Technical & Commercial Conference

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LNG Shipping, are we in front of a perfect storm? How can we balance energy security to climate alignment

Panos Mitrou

Global Gas Segment Director

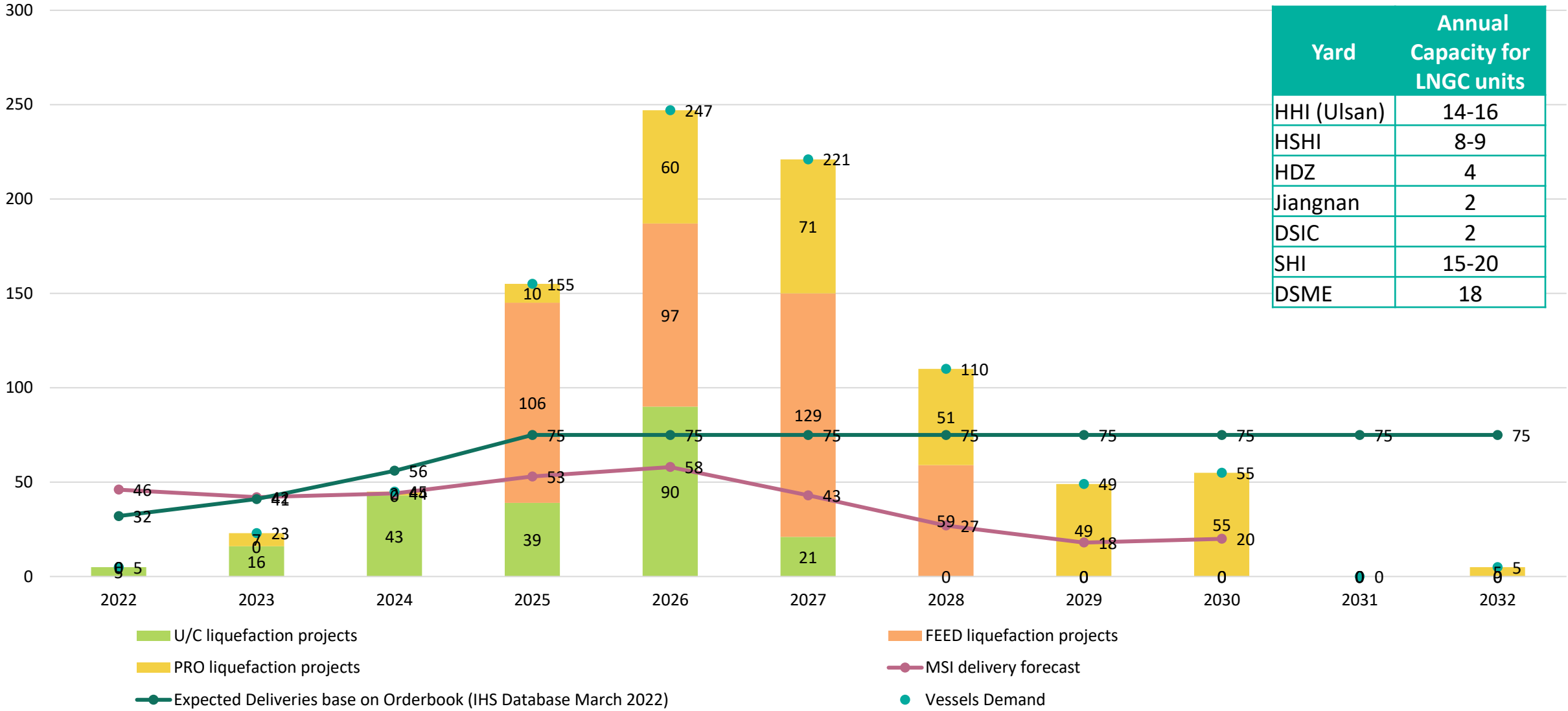
Lloyd's Register (LR)

Agenda

- Shipping Demand VS Yards Capacity Projection
- Liquefaction Projects & Orderbook Insight
- Fleet Anatomy and Technology
- GHG Regulatory Timeline
- CII Regulation Impact
- Key Design Trends
- Improving Returns by Technology
- Mega Trends – Cargo Footprint & Methane Emissions
- Technology Snapshot – Methane Abatement, Efficiency & CCS

Shipping Demand VS Yard Capacity Projection

Yard	Annual Capacity for LNGC units
HHI (Ulsan)	14-16
HSHI	8-9
HDZ	4
Jiangnan	2
DSIC	2
SHI	15-20
DSME	18

