Energy Efficiency Technologies

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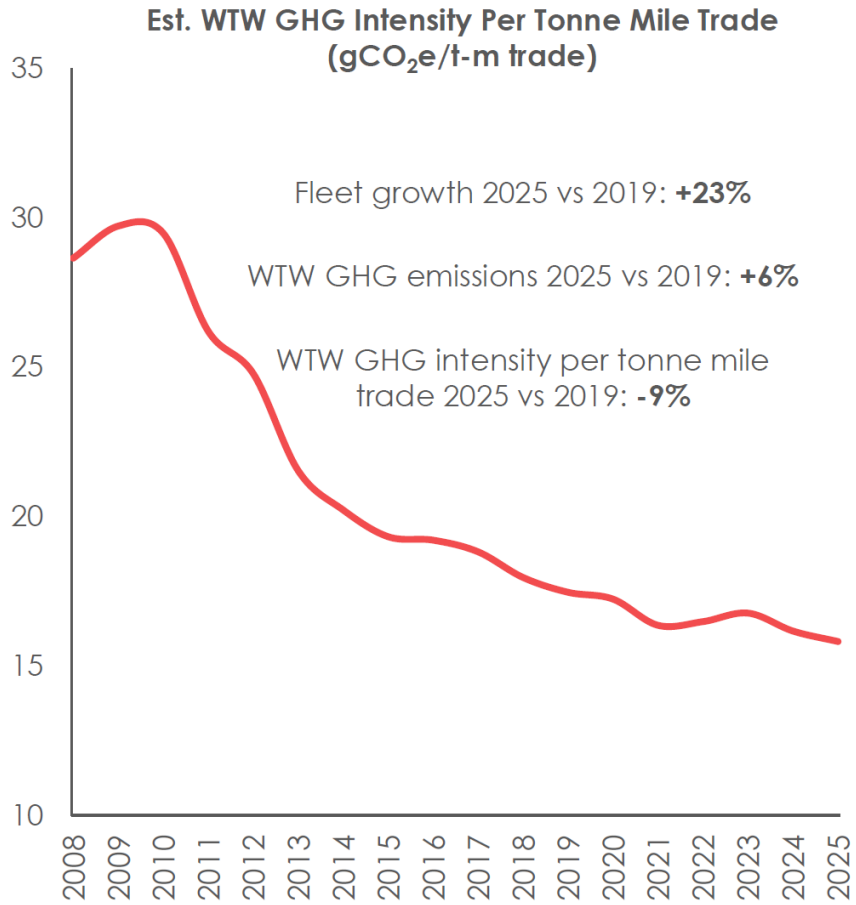
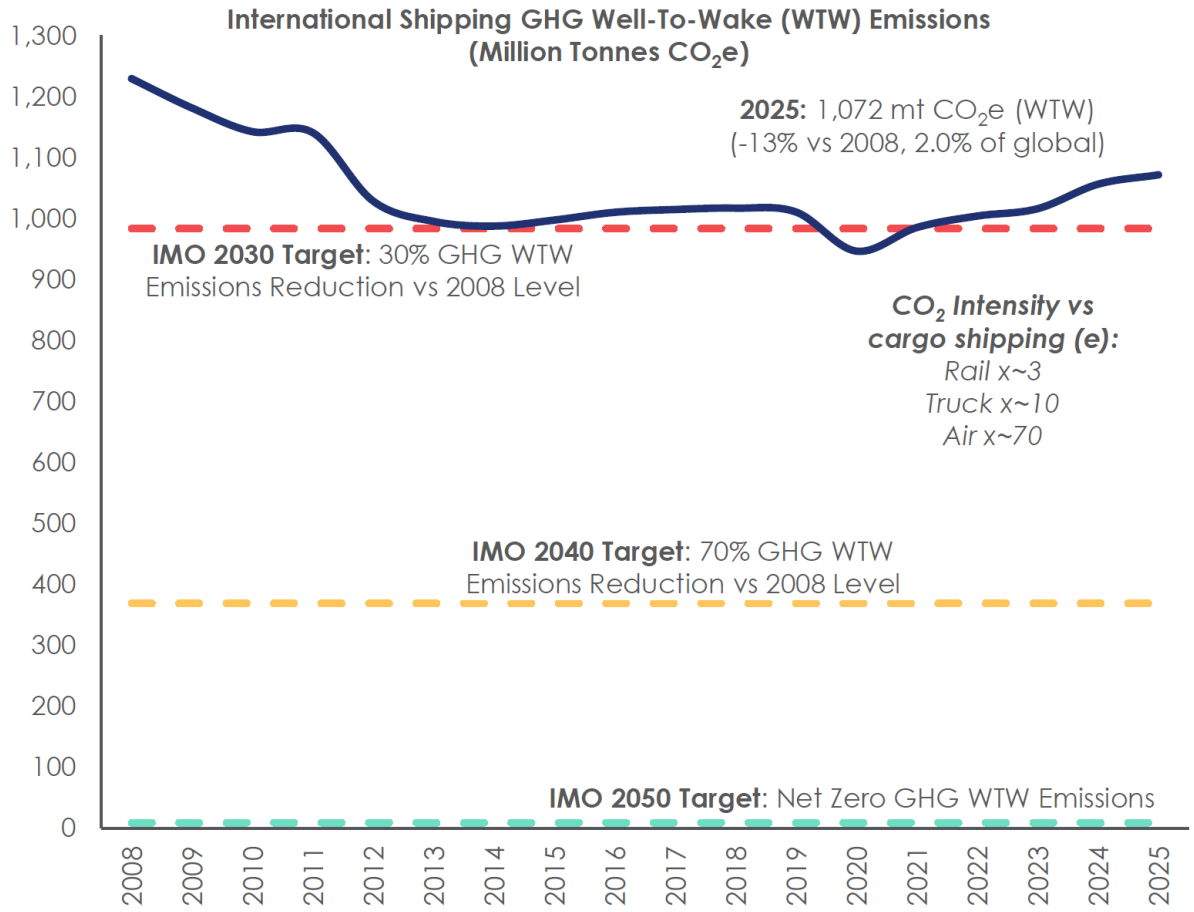
BUREAU VERITAS

