2021年驗船中心第二次技術研討會

符合NOx Tier III 與MEPC 76因應策略

Strategy for Complying with NOx Tier III Standards and MEPC 76

財團法人驗船中心
黃義順

報 告 內 容

財團法人驗船中心
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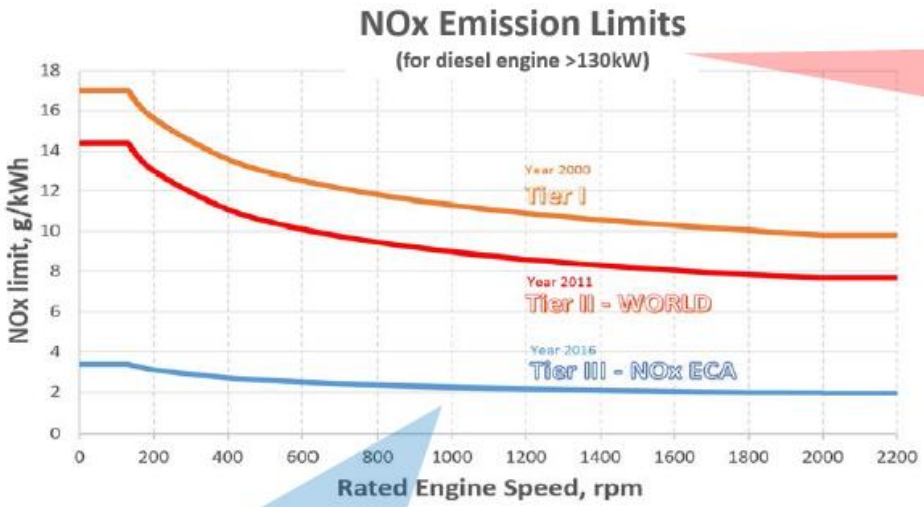
- 前言
- NOx Tier III的因應策略
- IMO減碳策略
- EEXI與CII因應策略
- 結論

前 言



Tier	Ship Construction Date	NOx Limit, g/kWh n = engine's rated speed(rpm)		
		n < 130	130 ≤ n < 2000	n ≥ 2000
I	2000	17	$45 \cdot n^{-0.2}$	9.8
II	2011	14.4	$44 \cdot n^{-0.23}$	7.7
III	2016	3.4	$9 \cdot n^{-0.2}$	2

ECA (for NOx) :
Baltic Sea & North Sea (from 2021)
North American area
United States Caribbean sea area

Figures source : http://www.gulf-marine.com/service/technical_detail/11

前 言

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NOx Tier III

Which fuels?

First cost?

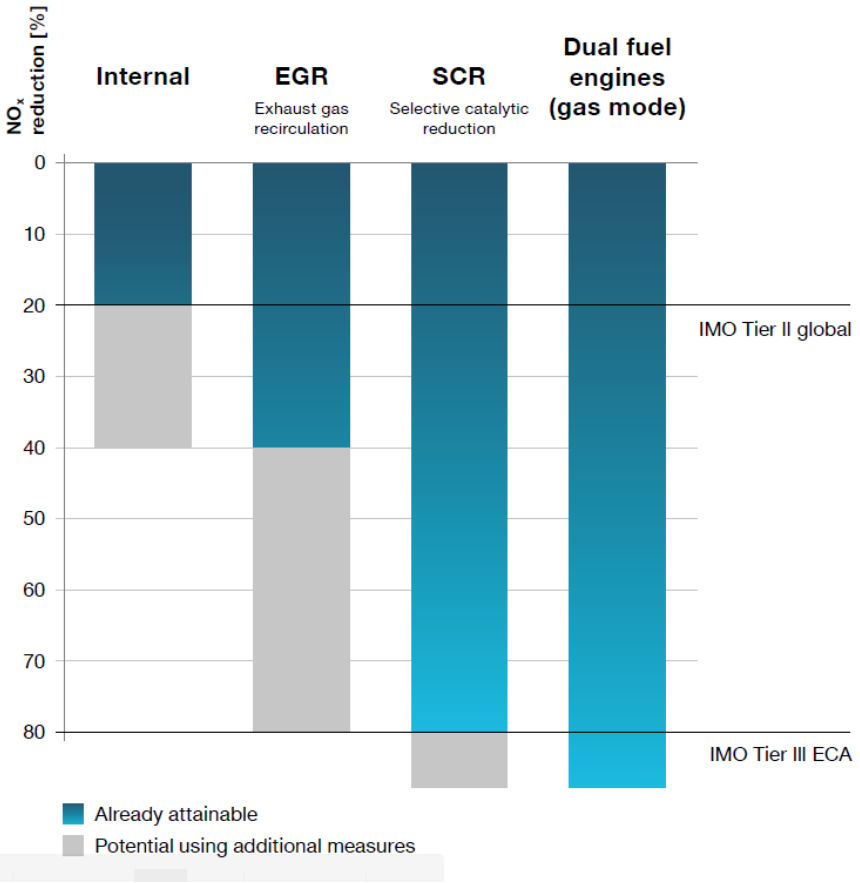
Operation cost?

Which Tier III technology?

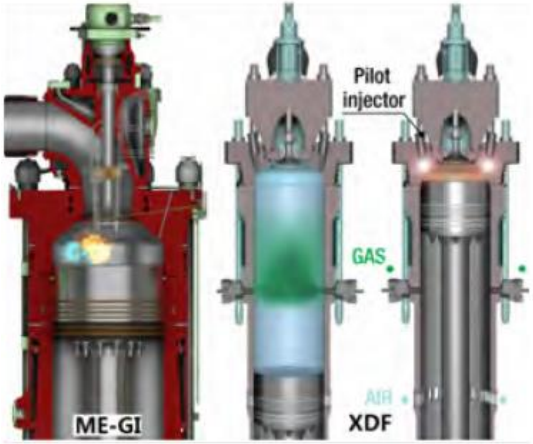
Space requirement in engine?

How long time in ECA?

前 言



採用EGR、SCR及Dual fuel(如WinGD XDF)可符合NOx Tier III標準。



參考資料:
https://www.man-es.com/docs/default-source/marine/2366382_technology-for-ecology_21082020.pdf

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NOx Tier III 的因應策略

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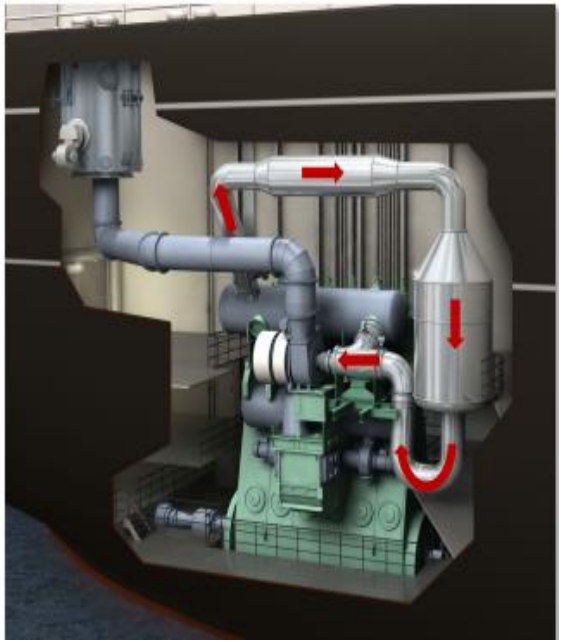
- SCR (Selective Catalytic Reduction)
- EGR (Exhaust Gas Recirculation)



SCR (Selective Catalytic Reduction)

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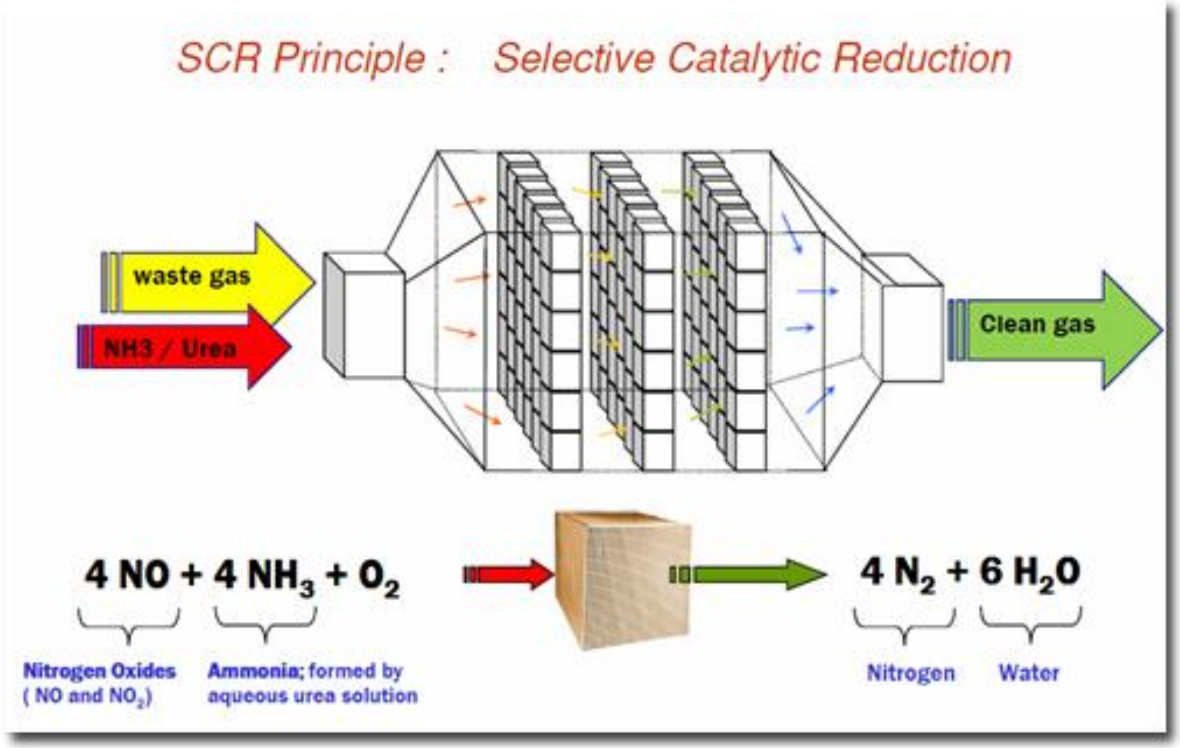
$NO_X + O_2 + NH_3(urea)$

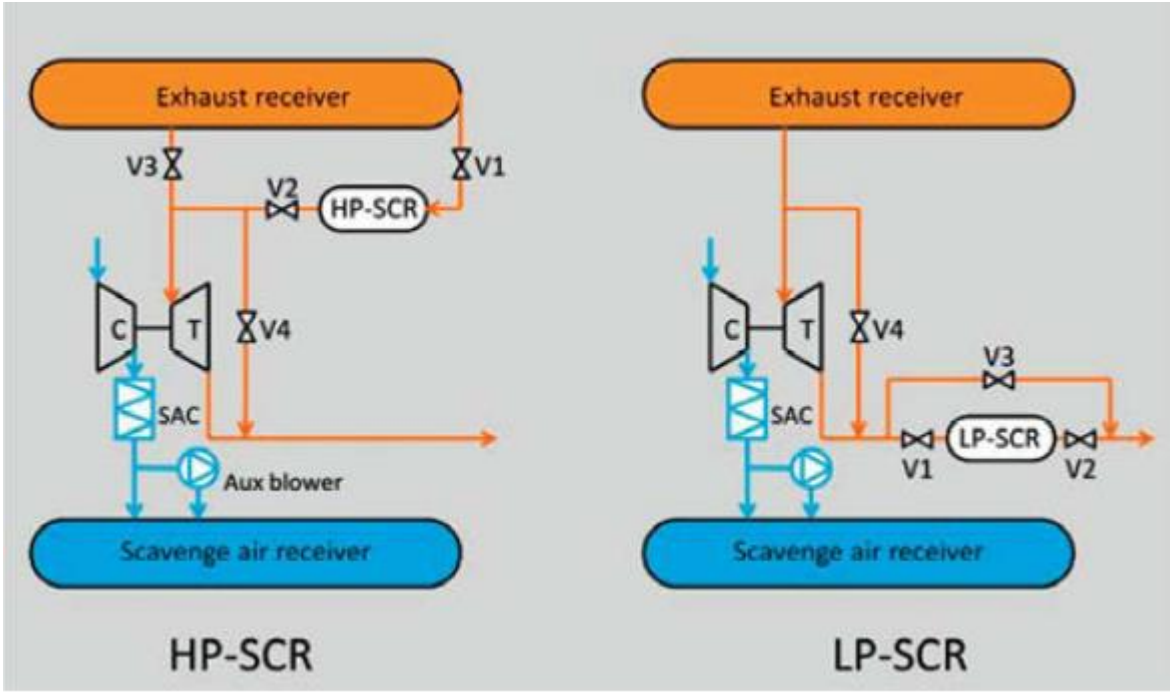
250 ~ 350 ℃

$N_2 + H_2O$



參考Panasia技術資料

SCR (Selective Catalytic Reduction)