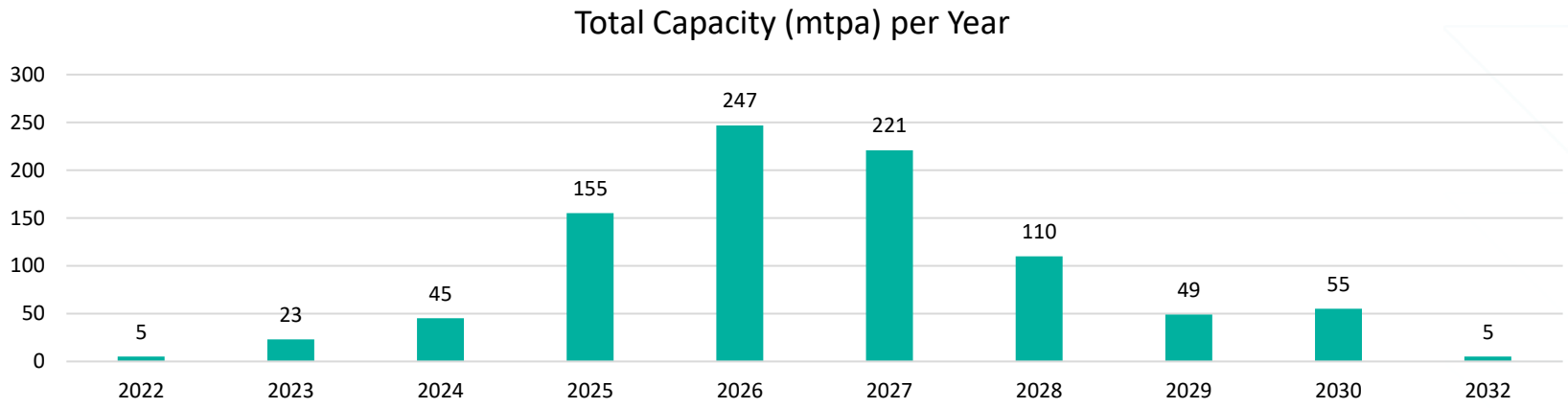


Liquefaction Projects Insight

Project Stage	Number of Projects	Capacity (mtpa)	Required LNG Carriers
U/C	32	164.80	214
FEED	38	293.30	391
PRO	58	294.90	310

U/C: projects currently under construction
FEED: projects at the Front-End Engineering and Design phase
PRO: projects mooted, prior to FEED stage

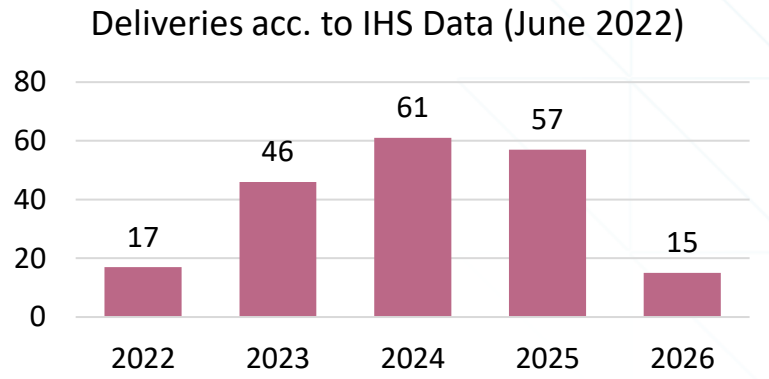
Top -5 U/C Liq. Projects by Capacity	Capacity (mtpa)
LNG Canada	14
Mozambique LNG	13.12
Baltic LNG	13
Plaquemines LNG	10
North Field LNG Expansion Train 1	7.8



Source: Clarksons Research estimates July 2022.

LNGC Orderbook Insight

Owner	Number of Vessels	Shipyard	Engine Type
MOL	9	DSME	ME-GA
	10	Hudong-Zhonghua Shipbuilding	X-DF
ADNOC Logistics & Services	6	Jiangnan Shipyard	X-DF
	3+2	Jiangnan Shipyard	
Knutsen OAS Shipping AS	2	HHI-Ulsan	X-DF
	2	HSHI	X-DF
	6	HSHI	ME-GA
Global Meridian Holdings	2	HHI-Ulsan	ME-GA
	8	SHI	X-DF
Hyundai LNG Shipbuilding Co Ltd	2	DSME	ME-GI
	6	HHI-Ulsan	X-DF
Celsius Shipping ApS	6	SHI	
	3	SHI	ME-GA
Maran Gas Maritime Inc	5	DSME	ME-GI
	3	SHI	
Global Meridian Holdings	2	HHI-Ulsan	ME-GA
	6	SHI	
Hyundai LNG Shipbuilding Co Ltd	2	DSME	ME-GI
	6	HHI-Ulsan	X-DF
H-Line Shipping Co Ltd	1	HSHI	X-DF
	7	SHI	ME-GA
Capital Maritime & Trading	4	HHI-Ulsan	ME-GA
	1	HHI-Ulsan	X-DF
	2	HSHI	ME-GA
COSCO Shipping Energy Trans	6	Hudong-Zhonghua Shipbuilding	X-DF
CSLNG	6	Hudong-Zhonghua Shipbuilding	
NYK + CM	6	Hudong-Zhonghua Shipbuilding	
CLNG/MISC	5+1	Hudong-Zhonghua Shipbuilding	
Pan Ocean Co Ltd	4	HHI-Ulsan	ME-GA
	1	SHI	X-DF
SK Shipping Co Ltd-KRS	2	HHI-Ulsan	ME-GA
	3	HSHI	ME-GA
Dynacom Tankers Management Ltd	4	HHI-Ulsan	ME-GA
	1	HHI-Ulsan	X-DF

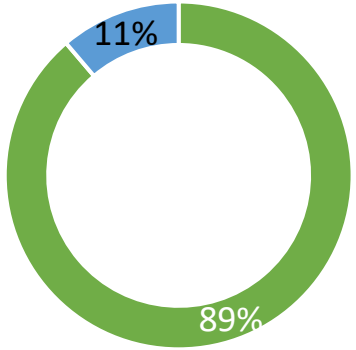


Source: IHS Data - June 2022

Fleet Anatomy and Technology

Source: IHS Database (June 2022)

