Introduction

Gas Trade Review is a publication in which the shipping and contractual issues relevant to the global LNG trade and the European pipeline trade with natural gas are analyzed.

In this edition, you can read about the following topics:

- The Ever-Increasing Transport Capacity Of Conventional LNG Carriers

- The Features Of The Modern Japanese LNG Carriers

- Assignment Of CII Rating To LNG Carriers

If you have any comments about the matters reviewed in this edition, please address them to **editor@commoditylaw.eu**

The Ever-Increasing Transport Capacity Of Conventional LNG Carriers

by Vlad Cioarec, International Trade Consultant

Until the year 2000, the LNG Carriers with the carrying capacity between 120,000 and 138,300 cbm were considered to be within the conventional size range. By the year 2010, the LNG transport capacity of LNG carriers labelled as “conventional LNG carriers” increased up to 177,000 cbm.

The LNG carrier “Spirit of Hela”, built by Hyundai Heavy Industries in 2009, with an LNG transport capacity of 177,000 cbm, was the largest conventional LNG carrier at the time.

By the year 2020, the LNG transport capacity of LNG carriers labelled as “conventional LNG carriers” exceeded 180,000 cbm. The LNG carrier “Pacific Breeze”, built by Kawasaki Heavy Industries in 2018, with an LNG transport capacity of 182,683 cbm, was the largest conventional LNG carrier until the year 2022. It is still the largest LNG carrier with Moss-type tanks (Spherical IMO Type-B Tanks).

After the year 2021, the transport capacity of LNG carriers labelled as “conventional” reached the threshold of 200,000 cbm. There are currently six LNG carriers with the transport capacity of 200,000 cbm in operation:

- LNG Carrier “Clean Cajun” built by Hyundai Heavy Industries for Dynagas Ltd. It was delivered in May 2022.
- LNG Carrier “Clean Copano” built by Hyundai Heavy Industries for Dynagas Ltd. It was delivered in July 2022.
- LNG Carrier “Clean Resolution” built by Hyundai Heavy Industries for Dynagas Ltd. It was delivered in September 2023.
- LNG Carrier “Clean Destiny” built by Hyundai Heavy Industries for Dynagas Ltd. It was delivered in November 2023.
- LNG Carrier “Clean Vitality” built by Hyundai Heavy Industries for Dynagas Ltd. It was delivered in February 2024.
- LNG Carrier “Clean Future” built by Hyundai Heavy Industries for Dynagas Ltd. It was delivered in April 2024.

In 2025, Hyundai Heavy Industries is expected to deliver to Dynagas Ltd. another three 200,000 cbm LNG carriers:

- LNG Carrier “Clean Mistral” (Hull No. 3356) in March 2025;
- LNG Carrier “Clean Levant” (Hull No. 3357) in April 2025;
- LNG Carrier “Clean Srocco” (Hull No. 3358) in December 2025.

In 2026, Hyundai Heavy Industries is expected to deliver to Dynagas Ltd. another three 200,000 cbm LNG carriers:

- LNG Carrier “Clean Texas” (Hull No. 3433) in April 2026;
- LNG Carrier “Clean Rio Grande” (Hull No. 3434) in July 2026;
- LNG Carrier “Clean Brownsville” (Hull No. 3435) in November 2026.

In 2027, Hyundai Heavy Industries is expected to deliver to Dynagas Ltd. another two 200,000 cbm LNG carriers:

- Hull No. 3452 in May 2027;
- Hull No. 3453 in November 2027.

