



**BUILD  
ECONOLOGY**

# **DSME GreenShip 18,000 TEU Container Carrier**

Odin Kwon / Director  
Marketing Engineering Team, DSME Seoul  
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## Pollution/Emission from Ships & Regulations

## DSME Green Ship – Econology

## Introduction - 18,000 TEU Containership

## Conclusion



# Pollution & Emission from Ships



Air pollution on voyage	Water pollution on voyage	Ground pollution on voyage	Pollution on ship recycling
SOx NOx GHG* PM* VOC*	Waterproof oil Bilge water Cooling water Grey water Antifouling materials Ballast water Noise	Precipitates Wastes Chemical residues Oil residues	Paint Plastic Electrical product Sealed gas Chemical product

\*GHG (Green House Gas; CO2)  
 \*PM (Particulate Matter)  
 \*VOC (Volatile Organic Compound)

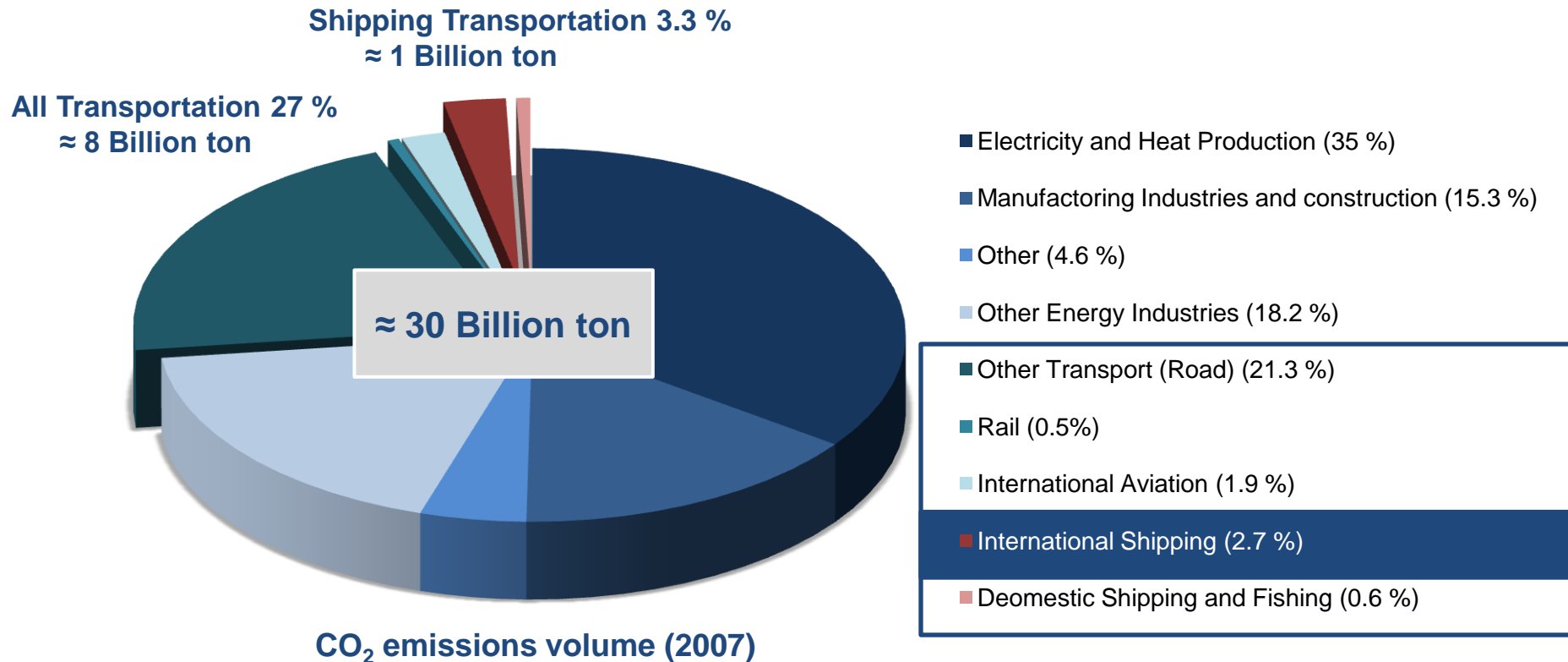


# Pollution & Emission from Ships



**Total CO<sub>2</sub> emissions from shipping are 3.3 % of the global total.**

Shipping transportation shares 90% of total transportation.

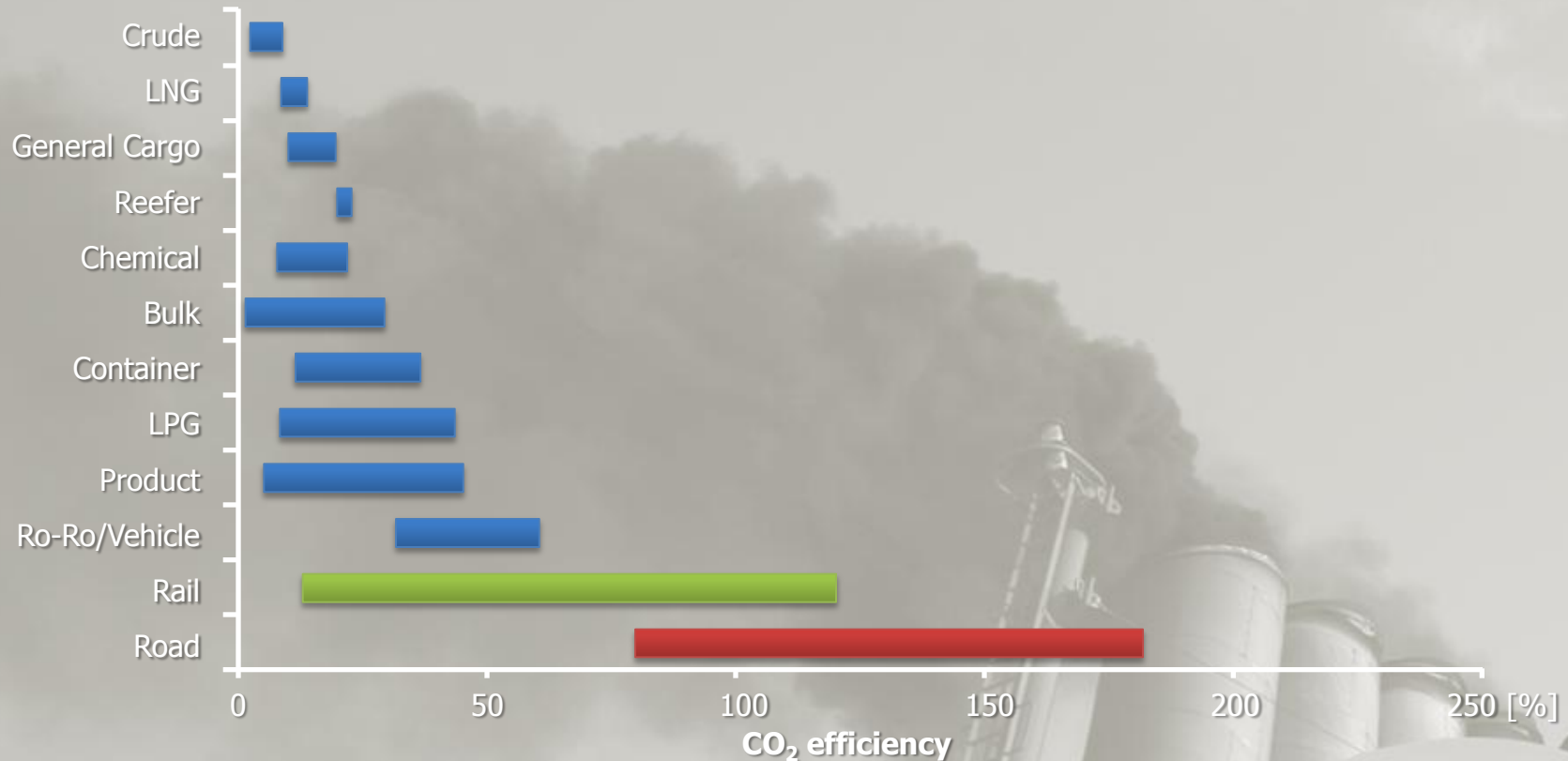


\* Source ; Second IMO GHG Study 2009.