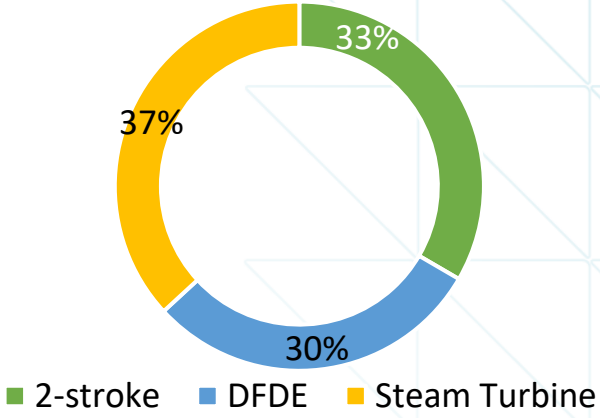
Orderbook by Propulsion System



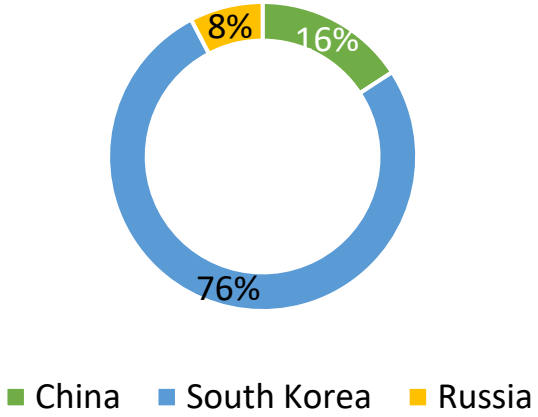
LNGC Fleet by Age

Age category	No of LNGCs
Orderbook	196
0-4	192
5-9	135
10-14	127
15-19	110
20-24	34
25+	45

Existing LNGC Fleet by Propulsion System



Orderbook by Country of Shipyard



Containment System Technology Evolution

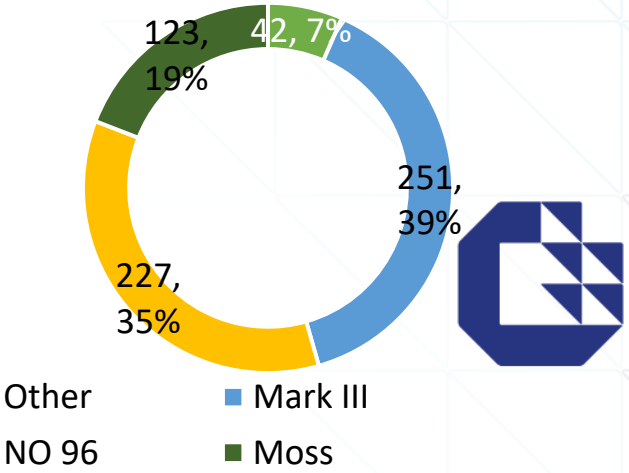
GTT Mk III	Mk III	Mk III Flex	Mk III Flex+
BOR	0.15 % - 0.125 %	0.085 %	0.07 %

GTT NO96	NO96	NO96 GW	NO96 LO3	NO96 LO3+	NO96 Super+
BOR	0.15 %	0.125 %	0.11 %	0.10 %	0.085 %

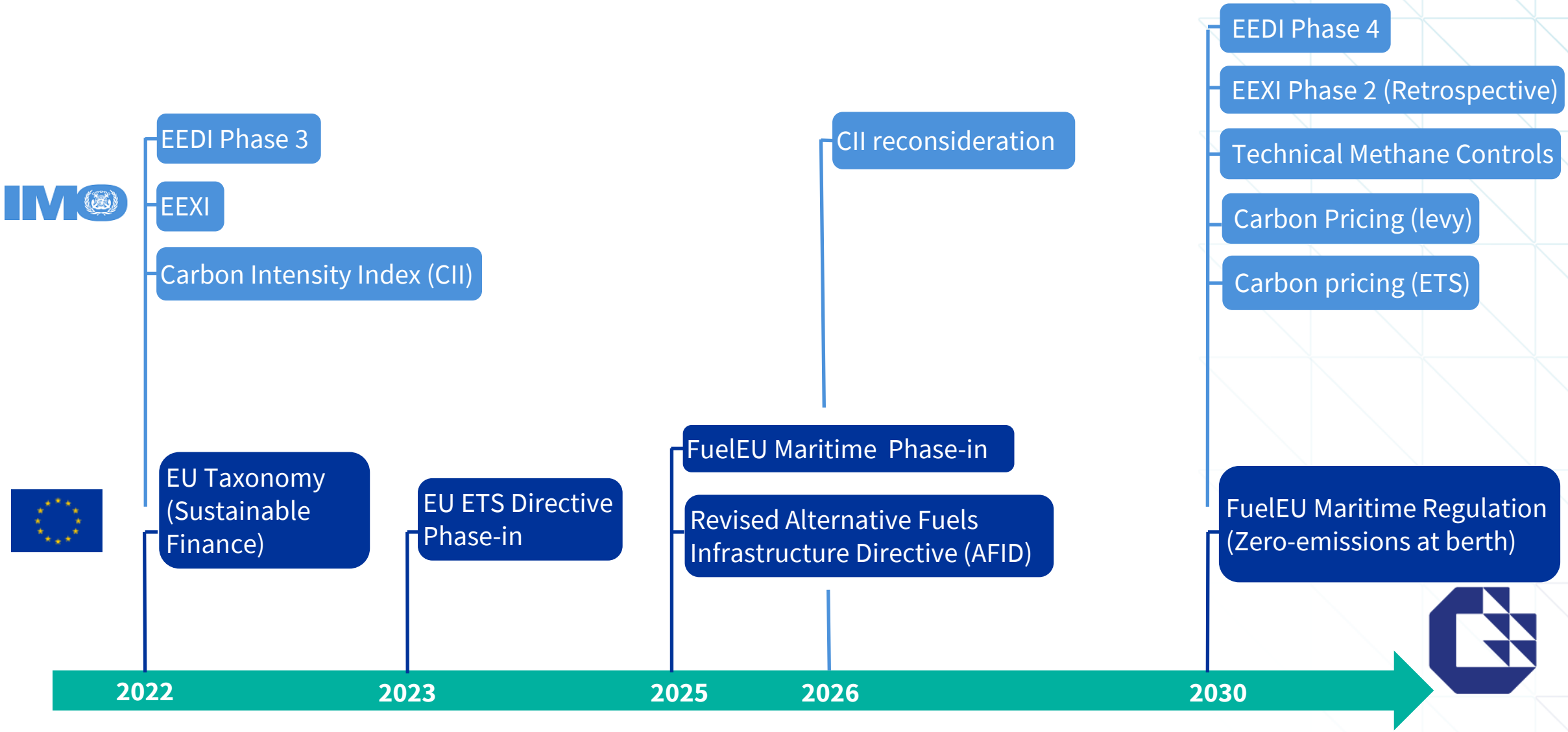
There are currently only 386 2-stroke LNG Carriers