Pollutants	Measure 1	Measure 2
	(MDO 0.1% Sulphur)	(HFO)
SOx	-	Scrubber
NOx	LP-SCR or HP-SCR or EGR	HP-SCR or EGR

HP-SCR

1. SCR 反應器安裝在渦輪增壓機之前的高壓側。
2. 壓力約4bar, 最小工作溫度310˚C (for 0.1%S)

LP-SCR

1. SCR 反應器安裝在渦輪增壓機之後的低壓側。
2. 低壓 SCR 系統通常體積較大。
3. 壓力約0.6bar,最小工作溫度230˚C (for 0.1%S)

參考WinGD技術資料

SCR (Selective Catalytic Reduction)

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If this is important, you will lean towards:	LP SCR	HP SCR
Certification (Scheme A/Scheme B)	←	→
Urea consumption	←	→
SFOC penalty	←	→
CAPEX	←	→
Combination with SOx scrubber		→
Fuel oil flexibility		→
Compact and engine-close design		→
No OPEX increase for exhaust gas temperature increase		→
No need for separate catalyst regeneration strategy		→
Free installation position in engine room	←	
Less complex piping/less gas forces	←	
Engine with more than 2 T/C	←	

參考MAN技術資料

SCR (Selective Catalytic Reduction)

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- SCR能減少NOx排放量達80%以上。
- 船舶進入 ECA 區域前，須根據廠家說明的加熱程序，將催化劑元件加熱到 SCR 的最低工作溫度。
- 柴油機處於低負荷狀態時，可能產生固態的銨鹽(硫酸氫銨)，因此廢氣入口須維持高溫來避免觸媒當中的銨鹽凝結黏附。
- 一般催化劑元件的壽命為5年，可搭配進塢時程更換，正確維護催化劑元件如定期吹灰及避免銨鹽凝結黏附是延長使用壽命和 SCR 裝置運行良好的關鍵。
- SCR系統中，作為還原劑的尿素溶液需儲存於特殊的尿素櫃，必須持續地補充尿素，尿素帶來的額外運作成本，相當於燃料費的 10%左右。為確保SCR系統持續脫硝和避免阻塞現象，對於廢氣溫度須特別注意。
- 尿素溶液的儲存時間取決於溫度，大約 20°C 的溫度下，尿素可以儲存長達 2 年，尿素櫃應遠離火源或高溫環境以避免蒸發。尿素對碳鋼、鎳和有色金屬（銅、鋅等）有腐蝕性，尿素櫃一般需有適當的塗層處理或由不銹鋼或精選塑料製成。
- Tier II柴油機若加裝SCR以符合Tier III，修改後之NOx技術卷應提送主管機關/RO認可。

SCR (Selective Catalytic Reduction)

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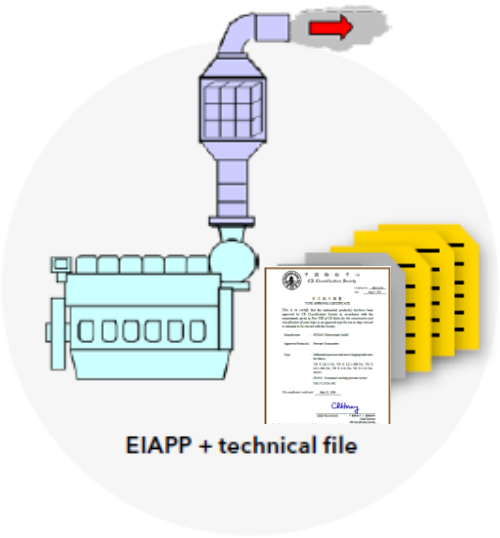
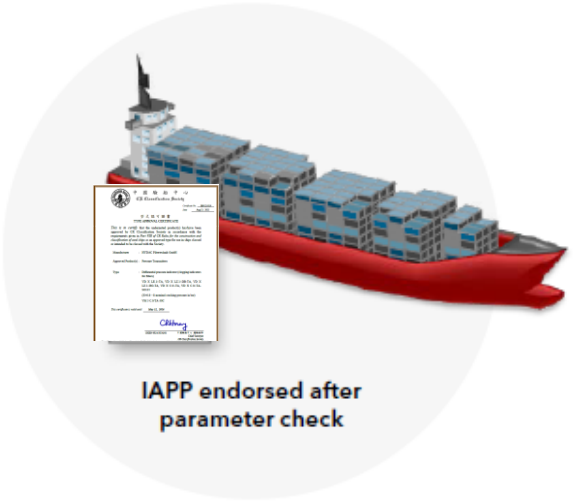
SCR系統 認證方式 ➔ **SCHEME A**

MEPC.291(71)





SCR (Selective Catalytic Reduction)

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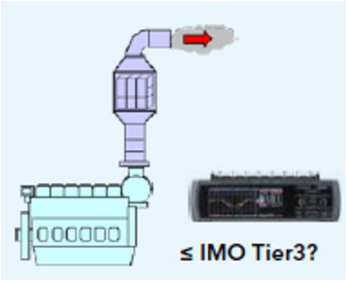
SCR系統 認證方式 ➔ **SCHEME B**

SCR反應裝置試驗
(全尺寸或比例縮放的理論分析或計算)

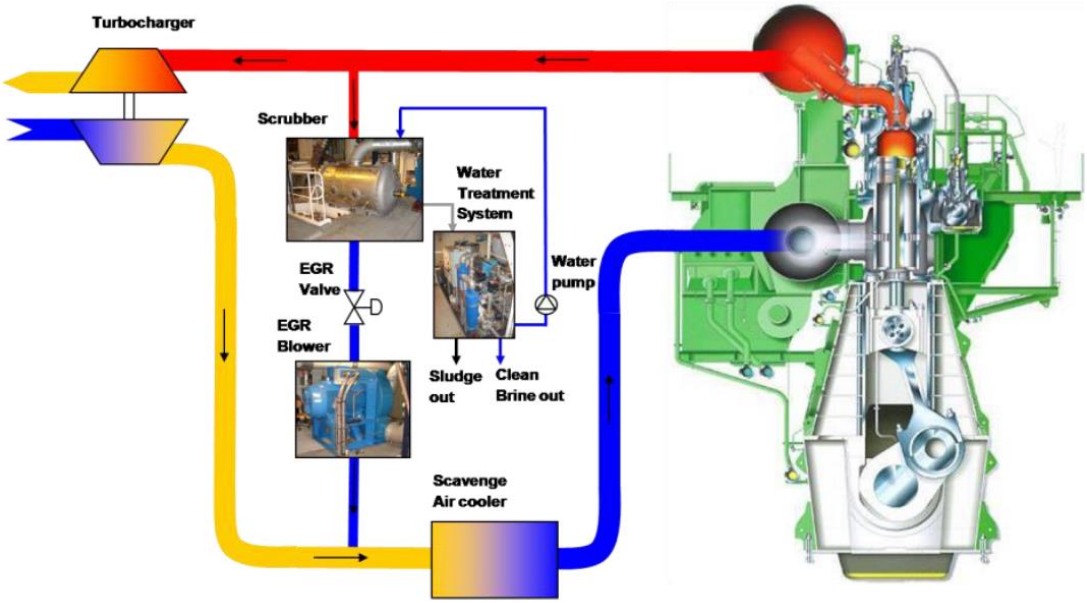
SCR反應裝置試驗的工況應對應於柴油機的每個模式點



建模去計算NOx轉化效率(%) ➕ 柴油機參數 ➡ NOx值(g/kWh) ⬇

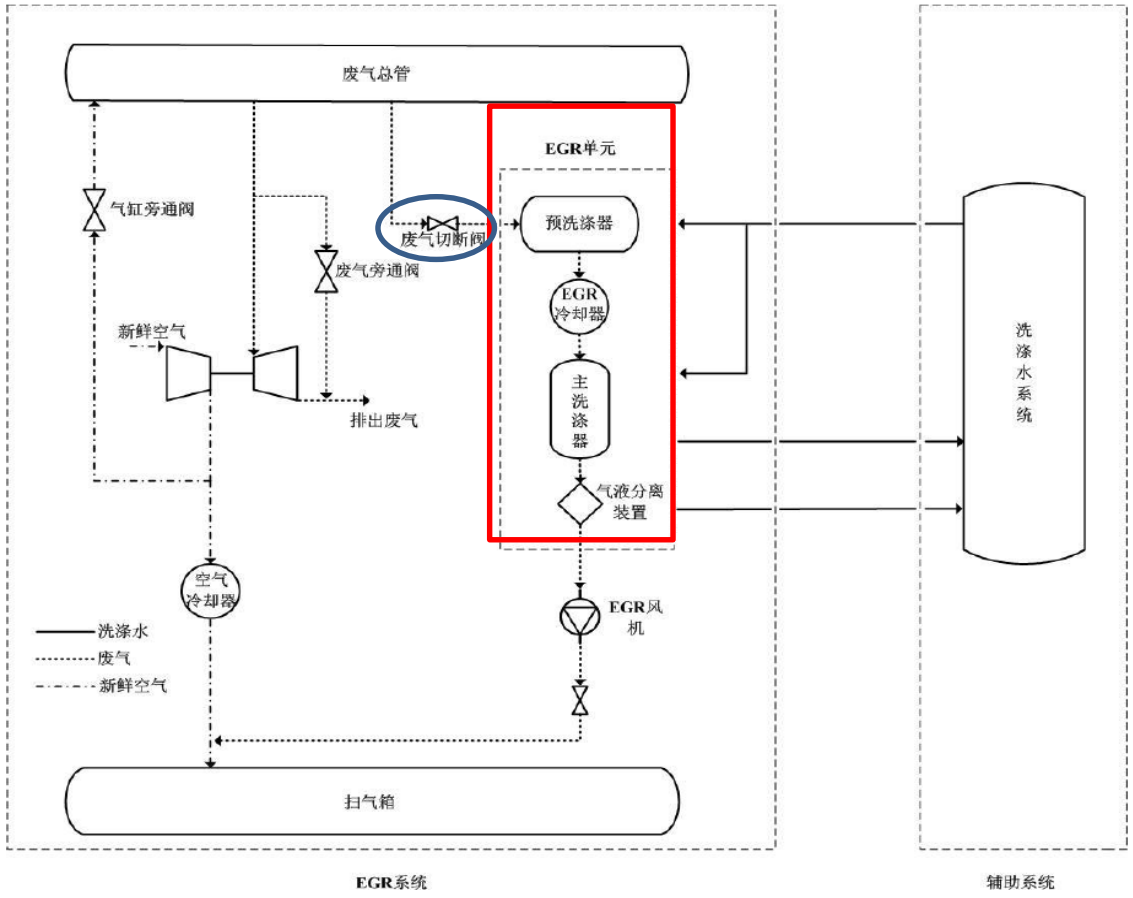
EIAPP ⬅ 船上驗證排放符合性(柴油機+SCR) ⬅ IAPP

廢氣再循環系統(EGR)簡介



參考MAN技術資料

廢氣再循環系統(EGR)簡介



EGR系統及輔助系統示意圖

廢氣再循環系統(EGR):

為減少柴油機NOx排放，將柴油機排氣中的一部分經處理與新鮮空氣混合後引入氣缸，降低燃燒室內氧濃度及燃燒溫度，降低NOx生成量。一般包括EGR單元、閥件、EGR風機及控制與監測警報系統等。

