Current status of development of lifecycle GHG/carbon intensity guidelines for marine fuels in IMO

Seungman Ha

University of Strathclyde & Korean Register

Contents

1. Background

2. IMO Discussion on LCA guidelines

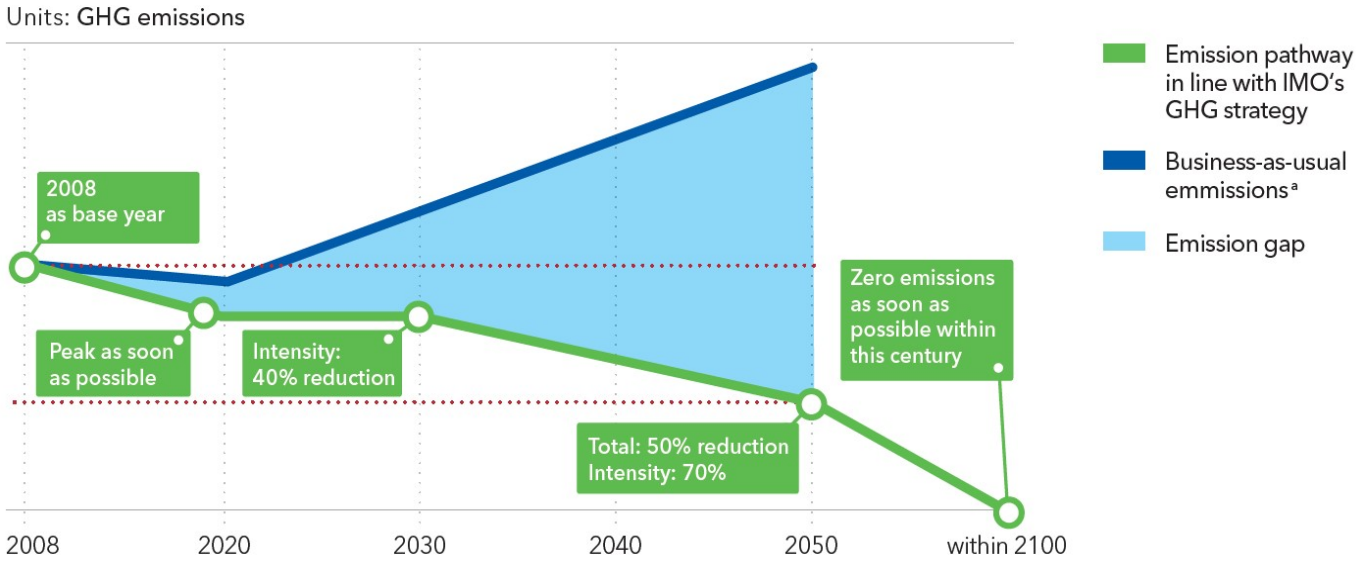
3. Possible LCA guideline application

IMO GHG strategy

- In 2018, **IMO** adopted an initial strategy on the reduction of greenhouse gas emissions with following ambitious goals

  ➢To reduce CO2 emissions per transport work by at least 40% by 2030, pursuing efforts **towards 70% by 2050**, compared to 2008

  ➢To reduce the total annual GHG emissions by **at least 50% by 2050,** compared to 2008

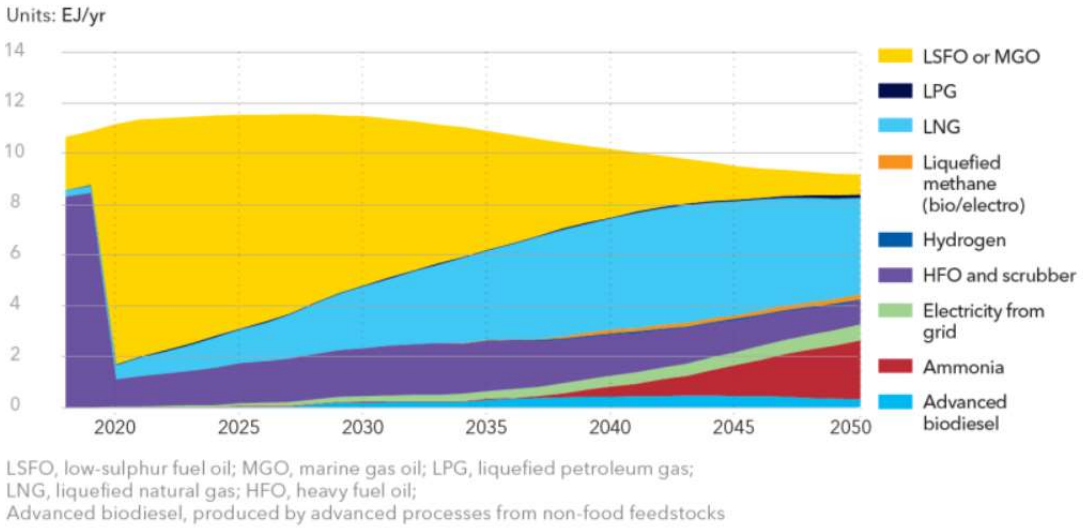


Source: DNV GL. Maritime forecast to 2050

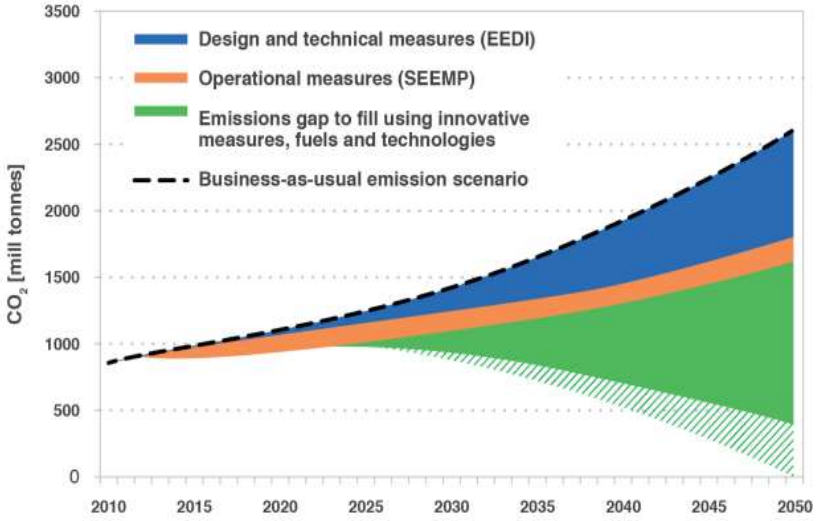
IMO GHG strategy

- How to achieve the ambitious goals set in IMO GHG strategy ?

➢ A shift to low-carbon and zero-carbon fuel will be necessary in order to reach the 2050 targets