Including both in service and orderbook units

Existing LNGC Fleet by Containment System



GHG Regulatory Timeline



CII the X Factor Governing the LNG Carrier Market

High level representation of the formula for CII calculation is as follows:

$$CII = \frac{CO2\ Emissions\ (Fuel\ Consumed\ X\ CO2\ Mass\ Conversion\ factor)}{Deadweight\ X\ Distance}$$

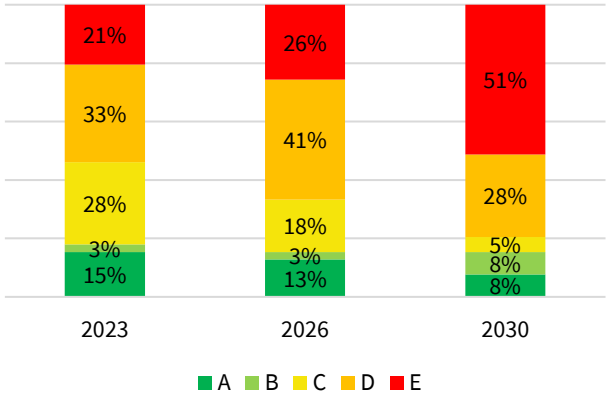
CII Timeline

- Ships will be subject to CII from and throughout 2023,
- By May 2024 the first ratings will be issued.
- Ships rated E will be required to comply following one year confirmed E, this means May 2024 and if not in compliance will be leaving the market by May 2025
- Ships rated D for three consecutive years will know this by May 2026, they will be expected to either comply or leave the market at their next year's rating around May 2027 if not compliant
- Things will get even worse once methane emissions will be integrated to the CII rating (after 2026)
- Approximately 400 ships (steamers + TFDE) may be at risk or operational limitations due to CII by the end of the decade
- The operational nature of the requirement is expected to incentivise the use of modern more efficient tonnage adding one more burden to operators, charterers employing old ships

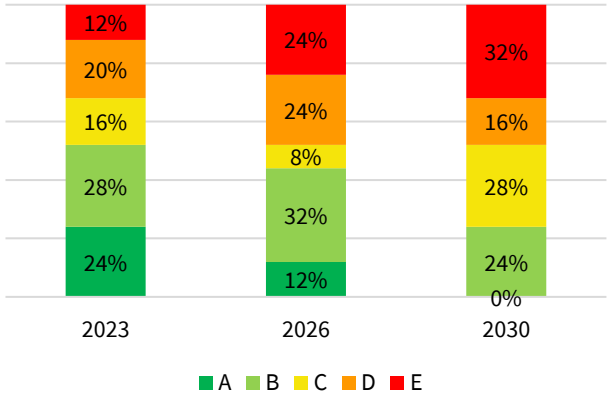
Year	Reduction ('Z') Factor Relative To 2019
2023	5%
2024	7%
2025	9%
2026	11%
2027-30	To Be Confirmed

