization by 2035.
- Ammonia (or Hydrogen) cannot beat batteries.
- Ammonia is the most energy-dense carbon-free fuel
- Liquid ammonia can be stored at more acceptable temperatures and pressures.



Fuel from micro-algae

→ Fuel from micro-algae *Botryococcus braunii*

- Algae naturally creates electrons during photosynthesis, and metal probes stuck into the plant can capture that energy and transfer it into electricity for batteries.
- The new technology has immense potential to reduce greenhouse gas emissions
- During photosynthesis, algae takes carbon dioxide out of the atmosphere, as an added benefit.
- Unlike traditional solar power algae works around the clock.



What about LNG & LPG

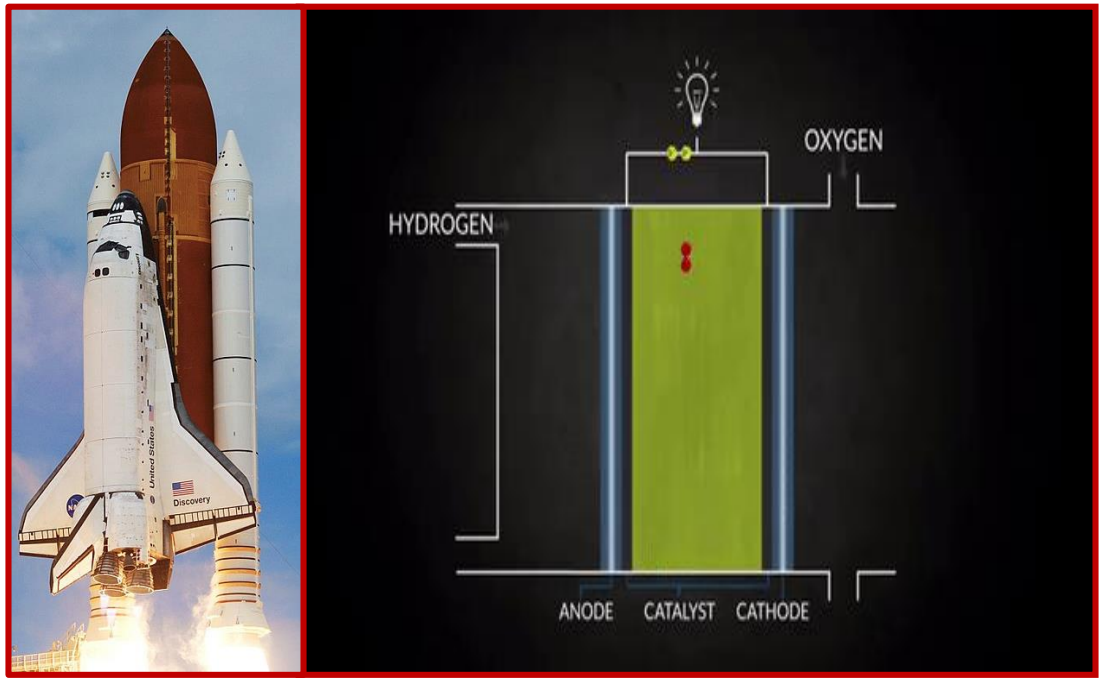
→ LNG will be an excellent bridge fuel to a zero carbon society

- ‘Maritime Energy Transition’ , ‘ Energiewende ’ in German, encapsulates MAN Diesel & Turbo’s call to action to reduce emissions and establish natural gas as the fuel of choice in global shipping.
- Energiewende promotes a global ‘turn to gas’, driven by the IMO, and a common approach by the shipping industry to invest in infrastructure development and retrofits.
- The development of MAN Diesel & Turbo’s two-stroke ME-GI/ME-LGI engine portfolio to enable dual-fuel operation on, primarily, natural gas but also on low-carbon gaseous and liquid fuels such as LNG (methane), LPG, ethane, methanol and ethanol
- The development of synthetic fuels created with renewable energy (i.e., power to gas), another technology with great CO2-reduction potential.
- And please do not shoot dual fuel engines on methane slip. ***REGULATE COW BELCHING!!!***