SHIPPING DECARBONIZATION STATUS

Emissions intensity of the fleet has been steadily declining



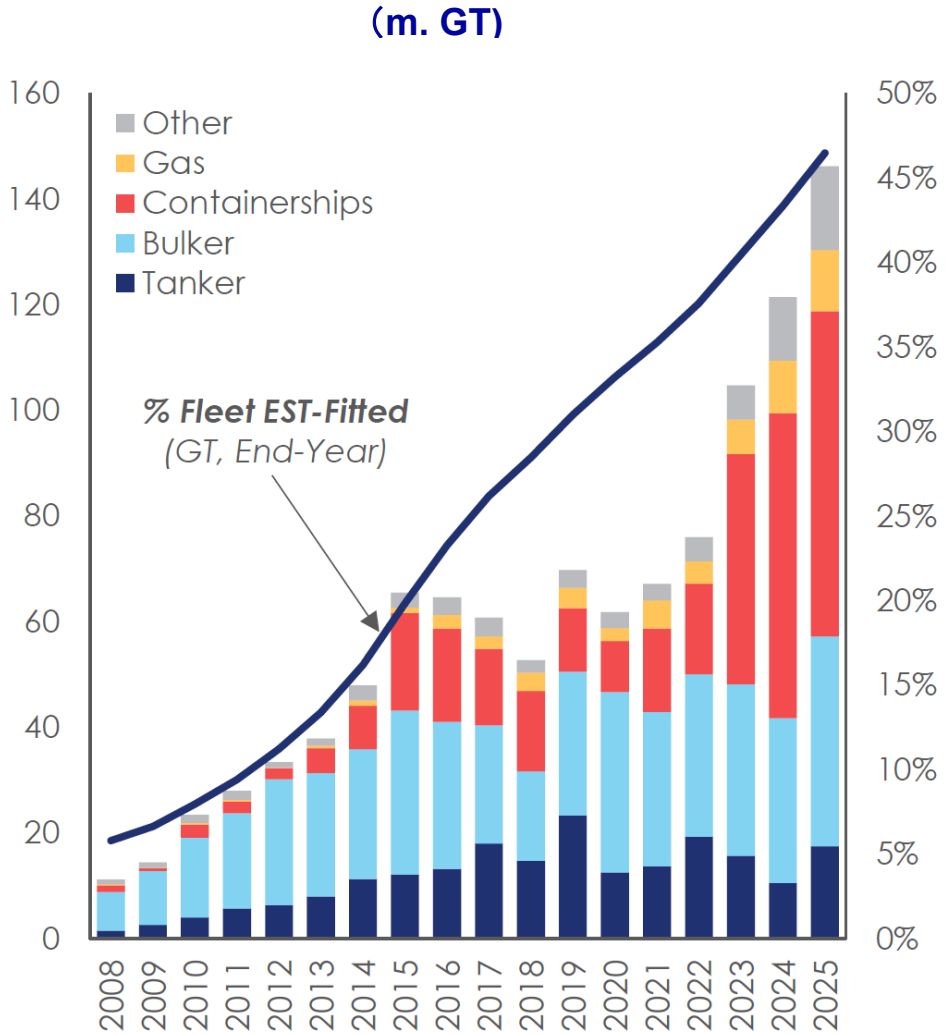
Emissions increased with firm fleet growth resulting higher overall emissions