CII Ratings Overview

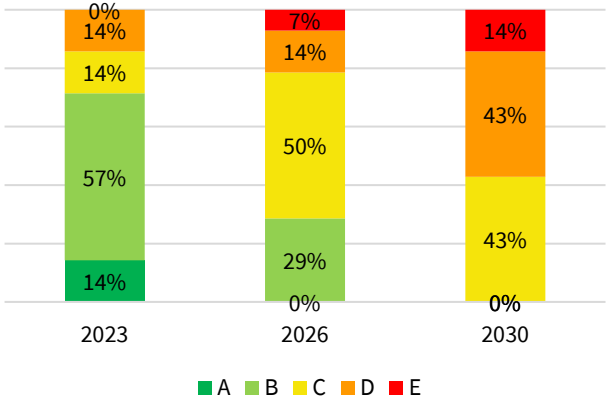
Steam Turbine Vessels



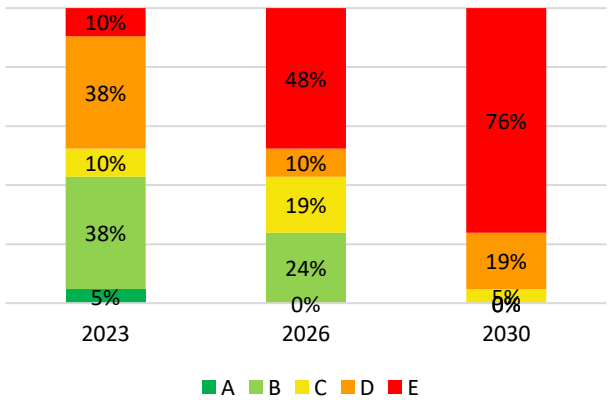
DFDE Vessels



2-Stroke Gas Injection Vessels



2-Stroke Diesel Vessels



Total of calculated vessels

39 Steam Turbine

25 DFDE

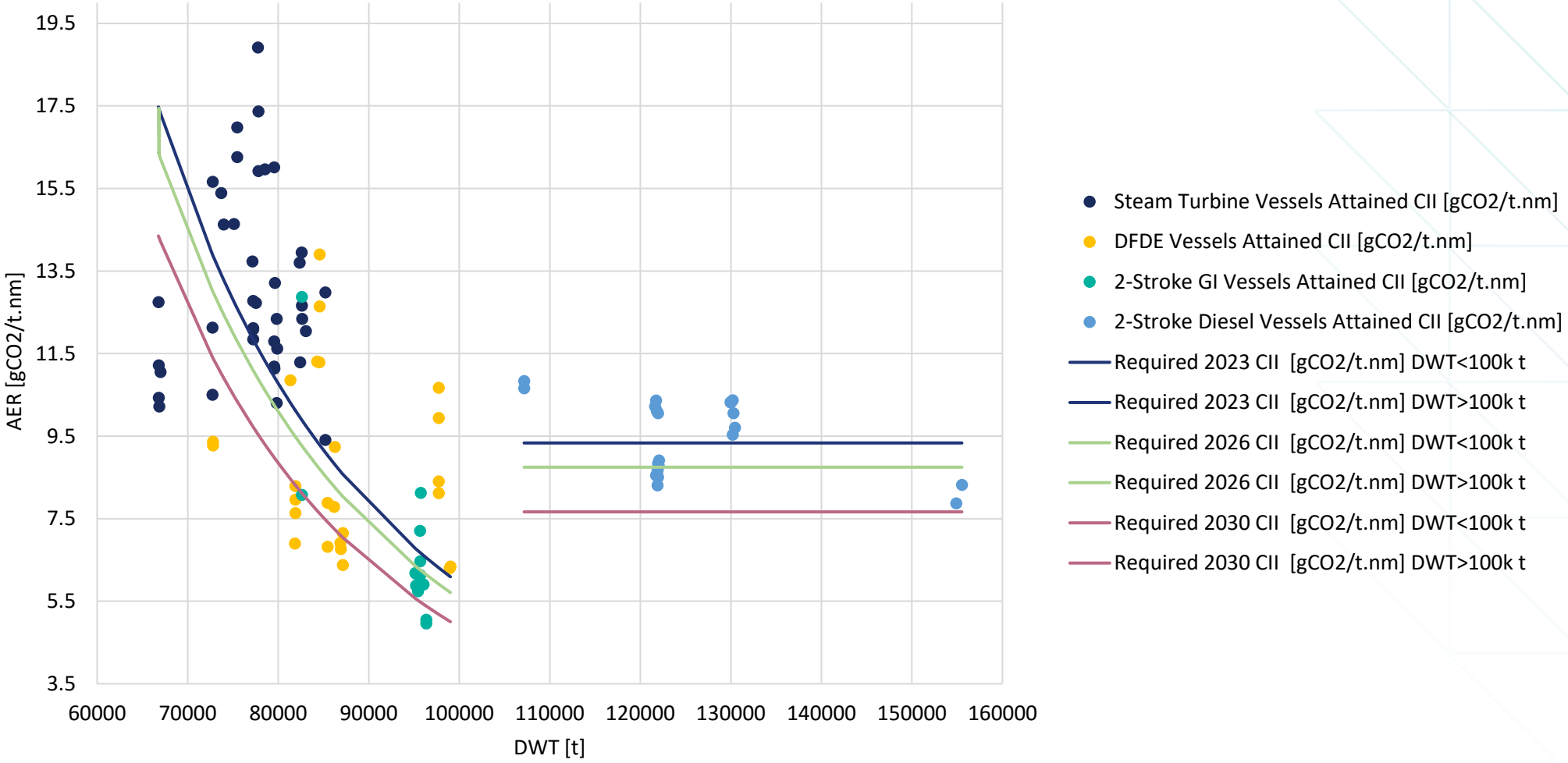
14 2-Stroke GI

21 2-Stroke Diesel

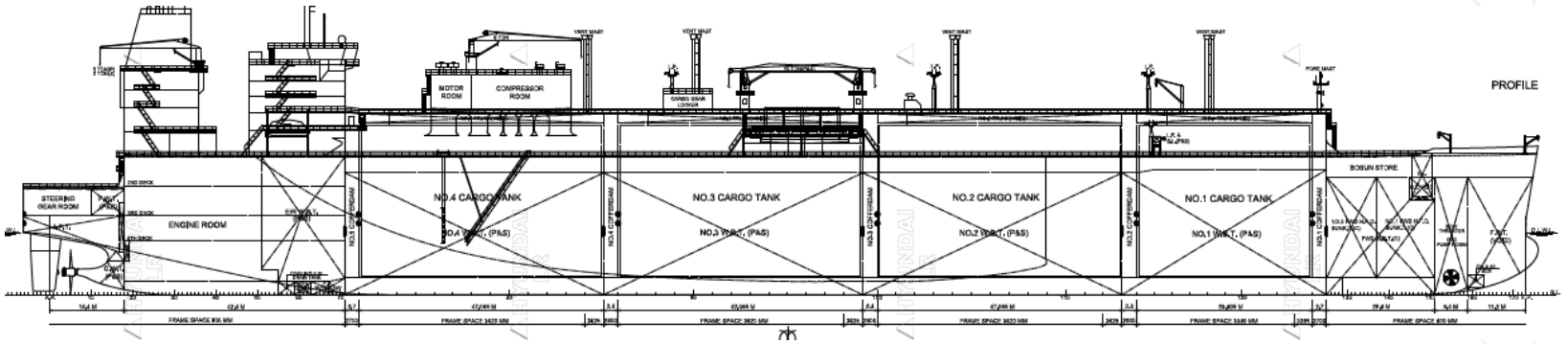
Average CO2 emissions reduction for CII alignment *(compared to 2020 CO2 emissions)*

	2023	2026	2030
Steam Turbine Vessels	-13%	-16%	-23%
DFDE Vessels	-20%	-17%	-28%
2-S GI Vessels	-13%	-14%	-11%
2-S Diesel Vessels	-4%	-9%	-14%

