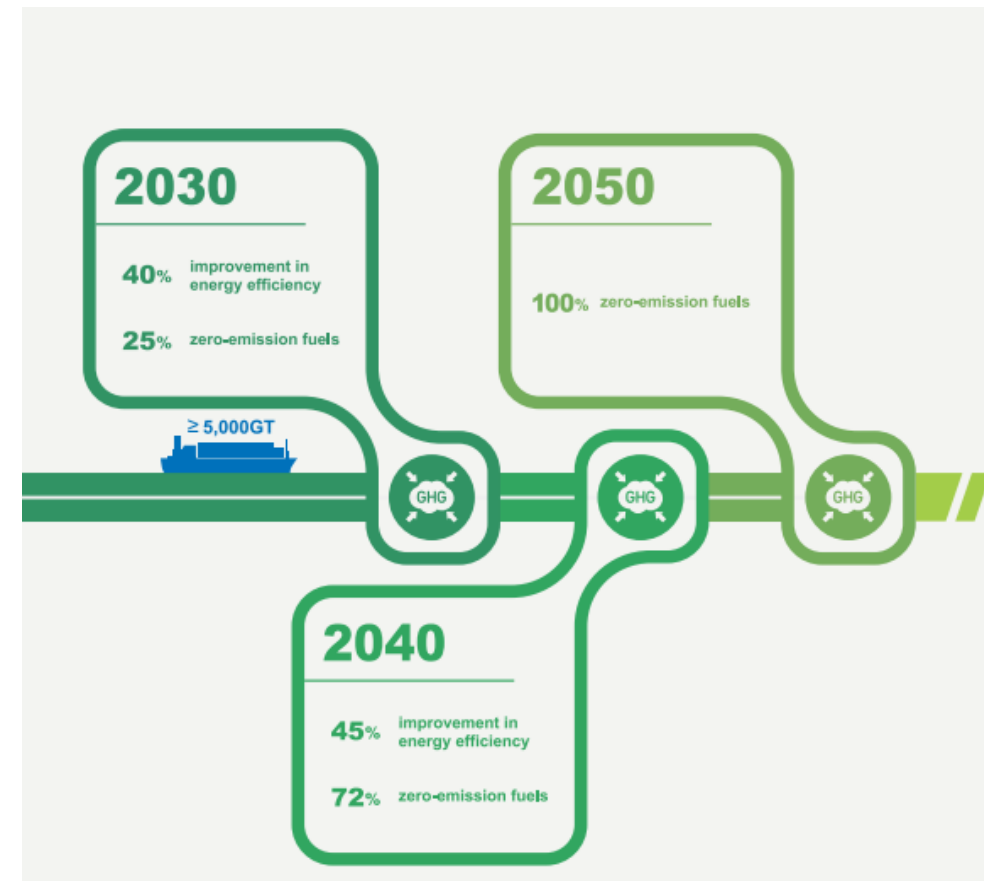


LNG as a Marine Fuel - Present and Perspective

March 2025 ClassNK

Background

- For reducing GHG emissions from ships, alongside energy efficiency improvements, **the adoption of alternative fuels with lower environmental impacts will become essential** in the future.
- However, given the wide range of alternative fuels available for ships, it is **necessary to understand** not only the technical aspects but also **the trends, including fuel availability and cost forecasts**, to make appropriate fuel selections.