# Pollution & Emission from Ships



## Ship is the most efficient transportation in view of CO<sub>2</sub> emission



CO<sub>2</sub> efficiency = CO<sub>2</sub> / (tonne \* kilometre) ≈ Fuel consumption

CO<sub>2</sub> = **total CO<sub>2</sub> emitted from the vehicle** within the period

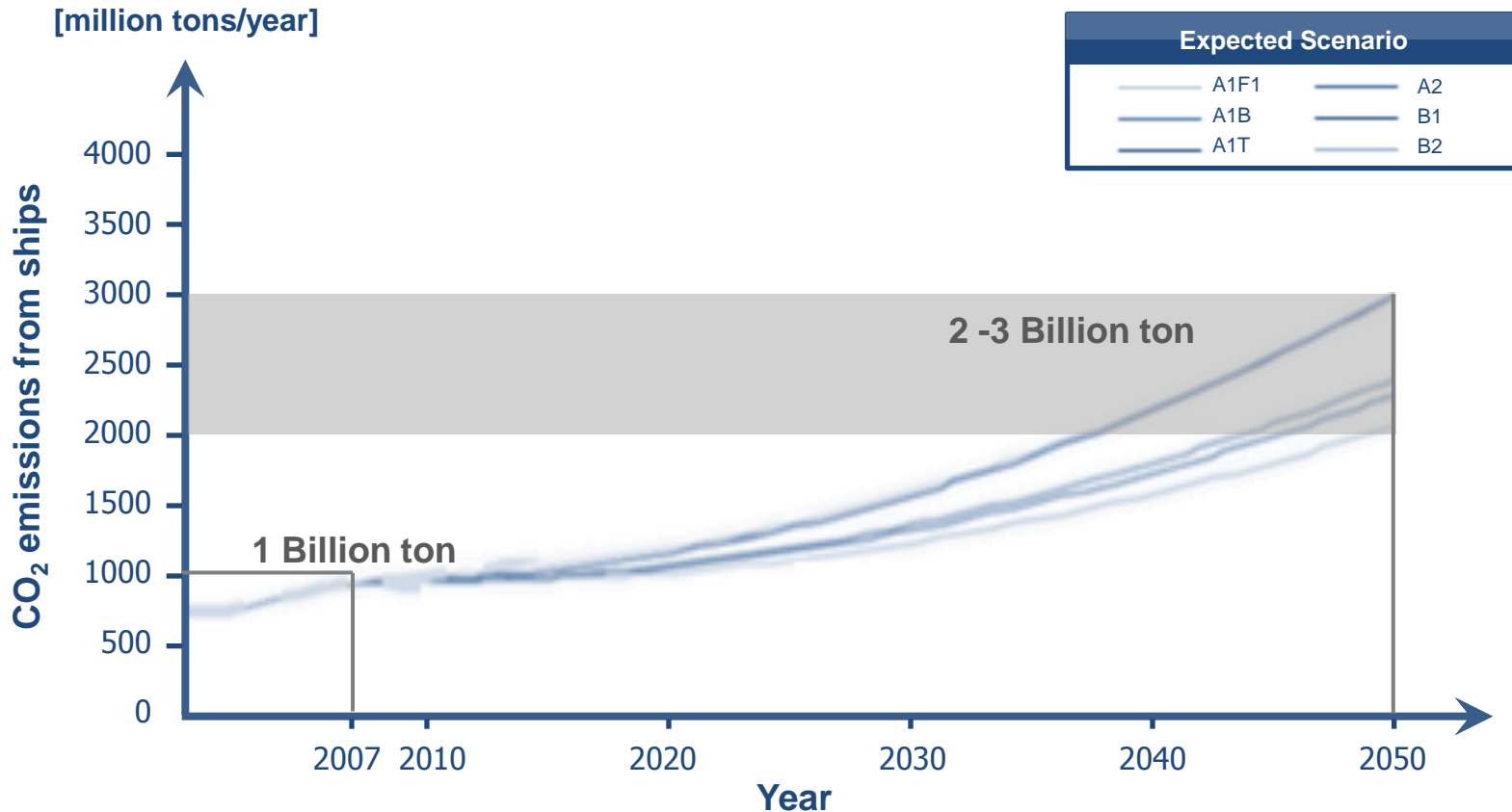
tonne\*kilometre = total actual number of tonne-kilometres of work done within the same period

\* Source ; Second IMO GHG Study 2009.

# Pollution & Emission from Ships

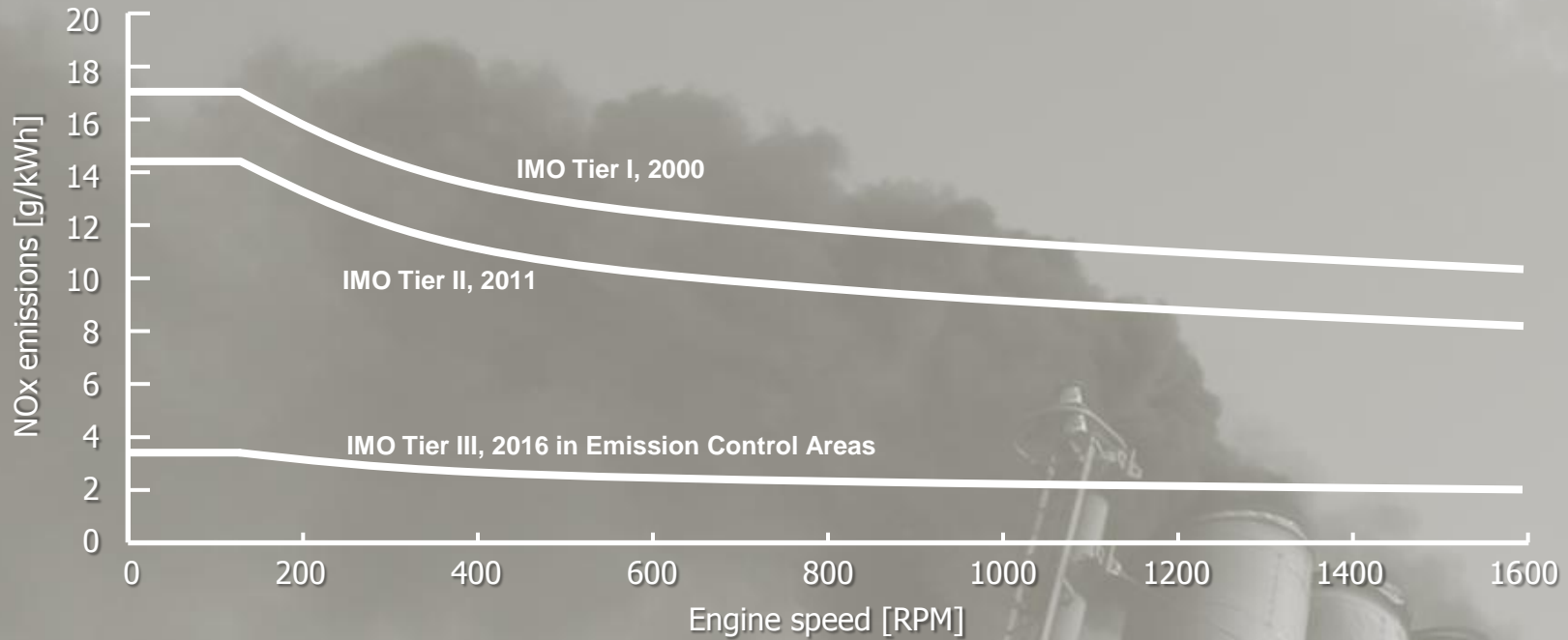


**GHG emissions from ships are predicted to be at least doubled by 2050**



\* Source ; Second IMO GHG Study 2009.