Attained & Required CII by Propulsion Type



Key Design Trends – Size, 174k to 180k to 200k



- Out of 159 LNG terminals , generic* compatibility provided to 8 more terminals for 174 K Vs 200 K
- Greater size providing greater compliance depth Vs CII and EEXI/EEDI
- Best BOR attained by 200 K due to tank geometry
- Some charterers already implying preference for 180 or 200 K

	174 K LNG	180 K LNG	200 K LNG
Terminal Compatibility	97	92	89
EEXI - CII	Basis	+	++
Charterers Preference			
BOR	0.075	0.075-0.070	0.065

Key Design Trends- Improving Returns by Technology

Ways to reduce OPEX

Manning,

- Setup a reasonable, tangible OPEX reduction level,
- Perform a complete detailed feasibility analysis regarding, roles, level of automation, safety impact
- Engage with an FSA to tangibly validate any outcomes

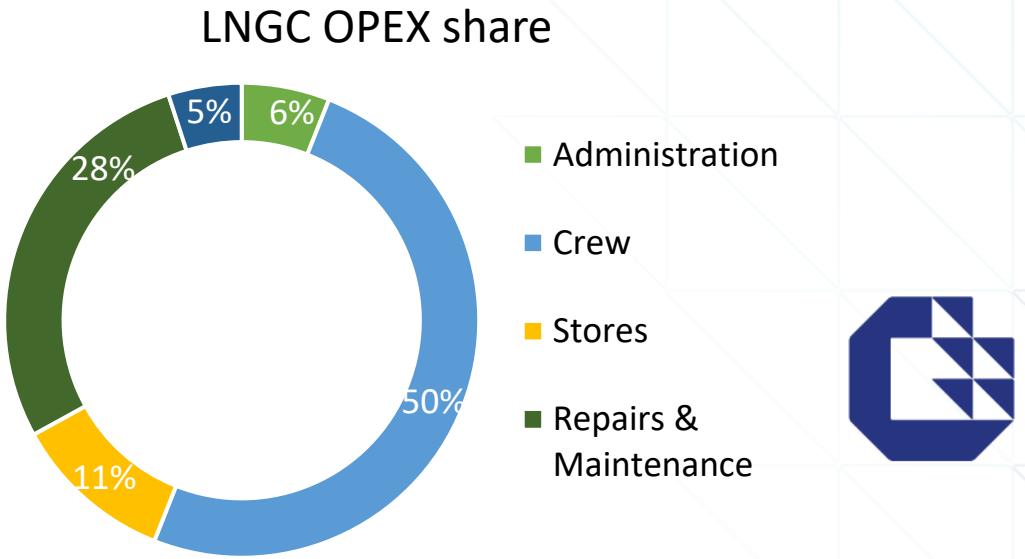
Repairs and Maintenance,

- Consider several alternative maintenance schemes
- Extended Dry Dock in conjunction with Extended Cargo Tank Inspections Intervals
- Risk Based Inspection Schemes for Key components

Other Commercial Considerations

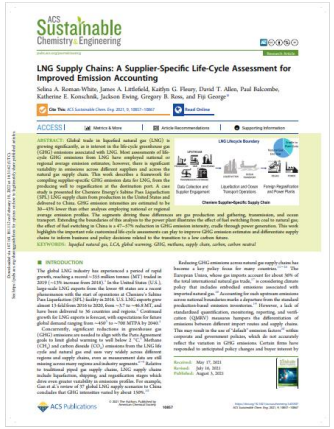
- Separating Fuel to Cargo
- Nuclear Propulsion

- Ways to reduce CAPEX
- Identify and assess areas where equipment may not add value to vessel operations
- Assess the impact of equipment 'lightering'
- Financing Optimization – Identify level of compliance with ESG financial criteria (Sustainability Linked Financing - Third Party Assurance)

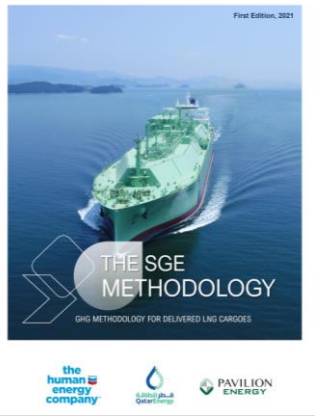


Mega Trends – Cargo Footprint

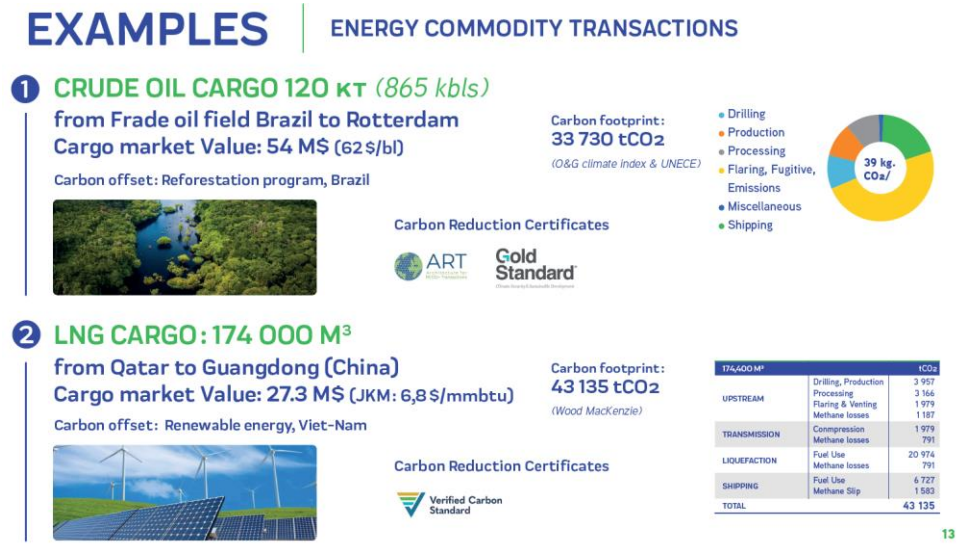
- Big Market players like Qatar Gas, Cheniere, Chevron, Pavilion Energy etc. published methodologies to **certify LNG cargo** against GHG footprint.
- **Nitrogen deduction** through cryogenic distillation
- **Bio-LNG and synthetic variants of LNG**
- Market Initiatives