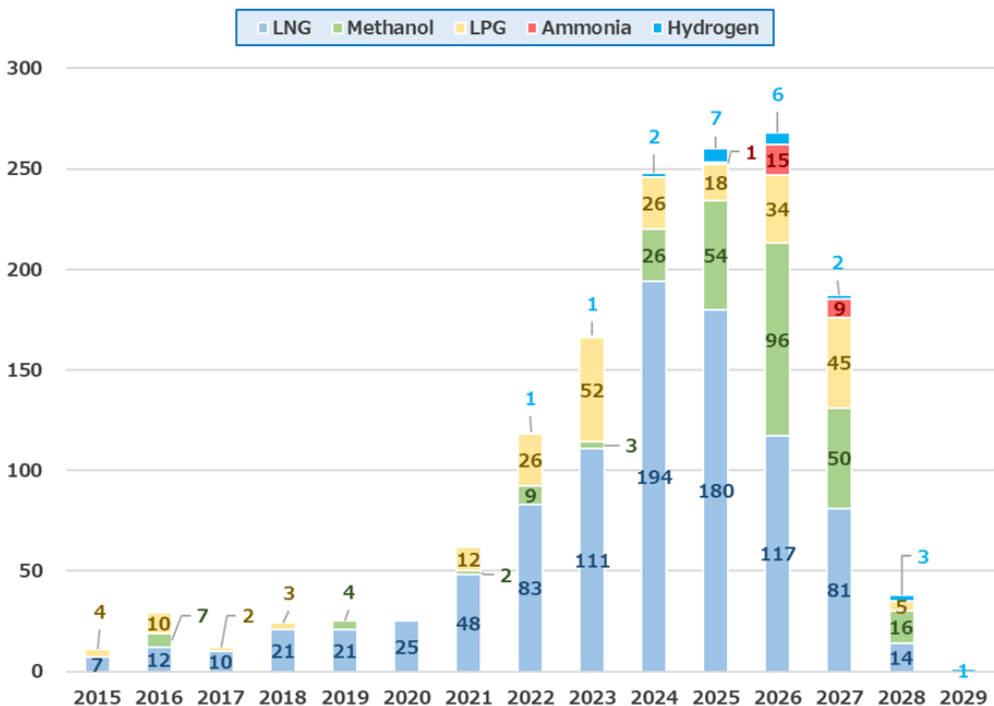
List of fuel properties (Overview)

Fuel type	HFO	LNG (Methane)	LPG		Methanol	Ammonia	Hydrogen
			Propane	Butane			
TtW CO ₂ emission [HFO = 1]	1	0.73	0.85	0.86	0.90	0	0
TtW GHG emission [HFO = 1]	1	0.82	0.85	0.86	0.92	0.04	0.01
Required to obtain the same amount of energy Fuel ton [HFO = 1]	1	0.84	0.87	0.88	2.02	2.16	0.34
In liquid form Fuel tank capacity [HFO = 1]	1	1.89	1.69	1.41	2.47	3.07	4.63
Flammability (Lower Explosive Limit)	0.7 vol%	5.0 vol%	2.1 vol%	1.8 vol%	6.0 vol%	15.0 vol%	4.0 vol%
Toxicity (TLV-TWA*)	-	-	-		200 ppm	25 ppm	-
Cryogenic (Boiling point)	- (Liquid at normal temp.)	-161°C	-42°C	-0.5°C	- (Liquid at normal temp.)	-33°C	-253°C

Trends in alternative fuel ships - 1

Source: The figures and tables presented in this section are created by ClassNK based on data from Clarkson Research Services Limited.