# Emission Regulations - NOx



RPM	Tier 1 (current)	Tier II (from 2011.1.1)	Tier III (from 2016.1.1)
Under 130	17.0 g/kWh	14.4 g/kWh	3.4 g/kWh
130 ~ 2000	$45.0 \times n^{(-0.2)}$ g/kWh	$44.0 \times n^{(-0.23)}$ g/kWh	$9 \times n^{(-0.2)}$ g/kWh
Over 2000	9.8 g/kWh	7.7 g/kWh	2.0 g/kWh

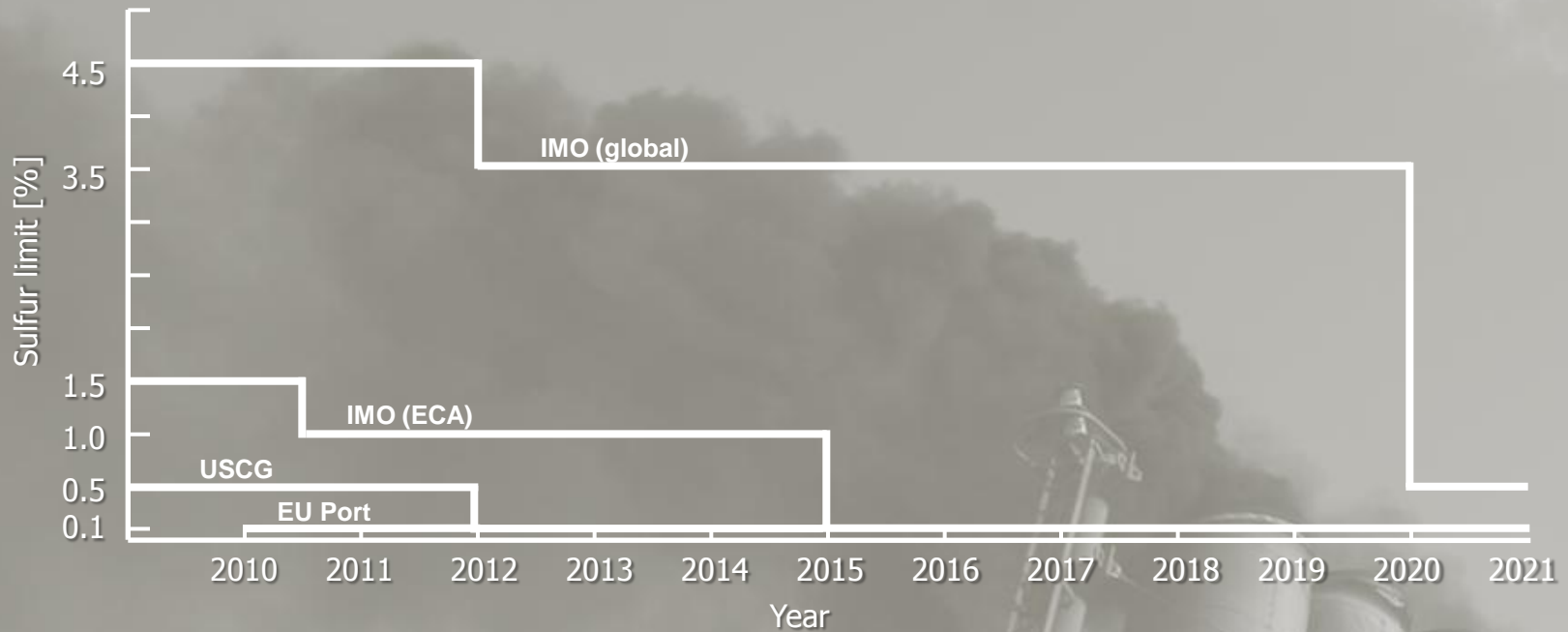
IMO NOx Tier II : Adopted on MEPC 58 (2008.10)

- After 1 January 2011 (Keel Laying)

IMO NOx Tier III : Tentative Assent

- After 1 January 2016 (Keel Laying)

# Emission Regulations - SOx



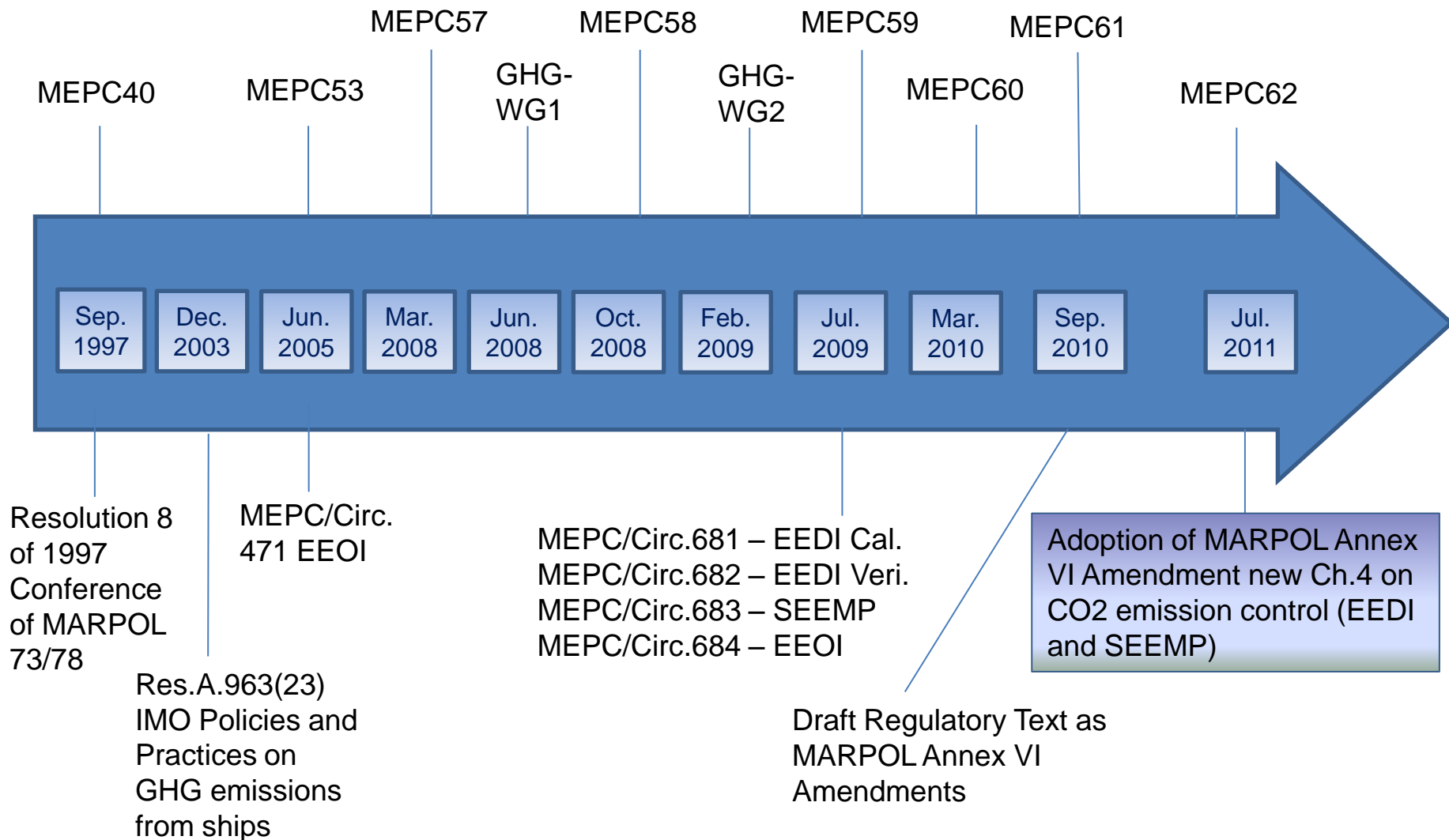
Regulation or Area	Sulfur Content			
	2010	2012	2015	2020
Global Limit	4.5 %	3.5 %		0.5 %
IMO ECA	1.5 %	1.0 % (after 2010.07)		0.1 %
EU Port	0.1 %			
USCG (within 24NM)	0.5 %		0.1 %	

- Residual Fuel (IFO380 or LS380)
- Distillate Fuel (MGO)



