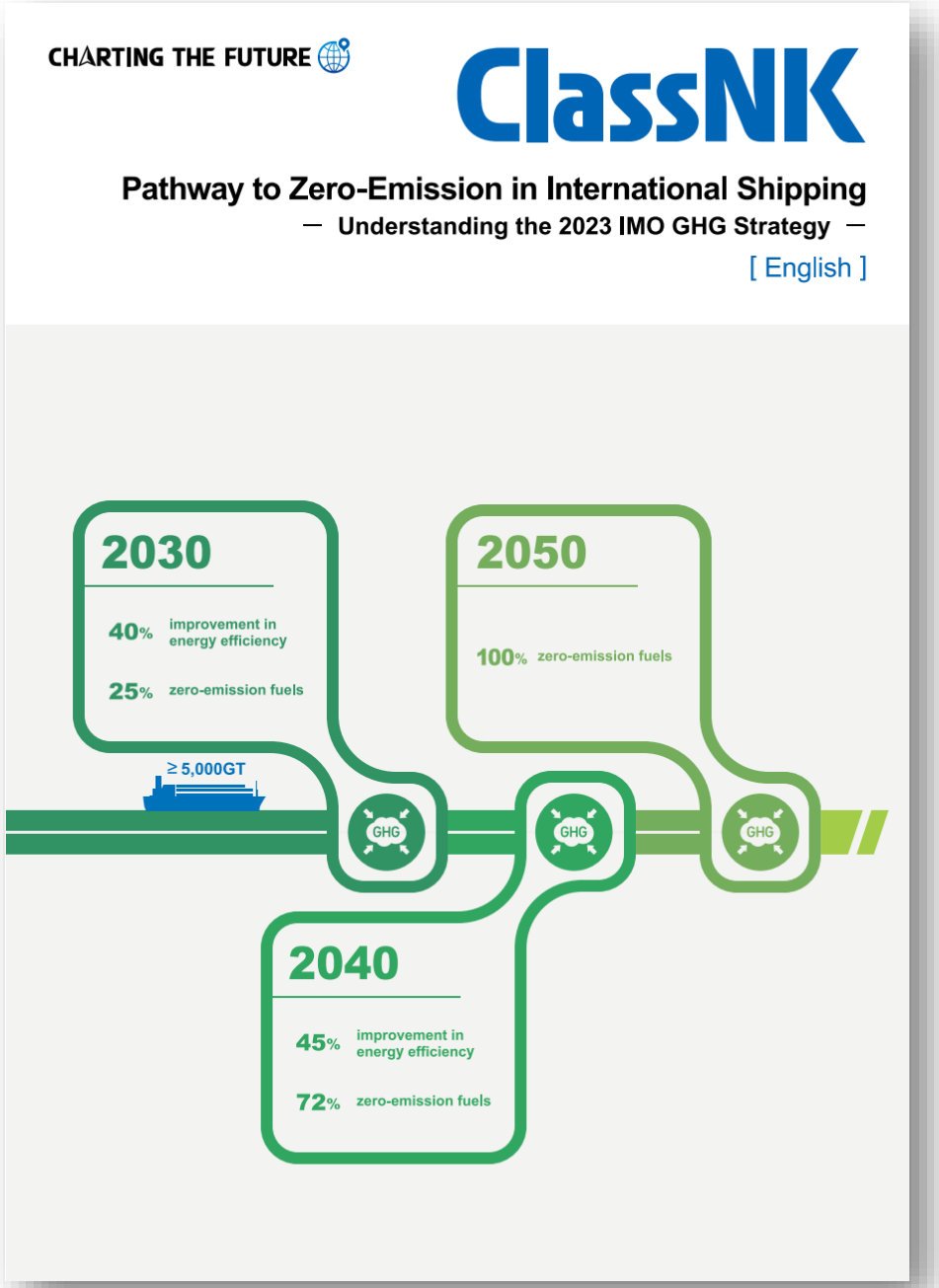


ClassNK
CHARTING THE FUTURE

Pathway to Zero-Emission in International Shipping

— Understanding the 2023 IMO GHG Strategy —

October 2023

Nippon Kaiji Kyokai (ClassNK)