The cargo tanks of these LNG carriers were designed by Gaztransport & Technigaz (GTT) with GTT Mark III Flex+ membrane containment and insulation system which keeps the LNG boil-off rate at 0.07% per day.
Dynagas Ltd. is not the only company which ordered 200,000 cbm LNG carriers. The US LNG supplier, Venture Global LNG ordered six 200,000 cbm LNG carriers to Hanwha Ocean, formerly known as Daewoo Shipbuilding & Marine Engineering, with three to be delivered in 2025 – Hull No. 2541 in July 2025, Hull No. 2542 in October 2025 and Hull No. 2543 in December 2025 – and three to be delivered in 2026.
The cargo tanks of these LNG carriers were designed by Gaztransport & Technigaz (GTT) with GTT NO96–L–03+ membrane containment and insulation system which keeps the LNG boil-off rate at 0.10% per day.
By the end of 2027, there will be twenty conventional LNG carriers with the transport capacity of 200,000 cbm. Their common feature is the M-type electronically controlled, gas admission (ME-GA) engine which has been designed by MAN B&W for large LNG carriers with high power consumption. It can be used with the shaft generator systems with a large power output to supply the necessary electricity to the ship.
ME-GA engine is a two-stroke dual-fuel LNG engine that runs on the Otto thermodynamic cycle.
It can operate in gas mode and diesel mode. In gas mode, it can operate with a wide range of boil-off gas qualities and with different quantities of fuel gas.
ME-GA engine has a low-pressure fuel gas supply system (FGSS) with low maintenance costs.
When operating in gas mode, ME-GA engine generates only a negligible methane slip because it is equipped with the Exhaust Gas Recirculation ByPass (EGRBP) technology which reduces significantly the methane slip[1].
ME-GA engine generates low NOx (nitrogen oxides) emissions. The Exhaust Gas Recirculation ByPass enables the ME-GA engine to comply with the NOx Tier III emission limits in the Emission Control Areas not only when operating in gas mode but also when operating in fuel oil mode.

1 The methane slip is the unburned methane that escapes into the atmosphere when an engine burns natural gas.

The Features Of The Modern Japanese LNG Carriers

by Vlad Cioarec, International Trade Consultant

Prior to the Fukushima nuclear accident in March 2011, the nuclear power reactors generated almost 30% from the electricity production. After the Fukushima nuclear accident, the nuclear reactors were shut down for inspection and upgrades. As a result, the demand for natural gas in the power generation in Japan increased considerably.
To fill the gap left by the closure of nuclear plants, Japan's top utility companies invested in LNG projects in Australia, US and elsewhere and concluded long-term LNG purchase agreements on FOB terms with the suppliers. To transport the LNG to Japan, the Japan's top utility companies ordered a new generation of LNG carriers to the Japanese shipbuilders – Mitsubishi Heavy Industries, Kawasaki Heavy Industries and Japan Marine United Corporation.
In the meantime, a part of the nuclear power plants' reactors have received the permission to reopen and restart the production of nuclear energy. Japan's government plans to increase the share of the nuclear power in the electricity generation to 20% by 2030, not only by restarting the existing nuclear reactors but also by building new reactors. This will gradually reduce the demand for natural gas in the power generation and a part of the LNG cargoes purchased by the Japan's utility companies under long-term agreements will be re-sold on a spot or short-term basis in other countries. The diverted cargoes will be transported to destination by the modern Japanese LNG carriers built by Mitsubishi Heavy Industries, Kawasaki Heavy Industries and Japan Marine United Corporation.

The Features Of Sayaendo LNG Carriers

Sayaendo class refers to a type of LNG carrier with a transport capacity of 155,000 cbm designed and built by Mitsubishi Heavy Industries (MHI) between 2011 and 2018 for the transport of LNG from the Australian LNG terminals to Japan.
Sayaendo LNG carriers have four spherical Moss-type tanks (Spherical IMO Type B Tanks) protected by a peapod-shaped continuous steel cover that is integrated with the hull.
Another feature of Sayaendo LNG carriers is the steel hull structure which is about 5% lighter in weight than that of the LNG carriers built before 2010.
Sayaendo LNG carriers are powered by MHI's Ultra Steam Turbine plant which utilizes the steam reheat technology. The Ultra Steam Turbine plant consists of a high pressure turbine, an intermediate pressure turbine, a low pressure turbine and a reheat boiler. It utilizes a reheat cycle whereby the exhaust steam from the high pressure turbine is returned to and re-heated in the boiler and then sent to the intermediate pressure turbine.
The steam reheat technology improves the thermal efficiency of the steam turbine propulsion system with approximately 15% compared to the conventional steam turbine plants.
The continuous steel cover over the cargo tanks that reduces the wind pressure from the front, the lighter hull structure and the steam reheat technology contribute to a 20% reduction in the fuel consumption and to a proportional CO_2 emission reduction compared to the conventional steam turbine LNG carriers built before 2010.
The use of additional energy saving devices improves the propulsion performance and reduces CO_2 emission per unit load (in actual operation) by up to approximately 25% in comparison with the conventional steam turbine LNG carriers with a 147,000 cbm transport capacity previously built by Mitsubishi Heavy Industries.