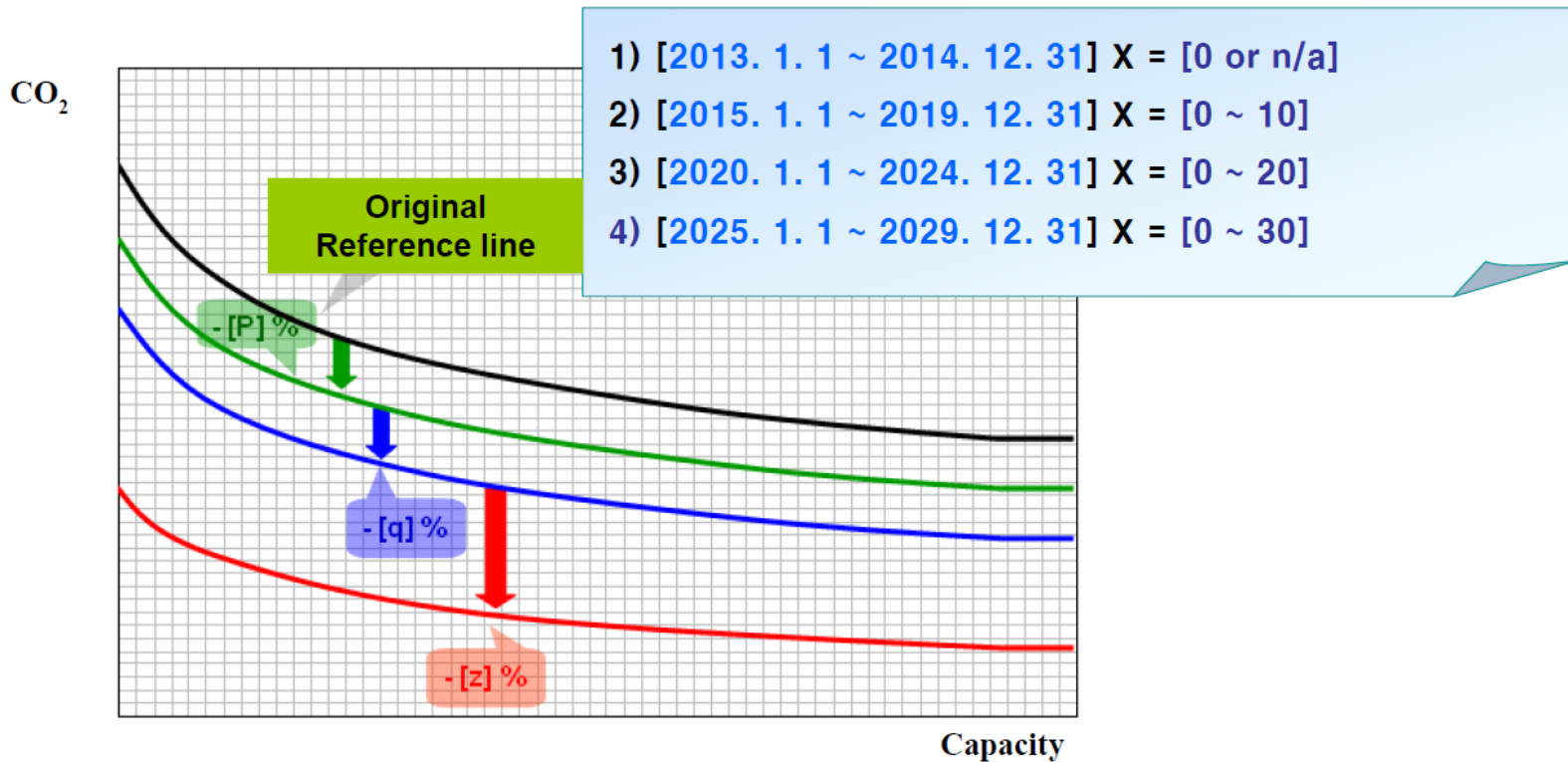


# Emission Regulations – CO<sub>2</sub>





● **Reduction rate** =  $(1 - \frac{X}{100}) \times \text{reference-line}$

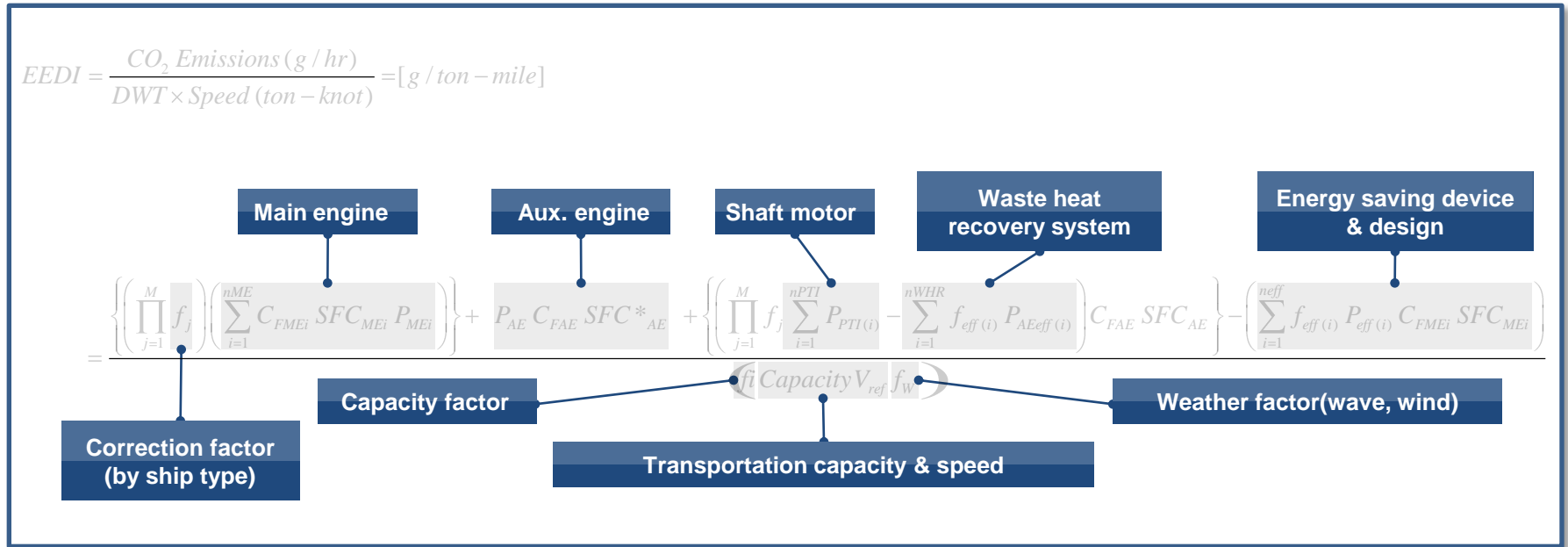




## EEDI (Energy Efficiency Design Index) – Technical Regulation

Design Specific

$$EEDI = \frac{CO_2 \text{ Emissions (g / hr)}}{DWT \times Speed \text{ (ton - knot)}} = [g / ton - mile]$$



Goal of EEDI

- Mitigate CO<sub>2</sub> emissions
- Increase cargo carrying capacity
- Enhance speed performance

If using LNG as ship fuel,

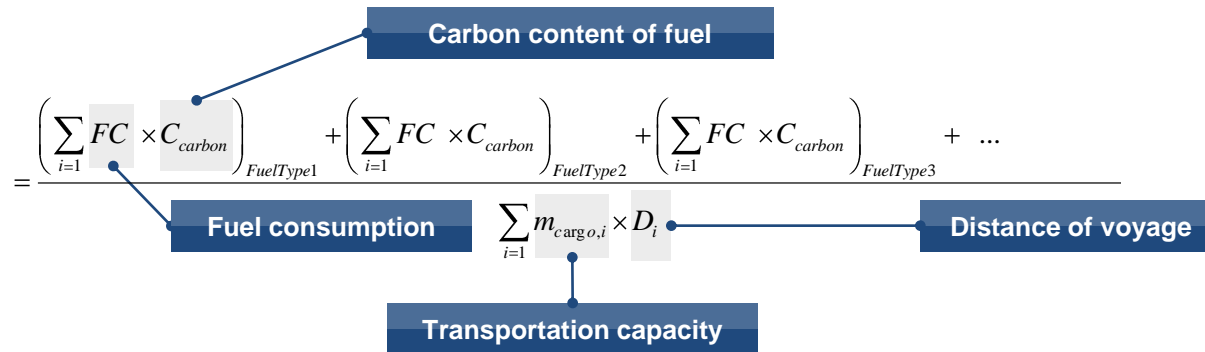
- ➔ Reducing CO<sub>2</sub> emission of Main engine & Aux. engine
- ➔ Reducing EEDI



## EEOI (Energy Efficiency Operational Indicator) – Operational Regulation

Voyage Specific

$$EEOI = \frac{CO_2 \text{ Emissions (g)}}{DWT \times \text{Miles (ton - knot)}} = [g / \text{ton - mile}]$$



### Effect of slow steaming

Ship speed	Engine power
100 % Service Speed	90% MCR
70 % Service Speed	30% MCR
50 % Service Speed	15% MCR

Service speed = guarantee speed at NCR with 15% sea margin

Slow steaming as 70 % of design speed

- ➔ Reducing fuel consumptions down to abt. 30 %
- ➔ Reducing EEOI



## Ballast Water Treatment System (BWTS)

### IMO Reg. B-3 Ballast Water Management for Ships

	Rule	Capa. of WBT (m <sup>3</sup> )	Keel laying	~ '08	'09	'10	'11	'12	'13	'14	'15	'16	'17
Exist. Ship	B-3.1.2	Above 5000 m <sup>3</sup>	Before '09	D-1 or D-2								D-2	
New Ship	B-3.2.2	5000 m <sup>3</sup> and above	'09 – '11	D-1 or D-2								D-2	
			After '12	D-1 or D-2				D-2					

- Note. 1. D-1: Exchange Standard, D-2: Performance Standard (BWTS)
2. The international convention for the control and management of ship ballast water and sediment, 2004 will enter into force 12 months after ratification by 30 states, representing 35% of world merchant shipping tonnage. To date, there are **28** States that represent **26.4%** of the world merchant shipping tonnage ([Apr. 2011](#)).