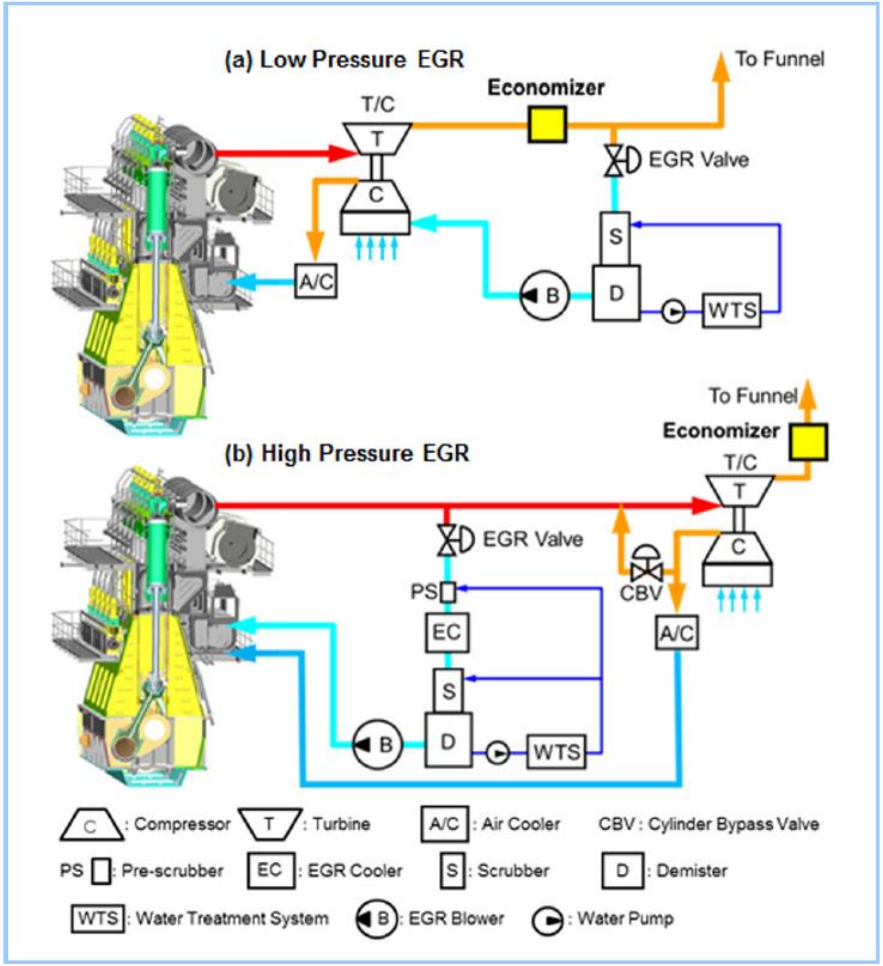
再循環廢氣與空氣混合進入氣缸前，需進行必要冷卻、清潔及脫硫等處理，以確保不造成柴油機系統部件損壞。

輔助系統: 一般包括洗滌水、鹼液(NaOH)櫃(如有)、排放水、殘渣、海水/淡水及控制與監測警報系統等。

廢氣切斷閥：

1.應監測閥的工作狀態。
2.防止廢氣洩漏。
3.防止灰塵積聚導致閥門卡死。

HP-EGR vs LP-EGR

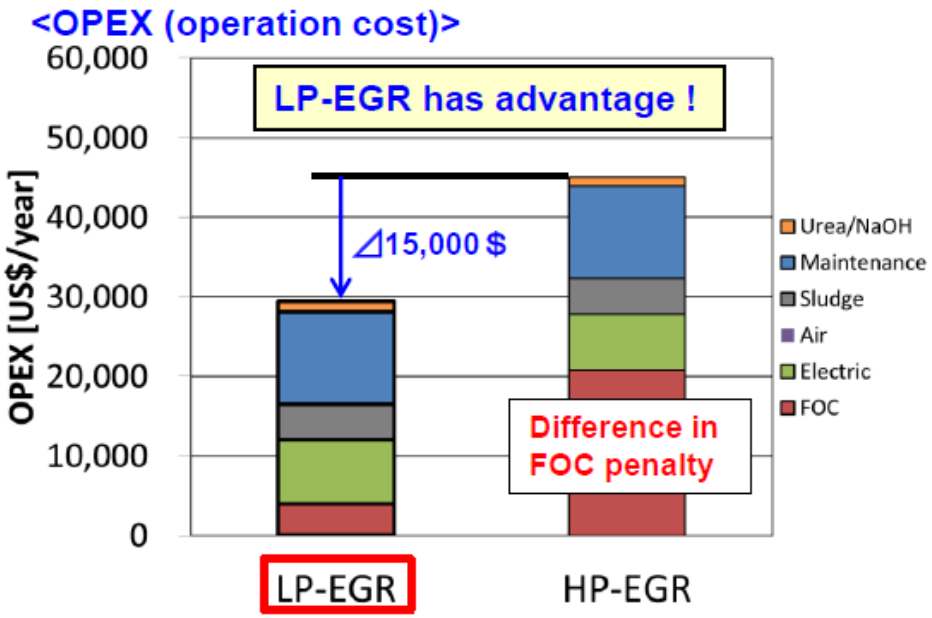


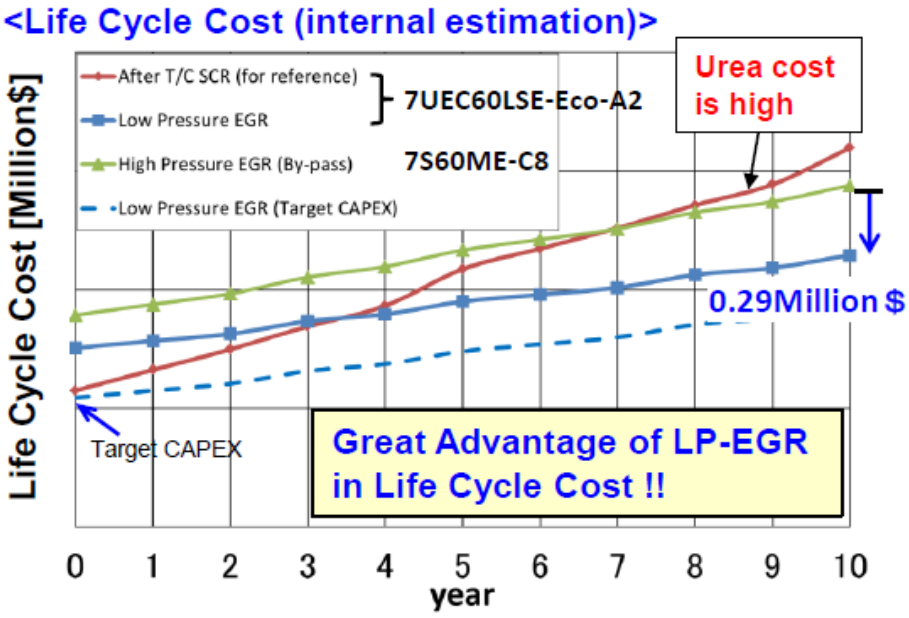
1. LP-EGR 的優點是系統結構簡單，因為廢氣壓力較低，溫度較低。
2. 因為利用了渦輪增壓器吸入壓力， 所需的 EGR 鼓風機功率低於 HP-EGR。
3. LP-EGR設備一般較 HP-EGR 系統大，因為低壓會增加氣體體積。
4. 運營成本較具優勢。

1. HP-EGR由於氣體的高壓和高溫，用於淨化氣體的洗滌器結構較複雜。
2. 由於高壓使氣體體積減小，設備緊湊
3. 需要較大功率的EGR 鼓風機將排氣壓力升高到與掃氣壓力相當。

參考MHI技術資料

HP-EGR vs LP-EGR



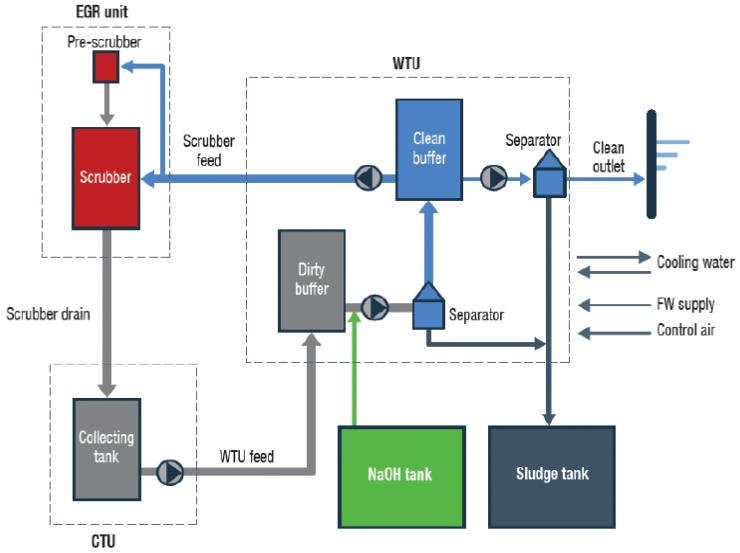


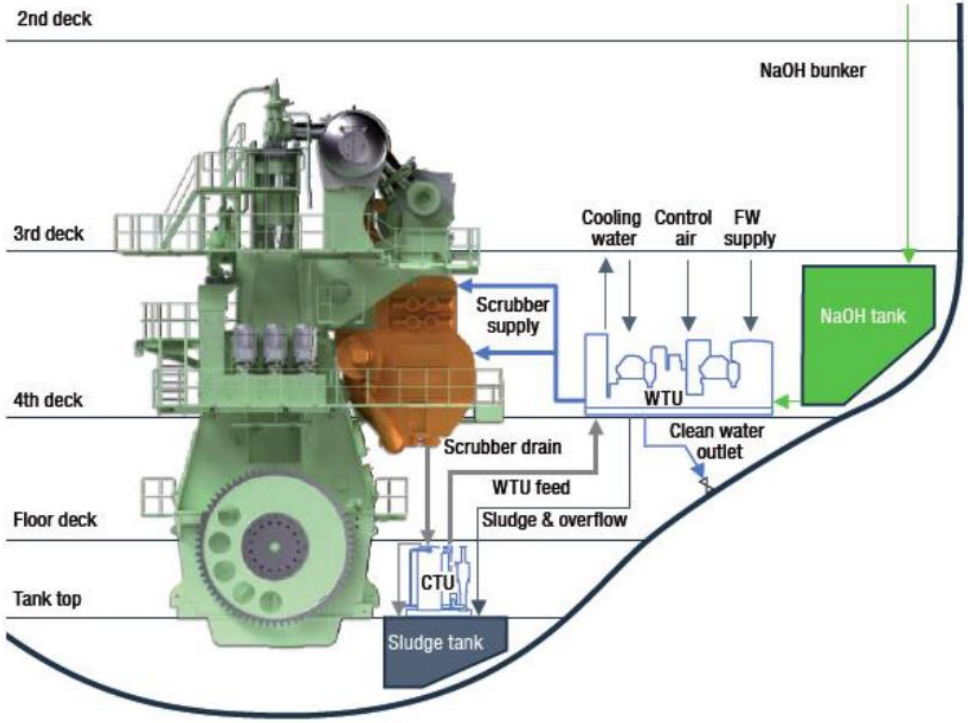
Running hour: 6,000 h/year, including ECA 10% (600 h/year)

