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**VARD**™

a Fincantieri company

Vard Marine Inc.



VARD 650B

## Challenges for Ship Designers Using Future Fuels

CISMaRT Workshop – April 2022

- Introduction
- Vard Marine and Decarbonization
- Emission Reduction
  - Goals
  - Mandates
  - Actions
- Future Fuels
  - Options and Characteristics
  - Green-ness
  - Challenges
- Question and Answers

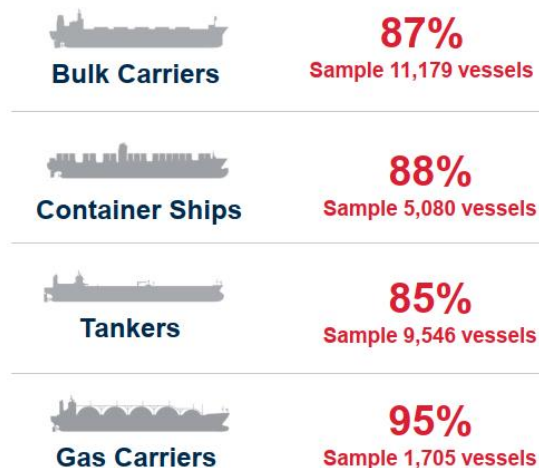
- First Canadian LNG dual fuel vessels – STQ Tadoussac ferries
- First US LNG dual fuel vessels – Harvey Gulf OSVs
- First North American hybrid-electric dual fuel/ESS vessels – Seaspan ferries
- First Canadian LNG bunker vessel
- Studies of future fuels for TC, CCG, Greening of Government Secretariat
- Exploration of fuel options for public and private sector clients | Canada and overseas.

- International Maritime Organization (IMO) Initial Strategy
  - Reduce carbon intensity 40% by 2030
  - Reduce carbon intensity 70% by 2050
  - Reduce total emissions 50% by 2050
  - 2008 baselines
- Nationally Determined Contributions
  - Every party to the Paris Agreement states NDCs for GHG reduction; e.g. Canada
    - 40-45% by 2030
    - Net zero by 2050

- IMO:
  - Energy Efficiency Design Index (EEDI)– progressive improvement for new vessels
  - EEXI – retroactive requirements for existing vessels (power limitation)
  - Carbon Intensity Index (CII) – progressive improvement in actual transport efficiency, based on fuel burned on voyages
  - Must be implemented/enforced by Flag States; does not necessarily apply to domestic vessels/internal waterways

## Potential Impact

Number of vessels requiring improvement to become EEXI compliant



Percent of vessels requiring an operational change or improvement by 2030 to stay within A, B or C for CII



# Emission Reduction – Commitments

- Major shipping lines have declared policies; typically “carbon neutrality” by 20xx
  - Maersk aims for 2040, utilizing methanol etc: “Green methanol is the only market-ready and scalable available solution today for shipping”, Maersk CEO
  - CMA/CGM aims for 2050, using LNG, biomethane, etc
- Major clients for international shipping have declared that they will only use carbon neutral shipping by 20xx
  - IKEA, Amazon and others have joined an initiative coordinated by the Aspen Institute for Carbon Neutrality by 2040.