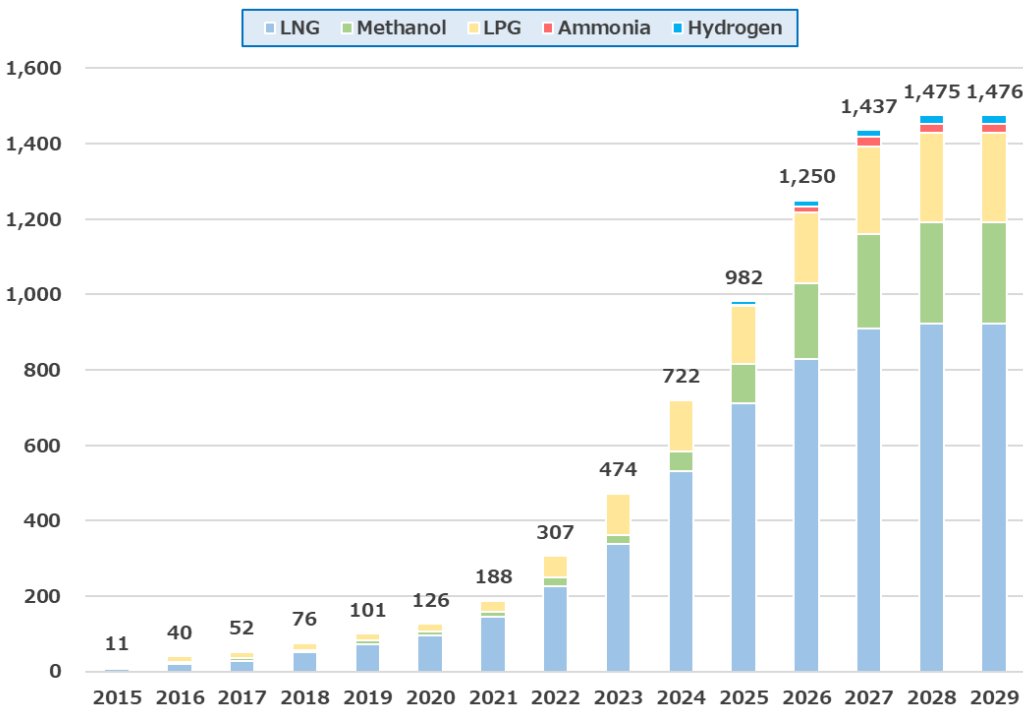
"Newbuilding" alternative fuel ship trend



- ✓ As of the end of June 2024 (Orderbook is included after 2024.)
- ✓ 5,000 gross tonnage and above
- ✓ LNG carriers are excluded from LNG fueled ships.
- ✓ Alternative fuel ready ships are not included.