LP-EGR➔ CAPEX 和 OPEX 都低於HP-EGR。
Life Cycle Cost 最低，因為SCR使用一定量的尿素。

參考MHI技術資料

廢氣再循環系統(EGR)簡介



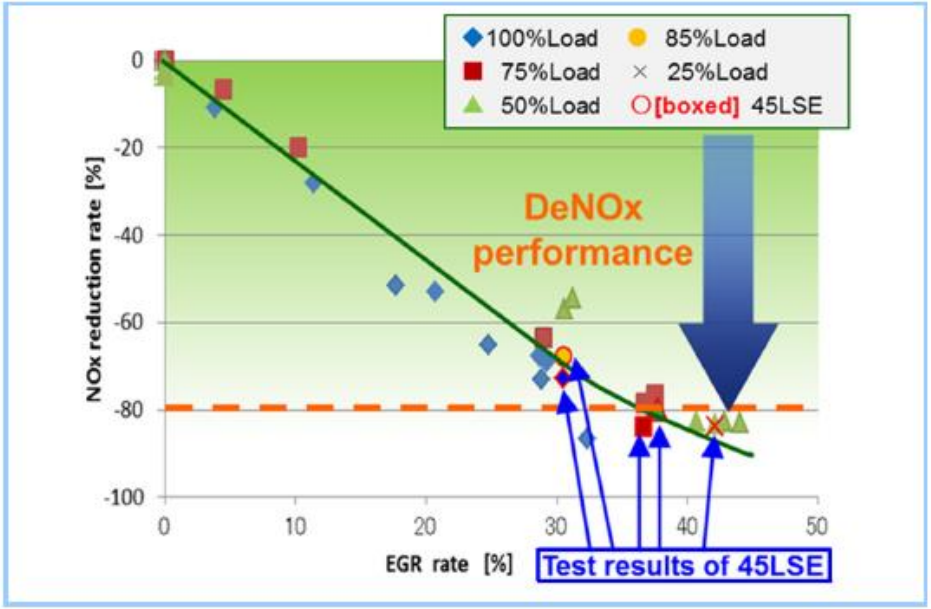


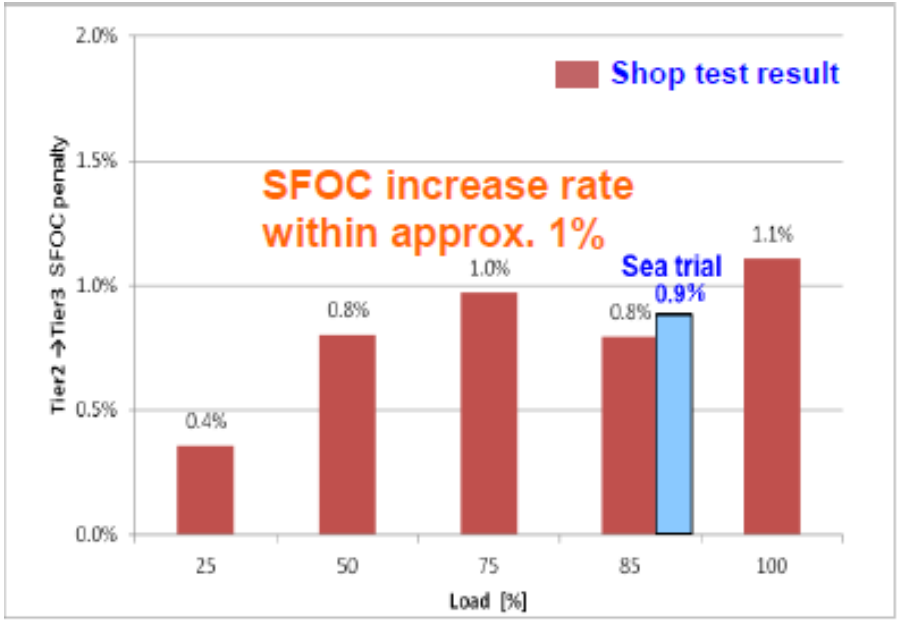
參考MAN技術資料

廢氣再循環系統(EGR)簡介

參考MHI技術資料

廢氣再循環系統(EGR)簡介





1. EGR 再循環率(recirculation rate) 達35%, 減少NOx排放量達80%以上。
2. 使用LP-EGR系統燃油消耗率增加約1%。

參考MHI技術資料

SCR vs EGR

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SCR與EGR裝機初期系統成本比較表

船舶類型	裝機功率(千瓦)	SCR系統成本(百萬美元)	EGR系統成本(百萬美元)
油輪	13,500	1.26 94 USD/kW	1.31 97 USD/kW
超大型油輪	25,900	1.90	1.75
5000 TEU貨櫃船	29,500	2.90	2.35
14000 TEU貨櫃船	78,500	3.86 13 USD/kW	2.91 37 USD/kW

裝機功率越高，價格遞減越大!

SCR與EGR運作成本比較表—影響因素

因素	SCR系統	EGR系統
尿素成本	X	
氫氧化鈉成本		X
催化劑更換成本	X	
額外燃料成本	些微	X
額外功率(輔助設備)		X
污泥處理成本(EGR系統洗滌器)		X

➔EGR初始投資成本略高，但運營成本低於SCR系統。

SCR 運營成本的最大部分是尿素的消耗。

SCR vs EGR

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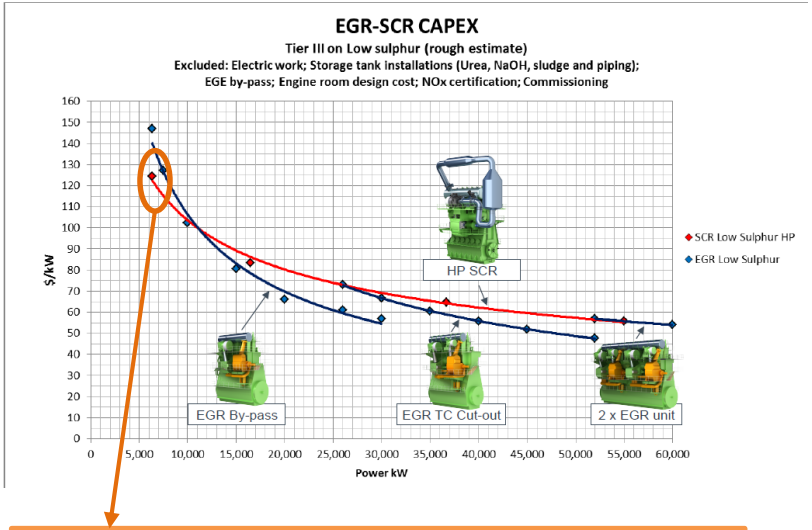
Example – 6S80ME-C9 SCR versus EGR

- SMCR 27,060 kW x 78.0 RPM
- Fuel sulphur 0.1% S
- Tank margin 33%
- NaOH/Urea bunker period 6 times/year.
- EGR Sludge discharge frequency 12 times/year
- ECA 2000 h/year - ISO 8178 E2 load weighting factors

3% S Tier III	EGR	SCR
Main components approximate size (without service area)	EGR unit enlarges engine outline. WTU 5100 x 4000 x 2600 (mm) CTU 2400 x 1400 x 2200 (mm)	SCR vaporizer and reactor enlarges engine outline. Reactor Ø4000 x L 6700 (mm) Vaporizer Ø1800 x L 6000 (mm)
Tanks	Sludge 32 m^3 NaOH tank 50 m^3	Urea 133 m^3

0.1% S Tier III	EGR	SCR
Main components approximate size (without service area)	Engine outline smaller than 3% S WTU Smaller than 3% S CTU Smaller than 3% S	Engine outline smaller than 3% S Reactor smaller than 3% S Vaporizer smaller than 3% S
Tanks	Sludge 7 m^3 NaOH tank 2 m^3	Urea 133 m^3



對於較小的裝機功率，選SCR系統更經濟

參考MAN技術資料

SCR vs EGR

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If this is important, you will lean towards:	EGR	SCR
Low First Cost *	←	→
Low Operating Cost	←	
Many ECA Hours	←	
Fuel Flexibility	←	→
No Sludge Production		→
Same Technology for ME and GenSets		→
Tier III Engine Outline	←	→
No Overboard Discharge		→
Possible New Tier II Modes	←	
WHR Possibilities	←	

參考MAN技術資料

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IMO 減碳策略

- 技術要求-現成船能源效率船舶指數(EEXI)
- 操作要求-碳強度指標(CII)

IMO 減碳策略

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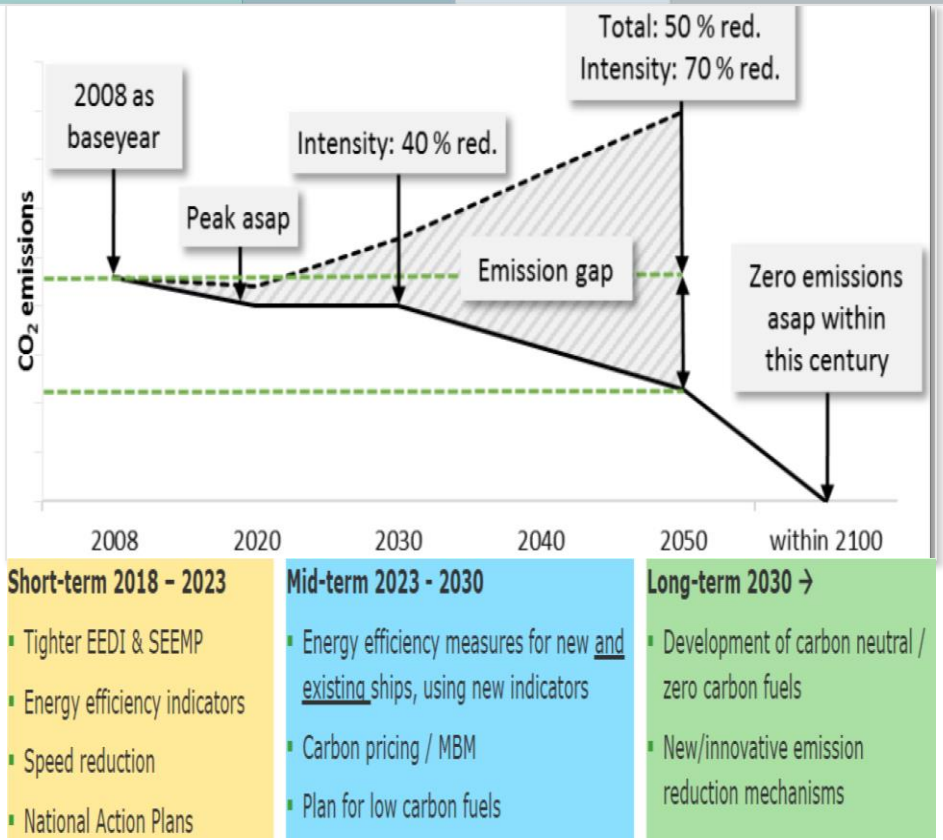
- IMO降低船舶溫室氣體排放戰略
  - 降低國際航線船舶**單位運輸**的CO_2排放：與2008年數值相比，到2030年需降低至少40%，並在2050年降低至少70%
  - 使國際航運**整體**的溫室氣體排放量儘早達峰值並開始降低，到2050年的年度溫室氣體排放量需降低50%(與2008年數值相比)
  - 藉由EEDI降低新船碳排放

註：EEDI意義為：每公噸貨物運輸每海浬所排放之CO_2重量，單位為g-CO_2/ton-nm，數值越低表示船舶能效越高



IMO 減碳策略

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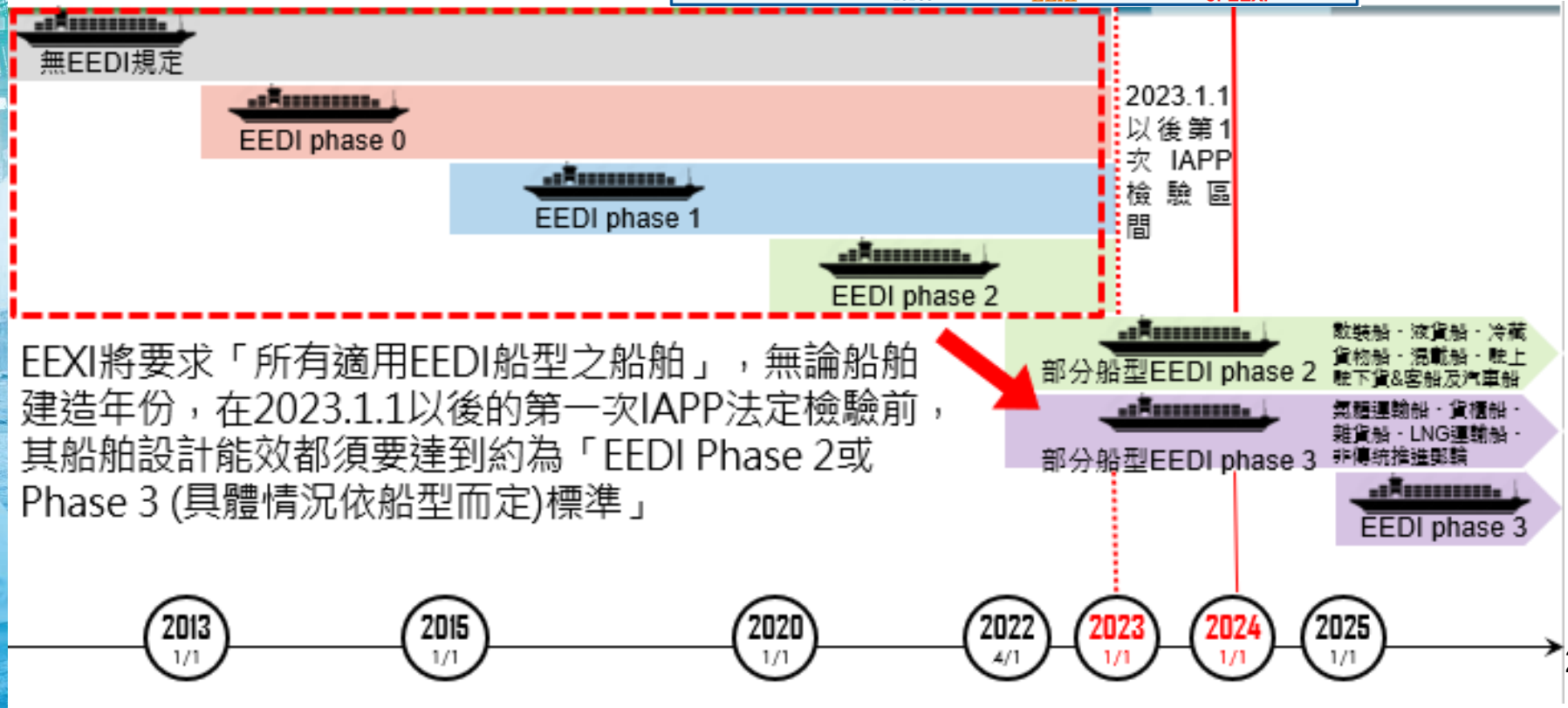
EEXI 規定概要示意圖