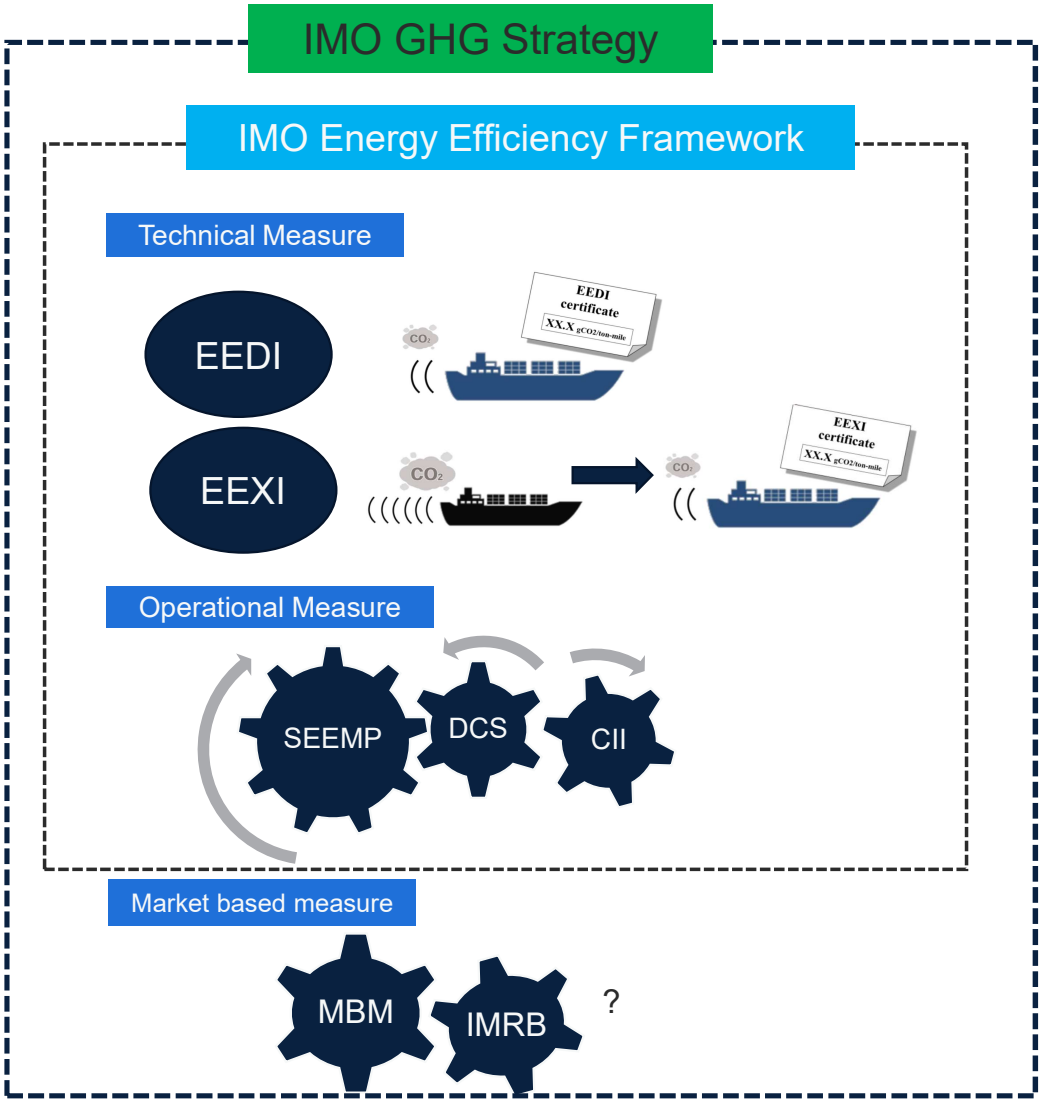


LSFO, low-sulphur fuel oil; MGO, marine gas oil; LPG, liquefied petroleum gas;
LNG, liquefied natural gas; HFO, heavy fuel oil;
Advanced biodiesel, produced by advanced processes from non-food feedstocks



Source: DNV GL. Maritime forecast to 2050

Current IMO legal Framework – GHG reduction

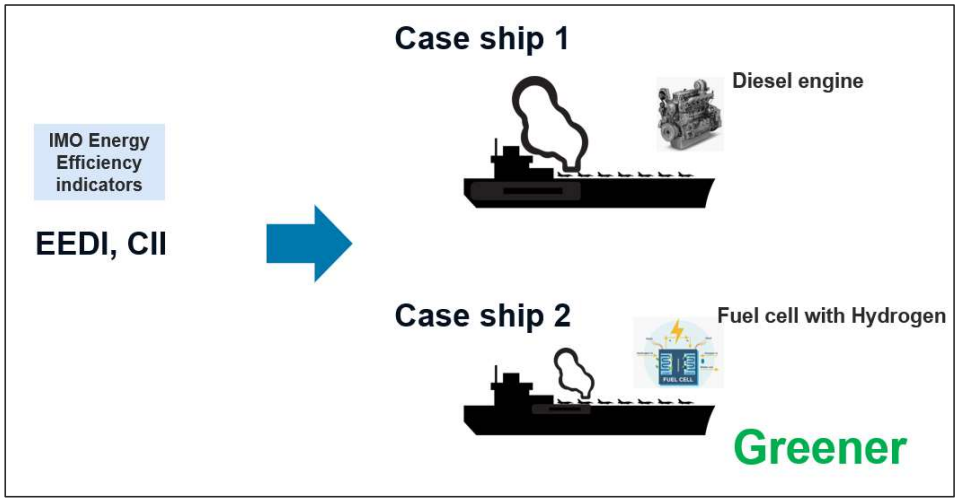


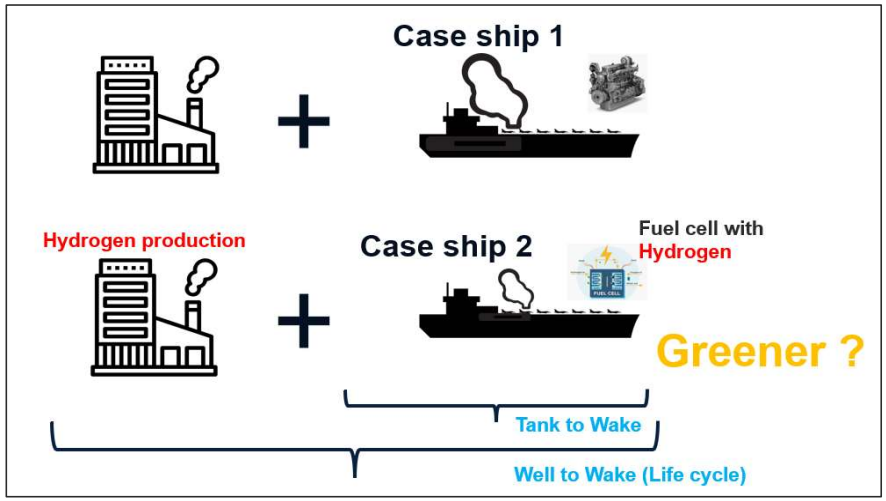
$$EEDI = \frac{\text{Main Engine CO2 emission} + \text{Aux.Engine CO2 emission} + \text{Shaft generator/motor CO2 emissions} - \text{Innovative technologies}}{\text{Transport work}}$$

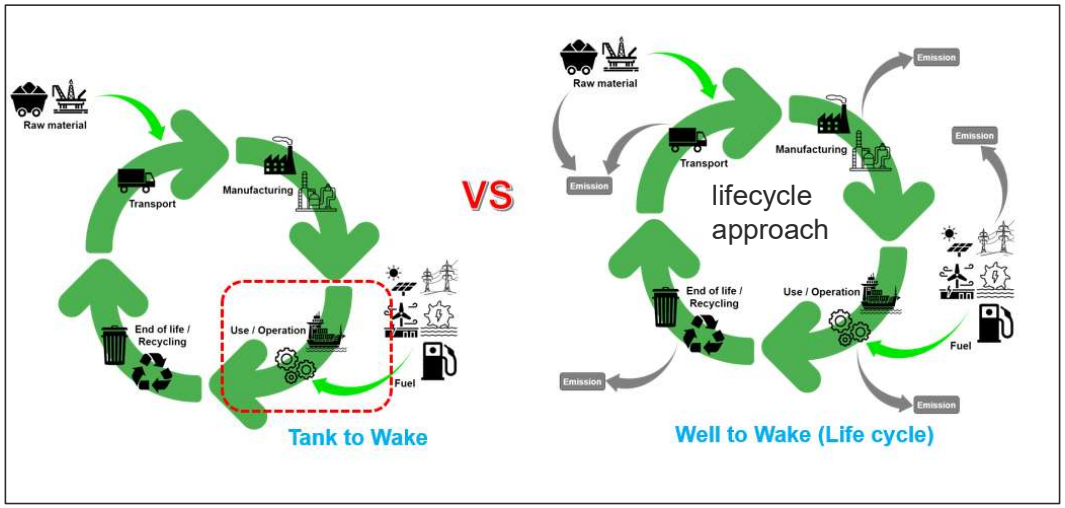
$$CII = \frac{\text{Annual fuel consumption} \times \text{CO2 factor}}{\underbrace{\text{Annual distance travelled} \times \text{Capacity}}_{\text{Transport work}}}$$

- EEDI : Energy Efficiency Design Index
- EEXI : Energy Efficiency Existing Ship Index
- SEEMP : Ship Energy Efficiency Management Plan
- DCS :Data collection system for fuel oil consumption of ships
- CII : Carbon intensity indicator, e.g EEOI
- MBM : Market Based Measures (MBMs)
- IMRB: International Maritime Research and Development Board

Limitation of current IMO Energy Efficiency indicators







IMO GHG strategy

- Which fuels are net GHG emissions benefit over their lifecycles??
- One of the short- term measure in initial IMO strategy: **development of lifecycle GHG/carbon intensity guidelines*** for all relevant types of fuels (target year : **2023**)

* **LCA guidelines ;** a methodology to quantify **well to wake GHG emissions** of sustainable alternative fuel (development of **default well to wake emission factor** of each fuel)

- Current practice from a regulatory perspective in IMO

	GHGs	Well to Tank or Well to Wake
1. Current IMO instruments, e.g. EEDI or EEOI	CO_2	Tank to Wake
2. IMO GHG Study, i.e. g CO2-equivalents	CO_2 ,CH_4,N_2O	Tank to Wake
3. **lifecycle GHG/carbon intensity guideline**	CO_2 ,CH_4,N_2O ??	Well to Wake ??