The cargo tanks' insulation panels supplied by Ti Group, a subsidiary company of Wilhelmsen Technical Solutions, enable Sayaendo LNG carriers to have an LNG boil-off rate of just 0.08%.
There are eight Sayaendo LNG carriers in service:
- "LNG Venus" delivered in 2014. It is co-owned by Mitsui O.S.K. Lines and Osaka Gas International Transport.
- "Esshu Maru" delivered in 2014. It is co-owned by Mitsui O.S.K. Lines and Osaka Gas International Transport.
- "Seishu Maru" delivered in 2014. It is co-owned by Chubu Electric, Mitsubishi and NYK Line.
- "LNG Jurojin" delivered in 2015. It is co-owned by Mitsui O.S.K. Lines and Kansai Electric Power Co., Inc.
- "LNG Mars" delivered in 2016. It is co-owned by Mitsui O.S.K. Lines and Osaka Gas International Transport.
- "LNG Saturn" delivered in 2016. It is co-owned by Mitsui O.S.K. Lines and Osaka Gas International Transport.
- "Oceanic Breeze" delivered in 2018. It is co-owned by K Line and INPEX Corporation.
- "Pacific Mimosa" delivered in 2018. It is owned by NYK Line.

The Features Of Sayaringo STaGE LNG Carriers

Sayaringo STaGE class refers to a type of LNG carrier designed in 2014 by Mitsubishi Heavy Industries (MHI) for the transport of LNG from the US Gulf LNG terminals to Japan through the Panama Canal.
Like the Sayaendo LNG carriers, Sayaringo STaGE LNG carriers feature a continuous steel cover over the cargo tanks, but unlike Sayaendo LNG carriers where the cargo tanks have a spherical shape, in the case of Sayaringo STaGE LNG carriers, the cargo tanks have the shape of apples, with the upper half larger than the lower half. This form of tanks was designed to transport larger volumes of LNG than Sayaendo LNG carriers, without increasing the ship's width beyond the maximum acceptable for the transit of the Panama Canal (48.94 meters). As a result, the maximum transport capacity of Sayaringo STaGE LNG carriers is 180,000 cbm, higher than that of Sayaendo class which is 155,000 cbm.
The cargo tanks' insulation panels supplied by Ti Group, a subsidiary company of Wilhelmsen Technical Solutions, enable Sayaringo STaGE LNG carriers to have an LNG boil-off rate of just 0.08%.
Sayaringo STaGE LNG carriers have a twin-shaft twin-rudder hybrid propulsion system called "STaGE", an abbreviation for "Steam Turbine and Gas Engine" which consists of an ultra steam turbine plant on the port side, a dual-fuel diesel engine and a propulsion electric motor on the starboard side. The STaGE plant enables Sayaringo STaGE LNG carriers to sail at a speed of 19.5 knots.
STaGE plant is more efficient than the Ultra Steam Turbine plant of Sayaendo LNG carriers. It uses a waste heat recovery system whereby the waste heat from the dual-fuel diesel engine is recovered to heat the boiler feedwater. The heated feedwater flows to the boiler to generate steam to be used to drive the main turbine. This technology enables the STaGE plant to emit about 20% less CO_2 than the conventional steam turbine plants. In addition, the enlarged lightweight hull form and the continuous cover over the cargo tanks enable the Sayaringo STaGE LNG carriers to reduce CO_2 emissions per cargo unit with 40% compared to the conventional steam turbine LNG carriers with a 147,000 cbm cargo capacity.
The ability to burn gas in all operation modes, including at LNG terminals, enables the Sayaringo STaGE LNG carriers to comply with IMO Tier III NOx emission limits in the North American and US Carribean Sea Emission Control Areas.

There are eight Sayaringo STaGE LNG carriers in service:
- “Diamond Gas Orchid” with an LNG transport capacity of 165,000 cbm. It was delivered in 2018 by Mitsubishi Heavy Industries. It is owned by NYK Line.
- “Diamond Gas Rose” with an LNG transport capacity of 165,000 cbm. It was delivered in 2018 by Mitsubishi Heavy Industries. It is owned by NYK Line.
- “LNG Juno” with an LNG transport capacity of 180,000 cbm. It was delivered in 2018 by Mitsubishi Heavy Industries. It is owned by Mitsui O.S.K. Lines.
- “Diamond Gas Sakura” with an LNG transport capacity of 165,000 cbm. It was delivered in 2019 by Mitsubishi Heavy Industries. It is owned by NYK Line.
- “Bushu Maru” with an LNG transport capacity of 180,000 cbm. It was delivered in 2019 by Mitsubishi Heavy Industries. It is co-owned by NYK Line and JERA.
- “Marvel Crane” with an LNG transport capacity of 177,000 cbm. It was delivered in 2019 by Mitsubishi Heavy Industries. It is co-owned by NYK Line and Mitsui & Co., Ltd.
- “Marvel Heron” with an LNG transport capacity of 177,000 cbm. It was delivered in 2019 by Mitsubishi Heavy Industries. It is co-owned by NYK Line and Mitsui & Co., Ltd.
- “Nohshu Maru” with an LNG transport capacity of 180,000 cbm. It was delivered in 2019 by Mitsubishi Heavy Industries. It is co-owned by NYK Line and JERA.