In July 2023, IMO GHG Strategy revised

	Initial Strategy (2018) (Tank-to-Wake)	Revised Strategy (2023) (Well-to-Wake: Life cycle)
Vision	Phase out GHG emissions as soon as possible in this century.	Phase out GHG emissions as soon as possible.
Levels of ambition	■ Total annual GHG emissions (compared to 2008)	
	At least 50% reduction by 2050	At least 20% (striving for 30%) reduction by 2030 (Indicative checkpoint) At least 70% (striving for 80%) reduction by 2040 (Indicative checkpoint) Reach net-zero GHG emissions by or around, i.e. close to 2050
	■ Uptake of zero or near-zero GHG emissions technologies, fuels, energy sources	
		At least 5% (striving for 10%) by 2030
	■ Carbon intensity improvement (CO_2 emissions per transport work) (compared to 2008)	
	At least 40% reduction by 2030 At least 70% reduction by 2050	At least 40% reduction by 2030

Key points of the revision as follows:

- ✓ Reach **net-zero GHG emissions** by or around 2050
- ✓ Consider not only onboard emissions, but also life cycle emissions, including fuel manufacturing, transportation, and storage to onboard use
- ✓ Monitor the level of achievement of the targets in terms of **total GHG emissions**
- ✓ Adopt **a target of uptake** of zero or near-zero GHG emissions technologies, fuels, and/or energy sources

2023 IMO GHG Strategy

What is the significance of the numerical targets outlined in the 2023 IMO GHG Strategy?

	Revised Strategy (2023) (Well-to-Wake: Life cycle)
Vision	**Phase out GHG emissions** as soon as possible.
Levels of ambition	**Total annual GHG emissions (compared to 2008)** **At least 20% (striving for 30%)** reduction by 2030 (Indicative checkpoint) **At least 70% (striving for 80%)** reduction by 2040 (Indicative checkpoint) Reach **net-zero GHG emissions** by or around, i.e. close to 2050
	Uptake of zero or near-zero GHG emissions technologies, fuels, energy sources **At least 5% (striving for 10%)** by 2030
	Carbon intensity improvement (CO_2 emissions per transport work) (compared to 2008) At least **40% reduction** by 2030

Estimated[1] the followings to achieve the numerical targets for realizing net-zero GHG emissions:

- **GHG emissions**
- **Introduction amount of zero-emission fuels**
- **Introduction amount of zero-emission ships**

[1] Estimations were made for ships of 5,000 gross tonnage and above engaged in international voyages (ships subject to IMO DCS).

✓ **Visualizing** the actions required by the 2023 IMO GHG Strategy **in numerical form** and encouraging broad discussions among stakeholders to accelerate efforts towards achieving net-zero GHG emissions.

Allowable GHG emissions to achieve the indicative checkpoints for 2030/2040

→ Estimated the upper limit for the allowable lifecycle GHG emissions in international shipping to achieve the indicative checkpoints for 2030/2040

(Unit: million tons CO_{2eq})

GHG emissions	2008 (Base year)	2021 (Latest)	2030 indicative checkpoint (20% reduction from 2008)	2040 indicative checkpoint (70% reduction from 2008)
Life cycle GHG emissions (Well-to-Wake)	**731**	**798**	**585**	**219**
(Breakdown) Well-to-Tank	110	122	88	33
Tank-to-Wake	621	676	497	186

✓ GHG emissions in 2021 (Life cycle) > GHG emissions in 2008 (Life cycle)

→ **Approximately a 27%** reduction is required by 2030 compared to 2021 levels.