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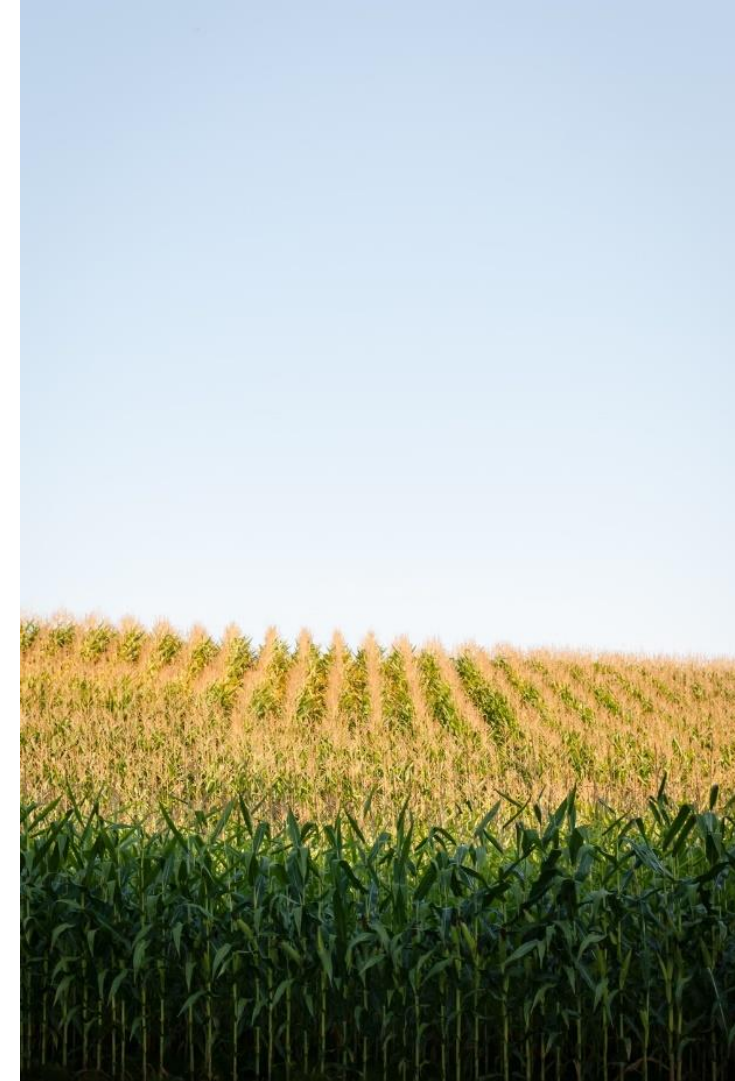
# Future Fuels - Options

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- Carbon - based
  - Methane (CNG/LNG); fossil or RNG
  - Methanol
  - Biodiesel/renewable diesel
- Carbon - free
  - Ammonia
  - Hydrogen/hydrides
  - Electricity (energy storage systems)
  - Wind
  - Nuclear

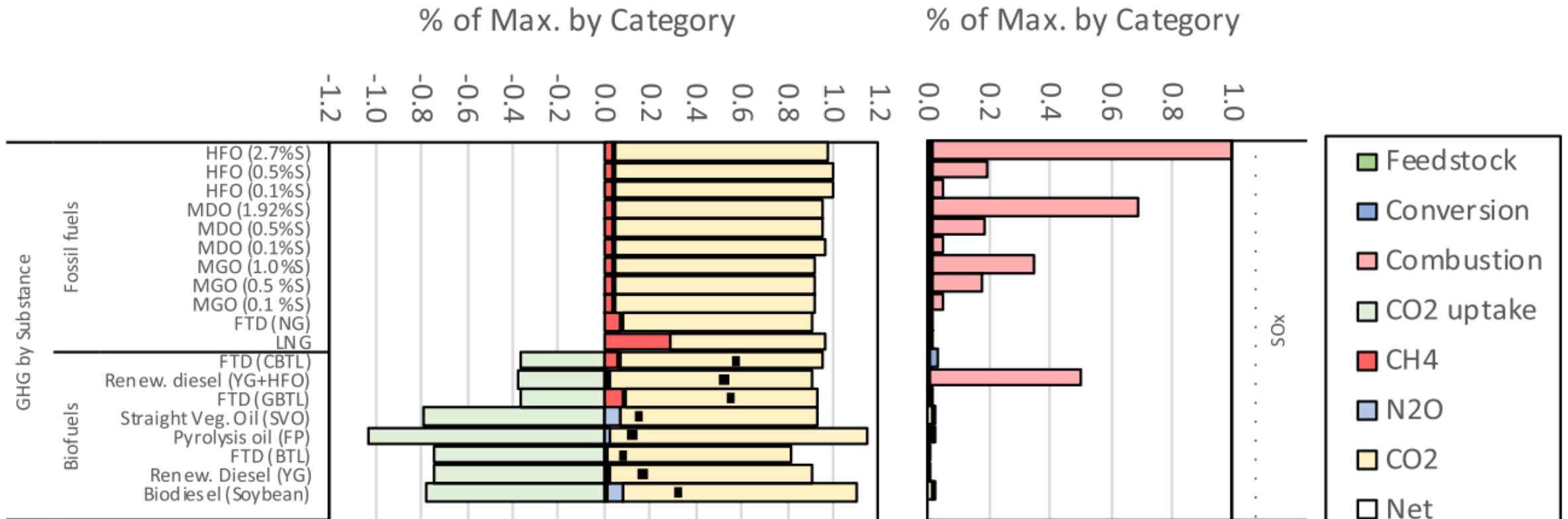


- Conventional diesel considered as the baseline = 1
- Lower carbon-intensity fossil fuels (LNG, also LPG) can offer benefits depending on application; 0.75 – 1.
- Renewable carbon-based fuels benefits highly dependent on feedstock and on processing/refining technology. Accounting methods can be highly misleading, but realistic benefits can range from 0 to 0.5. Indirect Land Use Charge (ILUC) is important consideration
- Carbon-free fuels GHG footprint is dependent on source. Currently most are derived from fossil fuels, and have values  $> > 1$  (“black”/“grey” options). Best case “green” options can achieve 0, “blue” options will be intermediate.