"In service" alternative fuel ship trend*

*Cumulative number of ships delivered since 2015, without considering scrapping

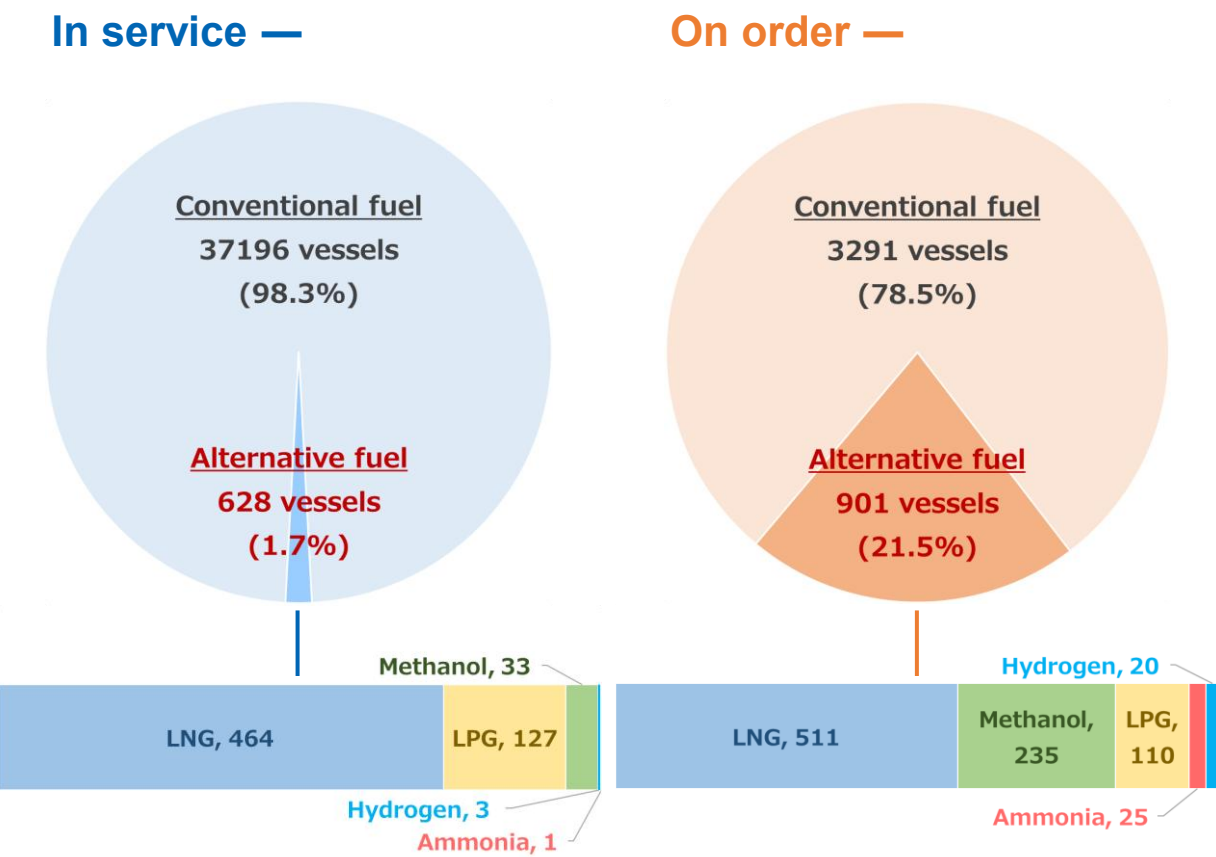


- ✓ As of the end of June 2024 (Orderbook is included after 2024.)
- ✓ 5,000 gross tonnage and above
- ✓ LNG carriers are excluded from LNG fueled ships.
- ✓ Alternative fuel ready ships are not included.

➤ While there is a noticeable increase in orders for methanol fueled ships, LNG fueled ships **still dominate the orderbook** for alternative fuel ships.

Trends in alternative fuel ships - 2

Share of alternative fuel ships



- ✓ As of the end of June 2024
- ✓ 5,000 gross tonnage and above
- ✓ LNG carriers are excluded from LNG fueled ships.
- ✓ Alternative fuel ready ships are not included.

Details of alternative fuel ships (Dec. 2023 → Jun. 2024)

In service —

	As of Dec. 31, 2023	As of Jun. 30, 2024
Number of vessels	522 vessels (1.4%)	628 vessels (1.7%)
Total GT	33,560,005 GT (2.2%)	42,327,700 GT (2.7%)

During the past six months, there has been an increase of 106 vessels totaling 8.8 million GT. This growth can be attributed to the successive deliveries of LNG fueled containerships, bulk carriers, vehicle carriers, and product/chemical tankers, etc. A certain number of LPG fueled ships (LPG carriers only) have also been delivered.