”2023 IMO GHG Strategy” in figures

Introduction amount of zero-emission fuels/ships to achieve the fuel introduction target for 2030

→ A minimum 5% introduction of zero or near-zero GHG emissions technologies, fuels, and/or energy sources

		2030 zero-emission fuel introduction target achieved (**5%** zero-emission fuels)	Current production scale for all sectors
Introduction amount of zero-emission **fuels**	for Methanol[1]	21 mil. ton	106 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)
	for Ammonia[1]	23 mil. ton	183 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)
Introduction amount of zero-emission **ships**	- 2026 (Orderbook)	Newbuildings 12 mil. GT	-
	2027 - 2030	Newbuildings[2] 15 mil. GT/year	
	2031 - 2040	-	-
	Total amount	72 mil. GT	-
Life cycle GHG emissions (Well-to-Wake)		731 mil. ton CO_{2eq} *585 mil. ton CO_{2eq} for 2030 indicative checkpoint	-

[1] Methanol/ammonia with zero GHG emissions throughout their entire life cycle from manufacturing, transportation, and storage to onboard use

[2] The world's current annual newbuilding deliveries are about 60 million GT per year.

✓ Only a **5%** introduction of zero-emission fuels in 2030 makes it difficult to achieve the indicative checkpoint for 2030.

"2023 IMO GHG Strategy" in figures

Introduction amount of zero-emission fuels/ships to achieve the indicative checkpoints for 2030/2040

→ A minimum of 20%/70% reduction by 2030/2040 (compared to 2008)

		2030 indicative checkpoint achieved (**25%** zero-emission fuels)	2040 indicative checkpoint achieved (**72%** zero-emission fuels)	Current production scale for all sectors
Introduction amount of zero-emission **fuels**	for Methanol[1]	106 mil. ton	311 mil. ton	106 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)
	for Ammonia[1]	114 mil. ton	333 mil. ton	183 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)
Introduction amount of zero-emission **ships**	- 2026 (Orderbook)	Newbuildings 12 mil. GT	←	-
	2027 - 2030	Newbuildings[2] & Retrofits 85 mil. GT/year	←	
	2031 - 2040	-	Newbuildings[2] & Retrofits 77 mil. GT/year	-
	Total amount	352 mil. GT	1,122 mil. GT	-

[1] Methanol/ammonia with zero GHG emissions throughout their entire life cycle from manufacturing, transportation, and storage to onboard use

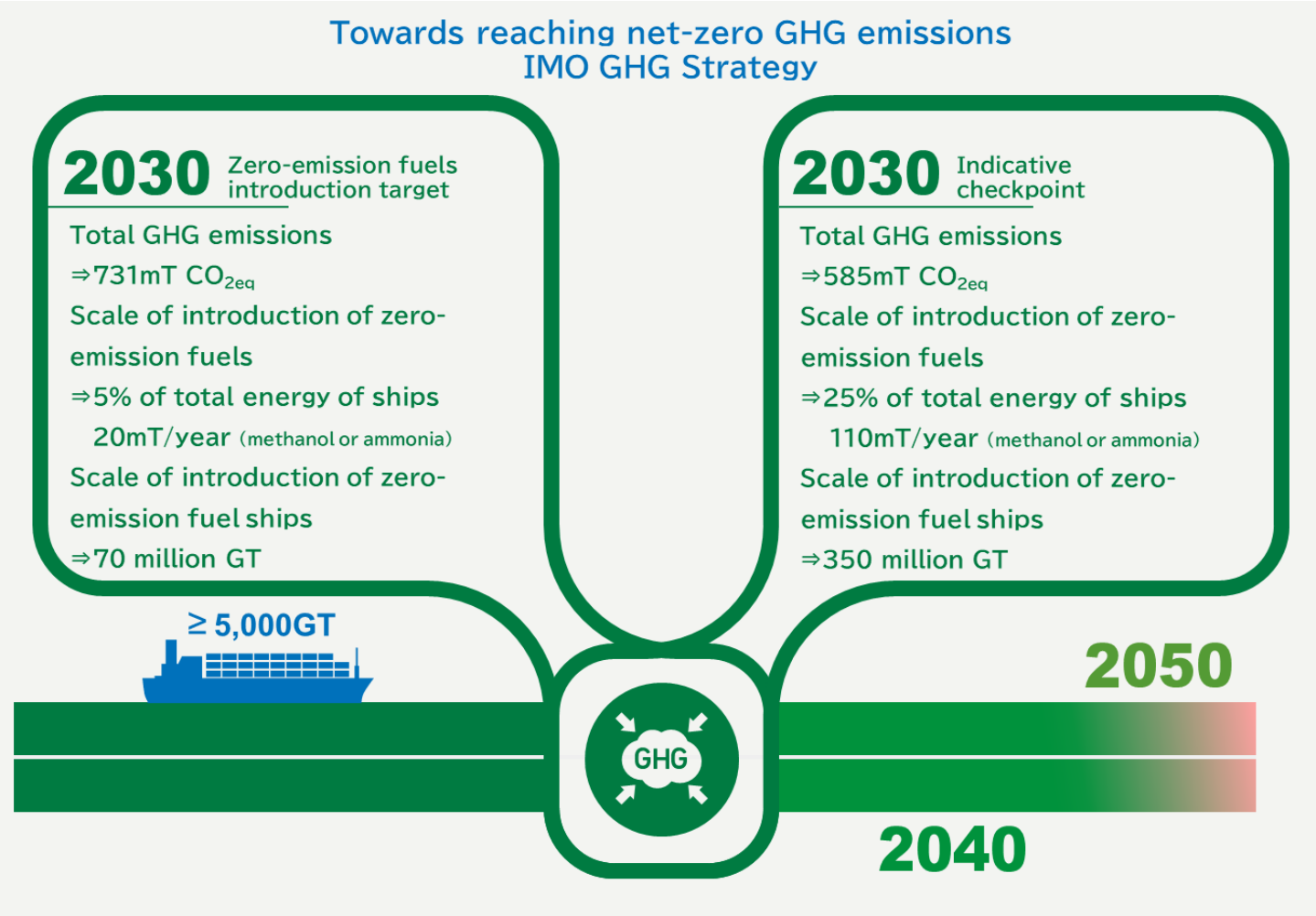
[2] The world's current annual newbuilding deliveries are about 60 million GT per year.