### List of BWTS which received Type Approval Certification by their respective Administrations

Supplier	Technology	IMO Final Approval	Administration
Alfa Laval	Filter + UV + TiO <sub>2</sub>	Yes	Norway
Hyde Marine	Filter + UV	Not Applicable	USA
Panasia	Filter + UV	Yes	Korea
OptiMarin	Filter + UV	Not Applicable	Norway
OceanSaver	Filter + Electrolysis + Deoxygenation + Cavitation	Yes	Norway
Techcross	No Filter + Electrolysis	Yes	Korea
Hamann HG	Filter + Hydrocyclone + Electrolysis	Yes	Germany
NK	No Filter + Ozonation	Yes	Korea
NEI Treatment System	No Filter + Deoxygenation + Cavitation	Not Applicable	Liberia/Marshall
Hitachi	Coagulation + Magnetic separation + Filter	Yes	Japan
.....			



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# Future Needs



## More Economic

- Rapid & continuous increase of oil price



## More Environmental Friendly

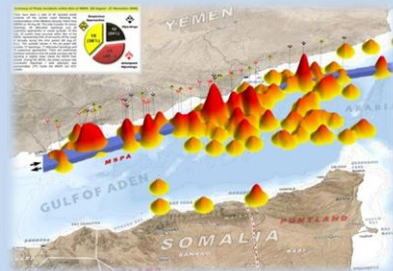
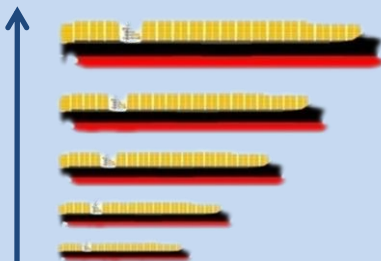
- Legislation intensified

Air emission limitation							
2006	2008	2010	2012	2014	2016	2018	2020
EU SO <sub>x</sub> regulation / 1.5 % sulphur in fuel/ passenger ships in EU + all ships in SECA							
Differentiated tonnage tax / NO <sub>x</sub> / Norway							
Differentiated fairway & harbour fee / NO <sub>x</sub> , SO <sub>x</sub> / Sweden / Finland							
EU SO <sub>x</sub> regulation/ 0.1 % sulphur in fuel/ EU ports + all inland waterways							
IMO SO <sub>x</sub> regulation / Sulphur in fuel/ SECA 2010 & 2015, globally 2020							
Marine CO <sub>2</sub> cap / IMO Energy Efficiency Operational Index							
US-EPA Tier III & IV / NO <sub>x</sub> , PM, THC/ US flagged, eng<30 l/cyl							
IMO Tier III on NO <sub>x</sub> / new ships in NECA							

● Foreseen, not yet in place

## Higher Performance

- Market wants a **BIGGER & SAFER** vessel

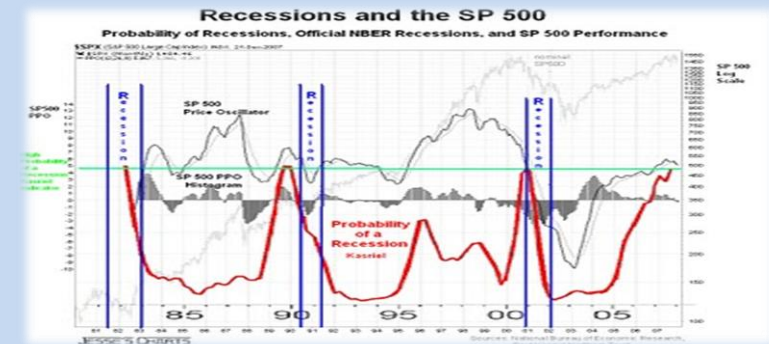


Pirate attack in gulf of aden

Now 18,000,  
How big in near future?

## Higher Operating Flexibility

- Cargo type/amount variation  
due to rapid economic change



# EX) Trends in Containership Design



## Overview of Dimension Parameter

Series	Breadth	ROW & BAY(DECK)	Series											
			0	1	2	3	4	5	6	7	8	9	10	
		LOA	260.0	275.0	300.0	315.0	330.0	345.0	365.0	380.0	395.0	410.0	425.0	
		LPP	249.6	264.0	288.0	302.4	316.8	331.2	350.4	364.8	379.2	393.6	408.0	
Series	Breadth	ROW & BAY(DECK)	16	17	18	19	20	21	22	23	24	25	26	
0	32.2	13	Td	12.0	12.0	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	17668.8	19177.8	21811.5	23462.9	25167.8	26926.1	29353.5	31236.5	33172.8	35162.5	37205.7
			DISP't	68211.0	72146.3	81984.4	89527.0	93790.2	101824.6	111717.4	120462.4	125217.5	129972.6	134727.7
			14T HOMO	3610	3783	4298	4719	4902	5350	5883	6373	6575	6772	6966
1	34.9	14	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	19150.4	20785.9	23640.4	25430.3	27278.2	29183.9	31814.9	33855.7	35954.3	38110.9	40325.4
			DISP't	77011.0	81454.0	88858.9	97033.9	101654.6	110362.7	121085.0	130563.3	135717.1	140871.0	146024.8
			14T HOMO	4133	4333	4658	5115	5313	5798	6376	6908	7126	7340	7550
2	37.6	15	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	20631.9	22394.0	25469.3	27397.7	29388.5	31441.6	34276.2	36474.9	38735.9	41059.3	43445.1
			DISP't	80945.3	85615.2	93398.4	101991.1	106847.8	116000.8	127270.9	137233.4	142650.5	148067.6	153484.7
			14T HOMO	4308	4516	4852	5328	5533	6040	6642	7197	7422	7643	7860
3	40.3	16	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	22113.4	24002.0	27298.3	29365.1	31498.8	33699.4	36737.5	39094.1	41517.5	44007.8	46564.9
			DISP't	88926.8	94057.2	102607.8	112047.8	117383.4	127438.9	139820.3	150765.1	156716.4	162667.6	168618.9
			14T HOMO	4772	5004	5379	5906	6135	6696	7363	7977	8228	8476	8718
4	43.0	17	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	23595.0	25610.1	29127.2	31332.5	33609.2	35957.2	39198.8	41713.3	44299.1	46956.2	49684.6
			DISP't	94884.7	100358.8	109482.3	119554.7	8400	135977.0	149187.9	160866.0	167216.0	173656.9	179915.9
			14T HOMO	5092	5339	5740	6302	8511	8780	9044	9302			
5	45.7	18	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	25076.5	27218.2	30956.1	33299.9	35719.5	38555.5	41215.0	43325.5	47080.6	49904.6	52804.3
			DISP't	100842.5	106660.4	7450	127061.6	133112.1	11000	158555.5	170966.9	177715.6	184464.3	191213.0
			14T HOMO	5412	5674	6697	6957	8350	9045	9331	9611	9886		
6	48.4	19	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	26558.1	28826.3	32785.0	35267.3	37829.9	40472.7	44121.5	46951.7	49862.2	52853.0	55924.1
			DISP't	106800.4	112962.0	8600	134568.5	10000	153053.2	13000	181067.8	188215.2	195362.6	202510.0
			14T HOMO	5732	6010	7093	7933	8041	9580	9882	10179	10470		
7	51.1	20	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	28039.6	30434.3	34613.9	37234.7	39940.2	42730.5	46582.8	49570.9	52190.1	55801.4	59043.8
			DISP't	112758.3	119263.3	131000.0	141884.0	148840.9	161591.3	14000	191168.7	198700.0	206260.9	213807.1
			14T HOMO	6051	6342	7889	8939	7779	8490	9300	10114	10434	10747	11055
8	53.8	21	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	32042.4	36442.8	39201.2	42050.6	44988.3	49044.1	52190.1	55425.3	58801.8	62163.5	
			DISP't	125565.2	136980.2	149582.4	156705.3	170129.4	186658.3	201269.5	16000	217159.2	225104.1	
			14T HOMO	6371	6680	7181	7884	8190	8939	9830	10649	11315	11639	
9	56.5	22	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	31002.7	33650.5	38271.7	41169.5	44160.9	47246.1	51505.4	54809.3	58206.9	61698.2	65283.3
			DISP't	124674.0	131866.8	143854.7	157089.3	164569.7	178667.5	196025.9	211370.4	219714.0	228057.6	236401.1
			14T HOMO	6691	7015	7542	8280	8601	9487	10323	11183	11536	11883	12223
10	59.2	23	Td	12.5	12.5	12.5	13.0	13.0	13.5	14.0	14.5	14.5	14.5	
			LWT	32484.3	35258.6	40100.7	43136.9	46271.3	49500.0	53966.8	57428.5	60988.5	64646.6	68403.0
			DISP't	130631.9	138168.4	150729.1	164596.2	172434.1	187205.6	203393.5	221471.3	18000	238955.9	247698.2
			14T HOMO	7011	7351	7902	8676	9012	9836	10646	11717	12451	12807	