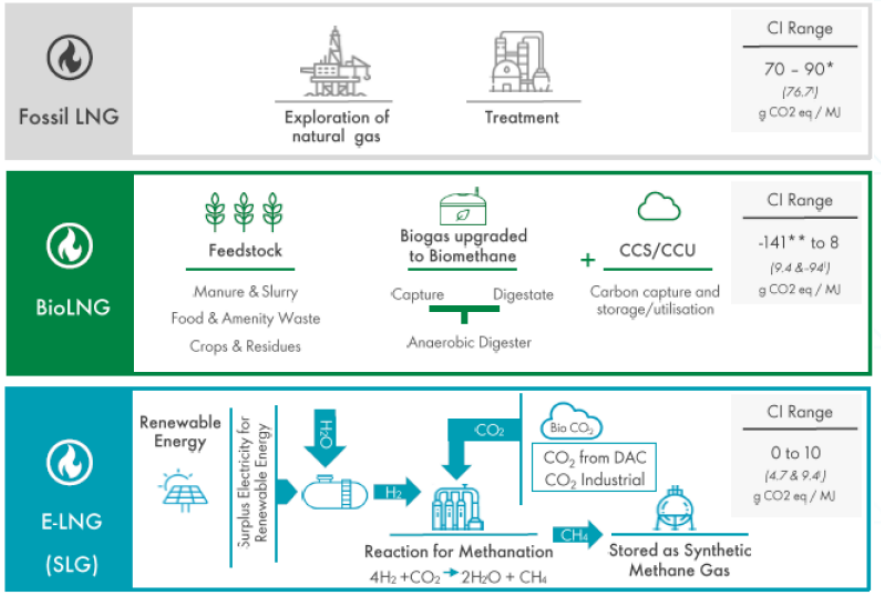


Source: Cheniere



Source: Chevron





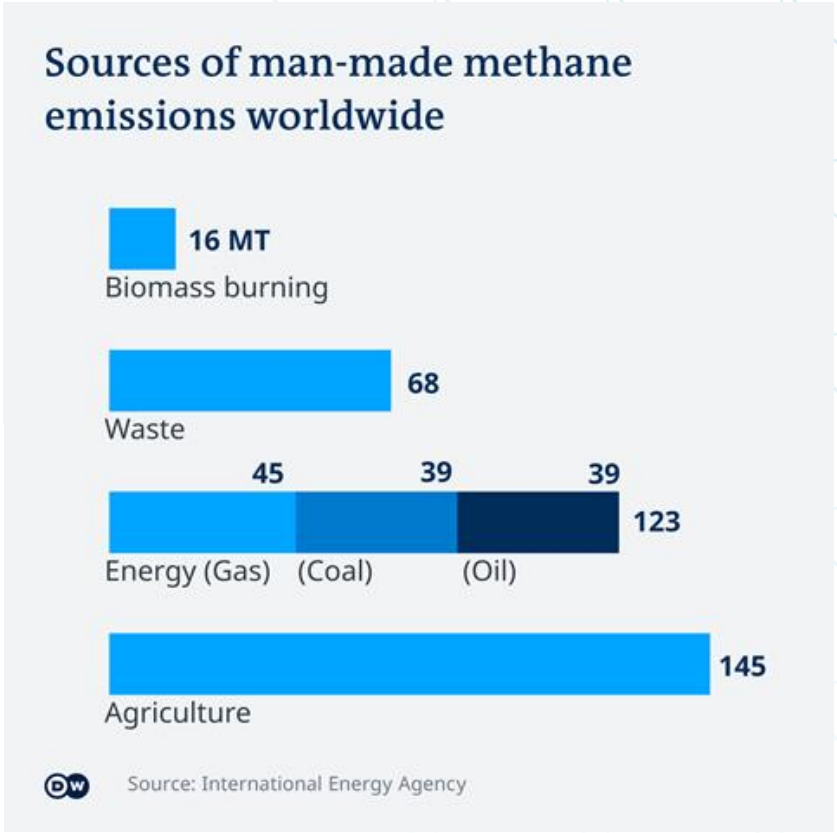
Source: Shell

Mega Trends – Methane Emissions

- 4-stroke & 2-stroke LP engines suffer from **methane slip**
- Methane is already integrated in the **FuelEU** and **LCA Guidelines**
- Methane integration into **EU ETS** regulations

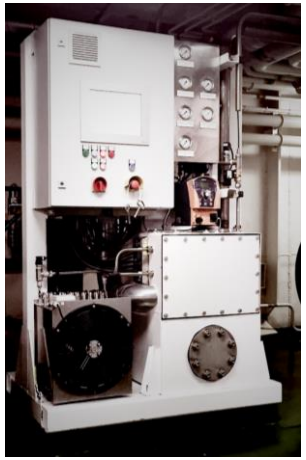
Large methane emissions from oil and gas operations detected by satellite, 2019 and 2020

Source: Kayrros analysis based on modified Copernicus data.