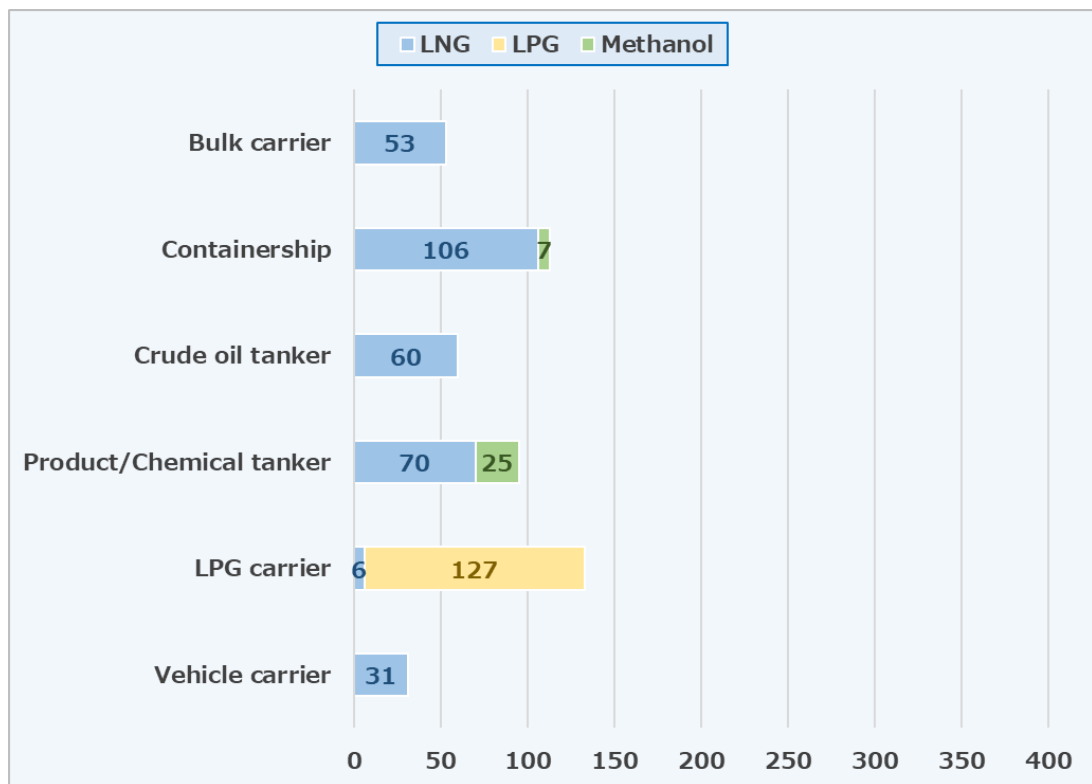
On order —

	As of Dec. 31, 2023	As of Jun. 30, 2024
Number of vessels	835 vessels (21.8%)	901 vessels (21.5%)
Total GT	66,431,935 GT (30.9%)	69,624,584 GT (30.4%)

During the past six months, there has been an increase of 66 vessels totaling 3.2 million GT. In terms of fuels, LNG, methanol and LPG (LPG carriers only) shared most of the new orders, with the main fuel still uncertain. A certain number of vessels were also ordered for ammonia fueled ships, despite the ongoing development of engines.

Trends in alternative fuel ships - 3 (by ship type)