✓ A **25%**/**72%** introduction of zero-emission fuels at 2030/2040 is required to achieve the indicative checkpoints for 2030/2040.

Discussion: achieving the numerical targets of the 2023 IMO GHG Strategy

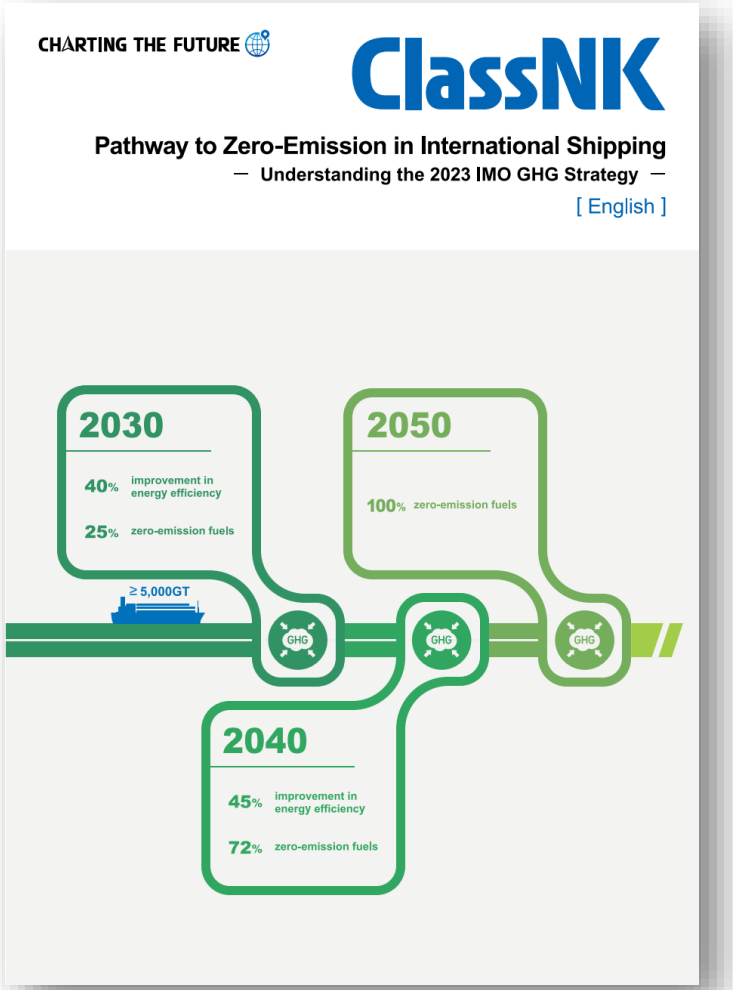
- **A substantial amount of zero-emission fuels** is required in international shipping to achieve the indicative checkpoints 2030/2040.
- Given the current scale of zero-emission fuel production, **prompt investment promotion** in the manufacturing and distribution of fuels, surpassing the pace of decarbonization in the overall energy sector, **will be necessary**. **Early adoption and implementation of a regulatory framework**, including effective carbon pricing, **is essential** to encourage these investment decisions.
- With regard to the newbuildings and retrofits of zero-emission fuel ships, there will not appear to be a significant bottleneck in supply capacity as long as a certain amount of zero-emission fuel ships are built and retrofitted each year. **It will be essential to secure newbuildings and retrofits capacity** in line with the pace of development of the zero-emission fuel production and distribution infrastructure.
- **Collective efforts** from all stakeholders, including international organizations, national governments, the maritime industry, the energy sector, shippers, and the financial sector **are needed**.