The Features Of Modern LNG Carriers Built By Kawasaki Heavy Industries

Between 2011 and 2019, Kawasaki Heavy Industries built eleven LNG carriers: five LNG carriers with Kawasaki URA-400 Plant and six LNG carriers with dual-fuel diesel electric propulsion system.
The LNG carriers with Kawasaki URA-400 Plant are:
- “Energy Horizon” with an LNG transport capacity of 177,000 cbm. It was delivered in 2011. It is owned and operated by NYK Line.
- “Grace Dahlia” with an LNG transport capacity of 177,427 cbm. It was delivered in 2013. It is owned and operated by NYK Line.
- “LNG Fukurokuju” with an LNG transport capacity of 165,134 cbm. It was delivered in 2016. It is co-owned by Mitsui O.S.K. Lines and Kansai Electric Power Co., Inc.
- “Bishu Maru” with an LNG transport capacity of 164,700 cbm. It was delivered in 2017. It is owned by Trans Pacific Shipping.
- “Enshu Maru” with an LNG transport capacity of 164,700 cbm. It was delivered in 2018. It is owned and operated by K Line.

These LNG carriers have four spherical Moss-type tanks (Spherical IMO Type B Tanks) insulated with polyurethane foam Kawasaki Panel System that keeps the LNG boil-off rate at 0.08% per day.
Kawasaki URA-400 Plant (Kawasaki Advanced Reheat Turbine Plant) is a reheating-type steam turbine propulsion plant. It consists of a high pressure turbine, an intermediate pressure turbine, a low pressure turbine and a reheat boiler. It utilizes a reheat cycle whereby the exhaust steam from the high pressure turbine is returned to and re-heated in the boiler and then sent to the intermediate pressure turbine. The steam reheat technology improves the thermal efficiency of the steam turbine propulsion system with approximately 15% compared to the conventional steam turbine propulsion plants.
Kawasaki URA-400 Plant enables the LNG carriers to sail at a speed of 19.5 knots.

DFDE LNG Carriers built by Kawasaki Heavy Industries are:
- “LNG Sakura” with an LNG transport capacity of 177,000 cbm. It was delivered in 2018. It is co-owned by NYK Line and Kansai Electric Power Co., Inc.

- “Marvel Eagle” with an LNG transport capacity of 155,000 cbm. It was delivered in 2018. It is owned by Mitsui O.S.K. Lines.
- “Pacific Breeze” with an LNG transport capacity of 182,000 cbm. It was delivered in 2018. It is owned by K Line.
- “Marvel Pelican” with an LNG transport capacity of 155,985 cbm. It was delivered in 2019. It is owned by Mitsui O.S.K. Lines.
- “Shinshu Maru” with an LNG transport capacity of 177,000 cbm. It was delivered in 2019. It is owned by Mitsui O.S.K. Lines.
- “Sohshu Maru” with an LNG transport capacity of 177,300 cbm. It was delivered in 2019. It is owned by Mitsui O.S.K. Lines and JERA.

These LNG carriers have four spherical Moss-type tanks (Spherical IMO Type-B Tanks) insulated with polyurethane foam Kawasaki Panel System that keeps the LNG boil-off rate at 0.08% per day.

The Features Of Modern LNG Carriers Built By Japan Marine United Corporation

Between 2018 and 2019, Japan Marine United Corporation built four LNG carriers:
- “Energy Liberty” delivered in 2018. It is owned by Mistui O.S.K. Lines and Tokyo Gas Co., Ltd.
- “Energy Innovator” delivered in 2019. It is owned by Mistui O.S.K. Lines and Tokyo Gas Co., Ltd.
- “Energy Universe” delivered in 2019. It is owned by Mistui O.S.K. Lines and Tokyo Gas Co., Ltd.
- “Energy Glory” delivered in 2019. It is owned by NYK Line and Tokyo Gas Co., Ltd.