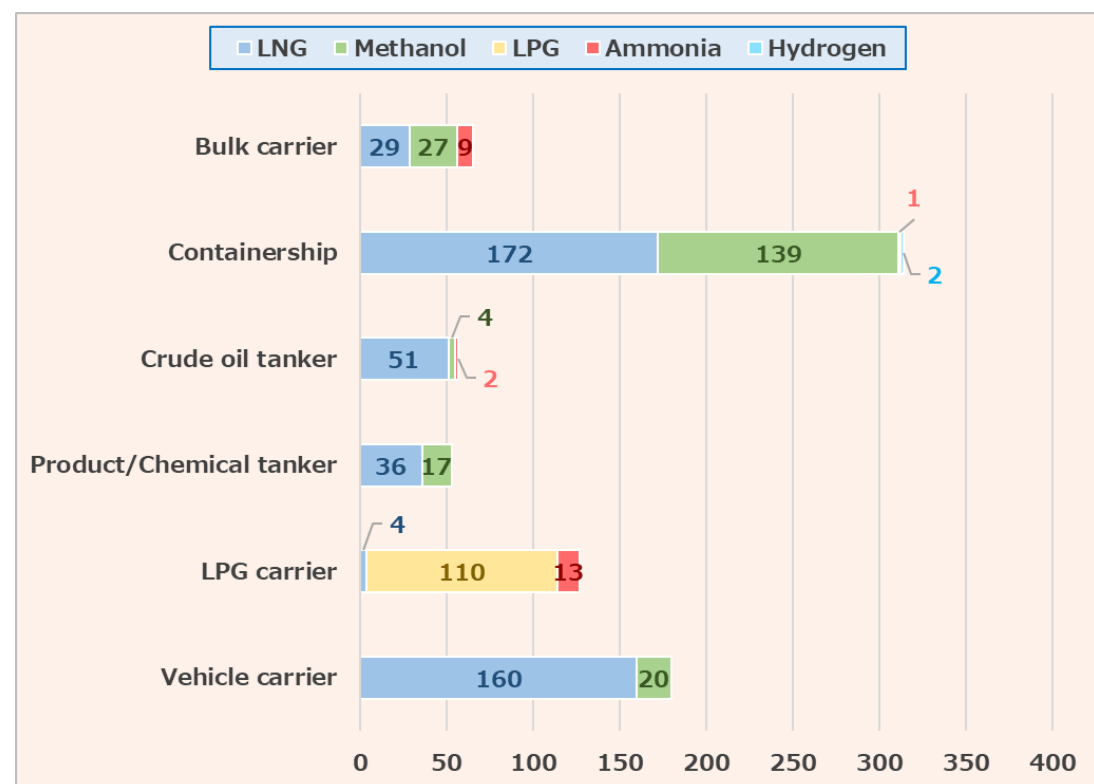
In service —



✓ As of the end of June 2024 / 5,000 gross tonnage and above / Alternative fuel ready ships not included.

- LNG fueled ships make up the majority of ships of all types, with the exception of product/chemical tankers, which include methanol carriers, and LPG carriers.

On order —



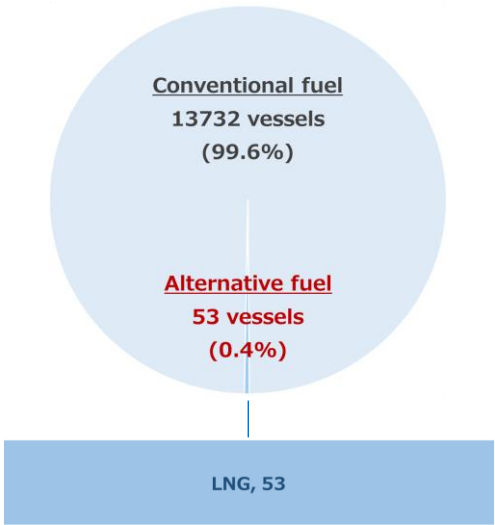
✓ As of the end of June 2024 / 5,000 gross tonnage and above / Alternative fuel ready ships not included.

- LNG fueled ships, mainly container ships and Vehicle carrier, will be ordered in the future.

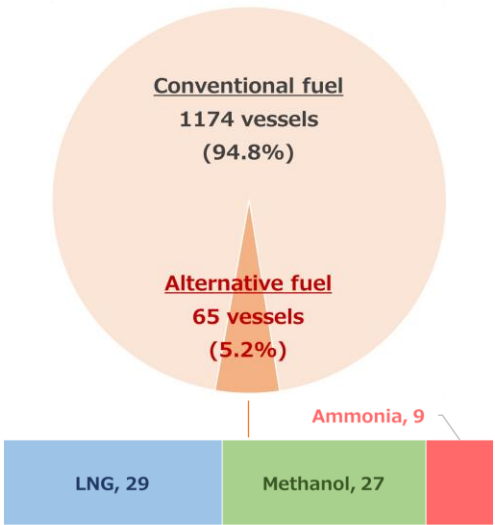
Trends in alternative fuel ships - 3 (by ship type)

Bulk carriers

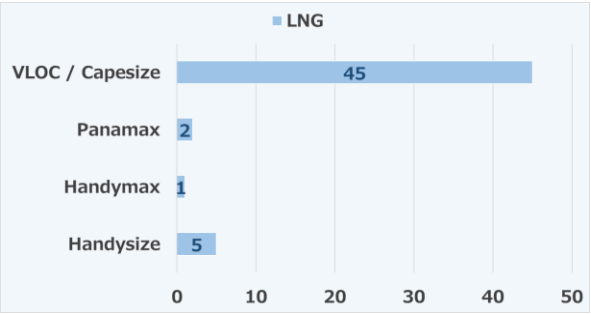
In service —



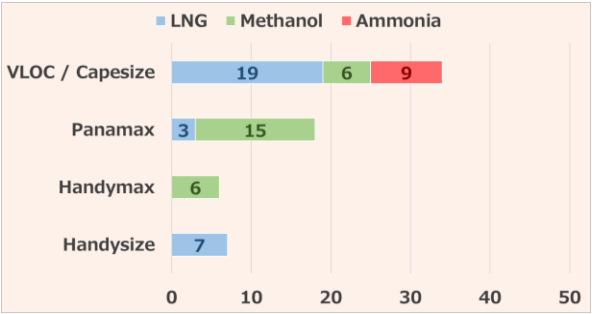
On order —



In service —



On order —



Details of alternative fuel ships (Dec. 2023 → Jun. 2024)