Contents

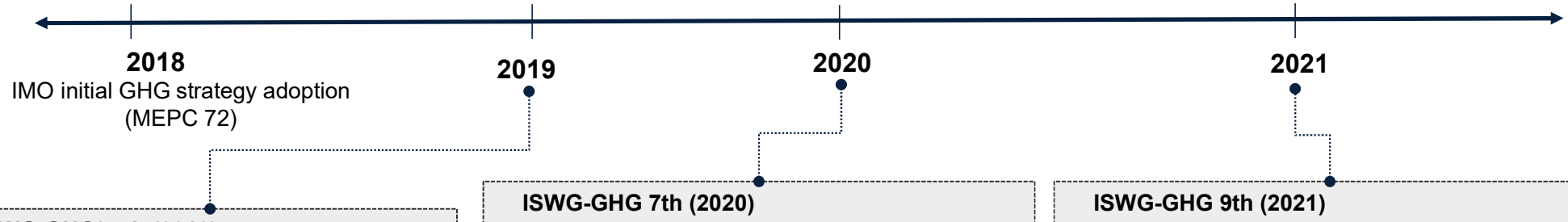
1. Background

2. IMO Discussion on LCA guidelines

3. Possible LCA guideline application

IMO discussion on LCA guidelines

- Submissions on development of LCA guidelines



ISWG-GHG* 5th (2019)
• ISWG-GHG 5/4/5(Republic of Korea) : Consideration on development of the lifecycle GHG/carbon intensity guidelines for all types of fuels

ISWG-GHG 6th (2019)
•ISWG-GHG 6/5(Norway): Principles for developing lifecycle carbon intensity guidelines
• ISWG-GHG 6/5/1(Republic of Korea): Further consideration on development of the lifecycle GHG/carbon intensity guidelines for all types of fuels (follow up on "ISWG-GHG 5/4/5")
• ISWG-GHG 6/5/2(UK): Setting the framework for shipping's new fuels

ISWG-GHG 7th (2020)

• ISWG-GHG 7/5/3(Republic of Korea) : Approaches to be considered in future work on "well-to-propeller" emission information
• ISWG-GHG 7/5/5(CESA) : Consideration of the life cycle assessment of alternative fuels and the incorporation of life cycle aspects into IMO instruments
• ISWG-GHG 7/5/6(IMarEST) : Life cycle GHG/carbon intensity through implementation with BDN (Bunker Delivery Note)
• ISWG-GHG 7/5/8(Norway et al.) : Draft life cycle GHG and carbon intensity guidelines for maritime fuels
• ISWG-GHG 7/5/9 (European Commission et al.) **:** Introducing life cycle guidelines to estimate well-to-tank greenhouse gas (GHG) emissions

ISWG-GHG 9th (2021)

• **ISWG-GHG 9/2(European Commission et al.) : FuelEU Maritime Initiative**

• **ISWG-GHG 9/2/3(Norway et al.) :Updated Draft Lifecycle GHG and Carbon Intensity Guidelines for maritime fuels(follow up on ISWG-GHG 7/5/8)**

• ISWG-GHG 9/2/2(SGMF et al.) : Lifecycle Assessment Framework

• ISWG-GHG 9/2/9(IMarEST) : Workstreams on LCA guideline

• ISWG-GHG 9/2/6 (IMO) : Sustainable criteria and lifecycle GHG emission assessment methods and standards for alternative marine fuels

*** ISWG-GHG : Intersessional Working Group on Reduction of GHG Emissions from Ships**

IMO discussion on LCA guidelines

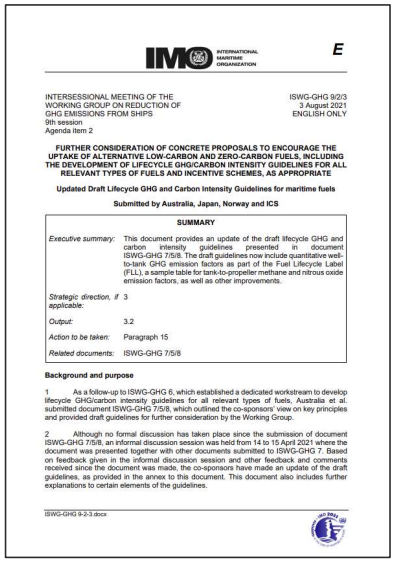
- Result of ISWG-GHG 9th meeting('21.09)

- to use the document **ISWG-GHG 9/2/3 (Norway et al.)** as a base document for the further development of the guidelines, to be complemented by elements in document **ISWG-GHG 9/2 (European Commission et al.)**

	ISWG GHG 9/2/3 (Norway et al)	ISWG GHG 9/2 (EU)	SWG GHG 9/2/9 (IMarEST)	ISWG GHG 9/2/2 (SGMF et al)	ISWG GHG 9/2/6 (IMO)	ISWG GHG9/2/7& 9/2/8 (WWF, PE, CSC)
Categorization of fuels	1) Fossil, 2) Biomass, 3) Cap 4) Ze 5) Ele	1)Fossil, 2)Sustainable Renewable Fuels	need for quantitative fuel lifecycle labelling	-	1)Fossil, 2) Fuels other than fossil fuels - Green fuel (H_2, NH_3, CH_4)	need for quantitative fuel lifecycle labelling

	ISWG GHG 9/2/3 (Norway et al)	ISWG GHG 9/2 (EU)	ISWG GHG 9/2/9 (IMarEST)	ISWG GHG 9/2/2 (SGMF et al)	ISWG GHG 9/2/6 (IMO)	ISWG GHG9/2/7& 9/2/8 (WWF, PE, CSC)
Methane emissi on factor	- Engine type and g eneration(build year)	- Engine type	-	-	-	- Engine type - consideration the lea kage into crankcase
Incentive scheme o ption (WtT, TtP or WtP GH G emission factor ap plication)	possible applications on EEDI, EEXI, DCS a nd CII(To be decided in MEPC in a timely manner)	- GHG Tax / Levy - Cap and trade - Fuel Standard - any other measures or combination	- possible applications on CII, not EEDI considere d as technical measur e	- possible applications on CII in order to ince ntivise use of biofuel	-	-
Inclusion of Bla ck carbon	not considered	not considered at this sta ge.	need to consider	not considered	-	considered
GWP100/GWP20	GWP 100 only	GWP 100 at this stage	GWP 100 & GWP 20	GWP 100 only	-	GWP 100 & GWP 20
Sustainability	No concrete proposal but application of a Fuel Life cycle Label (FLL) which broadly c ategories the fuel ba sed on well-to-tank GHG emissions, carb on source and other sustainability aspects.	need to consider but no concrete proposal Sustai nability	need to consider but no concrete proposal Sustai nability	Some of the main sus tainability aspects to be considered; - Resource use - LCA GHG emissions - Potential ecological i mpacts - Safe transport and ha ndling	Global Warming Potential (GWP), Ozone Depletion Po tential(ODP), Acidification P otential(AP), Human Toxicit y Potential (HTP), Eutrophic ation Potential (EP) etc,	-
Indirect land-us e change (ILUC)	-	need to define either q ualitatively or quantitati vely	need to consider ILUC	need to consider the "consequential" GHG emissions associated with ILUC	need to consider, in partic ular biofuel	need to consider ILUC i n a transparent manner
Unit	- t CO2eq/t fuel or - t CO2eq/GJ(electricit y)	- WtT: gCO2eq/MJ - TtW(TtP): gCO2eq/gfuel	Unit to be comparative	three options to be con sidered - gCO2e/MJLHV - gCO2e/MJ propulsive e nergy or gCO2e/kWh pr opulsive energy - gCO2e/tonne-nm	- gCO2eq/MJ gCO2eq emissions per 1 MJ of work output from the pr opulsion system	- gCO2e/gfuel

ISWG-GHG 9/2/3(Norway et al.)



IMO INTERNATIONAL MARITIME ORGANIZATION E

INTERSESSIONAL MEETING OF THE WORKING GROUP ON REDUCTION OF GHG EMISSIONS FROM SHIPS
9th session
Agenda item 2

ISWG-GHG 9/2/3
3 August 2021
ENGLISH ONLY

FURTHER CONSIDERATION OF CONCRETE PROPOSALS TO ENCOURAGE THE UPTAKE OF ALTERNATIVE LOW-CARBON AND ZERO-CARBON FUELS, INCLUDING THE DEVELOPMENT OF LIFECYCLE GHG/CARBON INTENSITY GUIDELINES FOR ALL RELEVANT TYPES OF FUELS AND INCENTIVE SCHEMES, AS APPROPRIATE

Updated Draft Lifecycle GHG and Carbon Intensity Guidelines for maritime fuels

Submitted by Australia, Japan, Norway and ICS

SUMMARY

Executive summary: This document provides an update of the draft lifecycle GHG and carbon intensity guidelines presented in document ISWG-GHG 7/5/8. The draft guidelines now include quantitative well-to-tank GHG emission factors as part of the Fuel Lifecycle Label (FLL), a sample table for tank-to-propeller methane and nitrous oxide emission factors, as well as other improvements.

Strategic direction, if applicable: 3

Output: 3.2

Action to be taken: Paragraph 15

Related documents: ISWG-GHG 7/5/8

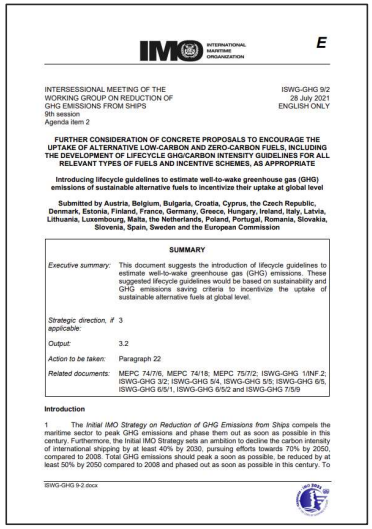
Background and purpose

1 As a follow-up to ISWG-GHG 6, which established a dedicated workstream to develop lifecycle GHG/carbon intensity guidelines for all relevant types of fuels, Australia et al. submitted document ISWG-GHG 7/5/8, which outlined the co-sponsors' view on key principles and provided draft guidelines for further consideration by the Working Group.

2 Although no formal discussion has taken place since the submission of document ISWG-GHG 7/5/8, an informal discussion session was held from 14 to 15 April 2021 where the document was presented together with other documents submitted to ISWG-GHG 7. Based on feedback given in the informal discussion session and other feedback and comments received since the document was made, the co-sponsors have made an update of the draft guidelines, as provided in the annex to this document. This document also includes further explanations to certain elements of the guidelines.