Technology Snapshot – Methane Abatement

FuelSave: Combustion Efficiency through Hydrogen Injection



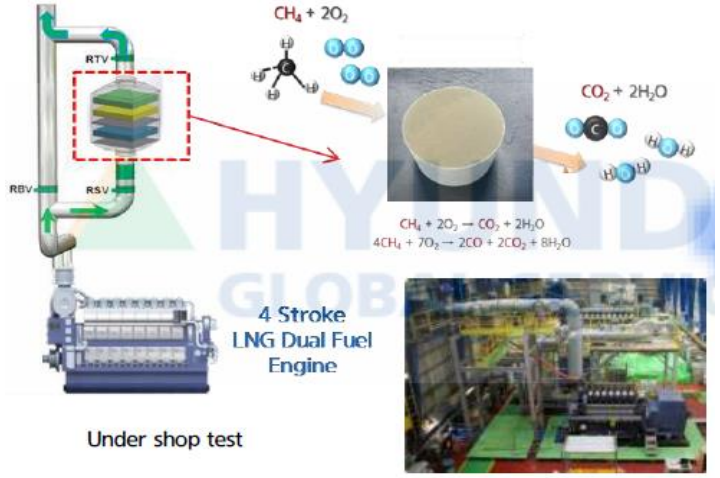
SlipPure : Methane transformation

SlipPure™ Methane

Courtesy Daphne Technology

Daphne Universal converter (DUC)

HiMSEN : Methane Catalyst , Under shop test , available Q3/2021



Under shop test

iCER - WinGD

Technology Trends - Carbon Capturing & Storage Onboard

EVALUATION CRITERION FOR CANDIDATE SHIP	CHEMICAL ABSORPTION	ADSORPTION	MEMBRANE SEPARATION	CRYOGENIC SEPARATION
Technology maturity	High	Low	Low	Medium
CO_2 purity (est.) from process	99%	Purity and capture rate are linked. In general, CO_2 purity is low (80% for adsorption, 60% for membranes)		99.9%
CO_2 capture rate potential (est.)	90-99%			90-99%
Sensitivity to impurities	NOx & SOx	H_2O, NOx and SOx	NOx & SOx	potentially SOx, H_2O

Source: Oil and Gas Climate Initiative

Type of Fuel	15-days at 15MW			15-days at 40MW		
	Fuel volume	CO_2 Volume	Total Volume (Fuel + CO_2)	Fuel volume	CO_2 Volume	Total Volume (Fuel + CO_2)
Diesel/Gas Oil	~ 504 m^3	~ 1304 m^3	~ 1808 m^3	~ 1345 m^3	~ 3477 m^3	~ 4823 m^3
Light Fuel Oil	~ 559 m^3	~ 1351 m^3	~ 1911 m^3	~ 1493 m^3	~ 3603 m^3	~ 5096 m^3
Heavy Fuel Oil	~ 503 m^3	~ 1417 m^3	~ 1920 m^3	~ 1341 m^3	~ 3780 m^3	~ 5122 m^3
Liquified Petroleum Gas	~ 795 m^3	~ 1148 m^3	~ 1943 m^3	~ 2121 m^3	~ 3061 m^3	~ 5182 m^3
Liquified Natural Gas	~ 947 m^3	~ 985 m^3	~ 1933 m^3	~ 2527 m^3	~ 2627 m^3	~ 5155 m^3
Methanol	~ 1232 m^3	~ 1195 m^3	~ 2427 m^3	~ 3286 m^3	~ 3187 m^3	~ 6473 m^3

Fuel and CO2 volumes calculated per voyage leg

CCS challenges:

- Storage and onward management
- Energy demand
- Purity of treated exhaust gas
- Purity of produced CO_2

CCS will be recognized by EU ETS

ECOSPRAY

WÄRTSILÄ

DAPHNE TECHNOLOGY

CHART
Cooler By Design.™

aqualung

Concluding Remarks

- LNG Carrier Fleet development may be detrimental to the global energy equilibrium,
- LNG Carrier Yard capacity can hardly cope with liquefaction projections
- LNG improved Carbon Footprint and Methane performance will dictate the sector's future
- In order to balance energy security and climate alignment we need to take action now,
- Be smart , focus on technology solutions development and uptake,

Investments in new LNG infrastructure are set to surge, reaching $42 billion annually in 2024, (Rystad Energy)

Are we Ready?

Photo: Wojciech Wrzesien/Shutterstock

We Need More LNG Tankers ASAP

Bloomberg

Total Views: 7717

June 26, 2021

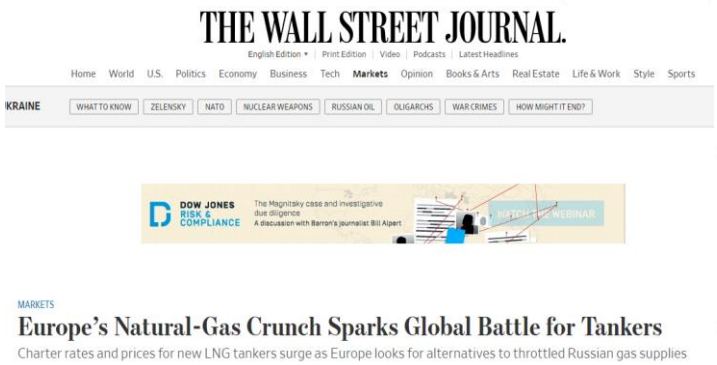
LNG industry hears horror story: the market could run out of ships

Fears voiced that shipping could be become bottleneck for LNG industry as regulatory and market pressures collide

3 December 2021 15:44 GMT | UPDATED 3 December 2021 15:44 GMT

By Lucy Hine in Rome

Incoming regulations for shipping could hit around two-thirds of the fleet as decarbonisation pressures intensify at a time when demand for vessels is also rising.



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MARKETS

Europe's Natural-Gas Crunch Sparks Global Battle for Tankers

Charter rates and prices for new LNG tankers surge as Europe looks for alternatives to throttled Russian gas supplies

Thank you

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