EEXI將要求「所有適用EEDI船型之船舶」，無論船舶建造年份，在2023.1.1以後的第一次IAPP法定檢驗前，其船舶設計能效都須要達到約為「EEDI Phase 2或Phase 3 (具體情況依船型而定)標準」

IMO 減碳策略

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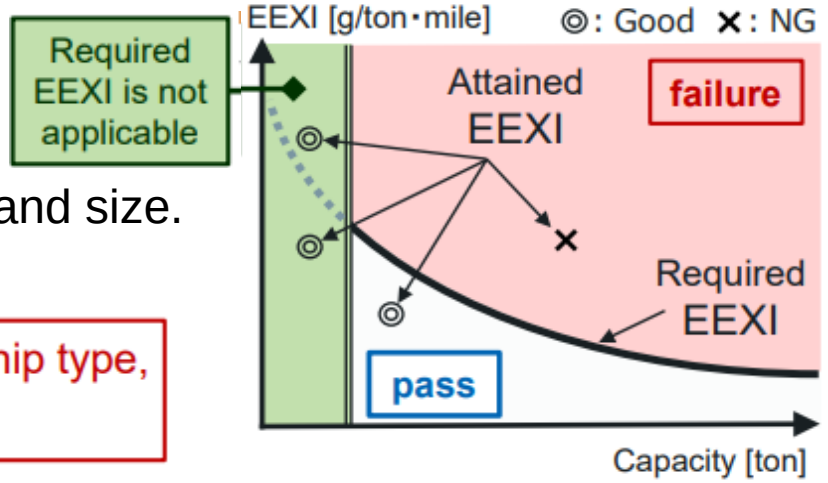
Attained EEXI

EEXI value is calculated by an individual ship.

Required EEXI

Required EEXI is specified for each ship type and size.



For ships with a certain size of specified ship type,

Attained EEXI ≦ Required EEXI

EEXI requirements shall apply to all ships of 400 GT and above which are engaged in the international voyages regardless of ship's delivery date, except the following ships as with the case of EEDI.

- Ships not propelled by mechanical means
- Platforms including FPSOs and FSUs and Drilling rigs, regardless of their propulsion
- Category A ships as defined in the Polar code
- Ships which have non-conventional propulsion such as diesel electric, turbine or hybrid propulsion system (except LNG carrier and cruise passenger ship)

IMO 減碳策略

The "calculation of EEXI (Attained EEXI)" and "conformity to the required value (Required EEXI)" shall apply to the following ship type and size as with the case of EEDI.

Type of ship	Calculation of Attained EEXI	Conformity to the Required EEXI
Bulk carrier	400 GT and above	10,000 DWT and above
Gas carrier	400 GT and above	2,000 DWT and above
Tanker	400 GT and above	4,000 DWT and above
Containership	400 GT and above	10,000 DWT and above
General cargo ship	400 GT and above	3,000 DWT and above
Refrigerated cargo carrier	400 GT and above	3,000 DWT and above
Combination carrier	400 GT and above	4,000 DWT and above
Ro-ro cargo ship (Vehicle carrier)	400 GT and above	10,000 DWT and above
Ro-ro cargo ship	400 GT and above	1,000 DWT and above
Ro-ro passenger ship	400 GT and above	250 DWT and above
LNG carrier	400 GT and above	10,000 DWT and above
Cruise passenger ship (non-conventional)	400 GT and above	25,000 GT and above
Passenger ship	400 GT and above	Not applicable

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Reference line value (baseline) shall be calculated as follows:
Reference line value = $a \times b^{-c}$
where a, b and c are the parameters given below:

Ship type	a	b	c
Bulk carrier	961.79	DWT of the ship	0.477
Gas carrier	1120.00	DWT of the ship	0.456
Tanker	1218.80	DWT of the ship	0.488
Container ship	174.22	DWT of the ship	0.201
General cargo ship	107.48	DWT of the ship	0.216
Refrigerated cargo carrier	227.01	DWT of the ship	0.244
Combination carrier	1219.00	DWT of the ship	0.488
Ro-ro cargo ship (vehicle carrier)	$(DWT/GT)^{-0.7} * 780.36$ where DWT/GT<0.3 1812.63 where DWT/GT≥0.3	DWT of the ship	0.471
Ro-ro cargo ship	1405.15	DWT of the ship	0.498
Ro-ro passenger ship	752.16	DWT of the ship	0.381
LNG carrier	2253.7	DWT of the ship	0.474
Cruise passenger ship having non-conventional propulsion	170.84	GT of the ship	0.214

Table 3 Reduction factors (in percentage) for the EEXI relative to the EEDI reference line

Ship type	Size	Reduction factor
Bulk carrier	200,000 DWT and above	15
	20,000 and above but less than 200,000 DWT	20
	10,000 and above but less than 20,000 DWT	0-20*
Gas carrier	15,000 DWT and above	30
	10,000 and above but less than 15,000 DWT	20
	2,000 and above but less than 10,000 DWT	0-20*
Tanker	200,000 DWT and above	15
	20,000 and above but less than 200,000 DWT	20
	4,000 and above but less than 20,000 DWT	0-20*
Containership	200,000 DWT and above	50
	120,000 and above but less than 200,000 DWT	45
	80,000 and above but less than 120,000 DWT	35
	40,000 and above but less than 80,000 DWT	30
	15,000 and above but less than 40,000 DWT	20
	10,000 and above but less than 15,000 DWT	0-20*

EEXI技術卷必須及時提交至船級協會認可，並在認可後放置船上。在EEXI要求的生效日期後的初次年度檢驗、中期檢驗或換證檢驗期間，即2023年內，需對已達到之EEXI進行驗證，並隨後簽發新的國際能效證書（**IEEC證書**, 同EEDI屬一次性驗證)

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5 Attained Energy Efficiency Existing Ship Index (EEXI)

5.1 The attained EEXI in accordance with regulation 23.1is calculated taking into account guidelines[73] developed by the Organization……..☐

The attained EEXI is:……..grams-CO_2/tonne-nautical mile

5.2 The attained EEXI is not calculated as:

5.2.1 the type of propulsion system is exempt in accordance with regulation 19.3…….☐

5.2.2 the type of ship is exempt in accordance with regulation 23.1……☐

6 Required EEXI

6.1 Required EEXI is:……grams-CO_2/tonne-nautical mile in a regulation 25

6.2 The required EEXI is not applicable as:

6.2.1 the type of propulsion system is exempt in accordance with regulation 19.3……..☐

6.2.2 the type of ship is exempt in accordance with regulation 25.1……☐

6.2.3 the ship's capacity is below the minimum capacity threshold in table 3 of regulation 25.1……☐

9 EEXI technical file

9.1 The IEE Certificate is accompanied by the EEXI technical file in compliance with regulation 23.1……☐

9.1.1 The EEXI technical file identification/verification number……

9.1.2 The EEXI technical file verification date……

9.2 The IEE Certificate is not accompanied by the EEXI technical file as the attained EEDI is used as an alternative to the attained EEXI……☐

IEEC新增欄位

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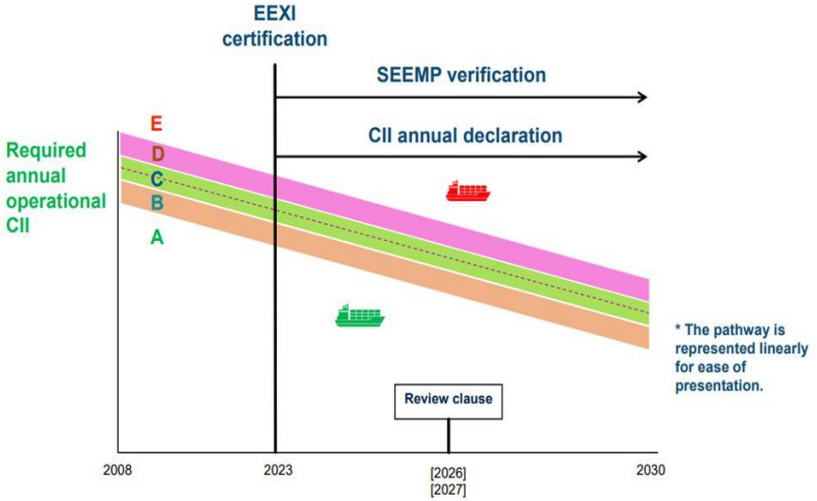
Carbon Intensity Indicator (CII) :

- CII為船舶碳排放強度指標，要求總噸位5,000以上且適用EEDI船型，用以表示船舶實際的營運能效程度。在每年對船舶 CII 進行驗證後，還將對船舶 CII 進行年度評級，表現不佳的船舶暫時不會直接導致懲罰性後果，但需要製定改正計劃並納入船舶能效管理計劃(SEEMP)。
- 為實施CII，後續將對 SEEMP 的製訂及實施進行強制化。SEEMP Part I 應進一步包括未來三年所需的年度運營碳強度指標(CII)，記錄所需的年度運營CII的實施計劃，及自我評估和改進的程序。
- 在修正案生效之後的每一個日曆年蒐集數據並計算當年的CII值，在下一個日曆年前三個月內報告主管機關或RO評定CII等級，由主管機關或RO驗證後簽發SoC，有效期為當年直至下一個日曆年前五個月。

從2024年開始，CII 評等併入IMO DCS每年簽發SoC

IMO 減碳策略

- 船舶於2023年1月1日前須於其船舶能效管理計劃(SEEMP Part I)制定其CII達成計劃並經RO認可簽發符合確認書(CoC)，並自2024年1月1日起，每年需計算並回報其年度CII值，等級按優劣分為A級到E級。此外，隨後每一年該等級閾值(Z)將越來越嚴格，若船舶連續三年落入D級或有一年落入E級，則須制訂矯正計劃並重新送審取得RO認可。
- 年度要求達到的CII 值，即為營運能效評級 C 等級的中間值。
- 為評估目前方案適用性與 2030 年目標的可達成能性，在修正案中納入了後審機制。在 2026 年將對目前修正案的實施情況和效果進行評估，以便進一步加強或改進相關的措施。



IMO 減碳策略

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- ***Required annual operational CII*** = (1 – Z/100) × CII_{ref})，Z is the annual reduction factor， CII_{ref} is the reference value。

Table 1: Reduction factor (Z%) for the CII relative to the 2019 reference line

Year	Reduction factor relative to 2019
2023	5%*
2024	7%
2025	9%
2026	11%
2027	- **
2028	- **
2029	- **
2030	- **

Note:

* Z factors of 1%, 2% and 3% are set for the years of 2020 to 2022, similar as business as usual until entry-into-force of the measure.

** Z factors for the years of 2027 to 2030 to be further strengthened and developed taking into account the review of the short-term measure.