ISWG-GHG 9-2-3.docx

ISWG-GHG 9/2(European Commission et al.)



IMO INTERNATIONAL MARITIME ORGANIZATION E

INTERSESSIONAL MEETING OF THE WORKING GROUP ON REDUCTION OF GHG EMISSIONS FROM SHIPS
9th session
Agenda item 2

ISWG-GHG 9/2
28 July 2021
ENGLISH ONLY

FURTHER CONSIDERATION OF CONCRETE PROPOSALS TO ENCOURAGE THE UPTAKE OF ALTERNATIVE LOW-CARBON AND ZERO-CARBON FUELS, INCLUDING THE DEVELOPMENT OF LIFECYCLE GHG/CARBON INTENSITY GUIDELINES FOR ALL RELEVANT TYPES OF FUELS AND INCENTIVE SCHEMES, AS APPROPRIATE

Introducing lifecycle guidelines to estimate well-to-wake greenhouse gas (GHG) emissions of sustainable alternative fuels to incentivize their uptake at global level

Submitted by Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the European Commission

SUMMARY

Executive summary: This document suggests the introduction of lifecycle guidelines to estimate well-to-wake greenhouse gas (GHG) emissions. These suggested lifecycle guidelines would be based on sustainability and GHG emissions saving criteria to incentivize the uptake of sustainable alternative fuels at global level.

Strategic direction, if applicable: 3

Output: 3.2

Action to be taken: Paragraph 22

Related documents: MEPC 74/7/6, MEPC 74/18; MEPC 75/7/2; ISWG-GHG 1/INF.2; ISWG-GHG 3/2; ISWG-GHG 5/4, ISWG-GHG 5/5; ISWG-GHG 6/5, ISWG-GHG 6/5/1, ISWG-GHG 6/5/2 and ISWG-GHG 7/5/9

Introduction

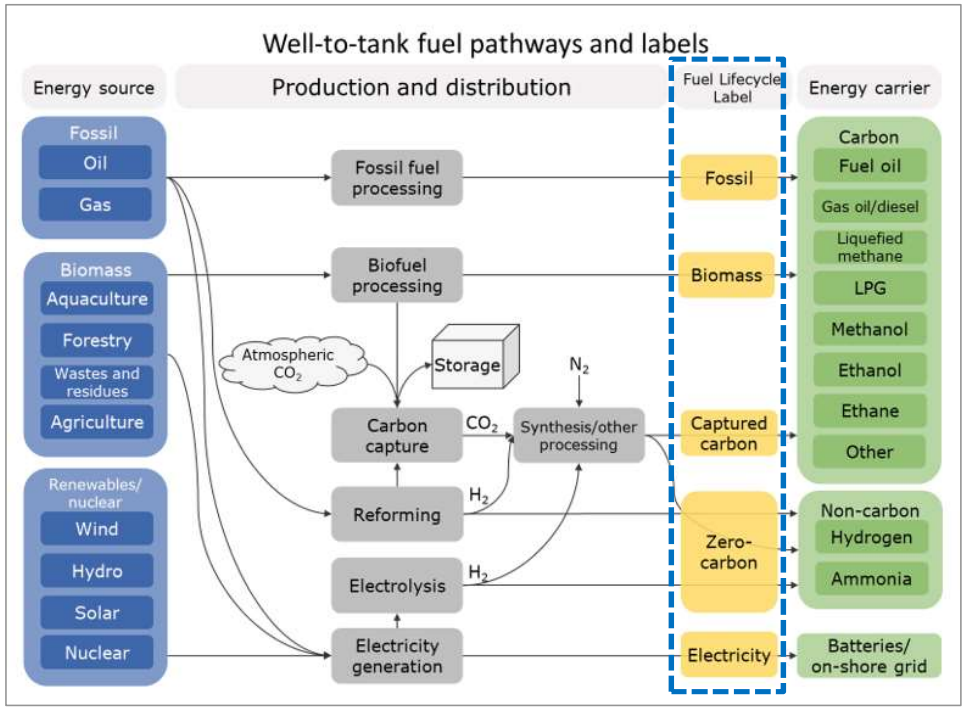
1 The *Initial IMO Strategy on Reduction of GHG Emissions from Ships* compels the maritime sector to peak GHG emissions and phase them out as soon as possible in this century. Furthermore, the Initial IMO Strategy sets an ambition to decline the carbon intensity of international shipping by at least 40% by 2030, pursuing efforts towards 70% by 2050, compared to 2008. Total GHG emissions should peak a soon as possible, be reduced by at least 50% by 2050 compared to 2008 and phased out as soon as possible in this century. To

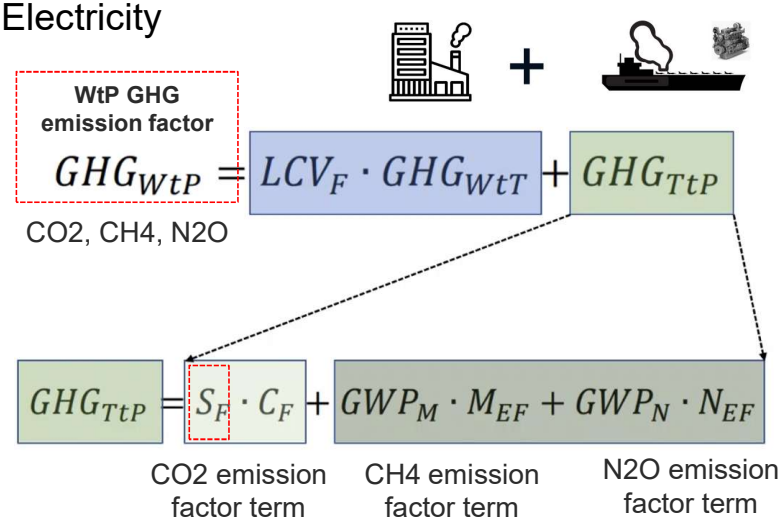
ISWG-GHG 9-2.docx

Proposal 1 _ ISWG-GHG 9/2/3(Norway et al.)

- Including **quantitative** WtT GHG emission factors (GHG_{WtT})
- Introducing **Fuel life cycle label(FLL)*** which categorizes the fuel based on carbon source and other sustainability aspect

* 1) Fossil, 2) Biomass, 3) Captured carbon, 4) Zero-carbon, 5) Electricity

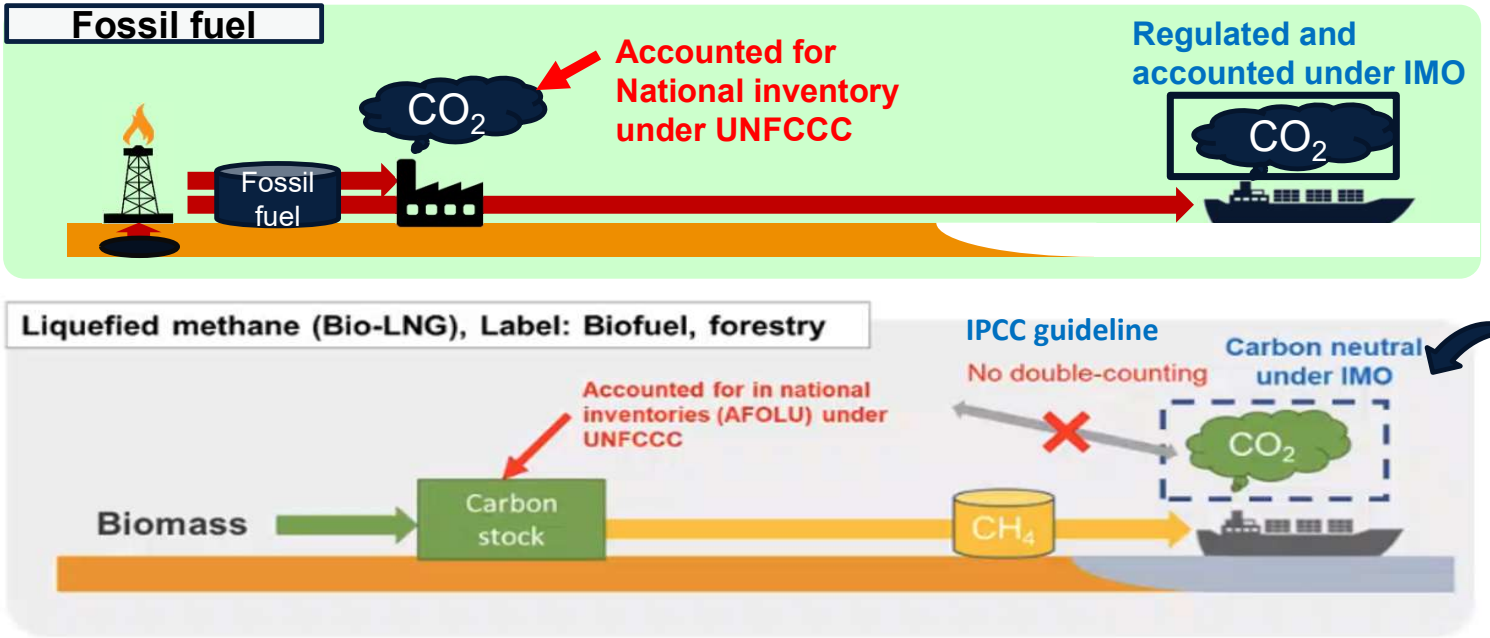




- LCV_F :The lower calorific value for the relevant fuel
- GWP: Global warming potential
- S_F: The carbon source factor of the specific fuel
- C_F: The conversion factor between fuel consumption and CO2
- M_{EF}: The methane emission factor
- N_{EF}: The nitrous oxide emission factor

Proposal 1 _ ISWG-GHG 9/2/3(Norway et al.)