Towards the immediate target and indicative checkpoint for 2030



- To be continuously updated through dialogues with stakeholders.
- ClassNK will continue to focus on support services for zero-emission efforts.

“Pathway to Zero-Emission in International Shipping” White Paper Table of Contents



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Scenario for achieving the indicative checkpoint for 2040
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References

【Reference】Assumptions and details of the estimation

Study of scenarios to achieve the indicative checkpoints for 2030/2040

The scenarios were developed and visualized to determine how to achieve the indicative checkpoints for 2030/2040. (Estimations were made for ships of 5,000 gross tonnage and above engaged in international voyages.)

Method

1. The amount of energy consumption of ships in 2030/2040 is estimated by converting the amount of fuel consumption of ships in 2021 into the amount of energy consumption of ships and multiplying it by the rate of increase in marine transport volume and the rate of improvement in energy efficiency of ships from 2021 to 2030/2040.

   Energy consumption of ships in 2021[1] x Rate of increase in marine transport volume[2] x Rate of improvement in energy efficiency of ships[3]

   8.79 EJ[4] x +25%/+39% x -23%/-30%

   = Energy consumption of ships in 2030/2040

   8.47 EJ/8.60 EJ

   [1] Calculated based on the breakdown of fuel consumption in 2021 (fuel oil 93% and LNG 7%)
   [2] Assumed an average increase based on the Fourth IMO GHG Study 2020 scenario of increased marine transport volume
   [3] In 2030, an assumption of 23% improvement compared to 2021 is made, assuming the achievement of the carbon intensity improvement target (40% improvement compared to 2008).
   [4] Exajoules (Exa is 10 to the power of 18.)

2. Regarding the energy consumption of ships in 2030/2040, scenarios were set up to allocate between conventional fuels and zero-emission fuels, comparing the "GHG emissions in these scenarios" with the "GHG emissions required to achieve the indicative checkpoints for 2030/2040." Examples of such scenarios that align are presented.

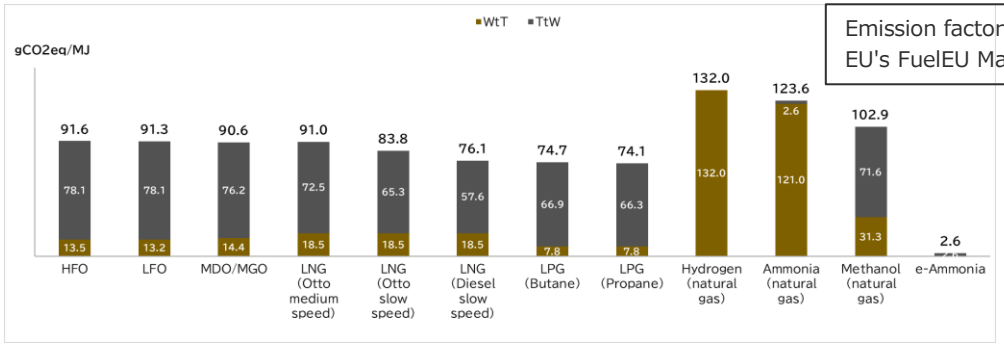
Allowable GHG emissions to achieve the indicative checkpoints for 2030/2040