Table 1: Parameters for determining the 2019 ship type specific reference lines

Ship type		Capacity	*a*	*c*
Bulk carrier	279,000 DWT and above	279,000	4977	0.626
	less than 279,000 DWT	DWT	4977	0.626
Gas carrier	65,000 and above	DWT	2384E7	1.910
	less than 65,000 DWT	DWT	8032	0.638
Tanker		DWT	5118	0.607
Container ship		DWT	1963	0.487
General cargo ship	20,000 DWT and above	DWT	61293	0.854
	less than 20,000 DWT	DWT	361	0.336
Refrigerated cargo carrier		DWT	6736	0.599
Combination carrier		DWT	151991	0.930
LNG carrier	100,000 DWT and above	DWT	9.860	0
	65,000 DWT and above, but less than 100,000 DWT	DWT	1966E10	2.498
	less than 65,000 DWT	65,000	1966E10	2.498
Ro-ro cargo ship (vehicle carrier)		GT	5831	0.633
Ro-ro cargo ship		DWT	15958	0.677
Ro-ro passenger ship		GT	7691	0.586
Cruise passenger ship		GT	904	0.380

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- ***Attained annual Carbon Intensity Indicator (CII)***

$$\textbf{\textit{Attained}}\ CII_{ship} = \frac{\textbf{Mass of CO2 emissions (M)}}{\textbf{Transport work (W)}}$$

- ***Width of the rating mechanism***

有關CII中A、B、C、D以及E級帶寬評等方式將採用向量(dd vector)方式，以Required CII數值為C等級中間點上下展開(如下圖)：

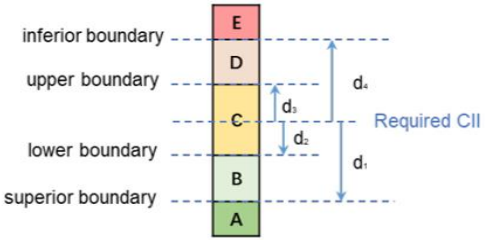

Figure 2: *dd* vectors and rating bands

$$\text{superior boundary} = \exp(d_1) \cdot \textit{required CII}$$
$$\text{lower boundary} = \exp(d_2) \cdot \textit{required CII}$$
$$\text{upper boundary} = \exp(d_3) \cdot \textit{required CII}$$
$$\text{inferior boundary} = \exp(d_4) \cdot \textit{required CII}$$

說明範例：若以某一年散裝船其required CII 數值為10 gCO2/(dwt.nmile)，則superior boundary、lower boundary、upper boundary以及inferior boundary 分別為8.6, 9.4, 10.6 and 11.8 gCO2/(dwt.nmile). 若該船之attained CII 為9 gCO2/(dwt.nmile), 則該船當年為B等級。

Table 1: *dd* vectors for determining the rating boundaries of ship types

Ship type		Capacity in CII calculation	*dd* vectors (after exponential transformation)			
			exp(d1)	exp(d2)	exp(d3)	exp(d4)
Bulk carrier		DWT	0.86	0.94	1.06	1.18
Gas carrier	65,000 DWT and above	DWT	0.79	0.89	1.12	1.38
	less than 65,000 DWT	DWT	0.85	0.95	1.06	1.25
Tanker		DWT	0.82	0.93	1.08	1.27
Container ship		DWT	0.83	0.94	1.07	1.19
General cargo ship		DWT	0.84	0.95	1.07	1.19
Refrigerated cargo carrier		DWT	0.77	0.90	1.07	1.21
Combination carrier		DWT	0.88	0.95	1.06	1.26
LNG carrier	100,000 DWT and above	DWT	0.91	0.98	1.05	1.11
	less than 100,000 DWT		0.77	0.91	1.12	1.37
Ro-ro cargo ship (vehicle carrier)		GT	0.86	0.94	1.06	1.16
Ro-ro cargo ship		DWT	0.67	0.90	1.09	1.37
Ro-ro passenger ship		GT	0.73	0.87	1.10	1.37
Cruise passenger ship		GT	0.85	0.94	1.04	1.15

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- **SEEMP應納入以下內容:**

1. 描述Attained annual operational CII的計算方法及將計算值報告給主管機關的流程。
2. 列出船舶未來三年(2023-2025年度) Required annual operational CII值。
3. 制定一個實施計劃描述如何滿足未來三年的Required annual operational CII值。
4. 制定一個自我評估與持續改進的程序。

- 如2023/01/01之後更換船旗或更換公司，船舶仍應在年度結束 之後，計算及報告發生上述變更年度從1月1日至12月31日的完整12個月的attained CII並進行評級。

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燃油消耗數據收集(DCS) 之SoC將納入CII 評等

2 The data was collected and reported in accordance with the methodology and processes set out in the ship's SEEMP that was in effect over the period from (dd/mm/yyyy) through (dd/mm/yyyy);

3 The attained annual operational CII of the ship from (dd/mm/yyyy) through (dd/mm/yyyy) was: …… pursuant to regulations 28.1 and 28.2 of Annex VI of the Convention, for ships to which regulation 28 applies;[83]

4 The annual operational carbon intensity of the ship in this period is rated as
☐A ☐B ☐C ☐D ☐E,
in accordance with regulation 28 of Annex VI to the Convention, for a ship to which regulation 28 applies;[82] and

5 A corrective action plan has been developed and included in the SEEMP (for a ship to which regulation 28 applies, rated as D for 3 consecutive years or rated as E)[82]

- 前言
- NOx Tier III的因應策略
- IMO減碳策略
- EEXI與CII因應策略
- 結論

EEXI與CII因應策略

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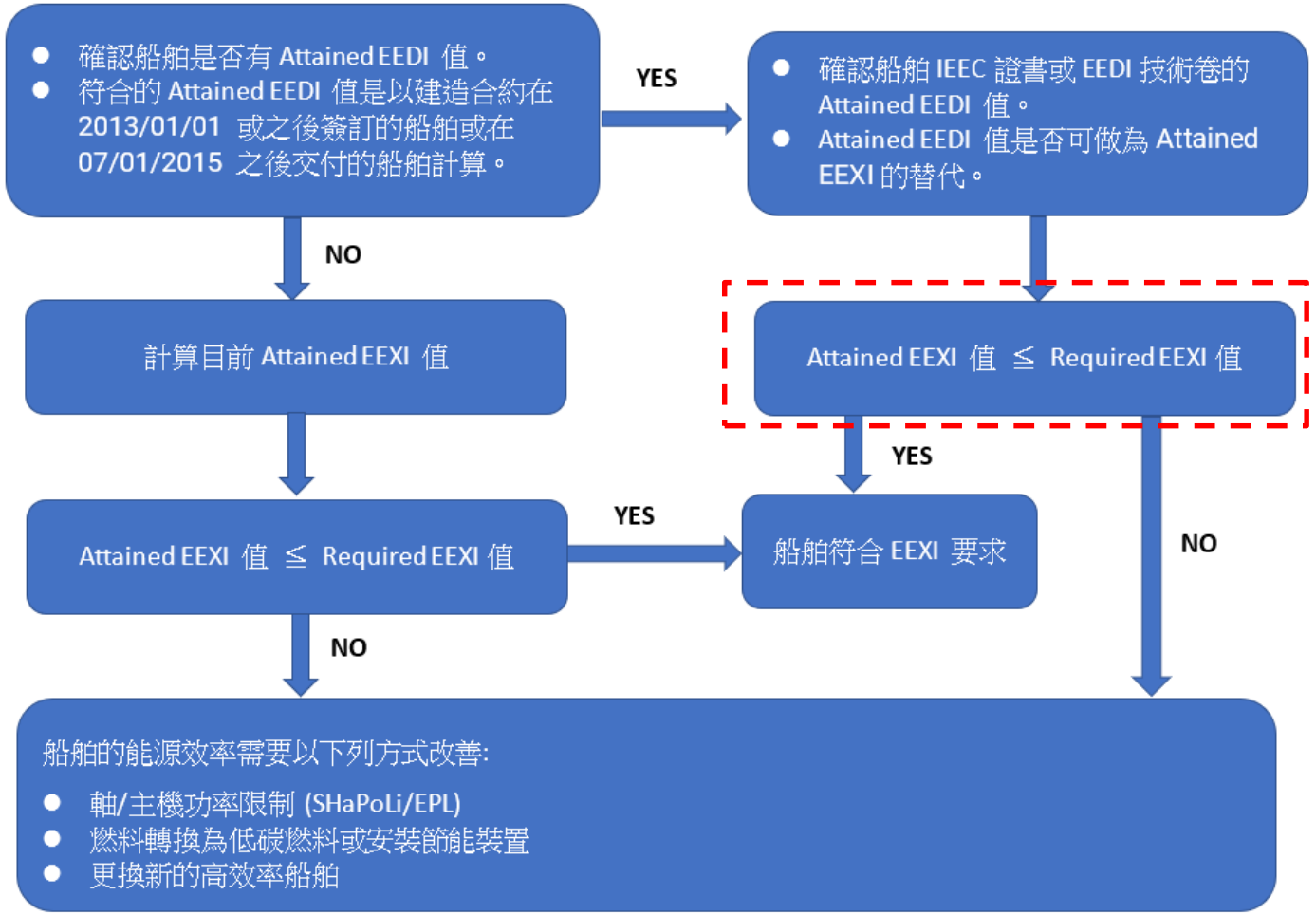
CR CLASSIFICATION SOCIETY

現成船
EEXI
先行評估



可依據原EEDI技術卷進行驗證

EEXI
改善方式

EEXI與CII因應策略

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CR CLASSIFICATION SOCIETY

Proposed EEXI framework

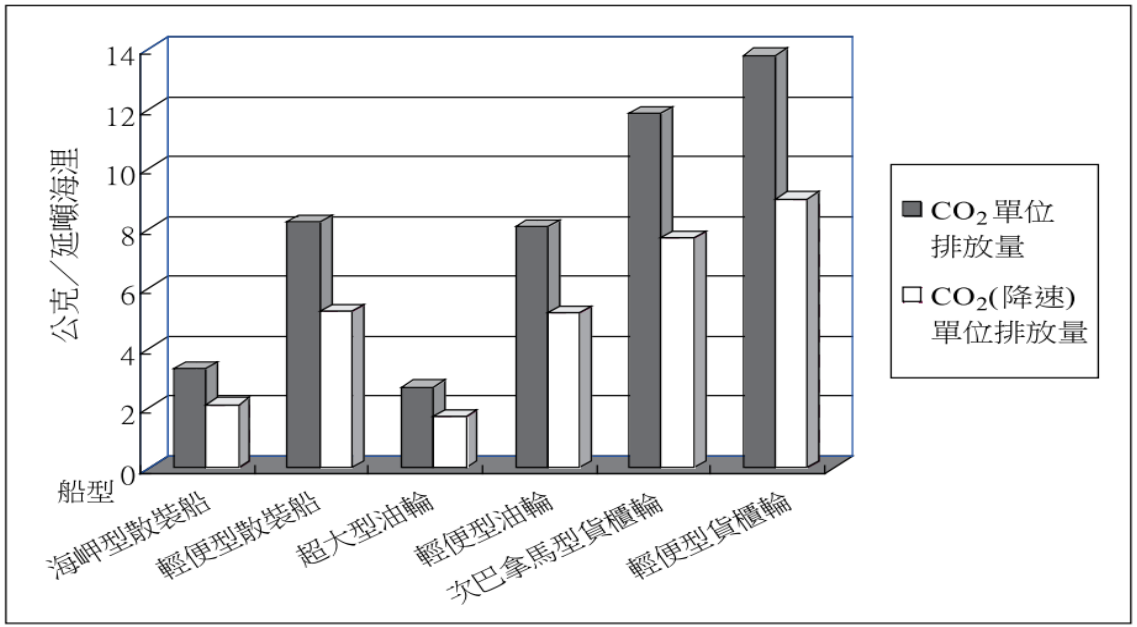
Attained EEDI/EEXI

Required EEXI

Survey & Certificate

Existing ship

Calculate energy efficiency performa



ent operation

Certificate

of Energy
nization of

圖 4　正常船速與降速 20%之各種船型 CO_2 排放量比較

Figures source:運輸計劃季刊第三十九卷 第四期徵收碳稅對船舶減速與營運成本間之 影響評估

EEXI與CII因應策略

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- MEPC76 定案之計算準則摘要：

1. 主機功率(P_{ME})：EEDI為最大連續輸出功率(MCR)的75%，當實施Engine power limitation (EPL)的情況下，EEXI計算中的(P_{ME})為最大限制功率(MCR_{lim})的83%或最大連續輸出功率(MCR)的75%，以較低者為準。