- Introducing **Carbon source factor(S_F)**
- The need for correctly accounting for CO2 emissions from biofuels according to IPCC guidelines
- Biomass may be considered carbon-neutral and consequently the TtP emission should be reported as zero



$$GHG_{WtP} = LCV_F \cdot GHG_{WtT} + GHG_{TtP}$$

$$GHG_{TtP} = S_F \cdot C_F + GWP_M \cdot M_{EF} + GWP_N \cdot N_{EF}$$

the fuels that absorb the carbon during the Well-to-Tank process(Carbon source factor(S_F = 0)

- UNFCCC: United Nations Framework Convention on Climate Change
- IPCC : Intergovernmental Panel on Climate Change

Proposal 1 _ ISWG-GHG 9/2/3(Norway et al.)

- Introducing Carbon source factor(S_F) ; biofuel

$$GHG_{WtP} = LCV_F \cdot GHG_{WtT} + GHG_{TtP}$$

$$GHG_{TtP} = S_F \cdot C_F + GWP_M \cdot M_{EF} + GWP_N \cdot N_{EF}$$

CO2 emission factor term =0

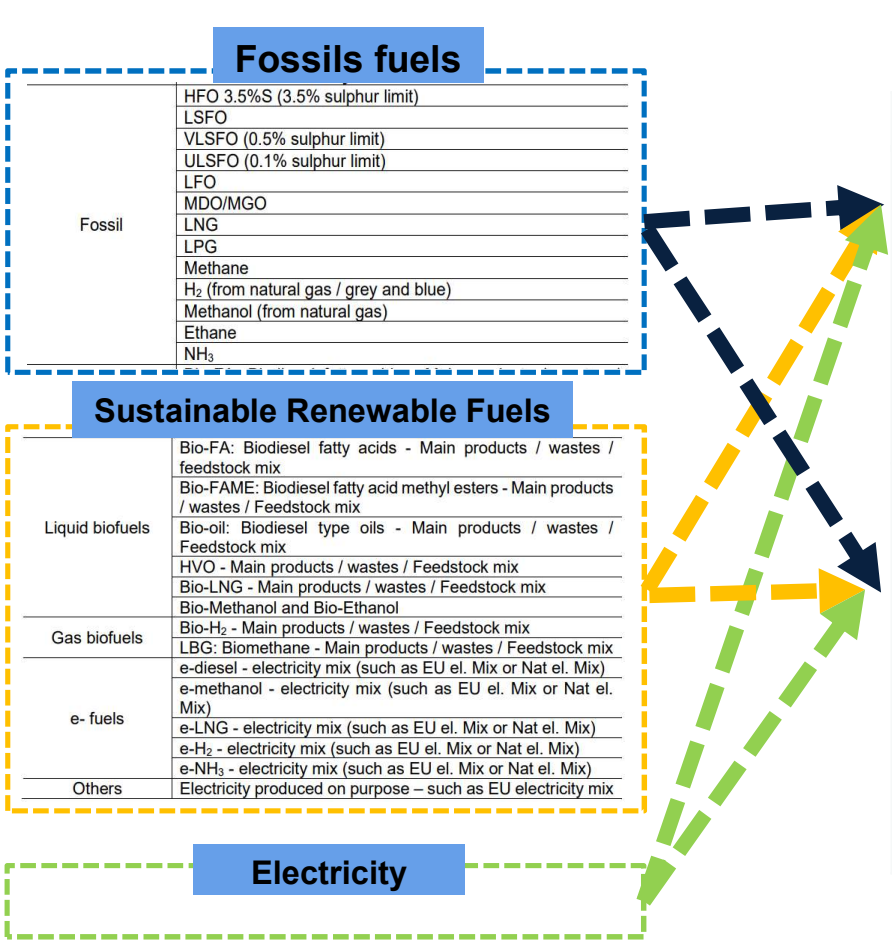
Fuel Lifecycle Label		Carbon source		GHG WTT factor	Source
Main label	Sub-category	Include CO_2 emissions in TTP	S_F	GHG_{WTT} (t CO_2-e/t fuel)	
Fossil	Heavy/Light Fuel Oil	Yes	1	[TBD]	
Fossil	Diesel/Gas Oil	Yes	1	[TBD]	
Fossil	LNG	Yes	1	[TBD]	
Fossil	LPG	Yes	1	[TBD]	
Fossil	...	Yes	1	...	
Biomass	...	For info	0	...	
Captured carbon	Fossil	[For info]	[0]	...	
Captured carbon	...	For info	0	...	
Zero-carbon	Reformed fossil without CCS	N/A	0	[TBD]	
Zero-carbon	Reformed fossil with CCS	N/A	0	[TBD]	
Zero-carbon	Electricity	N/A	0	[TBD]	
Zero-carbon	...	...	...	...	
Electricity	Region A	N/A	0	[TBD]*	
Electricity	...			...*	

Table 1: List of Fuel Lifecycle Labels.

	Main label	S_F	C_F	$S_F * C_F$
LNG	Fossil	1	2.750	**2.750**
	Biomass	0	2.750	**0**
	Captured carbon	0	2.750	**0**
Methanol	Fossil	1	1.375	**1.375**
	Biomass	0	1.375	**0**
	Captured carbon	0	1.375	**0**
Ammonia	Zero-carbon	0	0	**0**
Hydrogen	Zero-carbon	0	0	**0**

Proposal 2 _ ISWG-GHG 9/2(European Commission et al.)

- Verification and Certification for WtT / TtW emission factors



	Well to Tank	Tank to Wake
Default **values**		
Certified values (by certification scheme)	**existing certification scheme** • International Sustainability and Carbon Certification (ISCC) • Roundtable on Sustainable Biomaterials (RSB) • REDCert	**certification scheme to be defined** • Certified values by mean of laboratory testing or direct emissions measurements

1	2	3	4	5	6	7	8	9
	WtT			TtW				
Class	Pathway name	LCV $\left[\frac{MJ}{g}\right]$	$CO_{2eq\ WtT}$ $\left[\frac{gCO2eq}{MJ}\right]$	Energy Converter Class	$C_{f\,CO_2}$ $\left[\frac{gCO2}{gFuel}\right]$	$C_{f\,CH_4}$ $\left[\frac{gCH_4}{gFuel}\right]$	$C_{f\,N_2O}$ $\left[\frac{gN_2O}{gFuel}\right]$	C_{slip} As % of the mass of the fuel used by the engine
	HFO ISO 8217 Grades RME to RMK	0,0405	9,6 - 14,1 Sphera 2nd GHG Study	ALL ICEs	3,114 MEPC245 (66) MRV Regulation	0,00005 TBM	0,00018 TBM	-
				Gas Turbine				
				Steam Turbines and Boilers				
				Aux Engines				

Gaps between two proposals

- TtW(TtP) emission factors

	ISWG-GHG 9/2/3(Norway et al.)	ISWG-GHG 9/2(European Commission et al.)
TtW(TtP) GHG in $[gCO2eq]$	Carbon source factor $GHG_{TtP} = S_F \cdot C_F + GWP_M \cdot M_{EF} + GWP_N \cdot N_{EF}$ CO2 emission / CH4 emission / N2O emission Methane slip $\sum_{i}^{n\ fuel} \sum_{j}^{m\ consumer} M_{ij} \times GHG_{TtP}$	Where: $CO_{2eq,TtW,i} = (C_{f\,CO_2} \times GWP_{CO_2} + C_{f\,CH_4} \times GWP_{CH_4} + C_{f\,N_2O} \times GWP_{N_2O})_i$ combustion emissions factor CO2 emission / CH4 emission / N2O emission $+ \sum_{i}^{n\ fuel} \sum_{j}^{m\ consumer} M_{ij} \times [(1 - C_{slip\,j}) \times (CO_{2eq,TtW,i}) + (C_{slip\,j} \times GWP_{CH_4})]$ Tank-to-Wake GHG in $[gCO_{2eq}]$ Methane slip Summation over the fuel type and the prime mover consuming it CO_{2eq} of the fuel combusted in the engine minus the % of the fuel that escapes combustion (fugitive, vented, leaked) in– see below Fugitive emission of fuel that does not reach the combustion chamber – see below
Differences	- Carbon source factor(Sf) - Methane slip calculation	