(Unit: million tons CO_{2eq})

GHG emissions	2008 (Base year)	2021 (Latest)	2030 indicative checkpoint (20% reduction from 2008)	2040 indicative checkpoint (70% reduction from 2008)
Life cycle GHG emissions (Well-to-Wake)	**731**	**798**	**585**	**219**
(Breakdown) Well-to-Tank	110	122	88	33
Tank-to-Wake	621	676	497	186

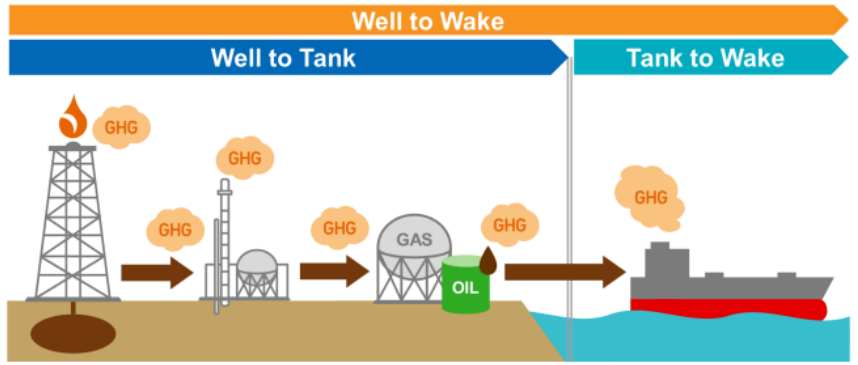
(Note) Well-to-Tank and Tank-to-Wake GHG emissions are estimated based on published fuel consumption data (IMO DCS data).

GHG emissions per unit energy value for Well-to-Tank and Tank-to-Wake for typical fuels (GHG Intensity)



Emission factors are based on the EU's FuelEU Maritime Regulation.

Image for Well-to-Tank and Tank-to-Wake



Study of an example scenario for achieving the fuel introduction target for 2030

→ Assumption: A 5% introduction of zero-emission fuels in 2030
→ Result of study: Only a 5% introduction of zero-emission fuels in 2030 makes it difficult to achieve the indicative checkpoint for 2030.

	Fuel oil	LNG	Zero-emission fuel	Total amount
Ship energy consumption	7.20 EJ (85%)	0.85 EJ (10%[1])	0.42 EJ (**5%**)	8.47 EJ (100%)
Life cycle GHG emissions (Well-to-Wake)	659 mil. ton CO_{2eq}	71 mil. ton CO_{2eq}	1 mil. ton CO_{2eq} (Methanol/Ammonia)	**731 mil. ton CO_{2eq}** *585 mil. ton CO_{2eq} for 2030 indicative checkpoint

[1] The share of LNG fuel is assumed to increase to 10% in 2030, taking into account the actual share (7%) in 2021.

Fuel type	Introduction amount of zero-emission fuels (**5%** zero-emission fuel)	Current production scale for all sectors
for Methanol	21 mil. ton	106 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)
for Ammonia	23 mil. ton	183 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)

	2021	- 2026	2027 - 2030 introduction amount of zero-emission ships	2030
Zero-emission ships	Existing ships 0.75 mil. GT	Newbuildings 12 mil. GT	Newbuildings **60 mil. GT (15 mil. GT/year)**	72 mil. GT
Entire fleet	1,250 mil. GT	1,330 mil. GT	-	1,430 mil. GT

Study of an example scenario for achieving the indicative checkpoint for 2030

→ Assumption: Zero-emission fuels are introduced to achieve the indicative checkpoint for 2030 (a minimum of 20% reduction).
→ Result of study: Achieving the indicative checkpoint for 2030 is made possible by introducing 25% (approximately 110 million tons per year) of zero-emission fuels. Considering current production levels, significant investments are required to expand the production and distribution of zero-emission fuels.