2. 船速(V_{ref})：

   1) 經EEDI認證之船舶(**EEDI ships**)：其EEXI之參考速度由先前EEDI海試之數據決定。

   2) EEDI規定生效前建造之船舶(**pre-EEDI vessels**)：其EEXI之參考速度可由模型試驗(model tests)所獲得之speed/power curve決定，在某些情況下可使用海試之數據配上CFD計算校正。

   3) EEXI calculation guideline亦提供依據船型、載重噸以及主機安裝功率做近似公式後所得參考速度之選項，不過由於此方案有餘裕係數(margin factor of 5%)，故其所得之參考速度較為保守，建議仍以模型試驗或海試報告為主。

   4) 當船舶加裝節能裝置而影響船速時，可採取下述方法進行驗證：安裝裝置後之海試(sea trials after installation of the device)及/或專用模型試驗(dedicated model tests)及/或數值計算法(numerical calculations)。

EEXI與CII因應策略

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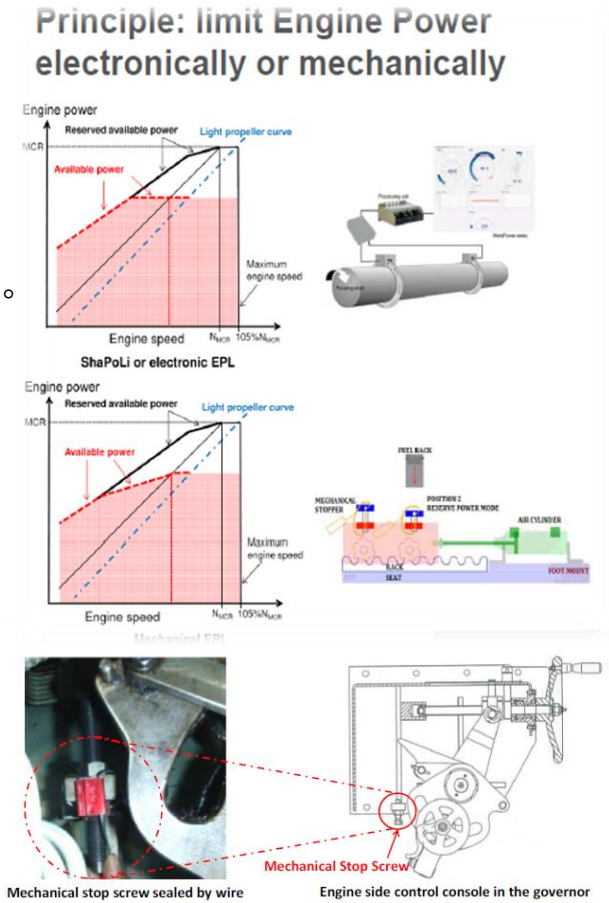
Engine Power Limitation (EPL)介紹：

- 引擎功率限制（EPL）是一種通過將船舶的引擎功率限制在最佳引擎設置內來提高船舶能效的系統。船速將受到限制。
- EPL由一個簡單的設備組成，可以通過調節引擎控制系統上的fuel index限制器限制最大引擎功率，無須改裝複雜的系統。
- 就EEXI而言，EPL可以用作提高現有船舶能源效率的有效措施之一。
- 船舶通過EEXI的檢驗之後，應由主管機關或RO驗證EPL的管理手冊，該管理手冊應永久放置在船上備查。
- 超過之出力將視為儲備功率(Power reserve)，一般情況下無法使用，僅能在為確保船舶航安(例如惡劣海況、參與搜救行動、遭遇海盜等)下進行越控(overridable)使用，當遇到上述情況使用儲備功率時需有相關紀錄並且立刻回報主管機關以及RO。



EEXI與CII因應策略

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- 傳統MC主機

1. 主機廠家改變調速器設定值(fuel limit)，調整及鎖定機械止動螺釘(Mechanical Stop Screw)，螺釘由金屬絲密封，從而限制可進入主機的燃油量。
2. 驗船師及PSC登輪確認止動螺釘密封狀態。

參考資料:
https://www.mitsui.gr/news/5d6f754dcfbd3/news-5d6f754dcfbd3.pdf

EEXI與CII因應策略

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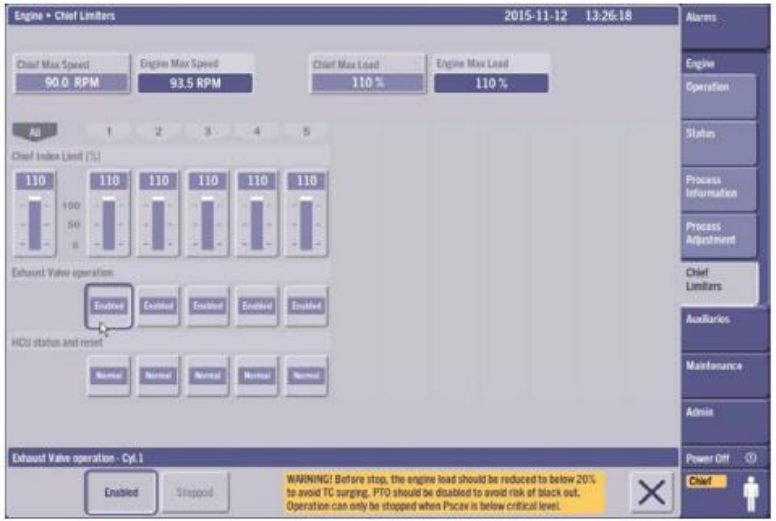
- 新型ME主機

1. 通過受密碼保護的燃油限制器軟體(如MAN Chief Limiters)直接設定引擎最大功率來實施EPL。
2. 電子控制式主機沒有物理式密封，因此通過檢查數據記錄程序中記錄的數據，確認自上次確認後沒有未經許可擅自解除 EPL 。



from MAN Energy Solutions

參考資料:
https://www.mitsui.gr/news/5d6f754dcfbd3/news-5d6f754dcfbd3.pdf

EEXI與CII因應策略

財團法人驗船中心
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執行EPL後需要什麼樣的文件/證明?

應提交以下文件：

1. EPL 設定值及相關程序（由主機製造商提供)。
2. EPL 安裝後的驗船師檢驗報告。
3. EPL 管理計劃。

EPL 是否會導致其他操作問題?

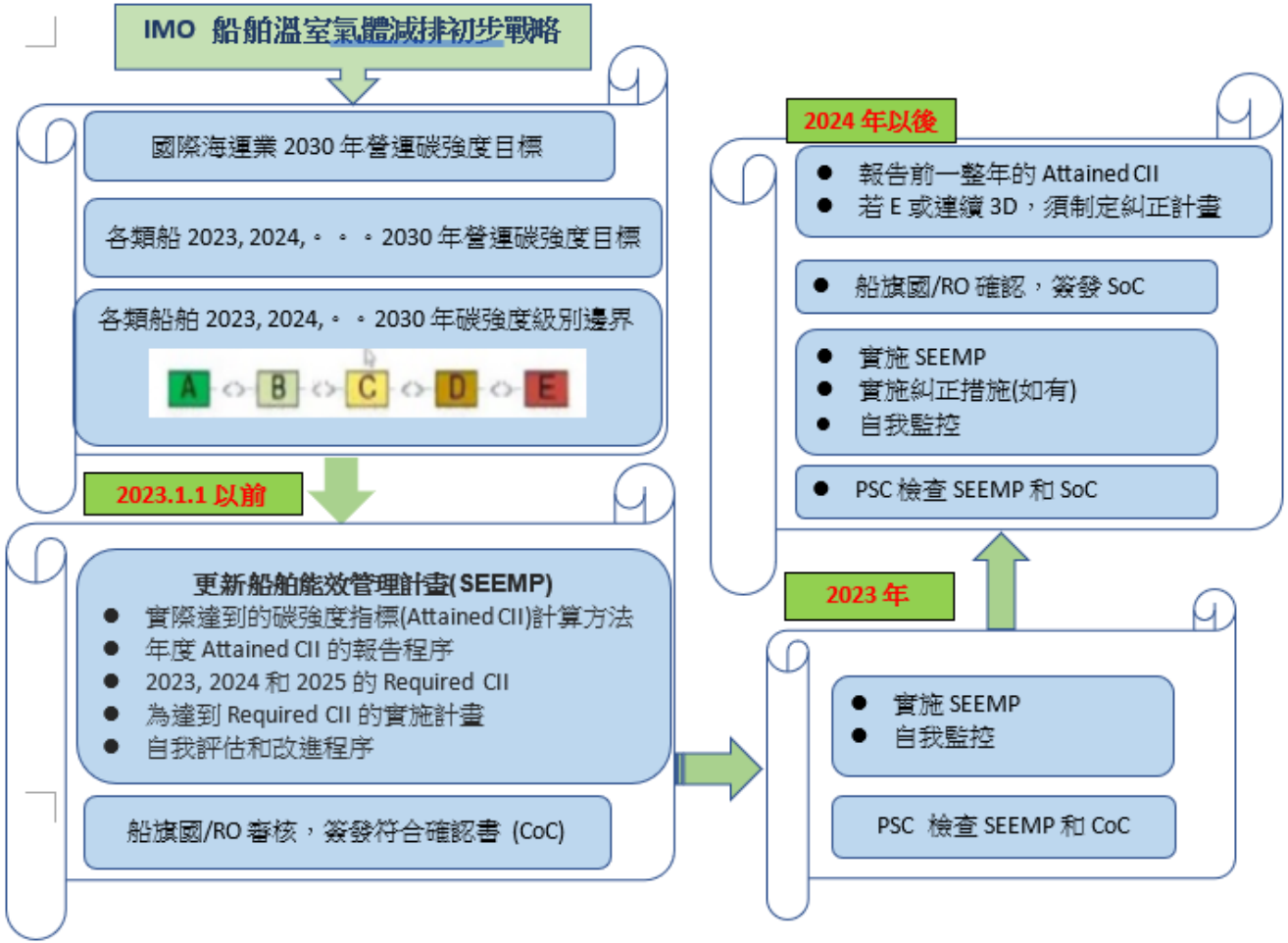
限制功率範圍是伴隨著操作轉速範圍的限制，新的運行轉速可能會導致共振情況，導致結構或機械振動增加，若有需要應尋求主機製造廠家進行相關評估。

EPL:

.1	rated installed power (MCR) and engine speed (N_{MCR});
.2	limited installed power (MCR_{lim}) and engine speed ($N_{MCR,lim}$);
.3	technical description of the EPL system;
.4	method for sealing the EPL (mechanically controlled engine);
.5	method for locking and monitoring the EPL (electronically controlled engine);
.6	procedures and methods for releasing the EPL;
.7	procedures for survey of the EPL system by the Administration/RO;
.8	procedure for the report on release of the EPL; and
.9	administrator of the EPL system.