These ships have the same features:
- The cargo tanks designed by IHI Corporation are self-supporting prismatic IMO type B (SPB) tanks. They have a volumetric capacity of 165,000 cbm.
- The propulsion system is a tri-fuel diesel electric engine with Selective Catalytic Reduction technology to comply with the NOx Tier III emission limits in the North American and US Carribean Sea Emission Control Areas.

Assignment Of CII Rating To LNG Carriers

by Vlad Cioarec, International Trade Consultant

The "Carbon Intensity Indicator" (CII) is an operational performance indicator provided in MARPOL Annex VI in order to measure the carbon intensity of the ships, based on their annual fuel consumption, the distance travelled in the course of the year (expressed in nautical miles) and the time (hours) spent on voyages.

The Regulation 28 of MARPOL Annex VI requires that, on the basis of the annual fuel consumption data, the distance travelled in the course of the year and the time spent on voyages, after the end of the calendar year 2023 and after the end of each following calendar year, each ship of 5,000 gross tonnage and above to calculate the attained annual operational CII over a 12-month period from 1 January to 31 December for the preceding calendar year.

The attained annual operational CII of individual ships has to be calculated as the ratio of the total mass of CO_2 emitted to the total transport work undertaken in a given calendar year[1].

The **total mass of CO_2** is the sum of CO_2 emissions (in grams) **from all the fuel consumed** on board a ship in a given calendar year. According to the Regulation 2.1.14 of MARPOL Annex VI, the fuel oil consumption data that has to be reported to the ship's Administration should include the consumption data with regard to any fuel used for propulsion, including gas, distillate or residual fuels. Therefore, the LNG carriers using the boil-off gas as fuel should report the mass equivalent of the LNG volume consumed less the nitrogen mass content because the nitrogen does not contribute to CO_2 emissions.

The **total transport work** is calculated as the product of the ship's capacity and the distance travelled in nautical miles in a given calendar year. In the case of LNG carriers, the ship's deadweight tonnage is used as the ship's capacity and not the tanks' volumetric capacity.

The CII reference line values were calculated for each ship type based on the attained operational CII of individual ships of that type within specified DWT ranges in the year 2019.

For the LNG carriers, the CII reference line values were calculated based on the parameters specified for three DWT ranges:

- above 100,000 tons DWT;
- between 65,000 and 100,000 tons DWT;
- below 65,000 DWT[2].

This was done without taking into consideration the difference between the propulsion systems installed on board the LNG carriers.

The world fleet of LNG carriers has 711 ships. Of these, there are 189 LNG carriers powered by conventional steam turbines, 17 LNG carriers powered by steam turbines with steam reheat technology, 8 LNG carriers powered by a hybrid propulsion system called "STaGE", 172 LNG carriers powered by the four-stroke dual or tri-fuel diesel electric engines, 48 LNG carriers powered by MAN B&W Diesel ME-C low speed two-stroke diesel engines and 277 LNG carriers powered by the two-stroke dual-fuel engines.

1 See Resolution MEPC.352 (78) – "2022 Guidelines on Operational Carbon Intensity Indicators and the Calculation Methods (CII Guidelines, G1)"

2 See Resolution MEPC.353 (78) – "2022 Guidelines On The Reference Lines For Use With Operational Carbon Intensity Indicators (CII Reference Lines Guidelines, G2)"

LNG Carriers Powered By Conventional Steam Turbines

The conventional steam turbines have a 30% propulsion efficiency. They were installed on board the LNG carriers build in the 1970s, 1980s, 1990s and early 2000s at a time when there was no other propulsion system available for this type of ships. They were designed not on fuel efficiency considerations but to use the boil-off gas generated by the LNG cargoes as fuel, taking into consideration a daily rate of boil-off gas of 0.15% based on the LNG tank insulation technology available at the time of the ship's building.

The LNG industry demand for ships with larger capacity able to transport larger LNG volumes led to the introduction in 2006 of the four-stroke dual-fuel diesel electric engines and subsequently in 2007 of the two-stroke low speed diesel engines and in 2015 of the two-stroke dual-fuel engines.