Source: Clarksons

EETs APPLICATION STATUS

- EETs are widely used onboard the fleet, above 45% in GT with at least 1 EETs installed, it was around 34% five years ago, and expecting to be more as the new building ships being delivered with some of the EETs as the standard design items such as before and after propellers, e.g., rudder bulb, PBCF or propeller duct etc.
- But based on the roughly estimation, ~42% of tankers, bulkers and containers tonnage would be CII rated as D or E rated in 2027;
- So, for those existing ships whose not able to convert into alternative fuels or not will not beneficial from convert into alternative fuel, and have not installed EET(s) onboard, it is a good option to consider EET(s).



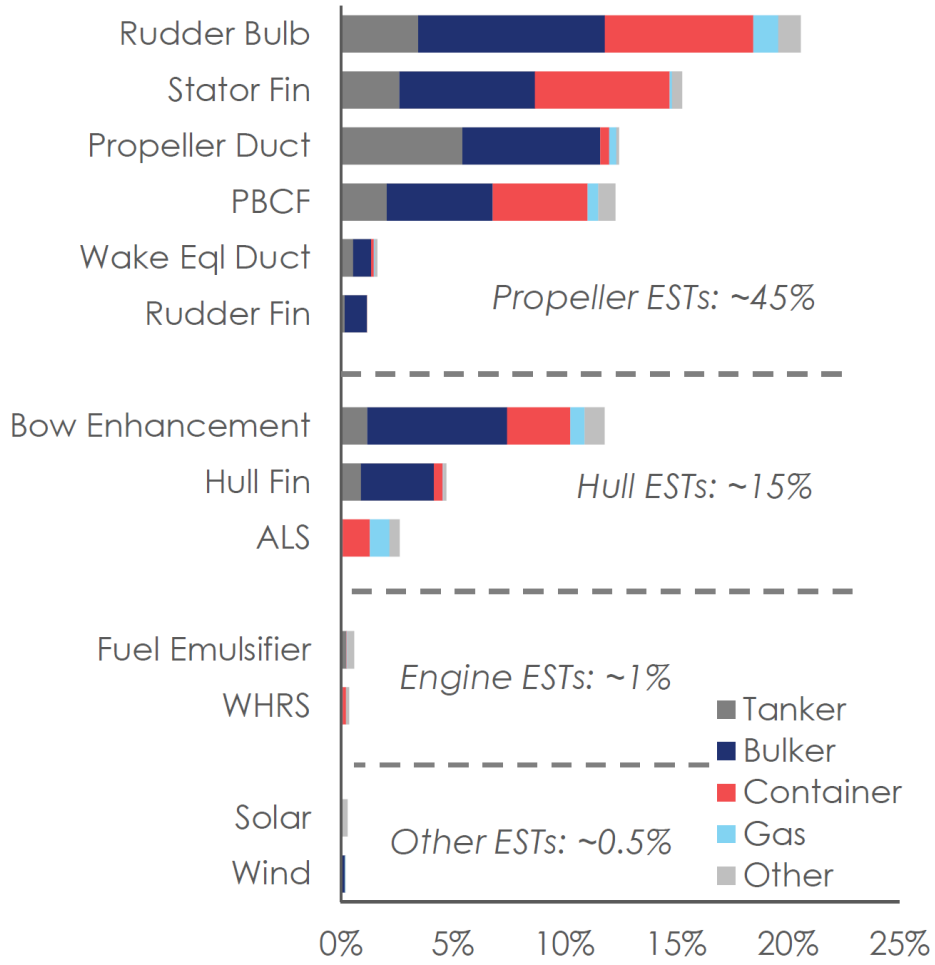
Source: Clarksons

EETs APPLICATION STATUS

EETs of propeller and hull are most popular, installed with about 45% and 15% of the fleet, some other innovative EETs are also being used with few percentage. Deep dive into the reasons are:

- Easier to install or retrofit, not caused a big change to the ship, e.g., stability, structure etc.
- Lower investment cost;
- More adaptability to most of the ship types.
- Etc.

Select EETs in % of total fleet GT



Source: Clarksons

EETs COVERED BY EEDI FORMULA 2021

Impact of propulsion | Impact of auxiliary services | Impact of PTI reduced with electrical innovations | Impact reduction due to mechanical innovations

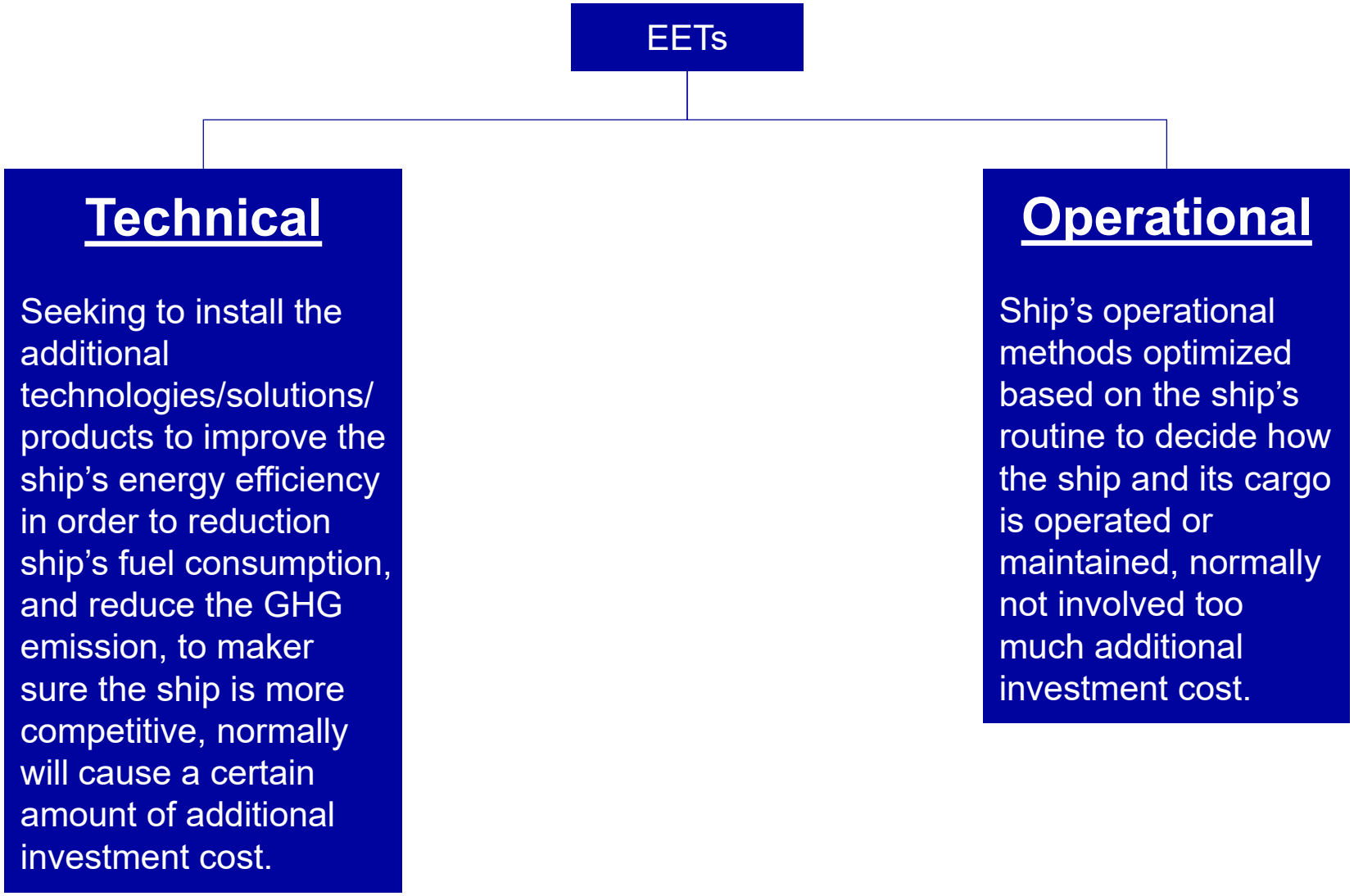
$$\frac{\left(\prod_{j=1}^{n} f_j\right) \cdot \left(\sum_{i=1}^{nME} P_{ME(i)} \cdot CF_{ME(i)} \cdot SFC_{ME(i)}\right) + (P_{AE} \cdot C_{FAE} \cdot SFC_{AE}) + \left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) \cdot C_{FAE} \cdot SFC_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\right)}{f_i \cdot f_c \cdot f_l \cdot f_w \cdot f_m \cdot Capacity \cdot V_{ref}}$$