尋求廠家提供資訊

EEXI與CII因應策略



船舶範圍:
5000GT及以上，12類船舶(同EEDI)
建造時間: 無關
實施機制:
船舶能效管理計劃(SEEMP)+符合聲明(SoC: DCS+CII rating)

EEXI與CII因應策略

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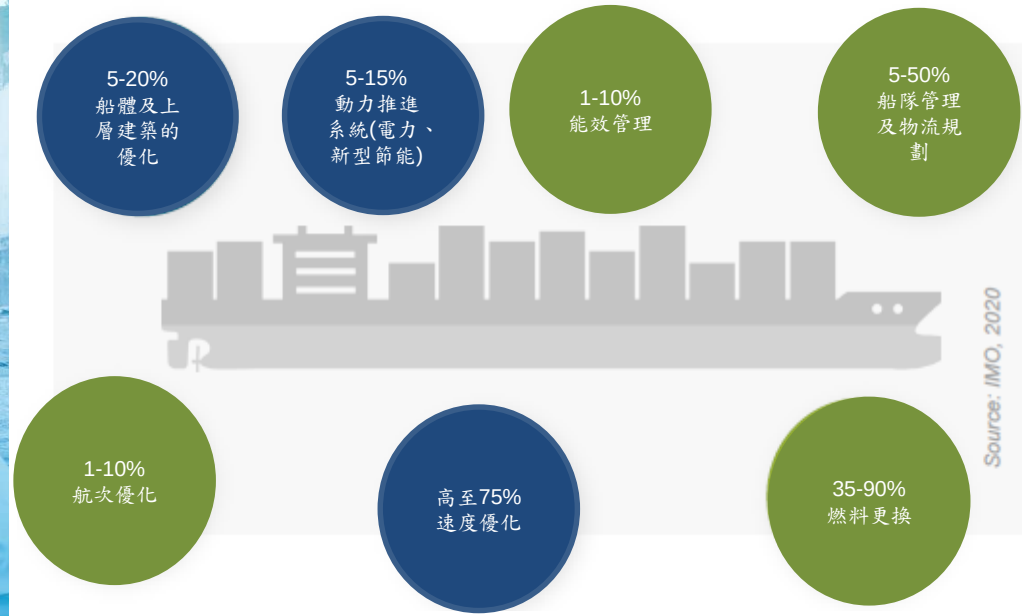
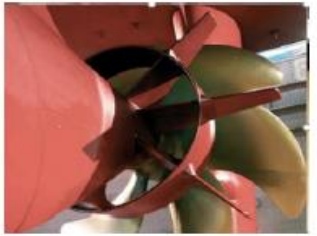
How to improve CII

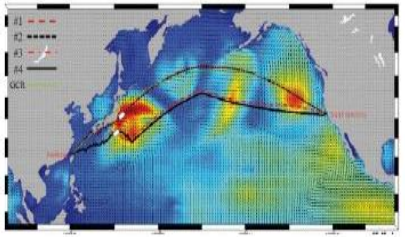
實現IMO溫室氣體初步戰略的目標，將適用於船舶的技術、操作和創新解決方案結合，達成溫室氣體減排。



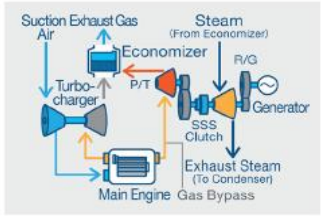
HULL CLEANING/COATING



ESD

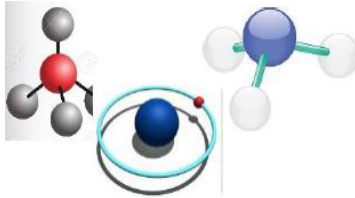


WEATHER ROUTING



WASTE HEAT RECOVERY SYSTEM

IMPROVED LOGISTICS

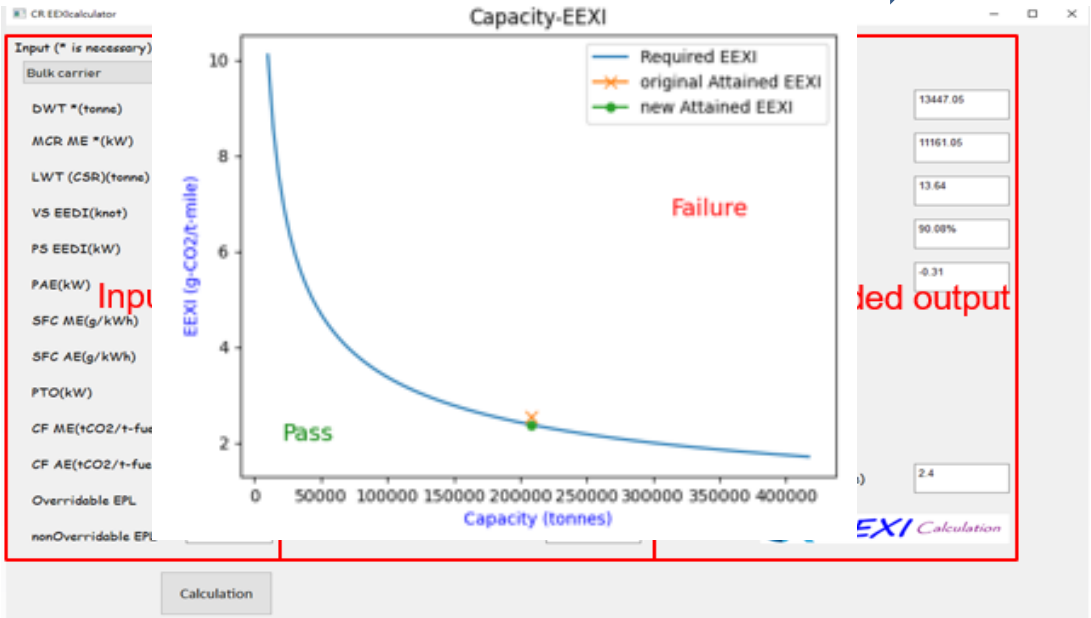


ALTERNATIVE FUELS

EEXI與CII因應策略

財團法人驗船中心
CR CLASSIFICATION SOCIETY

關於EEXI因應 ，CR能提供您



EEXI圖形化介面計算工具，快速得知船舶現有attained 、required EEXI 值及建議的主機出力與船速。

EEXI技術卷範本及主機EPL管理計劃等相關技術諮詢，以利船東盡快聯繫相關製造商進行改善規劃

本軟體之計算值僅供參考，並非正式之EEXI計算值

CR EEXI服務諮詢團隊，歡迎來信至 EEXI@crclass.org

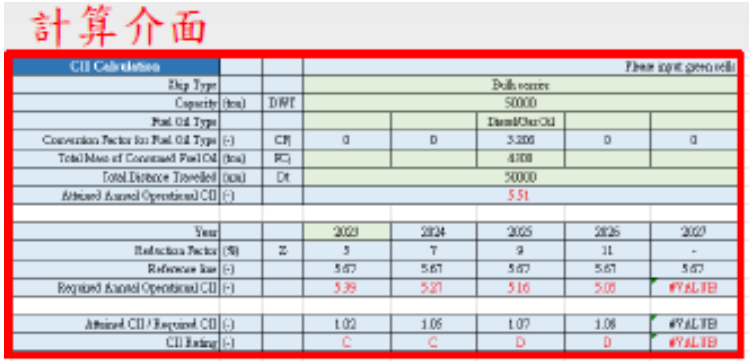
EEXI與CII因應策略

財團法人驗船中心
CR CLASSIFICATION SOCIETY

關於CII因應 ，CR能提供您

快速的CII計算與評級計算工具
及相關技術諮詢

計算介面



CII Calculation								Please input green cells
Ship Type			Bulk carrier					
Capacity	(ton)	DWT	50000					
Fuel Oil Type					Diesel/Gas Oil			
Conversion Factor for Fuel Oil Type	(-)	CF	0	0	3.206	0	0	
Total Mass of Consumed Fuel Oil	(ton)	FC			4108			
Total Distance Travelled	(nm)	Dt			50000			
Attained Annual Operational CII	(-)				5.51			
Year			2023	2024	2025	2026	2027	
Reduction Factor	(%)	Z	5	7	9	11	-	
Reference line	(-)		5.67	5.67	5.67	5.67	5.67	
Required Annual Operational CII	(-)		5.39	5.27	5.16	5.05	#VALUE!	
Attained CII / Required CII	(-)		1.02	1.05	1.07	1.08	#VALUE!	
CII Rating	(-)		C	C	D	D	#VALUE!	

使用說明(英文)

	How to do
Step 1	Please select a ship type.
Step 2	Please enter DWT or GT as capacity according to the ship type, as shown in Table 1.
Step 3	Please select the fuel oil type used.
	If there are multiple types of fuel oil, please select in different columns.
Step 4	Please enter the total mass of consumed fuel oil according to the selected fuel oil type.
Step 5	Please enter the total distance travelled.
Step 6	Please select the rating year.
Step 7	The CII Rating will be calculated automatically.
	Note: If Attained CII / Required CII < reqd(d1), the ship will be rated "A".
	If reqd(d1) < Attained CII / Required CII < reqd(d2), the ship will be rated "B".
	If reqd(d2) < Attained CII / Required CII < reqd(d3), the ship will be rated "C".
	If reqd(d3) < Attained CII / Required CII < reqd(d4), the ship will be rated "D".
	If reqd(d4) < Attained CII / Required CII, the ship will be rated "E".
	Please note that ship rated "D" for 3 consecutive years or rated as "E" shall develop a plan of corrective actions to achieve the required annual operational CII.

參考表格

Table 1 : DWT or GT should be used as capacity

Ship Type	Capacity
Bulk carrier	DWT
Gas carrier	DWT
Tanker	DWT
Container ship	DWT
General cargo ship	DWT
Refrigerated cargo carrier	DWT
Combination carrier	DWT
LNG carrier	DWT
Ro-ro cargo ship (vehicle carrier)	GT
Ro-ro cargo ship	DWT
Ro-ro passenger ship	GT
Cruise passenger ship	GT

Table 2: Conversion factor for fuel oil type

Fuel Oil Type	CF
Diesel/Gas Oil	3.206
Light Fuel Oil (LFO)	3.151
Heavy Fuel Oil (HFO)	3.114
Liquefied Petroleum Gas (LPG) Butane	3.030
Liquefied Petroleum Gas (LPG) Propane	3.000
Liquefied Natural Gas (LNG)	2.750
Methanol	1.375
Ethanol	1.913

Table 3 : Reduction factor (Z%) relative to 2019

Year	Z
2023	5
2024	7
2025	9
2026	11
2027	-
2028	-
2029	-
2030	-

Table 4 : Parameters for determining the 2019 ship type specific reference lines

Ship type		Capacity	a	c
Bulk carrier	279000 DWT and above	279,000	4745	0.622
	less than 279000 DWT	DWT	4745	0.622
Gas carrier	65000 DWT and above	DWT	14.405+11	2.671
	less than 65000 DWT	DWT	9184	0.639
Tanker		DWT	5247	0.610
Container ship		DWT	1984	0.489
General cargo ship	20000 DWT and above	DWT	31.948	0.792
	less than 20000 DWT	DWT	588	0.388
Refrigerated cargo carrier		DWT	4600	0.557
Combination carrier		DWT	40853	0.812
LNG carrier	100000 DWT and above	DWT	9.827	0.800
	65000 DWT and above, but less than 100000 DWT	DWT	14.405+14	2.579
	less than 65000 DWT	65,000	14.405+14	2.579
Ro-ro cargo ship (vehicle carrier)		GT	5729	0.631
Ro-ro cargo ship		DWT	18932	0.637
Ro-ro passenger ship		GT	7540	0.587
Cruise passenger ship		GT	930	0.383

Table 5 : All vectors for determining the rating boundaries of ship types

Ship type		exp(d1)	exp(d2)	exp(d3)	exp(d4)
Bulk Carrier		0.86	0.94	1.06	1.18
Gas carrier	65000 DWT and above	0.81	0.91	1.12	1.44
	less than 65000 DWT	0.85	0.95	1.06	1.25
Tanker		0.82	0.93	1.08	1.28
Container ship		0.83	0.94	1.07	1.19
General cargo ship		0.83	0.94	1.06	1.19
Refrigerated cargo carrier		0.78	0.91	1.07	1.20
Combination carrier		0.87	0.96	1.06	1.14
LNG carrier	100000 DWT and above	0.89	0.98	1.06	1.13
	less than 100000 DWT	0.78	0.92	1.10	1.37
Ro-ro cargo ship (vehicle carrier)		0.86	0.94	1.06	1.16
Ro-ro cargo ship		0.66	0.90	1.11	1.37
Ro-ro passenger ship		0.72	0.93	1.12	1.41
Cruise passenger ship		0.87	0.95	1.06	1.16

- 前言
- NOx Tier III的因應策略
- IMO減碳策略
- EEXI與CII因應
- 結論

結論

- 採用EGR、SCR及Dual fuel(如WinGD XDF)可符合NOx Tier III標準。
- IMO降低船舶溫室氣體排放戰略，技術面採取現成船能源效率船舶指數(EEXI)，操作面採取碳強度指標(CII)。
- Required EEXI近似Required EEDI等級，現成船需個別計算EEXI值，並評估是否符合規定。EEXI技術卷必須及時提交至船級協會認可，並在認可後放置船上。2023年內，需對已達到之EEXI進行驗證，並隨後簽發新的國際能效證書（**IEEC證書**, 同EEDI屬一次性驗證)
- **2023年1月1日前**須於其船舶能效管理計劃(SEEMP Part I)制定其CII達成計劃並經認可組織(RO)認可簽發符合確認書(CoC)，**自2024年1月1日起**，每年需計算並回報其年度CII值，並每年進行評等，等級按優劣分為A級到E級，若船舶連續三年落入D級或有一年落入E級，則須制訂矯正計劃並取得RO之認可。
- 現行燃料消耗數據收集(DCS) 之SoC自**2024年**起將納入CII評級。

報告完畢

CR EEXI服務諮詢團隊，歡迎來信至 EEXI@crclass.org