# Simple?



US Natural  
Renewable Fuel Lab  
study

Fuel Code	Fuel	Company	Carbon Intensity (gCO <sub>2</sub> e/MJ)	Effective Date	Expiry Date
BCLCF269.2	HDRD	Sinclair Wyoming Refining Company	20.28	Mar. 2, 2021	Dec. 31, 2022
BCLCF270.0	HDRD	Sinclair Wyoming Refining Company	28.04	Apr. 11, 2019	Apr. 10, 2020
BCLCF271.0	Ethanol	Terra Grain Fuels Inc.	41.81	Apr. 23, 2019	Apr. 22, 2022
BCLCF272.0	Biodiesel	Archer Daniels Midland Company	10.56	May 28, 2019	May 27, 2022
BCLCF273.0	Biodiesel	Mid-America Biofuels	10.15	May 29, 2019	May 28, 2022
BCLCF274.0	Biodiesel	Paseo Cargill Energy	-12.70	July 25, 2019	July 24, 2022
BCLCF275.0	Ethanol	Quad County Corn Processors Cooperative	61.57	Sept. 18, 2019	Sept. 17, 2022
BCLCF276.0	Ethanol	Red River Biorefinery, LLC	27.94	Mar. 4, 2020	July 3, 2021
BCLCF277.0	CNG	City of Surrey	-86.47	June 30, 2020	June 29, 2021
BCLCF278.0	Ethanol	Bonanza Bioenergy	23.88	Oct. 31, 2019	Oct. 30, 2022
BCLCF279.0	Biodiesel	REG Mason City, LLC	13.43	Oct. 25, 2019	Oct. 24, 2022
BCLCF280.0	Biodiesel	REG Grays Harbor, LLC	6.22	Jan. 15, 2020	Jan. 14, 2023
BCLCF281.0	Biodiesel	REG Grays Harbor, LLC	-5.73	Jan. 15, 2020	Jan. 14, 2023
BCLCF282.0	Biodiesel	REG Madison, LLC	8.34	Jan. 13, 2020	Jan. 12, 2023
BCLCF283.0	Biodiesel	REG Seneca, LLC	9.35	Jan. 13, 2020	Jan. 12, 2023
BCLCF284.0	Ethanol	Hub City, LLC	49.17	Apr. 8, 2020	Apr. 7, 2023
BCLCF285.0	Ethanol	Huron Energy, LLC	46.46	Apr. 8, 2020	Apr. 7, 2023
BCLCF286.0	Ethanol	Bonanza Bioenergy	39.56	June 11, 2020	June 10, 2023
BCLCF287.0	HDRD	Diamond Green Diesel LLC	25.20	May 13, 2020	May 12, 2023
BCLCF288.0	Biodiesel	REG Grays Harbor, LLC	-0.30	Jan. 15, 2020	Jan. 14, 2023
BCLCF289.0	Biodiesel	REG Grays Harbor, LLC	4.44	Jan. 15, 2020	Jan. 14, 2023
BCLCF290.0	Biodiesel	REG Grays Harbor, LLC	13.16	Jan. 15, 2020	Jan. 14, 2023

BC fuel carbon intensity indices, sample

- Key issues include:
  - Mass energy density (deadweight impacts)
  - Volume energy density (Space impacts)
  - Storage temperature (space, weight and cost impacts)
  - Safety (flash point, toxicity)
  - Cost (acquisition and through-life)
  - Availability (considering voyage profiles)

Fuel Type	Liquified Gas	Corrosive or Reactive	Toxic	Cryogenic	Low Flashpoint
VLSFO	No	No	No	No	No
LNG	Yes	No	No	Yes	Yes
LPG	Yes	No	No	No	Yes
Methanol	No	Yes	Yes	No	Yes
Ammonia	Yes	Yes	Yes	No	No
H <sub>2</sub>	Yes	Yes	No	Yes	Yes