Correction factors

Ship's work

Innovative Energy Efficiency Technologies				
Reduction of Main Engine Power			Reduction of Auxiliary Power	
Category A	Category B-1	Category B-2	Category C-1	Category C-2
Cannot be separated from overall performance of the vessel	Can be treated separately from overall performance of the vessel		Effective at all time	Depending on ambient environment
	$f_{eff} = 1$	$f_{eff} < 1$	$f_{eff} = 1$	$f_{eff} < 1$
- low friction coating - Bare optimization - rudder resistance - propeller design	-hull air lubrication system (air cavity via air injection to reduce ship resistance)(can be switch off)	- wind assistance (sails, Flettner-Rotors, kites)	- waste heat recovery system (exhaust gas heat recovery and conversion to electric power)	- photovoltaic cells

DIG INTO THE EETs



DIG INTO THE EETs

EETs

Technical

Lower Cost	Notes	High cost (Maybe financing)	Roughly cost (m. USD)
ESDs before and aft propeller	Rudder bulb, PFCF, stator fin etc.	Solar panel	0.08~0.3
High eff. Propeller and rudder		Wind propulsion system	1~1.5/unit
LED lighting system		Air lubrication system	0.88~1.5
Low friction coating		Windshields (container/gas carrier)	0.15~0.9
Hull line optimization		Bulbous bow retrofit (container)	0.3~1.5
VFD control		Shaft generator	0.5~1 (1200kW)
Engine derating	Already done in 2022 for EEXI	Onboard carbon capture	0.4~1
Exhaust gas boilers for AEs		Waste heat recovery	1.5~3
		Batteries and energy storage system	0.5~0.75/MWh
		Onshore power connection	0.2~1

Note: the figures in the table are only for reference which is refer to the publica information of the projects, inquiry from the suppliers, papers from the marine industry peers etc.

EETs INVESTMENT IN DIFFERENT LEVEL

Energy Efficiency Technologies	Abbreviation	Energy saving (%)	Capex (m. USD)	Retrofit/Commissioning (month)
Waste heat recovery	**WHR**	3~8	1.5~3	1~2
Wind propulsion system	**WPS**	7~30	1~1.5/unit	1.5~2
Air lubrication system	**ALS**	5~10	0.88~1.5	1
Batteries and Energy Storage System	**BESS**	2.5~5	0.5~0.75/MWh	1.5~2
Solar panel and Energy Storage System	**SPV**	0~2	0.08~0.3	1
Shaft generator	**PTO**	2~5	0.5~1 (1200kW)	2~3
Onboard carbon capture	**OCC**	40~70% CO2 reduce	0.4~1	3~4
Bulbous bow retrofit (container)	**--**	2~15	0.3~1.5	1.5~2.5
Onshore power supply	**OPS**	depends	0.2~1	1~1.5
Windshield	--	1~2	0.15~0.9	1

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VOTE

Wind Propulsion System

Batteries and Energy Storage System

Waste Heat Recovery

- Energy saving achievable
- High reliability & maintenance friendly
- Low operating Costs
- Short breakeven time

Shaft Generator/PTO

Air Lubrication System