Hydrogen

→ Hydrogen the fuel of the Space Shuttle

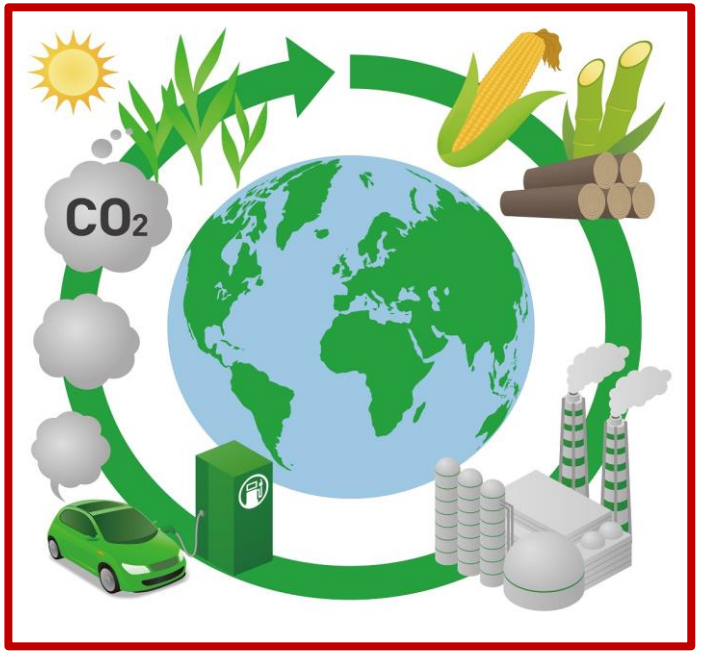
- It differs from natural gas. It has higher explosion potential, low density and lower storage temperature as liquid.
- Fuel cells employing hydrogen are being utilized today for small size vessels and short ranges.
- Safety issues are to be given significant consideration.
- It must be produced via renewable sources of energy/



More solutions from CO2 capture and biofuels

→ Need to look into the life cycle of production

- Renewable fuel from carbon dioxide captured from the air.
- The catch: Carbon dioxide is a stable molecule. Chemists have to put in energy to break its bonds and produce carbon monoxide, which can then be combined with hydrogen to make fuels such as gasoline and kerosene.
- The development of synthetic fuels created with renewable energy is a technology with great CO2 reduction potential
- Use of biofuels will depend on a number of factors, including environmentally sustainable biomass feedstock for their production, cost effective production technologies and ultimately on their market penetration.
- About 9% of total transport fuels will be achieved through biofuels.



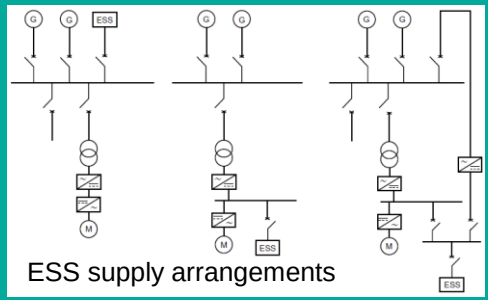
05 Alternative Sources of Energy

Moving into electric-hybrid power systems

On-board energy storage systems (ESS) picking up pace

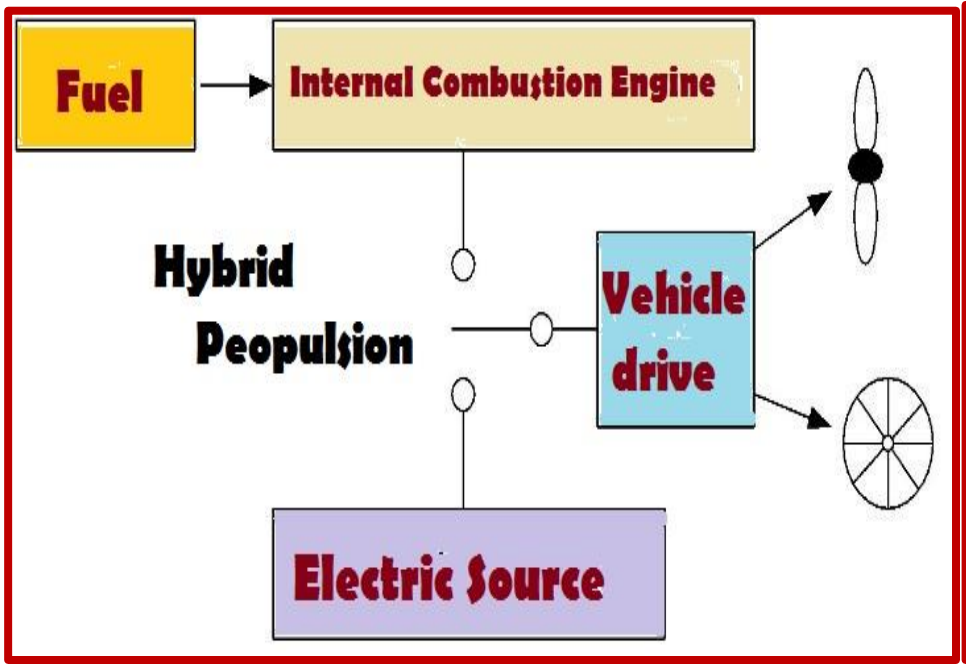
BV class notations:

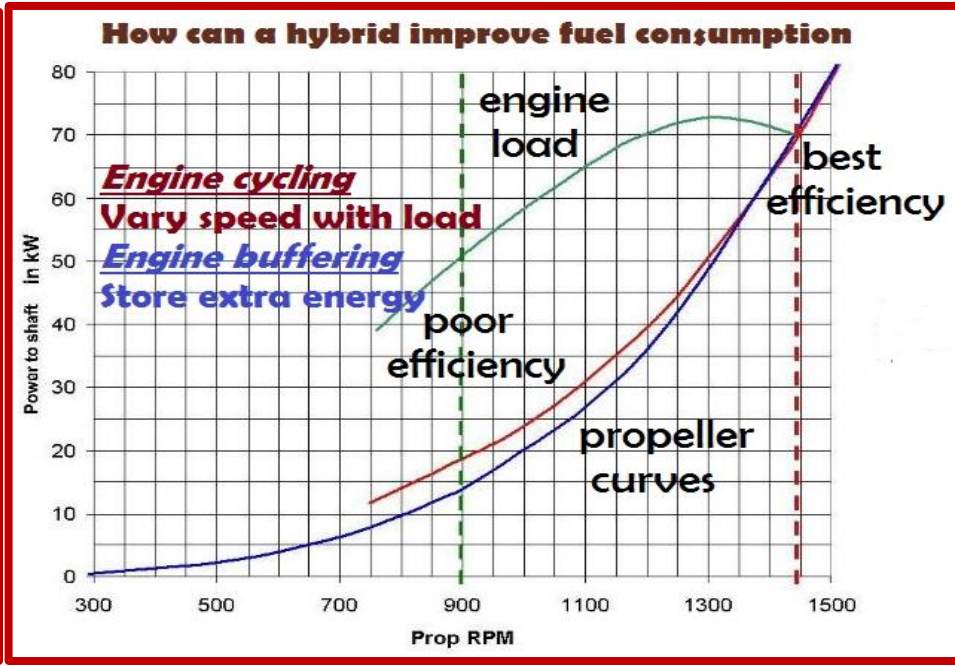
- **BATTERY SYSTEM**
- **ELECTRIC HYBRID (xxx)**
  - **PM** (power management)
  - **PB** (power backup)
  - **ZE** (zero emission)



ESS supply arrangements

What is a hybrid?

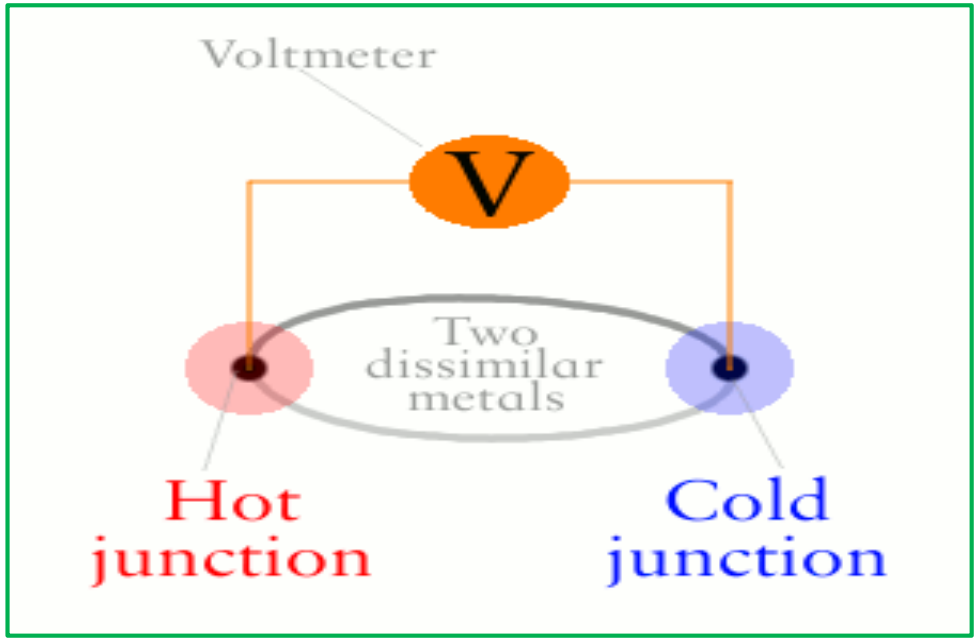




Propulsion using a fueled power source (diesel engine) or through a stored energy source (battery bank and electric motor)

The Zero Emissions Vessel (ZEV)

A combination of technologies



Renewable energy

Renewable energies are non-mature with low degree of efficiency

The "Teslas of the seas"

→ So how will ships look in the future?

- Investment in low/zero carbon fuels, sleeker ships
- Strong policy signal from governments about total decarbonization.
- Ships that don't meet the standards of IMO can be denied entry to port, fined and have their licenses to operate removed.
- A more rapid uptake of new and emerging technologies will be a critical factor in achieving success.
- Some of these solutions are still in late-stage development, not yet mature, or require significant work to integrate into the marine environment for deployment in the global fleet.

In our unpredictable regulatory regime, will today's ships become obsolete in 5-10 years ?