# Density Comparisons

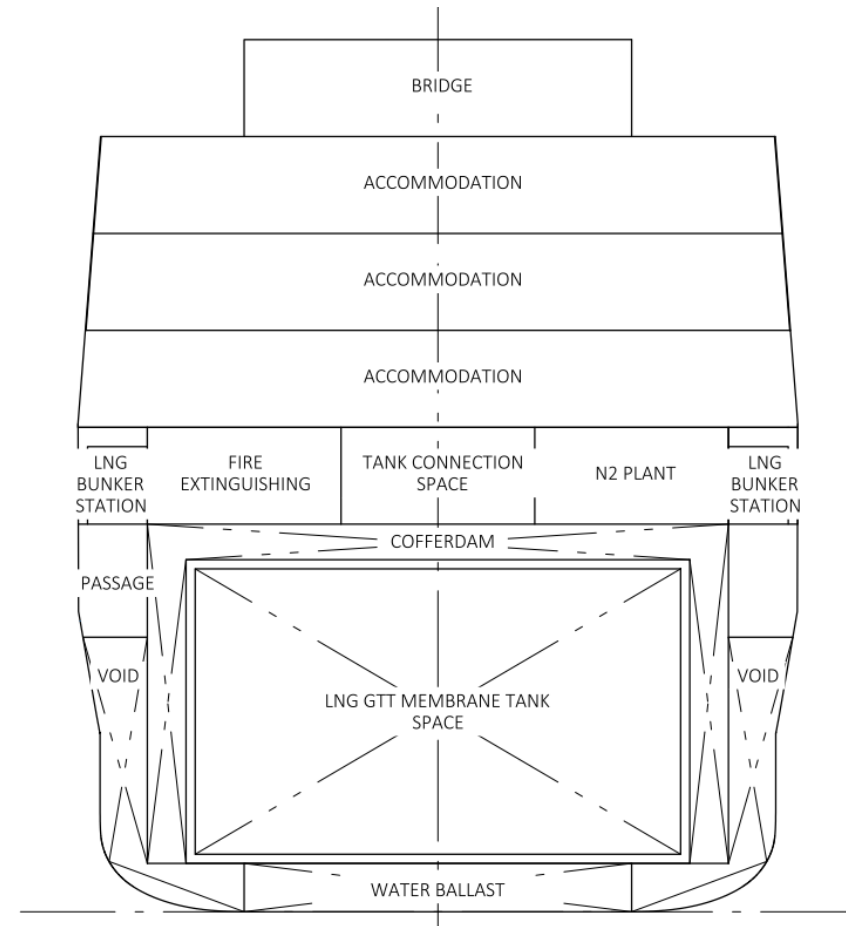
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Fuel	Mass Energy Density (MJ/kg)	Volume Energy Density (MJ/l)	Liquefaction Temp at atmospheric pressure (°C)
Marine Diesel	45.6	38.6	n/a
LNG	55.0	22.2	-162
LPG	49.5	26.0	-42
Methanol	20.0	16.0	n/a
Ammonia	18.6	11.4	-35
Hydrogen (LH <sub>2</sub> )	140.0	10.0	-253
Battery	0.4	0.6 (cell)	n/a

# Cryogenic Fuel Storage (LNG, LH<sub>2</sub>)

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- Containment systems add 40-150% to fuel volume requirements, and reduce/remove mass energy density advantage
- Tankage location often requires prime real estate
- Containment system cost increases rapidly as temperature decreases
- Boil-off gas management a challenge for many operational profiles



- Dual-fuel engines (a necessity for most fuel options) are more expensive than single-fuel alternatives
- Fuel cells are much more expensive than internal combustion, and have limited life expectancy
- Fuel storage costs range from somewhat to very much higher for all alternative fuels (other than non-fossil diesel)
- All alternative fuels other than LNG/LPG are much more expensive than conventional fuels, and the gap is highest for “green” options
- Subsidies/incentives/penalty regimes for fuel selection are very limited

# Cost and Availability - Biofuel

- Biofuel costs with current technologies/feedstocks are 2-5 \* cost of fossil equivalents
- “Advanced” biofuels using new feedstocks do not offer expected lower costs
- Other future fuel types appear to have more cost reduction potential



Source: IEA

- Future-proofing new construction involves building in flexibility for fuel and engine options.
- Operators need to work closely with suppliers, ports and regulators to consider supply chains, which will require much higher overall levels of investment than the ships themselves.
- Government fleets (Canada and elsewhere) appear to be relying on a drop-in fuel (renewable diesel) future, which may decouple them from the broader marine industry.





THANK YOU FOR YOUR ATTENTION –  
QUESTIONS?