The conventional steam turbines became the least efficient propulsion systems in the global LNG fleet. The LNG carriers powered by conventional steam turbines have the highest fuel consumption and generate the highest CO_2 emissions per ton of all types of LNG carriers.

There are 189 conventional steam turbine LNG carriers currently in operation. Of these, there is one ship built in 1977 ("LNG Aquarius"), two ships built in 1989, 35 ships built in the 1990s, 146 ships built in the 2000s and 8 ships built between 2010 and 2014[3].

183 of the 189 conventional steam turbine LNG carriers have a deadweight between 66,000 and 90,000 tons.

The oldest ship "LNG Aquarius" built in 1977 has a deadweight of 72,622 tons.

In the case of the two LNG carriers built in 1989, "LNG Maleo" has a deadweight of 66,892 tons and "Northwest Sanderling" has a deadweight of 66,810 tons.

Of the 35 LNG carriers built in the 1990s, two ships have a deadweight of 35,760 tons, one ship has a deadweight of 48,817 tons, 32 ships have a deadweight between 71,000 and 77,000 tons.

Of the 146 LNG carriers built in the 2000s, one ship has a deadweight of 34,800 tons, two ships have a deadweight of 39,483 tons, 143 ships have a deadweight between 73,000 and 82,000 tons.

The 8 ships built between 2010 and 2014 have a deadweight between 79,000 and 90,000 tons.

LNG Carriers Powered By Steam Turbines With Steam Reheat Technology

The steam turbines with steam reheat technology have a 35% propulsion efficiency.

The steam reheat technology improves the thermal efficiency of the steam turbine propulsion system with approximately 15% compared to the conventional steam turbine plants. The improvements in the efficiency of the steam turbines brought by the steam reheat technology had as effect a lower fuel consumption than that of the conventional steam turbine plants.

In the case of Sayaendo class LNG carriers built by Mitsubishi Heavy Industries between 2014 and 2018, the continuous steel cover over the cargo tanks that reduces the wind pressure from the front, along with the lighter hull structure and the steam reheat technology contribute to a 20% reduction in the fuel consumption and to a proportional CO_2 emission reduction compared to the conventional steam turbine LNG carriers built in the 2000s.

There are 17 LNG carriers powered by steam turbines with steam reheat technology:

- 5 LNG carriers with a deadweight between 83,000 and 87,257 tons, built by Kawasaki Heavy Industries between 2011 and 2018;
- 8 LNG carriers with a deadweight between 80,000 and 86,497 tons, built by Mitsubishi Heavy Industries as Sayaendo class between 2014 and 2018;
- 4 LNG carriers with a deadweight between 84,291 and 84,333 tons, built by Hyundai Heavy Industries between 2017 and 2018.

3 LNG carrier "Pacific Arcadia" was the last LNG carrier built with conventional steam turbines.

LNG Carriers Powered By STaGE Hybrid Propulsion System

STaGE propulsion system has an approximately 40% propulsion efficiency.
There are 8 LNG carriers with STaGE hybrid propulsion system built between 2018 and 2019 by Mitsubishi Heavy Industries. They have a deadweight between 87,494 and 97,955 tons.

LNG Carriers Powered By The Four-Stroke, Dual Or Tri-Fuel Diesel Electric Engines

LNG carriers powered by the four-stroke, dual or tri-fuel diesel electric engines have a propulsion efficiency ranging from 40 to 45%.
There are 172 LNG carriers powered by four-stroke, dual or tri-fuel diesel electric engines, including 13 Icebreakers, built between 2006 and 2024. Of these, there are three small-scale ships with a deadweight between 16,250 and 31,712 tons and 169 conventional size ships with a deadweight between 72,800 and 99,000 tons.

LNG Carriers Powered By The Low Speed Two-Stroke Diesel Engines

There are 48 LNG carriers powered by low speed two-stroke diesel engines:

- 13 Q-Max LNG carriers powered by MAN B&W Diesel 7S70ME-C electronically controlled low speed two-stroke diesel engines running on heavy fuel oil in conjunction with reliquefaction plants. Ten of the thirteen ships have a deadweight of 130,000 tons. The other three ships have a deadweight of 155,000 tons. They were built between 2008 and 2010.

- 31 Q-Flex LNG carriers powered by MAN B&W Diesel 6S70ME-C electronically controlled low speed two-stroke diesel engines running on heavy fuel oil in conjunction with reliquefaction plants. They have a deadweight between 104,000 and 122,000 tons. They were built between 2007 and 2010.