In service —

	As of Dec. 31, 2023	As of Jun. 30, 2024
Number of vessels	39 vessels (0.3%)	53 vessels (0.4%)
Total GT	3,622,799 GT (0.7%)	5,072,048 GT (0.9%)

During the past six months, there was an increase of 14 vessels totaling 1.4 million GT. By ship size, the majority of ships delivered are VLOC/Capesize and bulk carriers have a marked tendency to use alternative fuels, especially in the larger sizes. All delivered ships were LNG fueled ships.

On order —

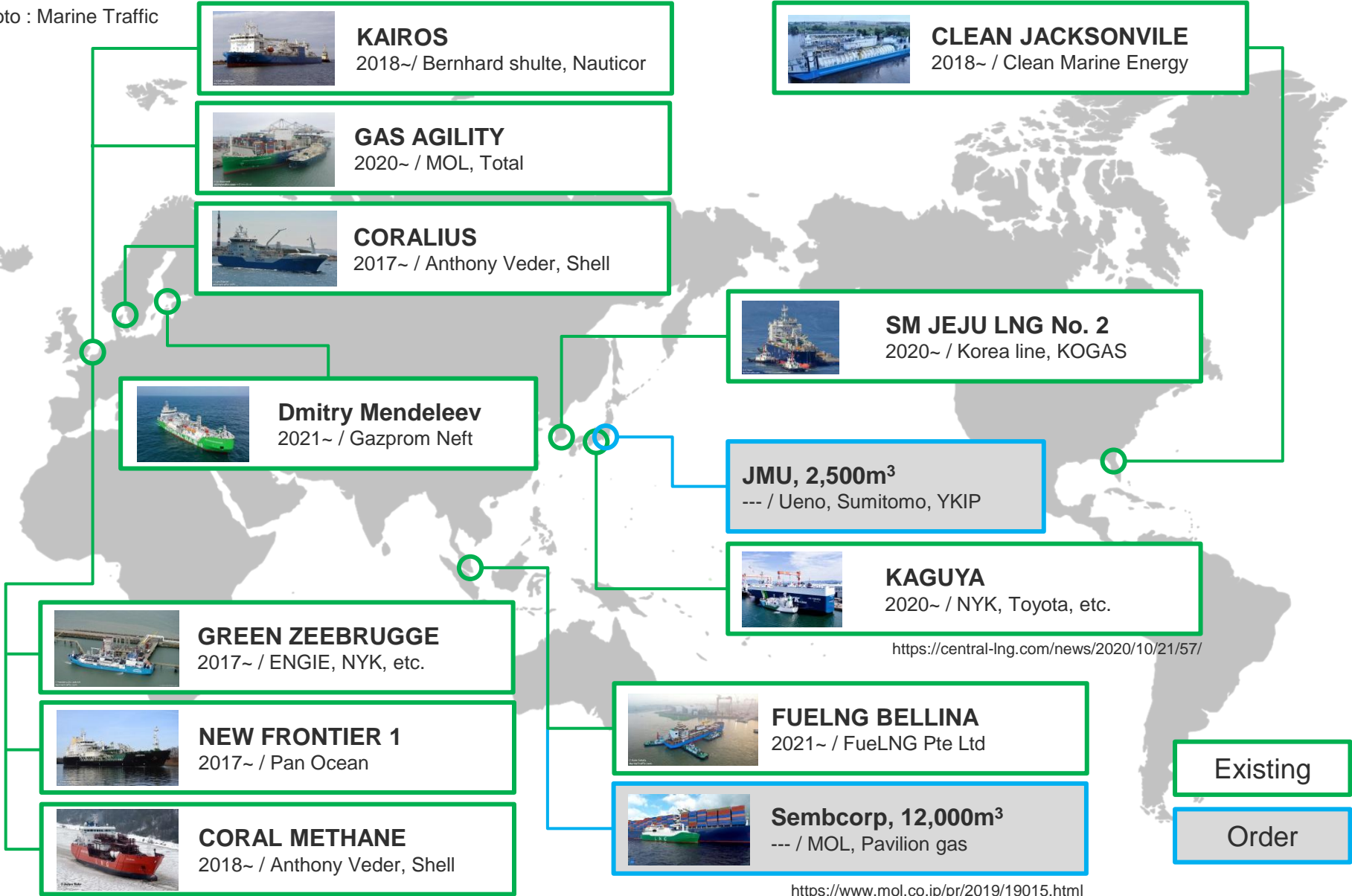
	As of Dec. 31, 2023	As of Jun. 30, 2024
Number of vessels	63 vessels (5.5%)	65 vessels (5.2%)
Total GT	4,926,559 GT (10.3%)	5,070,849 GT (9.6%)