Gaps between two proposals

- TtW Methane slip calculation

	Case 1 LNG Diesel (slow speed)	Case 2 LNG Otto (slow speed)	Case 3 LNG Otto (medium speed)
Methane slip(%)	**0.2**	**1.7**	**3.1**
LNG carbon factor	2.75	2.75	2.75
LNG fuel consumption	5685.87	5685.87	5685.87
ISWG-GHG 9/2(European Commission et al.)			
CO2eq,TtW(tCO2eq/tFuel)	2.77915	2.77915	2.77915
tCO2eq (A)	16088.7	18239.7	20247.4
ISWG-GHG 9/2/3(Norway et al.)			
GHG_{TtP}(t CO2eq/t fuel)	2.83515	3.25515	3.64715
tCO2eq (B)	16120.3	18508.3	20737.2
Difference tCO2eq [1- (B/A)]	**-0.20%**	**-1.47%**	**-2.42%**

the greater the amount of methane slip, the greater the difference

Contents

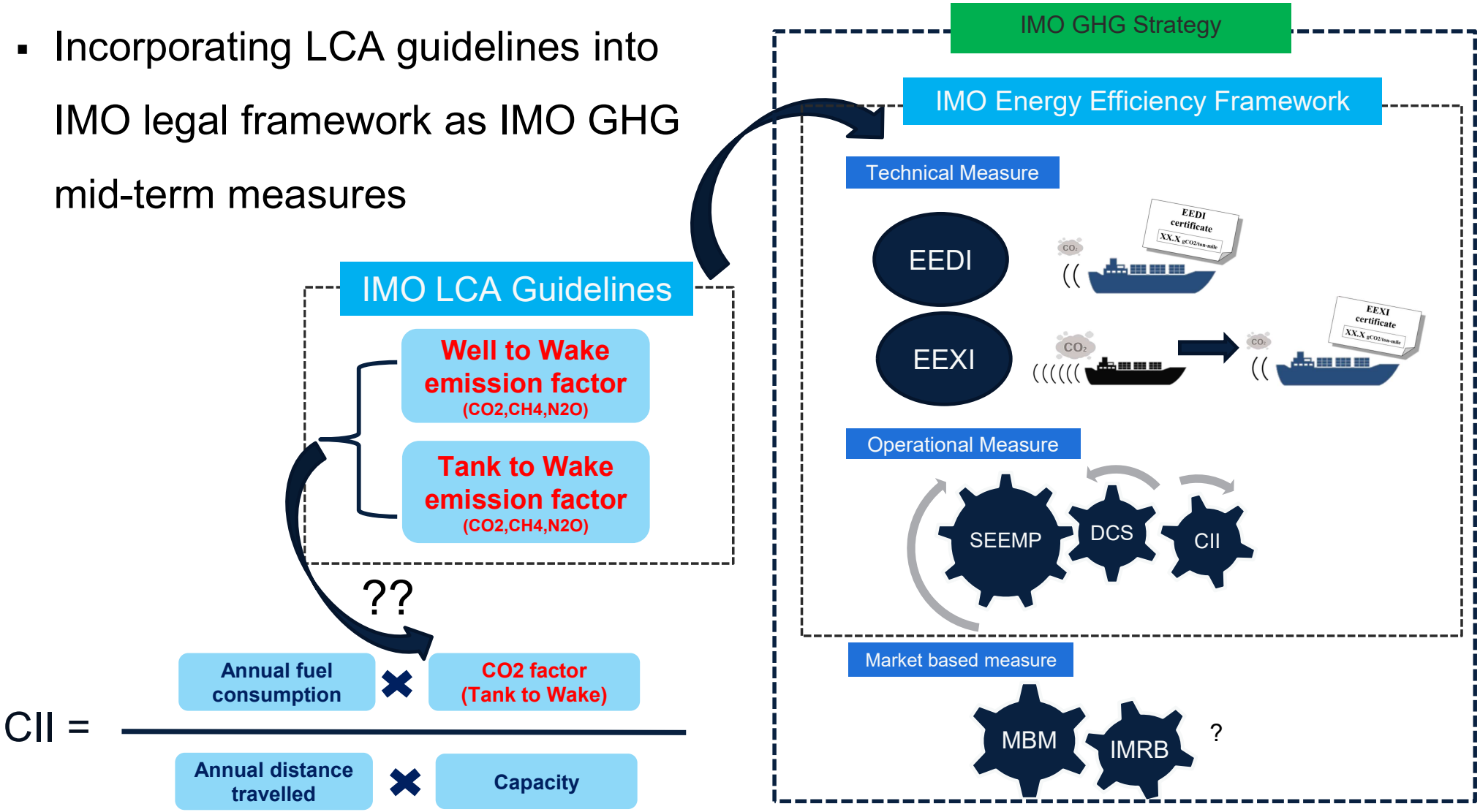
1. Background

2. IMO Discussion on LCA guidelines

3. Possible LCA guideline application

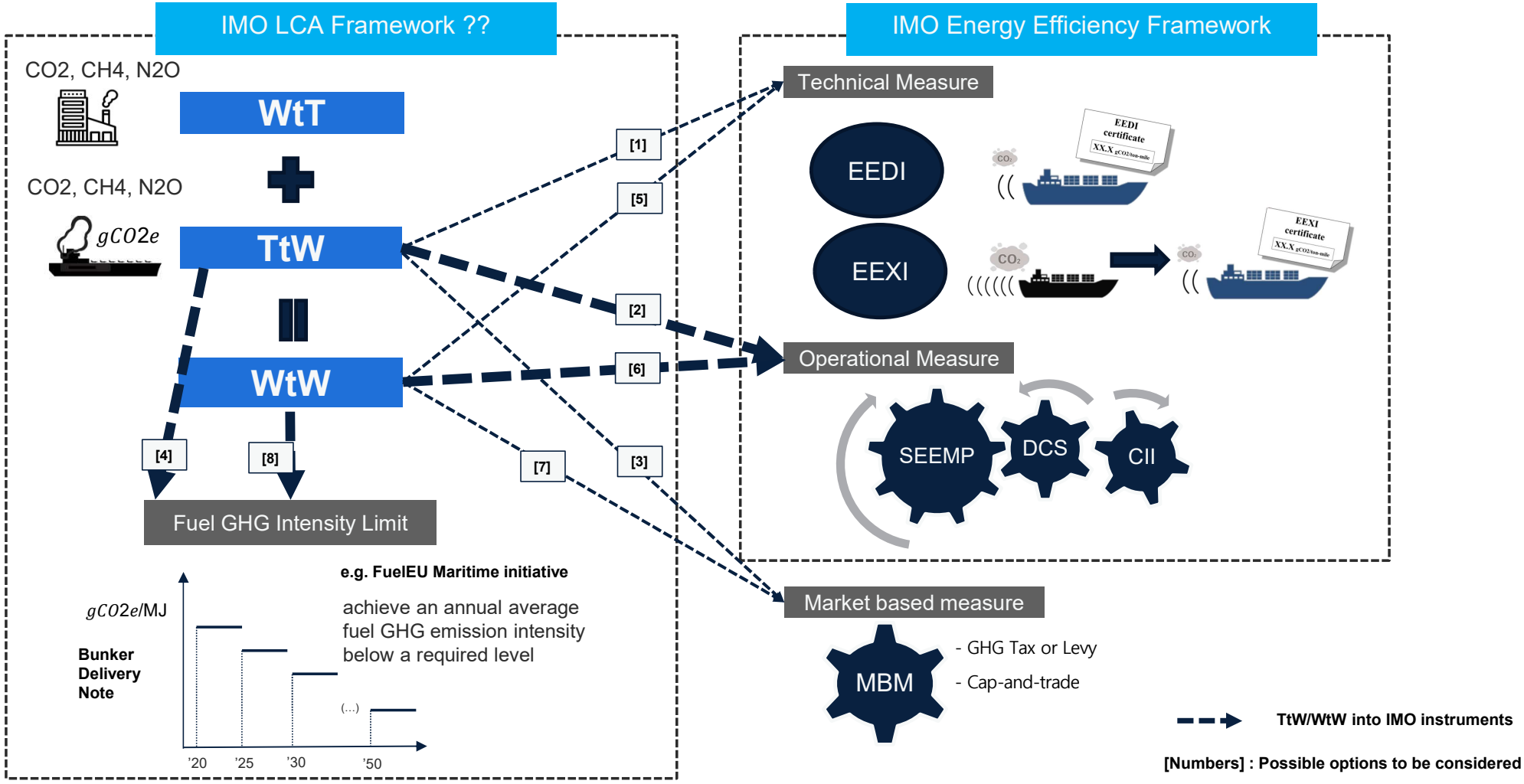
LCA guideline application

- Incorporating LCA guidelines into IMO legal framework as IMO GHG mid-term measures