	Fuel oil	LNG	Zero-emission fuel	Total amount
Ship energy consumption	5.50 EJ (65%)	0.85 EJ (10%)	2.12 EJ (**25%**)	8.47 EJ (100%)
Life cycle GHG emissions (Well-to-Wake)	504 mil. ton CO_{2eq}	71 mil. ton CO_{2eq}	5 mil. ton CO_{2eq} (Methanol/Ammonia)	580 mil. ton CO_{2eq} *585 mil. ton CO_{2eq} for 2030 indicative checkpoint

Fuel type	Introduction amount of zero-emission fuels (**25%** zero-emission fuel)	Current production scale for all sectors
for Methanol	106 mil. ton	106 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)
for Ammonia	114 mil. ton	183 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)

	2021	- 2026	2027 - 2030 introduction amount of zero-emission ships	2030
Zero-emission ships	Existing ships 0.75 mil. GT	Newbuildings 12 mil. GT	Newbuildings & Retrofits **340 mil. GT (85 mil. GT/year)**	352 mil. GT
Entire fleet	1,250 mil. GT	1,330 mil. GT	-	1,430 mil. GT

Study of an example scenario for achieving the indicative checkpoint for 2030 (Reference: For biodiesel[1])

[1] Currently, biodiesel (mainly FAME) is recognized as low-emission fuels (its GHG intensity is assumed to be 15 gCO_{2eq}/MJ, equivalent to waste cooking oil-derived), which is an 84% reduction compared to fuel oil, and calculations for biodiesel have been conducted for reference. It should be noted that the majority of currently produced biodiesel is consumed on land-based sectors.

→ Assumption: Biodiesel is introduced to achieve the indicative checkpoint for 2030 (a minimum of 20% reduction).

→ Result of study: Achieving the indicative checkpoint for 2030 is made possible by introducing 29% (66 million tons per year) of biodiesel. Considering current production levels (42 million tons per year, mainly for land-based sectors), further expansion of the current production and distribution is required.

	Fuel oil	LNG	Biodiesel	Total amount
Ship energy consumption	5.16 EJ (61%)	0.85 EJ (10%)	2.46 EJ (**29%**)	8.47 EJ (100%)
Life cycle GHG emissions (Well-to-Wake)	473 mil. ton CO_{2eq}	71 mil. ton CO_{2eq}	37 mil. ton CO_{2eq}	581 mil. ton CO_{2eq} *585 mil. ton CO_{2eq} for 2030 indicative checkpoint

Fuel type	Introduction amount of biodiesel (**29%** biodiesel)	Current production scale for all sectors
for Biodiesel	66 mil. ton	42 mil. ton/year

Study of an example scenario for achieving the indicative checkpoint for 2040

→ Assumption: Zero-emission fuels are introduced to achieve the indicative checkpoint for 2040 (a minimum of 70% reduction).
→ Result of study: Achieving the indicative checkpoint for 2040 is made possible by introducing 72% (approximately 320 million tons per year) of zero-emission fuels. 77 million GT of zero-emission ships per year will be required over the 10-year period of 2031 - 2040.

	Fuel oil	LNG	Zero-emission fuel	Total amount
Ship energy consumption	1.55 EJ (18%)	0.86 EJ (10%)	6.19 EJ (**72%**)	8.60 EJ (100%)
Life cycle GHG emissions (Well-to-Wake)	142 mil. ton CO_{2eq}	72 mil. ton CO_{2eq}	0 mil. ton CO_{2eq} (Methanol/Ammonia)	214 mil. ton CO_{2eq} *219 mil. ton CO_{2eq} for 2040 indicative checkpoint

Fuel type	Introduction amount of zero-emission fuels (**72%** zero-emission fuel)	Current production scale for all sectors
for Methanol	311 mil. ton	106 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)
for Ammonia	333 mil. ton	183 mil. ton/year (of which zero-emission fuels account for less than 1% of the total)

	2030	2031 - 2040 introduction amount of zero-emission ships	2040
Zero-emission ships	352 mil. GT	Newbuildings & Retrofits **770 mil. GT (77 mil. GT/year)**	1,122 mil. GT
Entire fleet	1,430 mil. GT	-	1,550 mil. GT

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