During the past six months, there was an increase of 2 vessels totaling 0.1 million GT. While ammonia and methanol fueled ships have been ordered in VLOC/Capesize, no LNG fueled ships have been ordered.

Maker	Engine Information	Type Approval by ClassNK
MAN (Mitsui, Makita, Hitachi, Kawasaki) (2st, Direct injection(GI, LGI) / Port injection (GA))	ME-GI (Bore 350 - 950 mm) ME-GA (Bore 700 mm)	Completed
WinGD (DU) (2st, Port injection)	X-DF (Bore 520 - 920 mm) RT-flex DF (Bore 500 mm)	Completed
Daihatsu (4st, Port injection)	DE DF (Bore 205 - 350 mm)	Completed (6DE20DF, 6DE23DF, 6DE28DF)
Yanmar (4st, Port injection)	EY DF (Bore 220 - 260 mm)	Completed (6EY22ALDF, 6EY26DF)
IHI (4st, Port injection)	28AHX-DF (Bore 280 mm)	Completed
Kawasaki (4st, Port injection & Spark Ignition)	L30KG (Bore 300 mm)	Completed

※Only Japanese manufacturers are listed.

Photo : Marine Traffic



LNG fueled ships

- ✓ Many ships in service and increasing the number of building.
 - more than 460 vessels in service, abt. 500 vessels on order (excl.LNG Carrier)
- ✓ Operating widely - Container, Tanker, Bulk Carrier, PCC, etc.
- ✓ ClassNK issued approval in principle;
 - 12,500m³ LNG Dual-fueled VLCC fitted with Mark III Flex system / GTT
 - Recycool™ system applied to LNG fueled vessels allowing the reliquefaction of LNG evaporation



LNG fueled BC
"CAPE HAYATE" CNo. 241401



LNG fueled PCC "SAKURA LEADER" CNo. 203324

© NYK



LNG fueled Container vessel
"MSC WASHINGTON" CNo. 220727

- For reducing GHG emissions from ships, alongside energy efficiency improvements, the adoption of alternative fuels with lower environmental impacts such as LNG will become essential in the future.
- LNG fueled ships still dominate the orderbook for alternative fuel ships.
- At present, LNG - fueled ships occupy most of the alternative fuel ships, but the proportion of alternative fuels other than LNG is expected to increase in the future.
- LNG bunkering vessels operate all over the world, and there is a global demand for LNG fuel carriers.

A person wearing a white lab coat is pointing their right index finger at a large architectural drawing spread out on a wooden table. The drawing features various lines, including a prominent orange one. The scene is brightly lit, and the background is slightly blurred.

THANK you

for your kind attention