LCA guideline application scenario

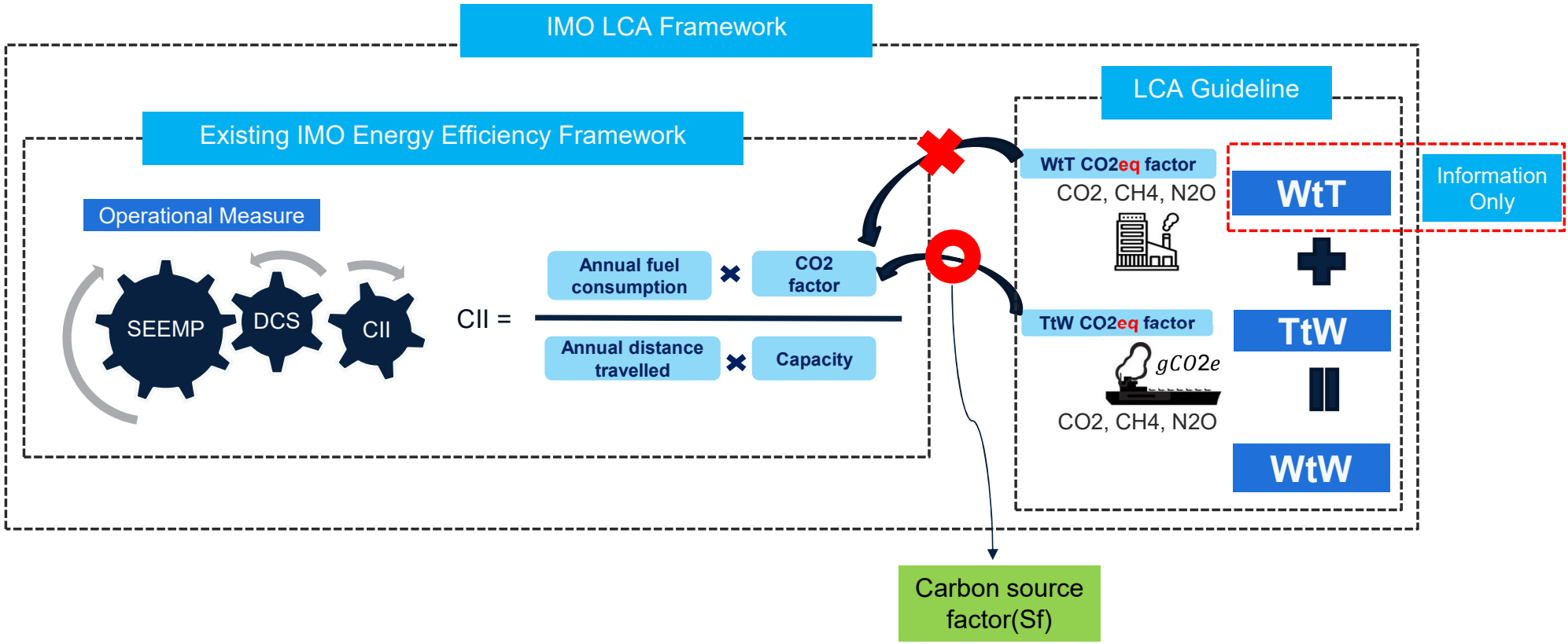
- Possible options ?



LCA guideline application scenario

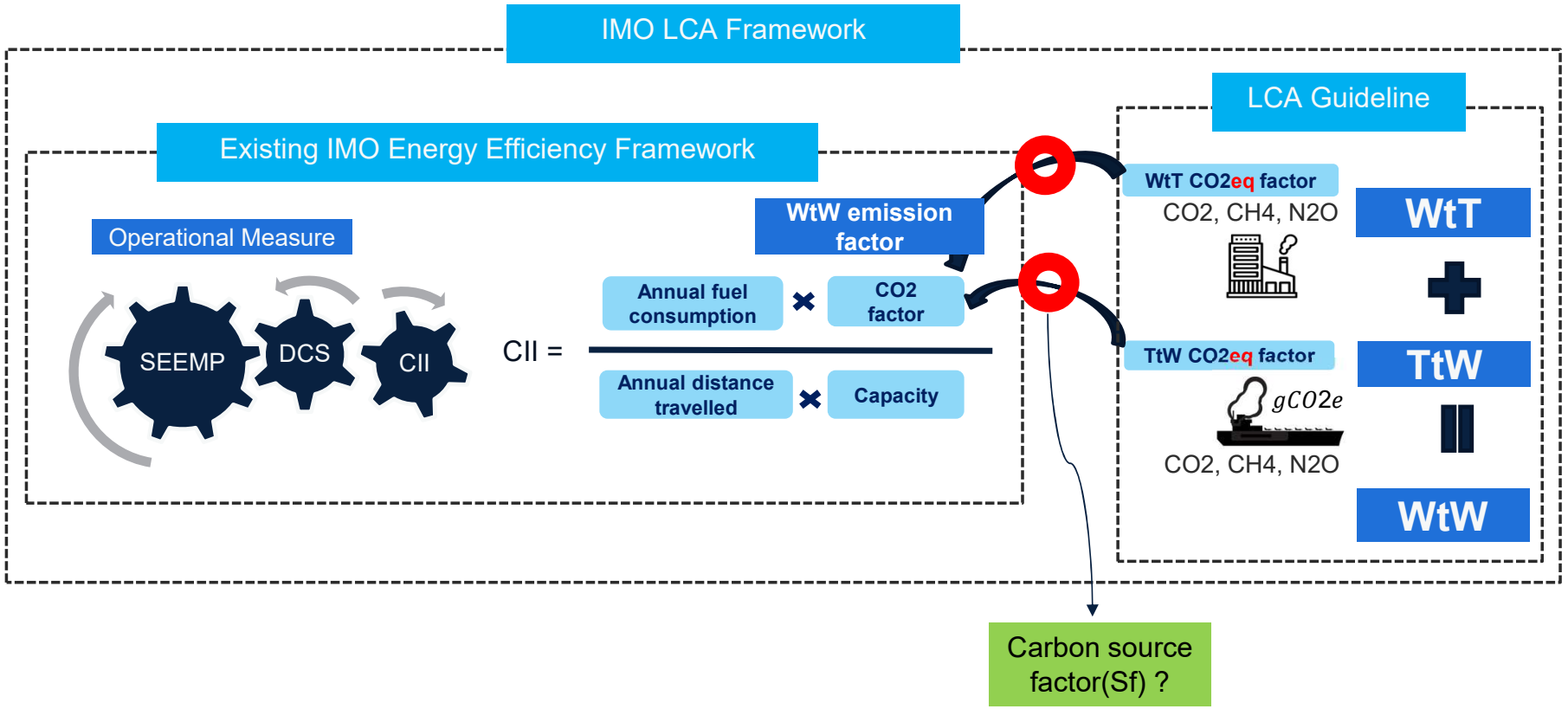
- Possible option 1 : Incorporating TtW CO2eq factor into CII

WtT emission factor to be used for information purpose



LCA guideline application scenario

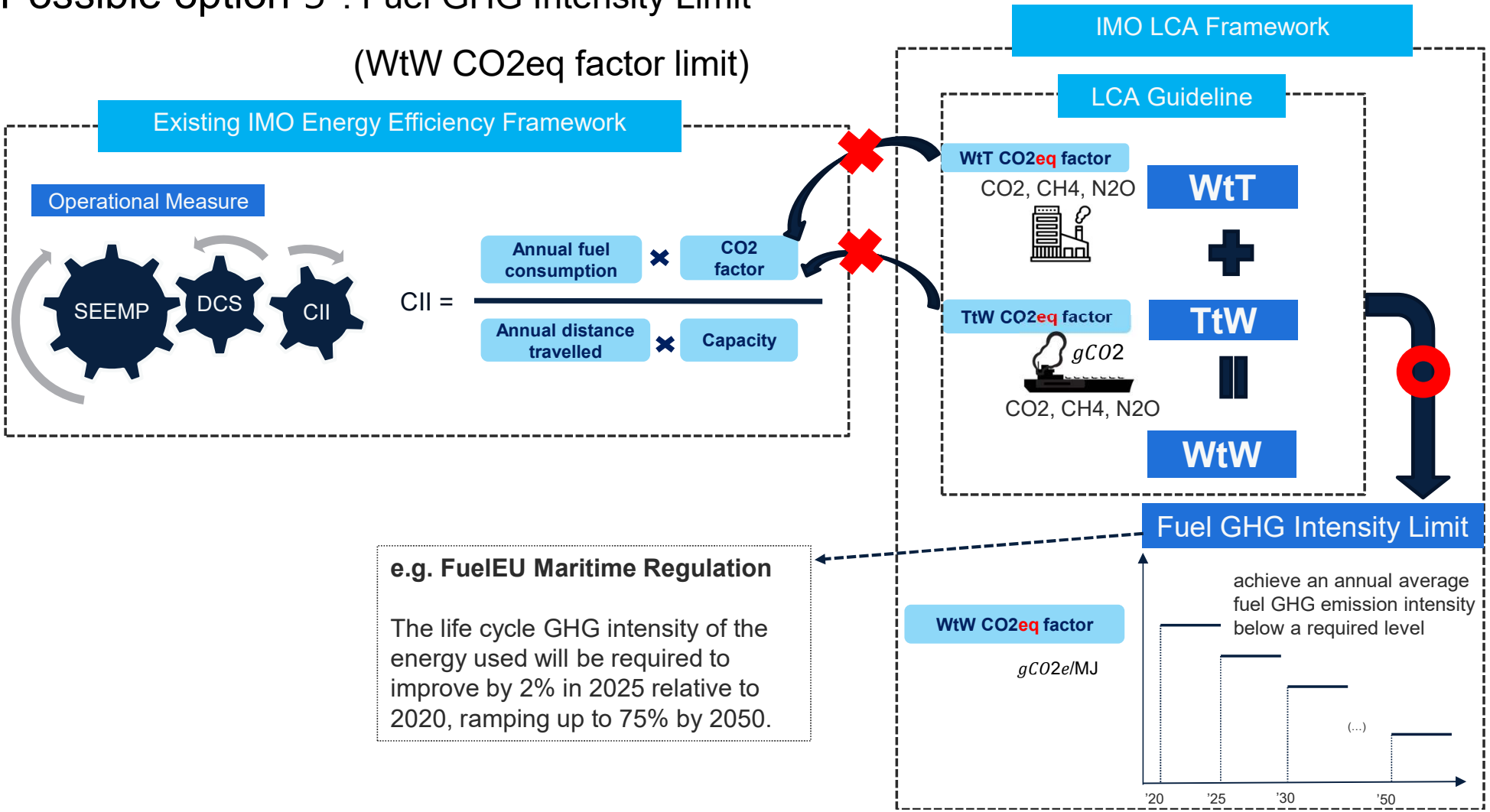
- Possible option 2 : Incorporating WtW CO2eq factor(WtT + TtW) into CII