- 4 Conventional size LNG carriers powered by MAN B&W Diesel 6S70ME-C8 electronically controlled low speed two-stroke diesel engines running on heavy fuel oil in conjunction with reliquefaction plants. They have a deadweight between 96,193 and 96,355 tons. They were built between 2015 and 2016.

MAN B&W Diesel electronically controlled low speed two-stroke diesel engines have a propulsion efficiency of approximately 50% but the power consumption by the reliquefaction plant reduces their efficiency.

LNG Carriers Powered By The Two-Stroke Dual-Fuel Engines

There are 277 LNG carriers powered by the two-stroke dual-fuel engines.
The largest LNG carrier with two-stroke dual-fuel engines currently in operation is the **Q-Max LNG carrier, “Rasheeda”** with a deadweight of 130,208 tons. When it was originally built in 2010, “Rasheeda” had two MAN B&W Diesel 7S70ME-C electronically controlled low speed two-stroke diesel engines running on heavy fuel oil in conjunction with a reliquefaction plant.
Those engines were converted in 2015 into ME-GI engines (M-type, Electronically Controlled, Gas Injection engines). These engines were the first two-stroke dual-fuel engines installed on board an LNG carrier.

ME-GI engines are high-pressure dual-fuel engines designed by MAN B&W for LNG carriers to comply with the IMO NOx Tier II emission limits[4]. They have a 50% propulsion efficiency.
MAN B&W has developed another engine based on ME-GI, the M-type, Electronically Controlled, Gas Admission (ME-GA) engine. The first LNG carriers equipped with ME-GA engine were built in 2023.
The other type of two-stroke dual-fuel engines are X-DF series built by Winterthur Gas & Diesel (WinGD). The first LNG carrier with X-DF engines, "SK Audace" was built in 2017.
The first generation of X-DF engines had a 47% propulsion efficiency.
In 2020, Winterthur Gas & Diesel introduced the second-generation of X-DF engines.
MAN B&W's ME-GA engines and WinGD's second-generation of X-DF engines are currently the most efficient engines in the global LNG fleet. They have the lowest fuel consumption and the lowest emission levels of CO_2 than all other engines currently used in LNG shipping.
Besides the Q-Max LNG carrier, "Rasheeda", among the LNG carriers with two-stroke dual-fuel engines, there are **6 LNG carriers with a transport capacity of 200,000 cbm** and a deadweight between 105,602 and 107,817 tons, **261 conventional size LNG carriers with a transport capacity between 170,000 and 180,000 cbm** and a deadweight between 90,000 and 96,000 tons, **one conventional size LNG carrier, "Seri Cempaka" with a transport capacity of 150,200 cbm** and a deadweight of 84,311 tons, **five mid-scale size LNG carriers** with a deadweight between 42,000 and 45,462 tons and **three small-scale size LNG carriers** with a deadweight between 17,000 and 18,433 tons.
The two-stroke dual-fuel engines have become the predominant propulsion system in the LNG fleet, particularly in the case of ships with a transport capacity between 170,000 and 180,000 cbm, the size range where the two-stroke dual-fuel engines are considered to be the most efficient. They set a CII reference line value too low not only for the steam turbine LNG carriers but also for LNG carriers with dual or tri-fuel diesel electric engines, which are within the 65,000 and 100,000 tons DWT range. As a result, most of the LNG carriers powered by steam turbines are unable to achieve the operational carbon intensity rating A, B or C.
In order to avoid a premature phasing out of 183 LNG carriers (steam turbine LNG carriers within the 65,000 and 100,000 tons DWT range), INTERTANKO proposed the introduction of a CII averaging mechanism that would enable the LNG carrier operators to calculate a CII for their entire fleet by averaging "D" and "E" ratings of the steam turbine LNG carriers with the ratings of the modern LNG carriers powered by two-stroke dual-fuel engines[5].

4 ME-GI engines are fitted with NOx emission control technologies, the exhaust gas recirculation (EGR) and the selective catalytic reduction (SCR), to comply with the NOx Tier III emission limits not only when operating in gas mode but also when operating in fuel oil mode.

5 See IMO document MEPC 79/7/1 – "The need for urgent mitigations to address the challenges of GHG short-term measures when applied to steam driven LNG ships" submitted by INTERTANKO at the 79th session of the Marine Environment Protection Committee.