Decrease L/B

Identical Capa.

Opt2: Widening  
L/B=6.5

Opt1: Lengthening  
L/B=7.1

Conventional

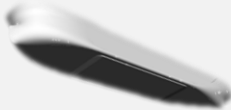

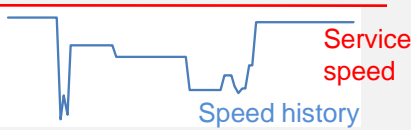
Slow steaming



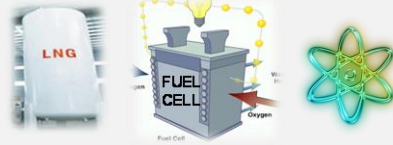

# Innovative Technology Keywords





## More Economic

Lower hull resistance	
Higher power train efficiency	
Slow streaming	



## More Environmental Friendly

Switching to more environmental friend fuel	
Emission reduction device	

## Higher Performance

Optimum vessel design ( speed , size etc. )	
Higher safety ( crew , system etc. )	

## Higher Operating Flexibility

CARGO multi purpose	
Less maintenance	



## Econology = Ecology + Economy + Technology

### High Performance Ship Design

- Optimum Dimensions
- Excellent Speed Performance
- Maximum Capacity (DWT, VOL)
- Competitive FOC
- Safety

Conventional Design Goals



### Green Enhanced Design

- F**uel(= CO<sub>2</sub>) Saving Max. (EEDI)
- E**fficient Operation (EEOI)
- E**mission Reduction
- L**ess Maintenance

New Requirements of  
Environmental Associations  
& Shipping Industry

*Hi-Performance & Environment Friendly Ship*



## FEEL 389

30% CO<sub>2</sub> reduction

80% NO<sub>x</sub> reduction

90% SO<sub>x</sub> reduction

by 2015

**ECONOLOGY EFFECT**

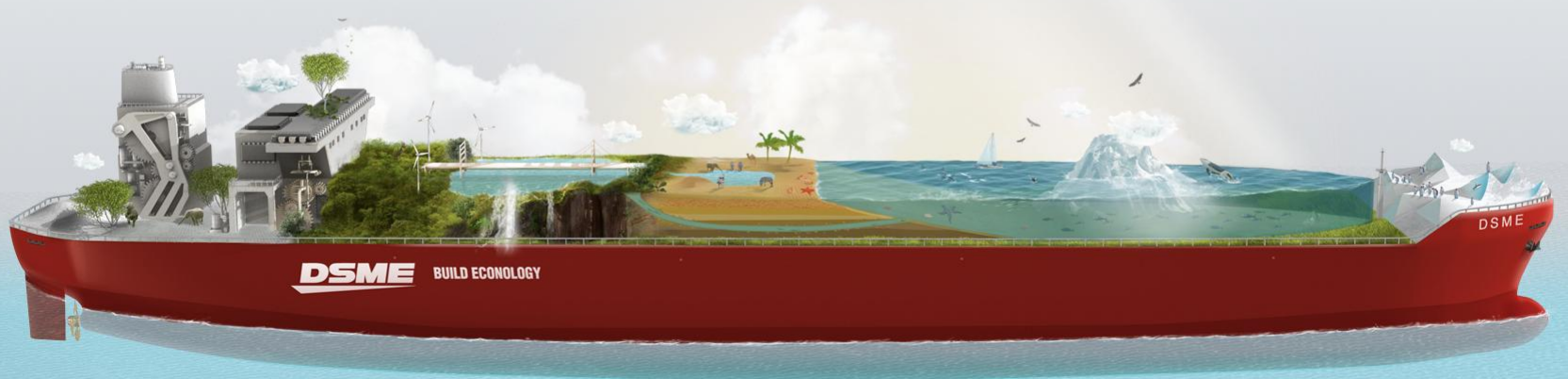
by 2020

## FEEL 599

50% CO<sub>2</sub> reduction

90% NO<sub>x</sub> reduction

90% SO<sub>x</sub> reduction



# Build Econology



## Energy

ECONOLGY ENERGY

- LNG Fueled Propulsion
- Nuclear Powered Propulsion
- Fuel Cell Hybrid Electricity Generation
- Solar Powered Ship
- Wind assisted Propulsion

## Material

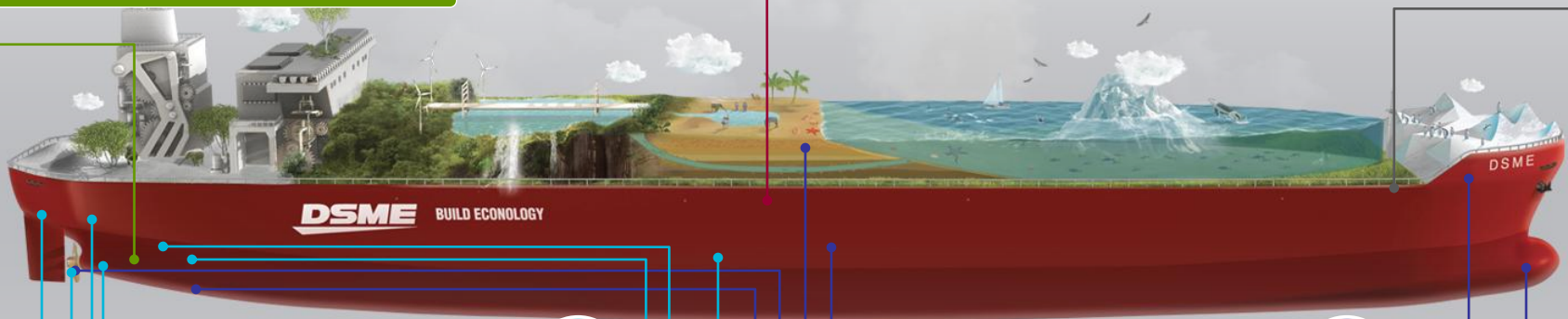
ECONOLGY MATERIAL

- Non-Corrosive Material
- Environment Friendly Painting Material
- Advanced A/F Paint
- Consideration of Ship Recycling Convention

## Operation

ECONOLGY OPERATION

- Trim Optimization
- Optimum Weather Routing
- Arctic Routing
- Slow Steaming (Eco-Speed)



## Device

ECONOLGY DEVICE

- Shaft Generator
- Pre-Swirl Stator (PSS)  
Ducted PSS  
Rudder Bulb Fin
- Ballast Water Treatment System (BWTS)
- Waste Heat Recovery System (WHRS)
- NOx Reduction Device  
SOx Reduction Device
- Air Cavity System (ACS)
- VOC Reduction Device
- Grey Water Treatment System

## Design

ECONOLGY DESIGN

- Optimized Hull Form Design
- Protective Piping Arrangement
- High Efficiency Propeller Design
- Optimized Main Engine Selection and De-rating
- Enhanced Hull Structure  
Electric Driven Deck Machinery
- Bulbous Bow Optimization