LCA guideline application scenario

- Possible option 3 : Fuel GHG Intensity Limit

(WtW CO2eq factor limit)

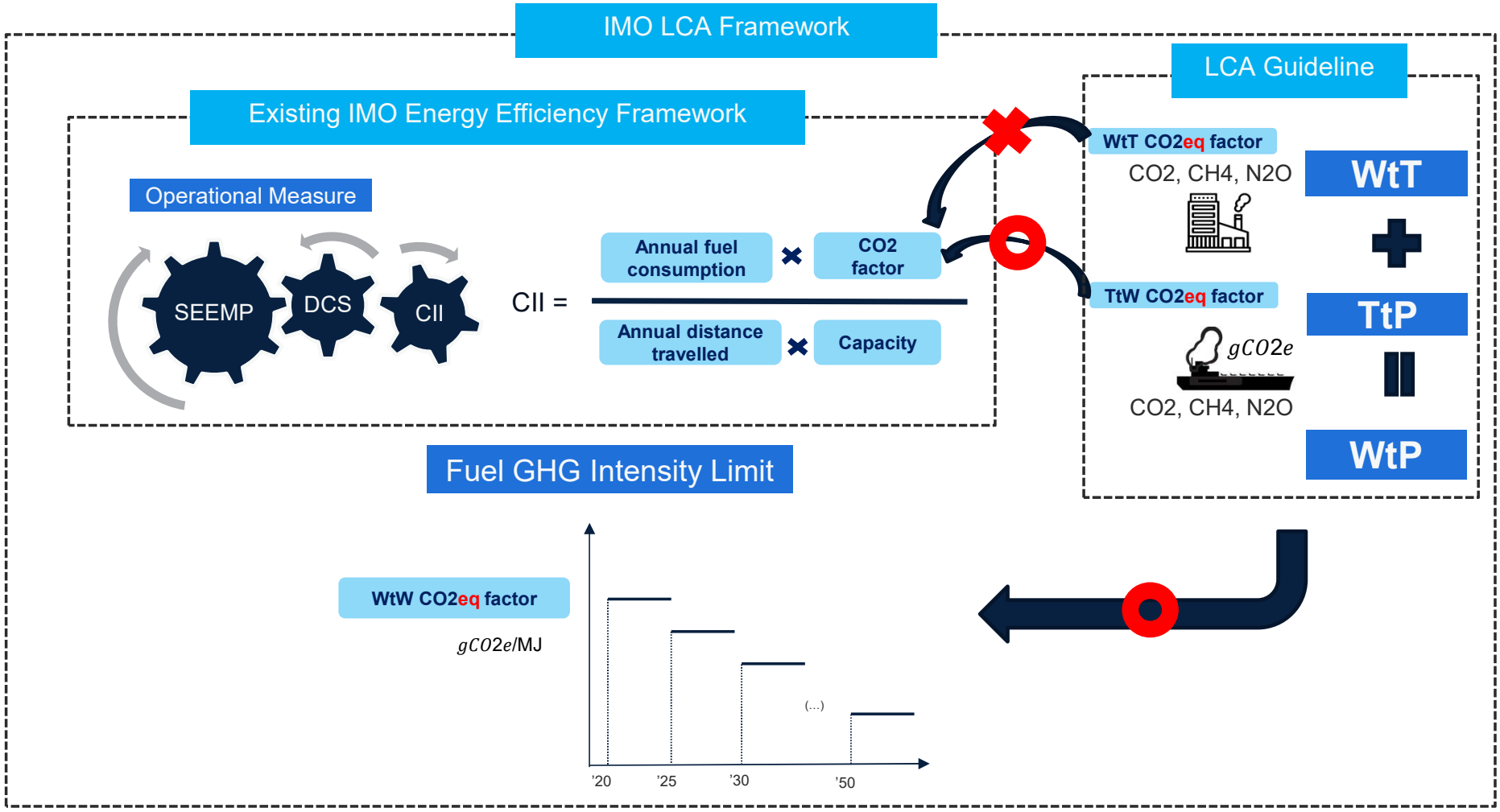


e.g. FuelEU Maritime Regulation

The life cycle GHG intensity of the energy used will be required to improve by 2% in 2025 relative to 2020, ramping up to 75% by 2050.

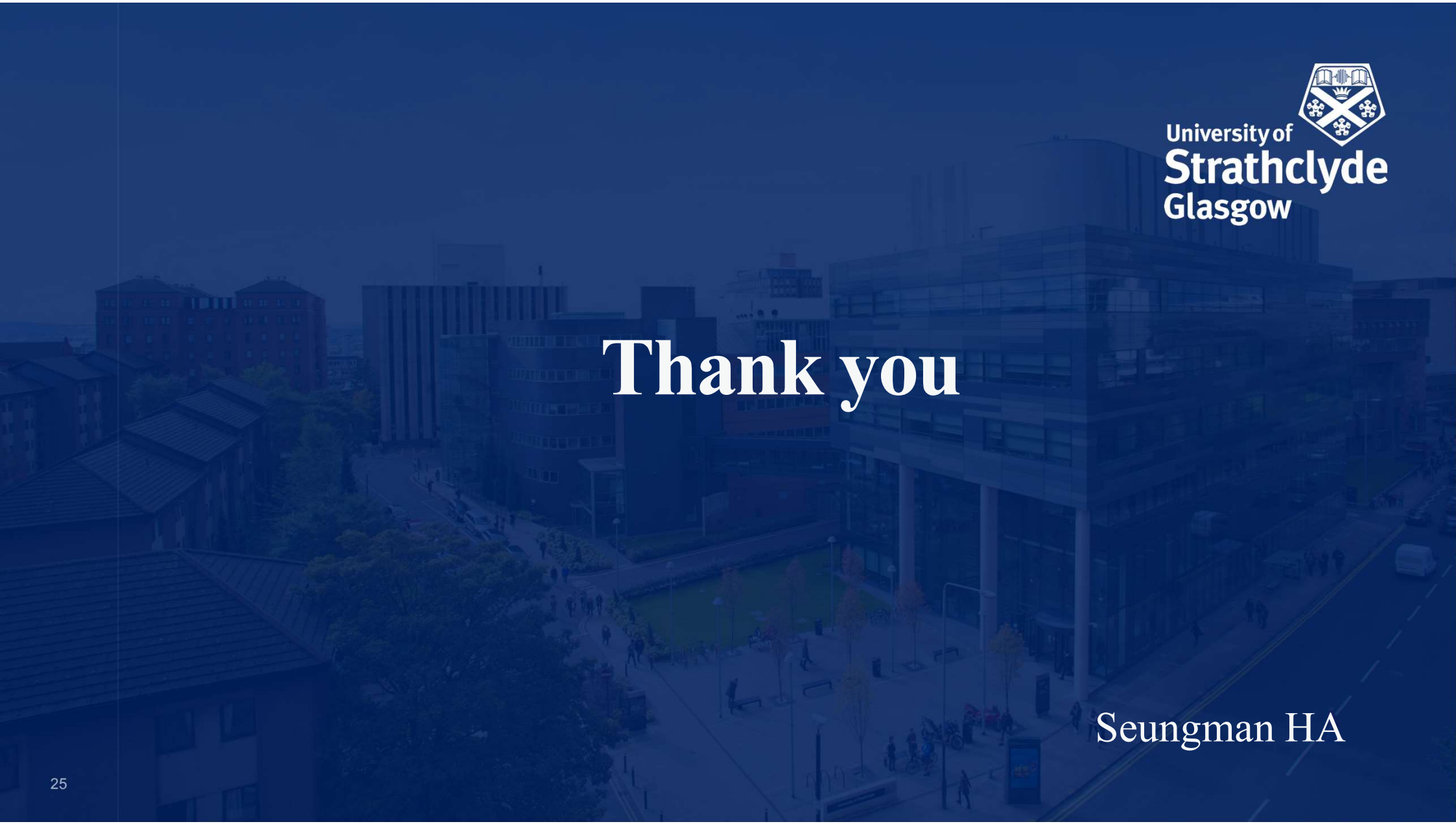
LCA guideline application scenario

- Possible option 4 : Incorporating TtW CO2eq factor into CII+ 2) Fuel GHG Intensity Limit



Summary

- The matters on carbon source factor(Sf) and Methane slip calculation are to be addressed with priority in the works of development of the LCA guidelines
- The impact assessment depending on LCA guideline application scenarios needs to be considered
- The regulatory application and implications of LCA guidelines should be defined as soon as possible in order to provide long-term certainty to industries.



Thank you

Seungman HA