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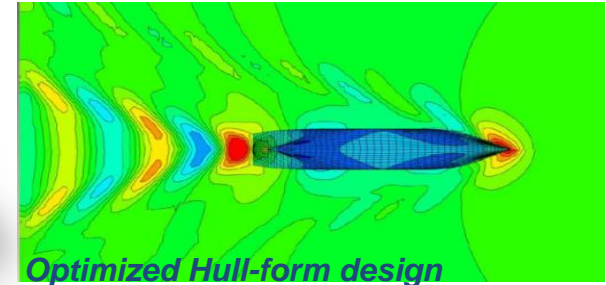
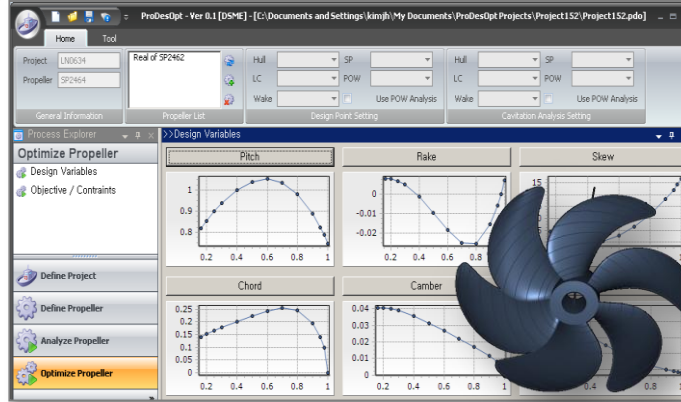
# Econology for DSME 18,000 TEU Containership



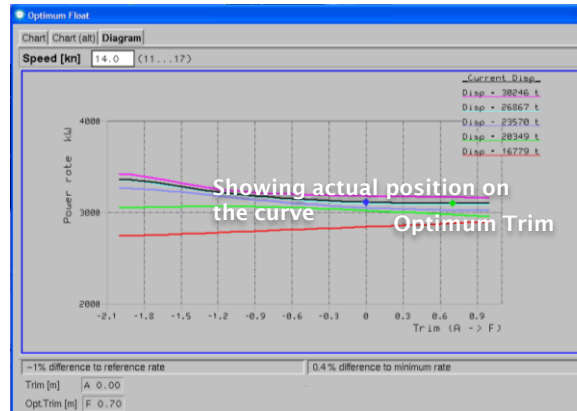
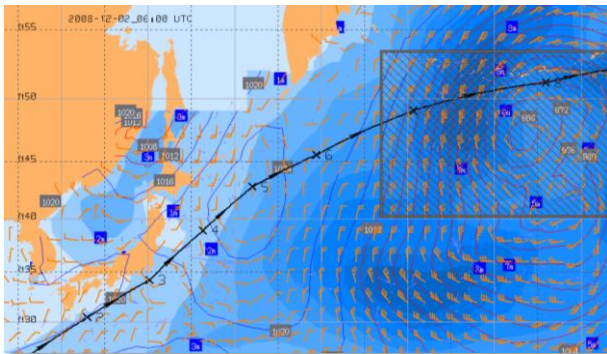
## Full Spade Rudder

Superior performance and efficiency  
Protective design against cavitation

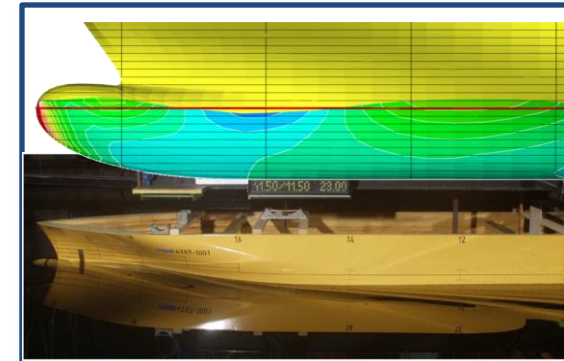
## High Efficiency Propeller design



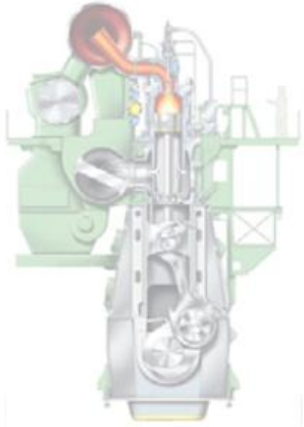
Optimization for wide operating range in draft, trim and speed



## Bulbous Bow optimization



# Econology for DSME 18,000 TEU Containership



## 8S80ME-C9 with Derating (Twin Skeg design)

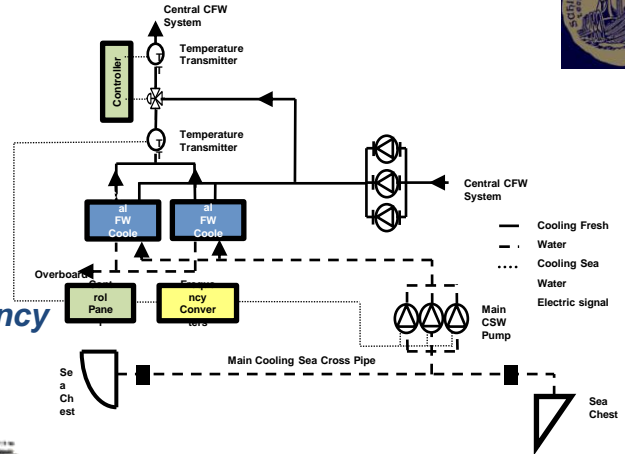
- Maximized fuel economy
- High efficiency in wide range with electronic control
- Superior performance at slow steaming

## Full Compliance of Emission Criteria

- MARPOL Annex VI (NOx, SOx)
- EU Port Regulation (SOx)
- CARB (SOx)

## Variable Frequency

## Control Motor

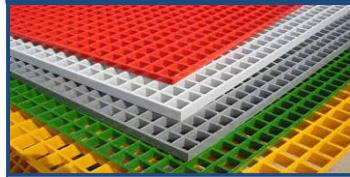


## GRE Pipe

- Ballast main lines in pipe duct
- Main sea cross pipe
- Non-Corrosive Material



GRE Pipe



GRP\* Grating

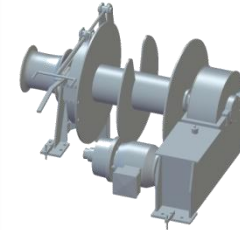


GRP Door

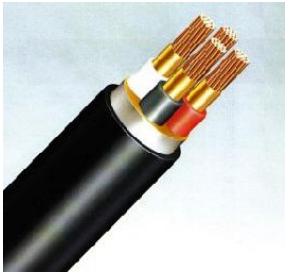
## Enhanced Hull Structure

## Electric Driven Type Deck Machinery

## Non-Corrosive Material



# Econology for DSME 18,000 TEU Containership



## Environment friendly material

- PVC free material for the finish of door, wall panel
- Steel furniture for future recycling potential and non-toxic material use
- Low energy type refrigerator
- Refrigerant with low global warming potential, R-134A
- Halogen-free cable

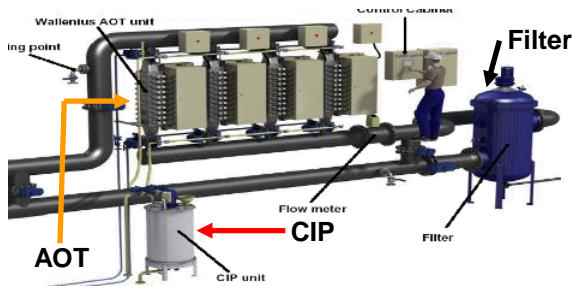
## Exh. gas economizer for GE

## High thermal insulation

100 mm thermal for accommodation



## Ballast water treatment system (UV type)

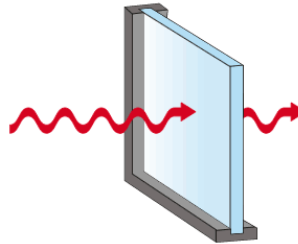


## Windows with Low U-value

- All window except wheelhouse : 1.1 W/m<sup>2</sup>K
- Wheelhouse : 2.8 W/m<sup>2</sup>K

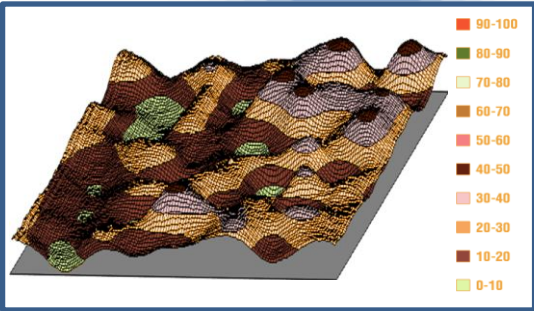
## Low energy loss & refrigerant leakage

Chilled water system for main air-con. unit  
Whole air con. plant (AHU & CDU) & Provision, ref. plant at the same air-con. machinery room





# Econology for DSME 18,000 TEU Containership

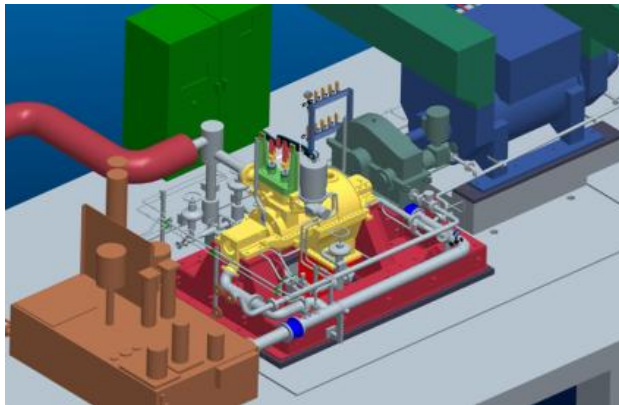


**Advanced A/F paint**  
Silyl acrylate type A/F paint

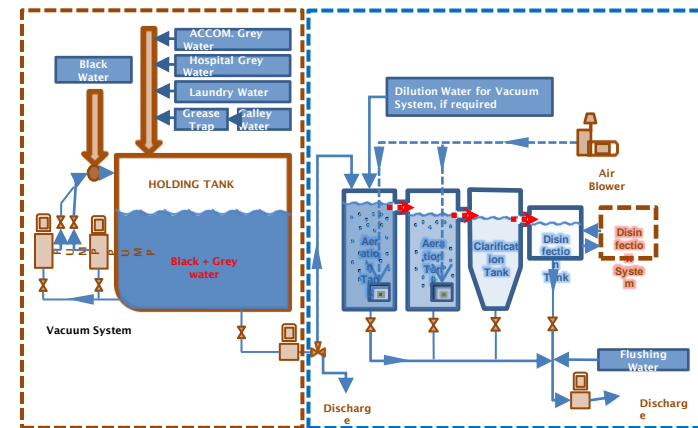
- Water-borne Epoxy in Accommodation and E/R Spaces
- High Solid Volume Epoxy
- Solvent Free Paint for Drinking Water Tanks

**Low VOC Emission Paint**  
No fire/explosion hazard  
Environmentally friendly

**Sewage & Grey water Treatment**  
Separate sewage treatment plant for Accommodation & Engine casing  
Disposal water tank for Grey water & Treated sewage



**Full scale Waste Heat Recovery System (WHRS)**  
**ME optimization /De-rating PTI/PTO (Shaft generator/motor)**  
**Exh. gas economizer for GE**





Maersk Triple-E

Smarter design,  
with room for  
18,000 containers



Maersk Triple-E

World's largest container vessel:  
What can actually fit inside its belly?



**Pollution/Emission from Ships & Regulations**

**DSME Green Ship – Econology**

**Introduction – 18,000 TEU Containership**

**Conclusion**



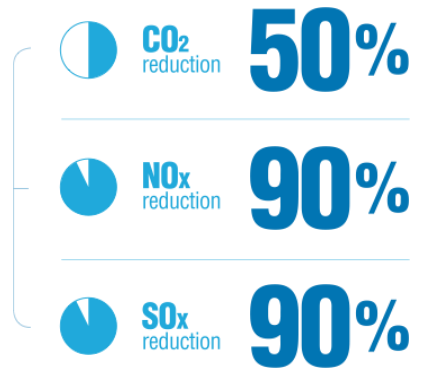
# Summary



CO2 Reductions



<b>Energy</b>	LNG Fueled Propulsion	23%
<b>Design</b>	Optimized Hull Form Design	
	High Efficiency Propeller Design	2~3%
	Bulbous Bow Optimization	
<b>Device</b>	Shaft Generator	1%
	Pre-Swirl Stator (PSS)	
	Ducted PSS	3~6%
	Rudder Bulb Fin	
	Waste Heat Recovery System (WHRS)	3~4%
	NOx Reduction Device SOx Reduction Device	
	Air Cavity System (ACS)	8~10%
<b>Material</b>	Advanced A/F Paint	2~5%
<b>Operation</b>	Trim Optimization	3~4%
	Optimum Weather Routing	4~5%

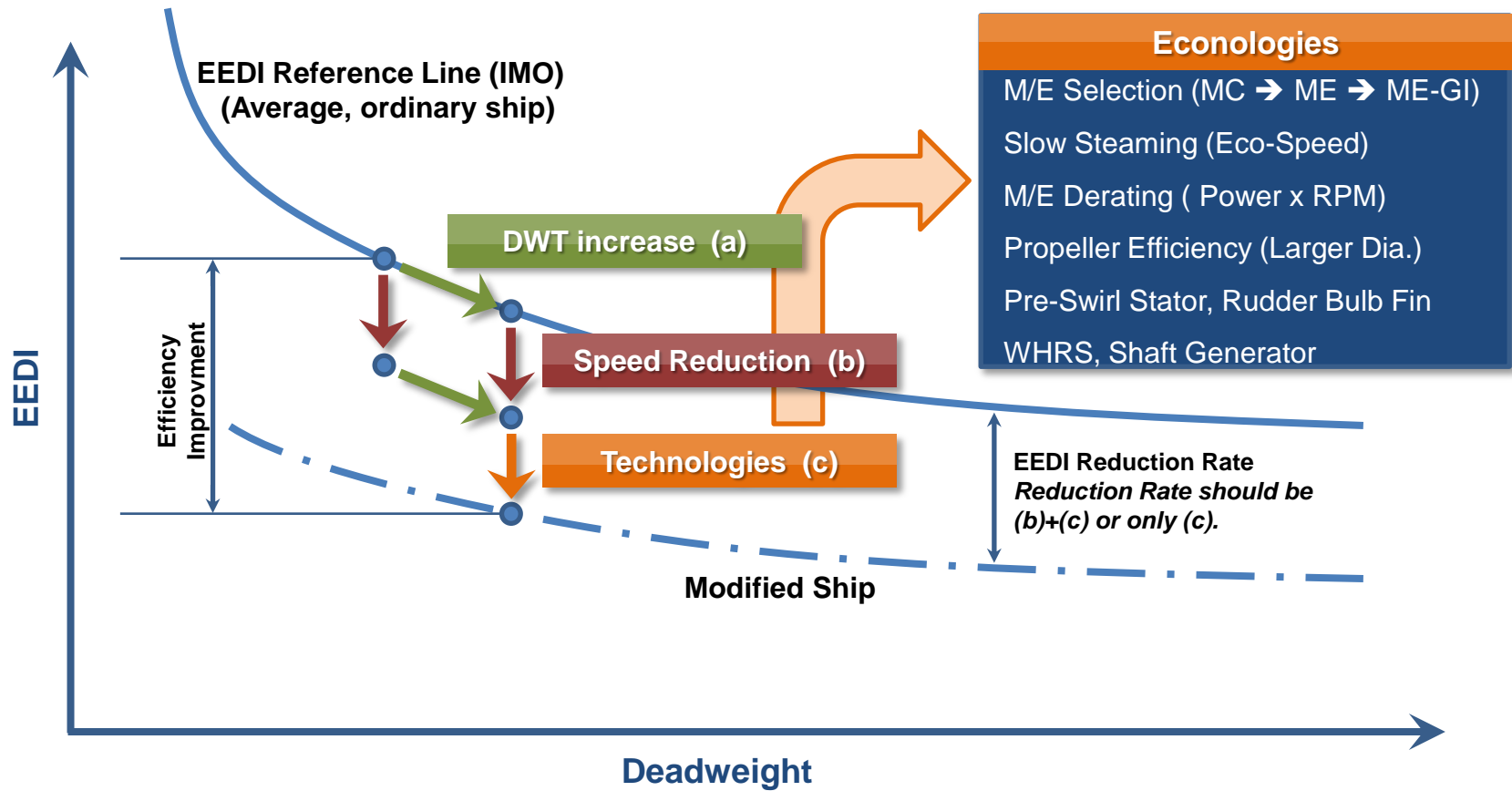


# EEDI evaluation



## EEDI (Energy Efficiency Design Index)

Speed reduction, increased Capacity and improved technology





**Environment Friendly**  
**Economical Operation**

**Through Green Ship Technologies**





# Thank You