



LNG Bunkering Global Report **2019**

Thank you for taking the time to download this report.

As a member of Oil & Gas IQ and the wider LNG industry, you are at the forefront of the market as we approach 2020, and the next few decades of progress.

This is an incredibly exciting time to be working in this field, as the LNG bunkering market is one of very few within oil and gas that is likely to consistently benefit from the rising environmental concerns we are all now accustomed to. The EU's Climate and Energy Package, the United States' Sustainable Development Goals, and even some transitional schemes in Russia have all started to affect demand for clean fuel and reduced emissions, massively affecting the LNG market - which is now set to exceed \$12 billion within the next five years.

Any company which employs a fuel oil bunkering strategy has felt the pressures of those environmental restrictions in recent years, and gas-based fuels have become ever-more appealing. Pressure to change fuels has also been felt in traditional land-based logistics, and with large operators currently facing financial, regulatory, and environmental burdens, adoption of LNG by even a small number of these companies could drastically change the global market strength of liquefied natural gas.

With worldwide growth in the market, and stabilisation with regards to fuel prices - we are approaching a new age for LNG development. Thanks for taking the time to read this report, and don't forget to stay tuned to Oil & Gas IQ for all our latest reports, infographics, and content.

Tom Stuchfield
Editor





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In this exclusive market report, drawing on conversations with and research conducted by some of the most prominent players in the LNG field, we at Oil & Gas IQ lay out our take on the current liquefied natural gas ecosystem - and the areas we expect to see the most development in the future.

“We are on the doorstep of 2020 and are still debating which fuels will be fuel of the future - but really we are struggling to look past 2030. The shipping sector is quite weak today, and the last thing it needs is more instability. We want to diversify and manage change effectively by spreading risk across many different fuel types.”

Paul Taylor

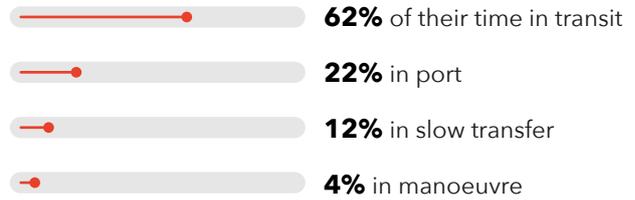
Global Head of Shipping & Offshore,
Societe Generale CIB

What happens beyond the next year or two remains unknown - but the consensus that is starting to emerge is that LNG will have a role to play as a transitional fuel for the next decade or so, with another fuel coming through after that.

There will certainly be some who benefit from these transitions, and some who suffer from the predicted brevity of the LNG period. If companies mismanage the transition to (and perhaps, from) LNG, then they will struggle to remain competitive. Fuel quality simply won't matter if companies aren't relying on certain types of fuel to the right extent.

Vessel movement

Part of navigating LNG as we approach this tumultuous time is properly understanding the activities of the vessels that will be running on LNG - and this is something most of us simply do not know. According to research conducted by Rolls Royce on their own fleet, vessels spend:



This unique breakdown has allowed the firm to develop an LNG strategy that matches the movements of their fleet - predicted to provide a 30 per cent CO2 reduction by 2020, up to 35 per cent if hybrid engines are used.

Transfer types

According to certification agency Bureau Veritas, LNG bunkering supporting infrastructure is often overlooked - particularly the effect of transfer systems. With LNG bunkering stations relatively widely available in Bureau Veritas' portfolio - 10 currently in operation, a further 10 in progress, and talks underway for an additional nine - focus now needs to move onto potential supporting infrastructure. Some available options for the needs of larger firms include:

Truck-to-ship

(TTS) transfer, which has operational flexibility, limited infrastructure requirements, but the trucks themselves have a relatively small capacity, coupled with a limited flow rate.

Ship-to-ship

(STS) transfer, is also flexible and allows simultaneous operations, or SIMPOS. This method also boasts a larger capacity and flow rate because the bunkering can take place right alongside the ship. However, the capital investment cost is quite high, as is the relative life cycle cost when compared to other bunkering methods. The entire process is also dependent on the limits imposed by the port itself, be they technical, physical, or legal.

Port-to-ship

(PTS) bunkering. This method has the option to sustain itself for long-term demand, but can cause problems for larger vessels which may struggle to approach the terminal.

Pressure differences

Pressure differences

Pressure differentials within the flow of LNG fuel must also be carefully monitored and factored into the normal running of the bunkering process. The types of interchange include any combination of pressurised and non-pressurised fuel transport methods – a shift from non-pressurised to pressurised fuel, for example. Some of the factors you need to be aware of when dealing with fuel pressure across these interfaces are as follows:

Pressurised to pressurised:

there is flexibility on boil-off gas management and vapour line return, but the LNG filling rate and tank temperature may be adversely affected

Non-pressurised to non-pressurised:

boil-off gas management is simpler, and storage volume is increased, but precautions need to be taken with regards to roll-over phenomena and control tank pressure

Pressurised to non-pressurised:

there is flexibility in terms of capacity and flow rates for the bunker vessel, but there is a precaution for roll over, issues with control tank pressure, and with the boil-off gas compressor for the receiving vessel



LNG in EMEA: Total in Iran

LNG delivered ex-ship is cheaper in Europe than in the US and Asia, and the LNG molecule price itself is cheaper than the products on the gasoil and heavy fuel markets. As such, Total has been pursuing major LNG contracts - and in December 2017, won their first supply contract with CMA CGM for 300,000 tonnes of LNG per year for ten years.

Then, in the following February, they signed an 18,600 m³ LNG bunker vessel. Current developments in Oman, focussing around a well in the port of Sohar, are set to produce "the first well-to-wheel project dedicated to LNG bunkering. Growing from a simple production field, Total's Sohar project will tap into the Oman gas field using the existing pipeline network, leading to a one million tonnes per annum LNG plant, and then numerous bunkering vessels.

LNG in Europe: Fluxys in Germany, and beyond

Fluxys, the natural gas transmission system operator, are now working on building the first LNG terminal in Germany that is focussed solely on LNG. This facility will have the ability to load trucks and small ships to distribute LNG as a fuel within the region - but is still in the design phase as of February 2019. Ongoing European standardisations, which will include parity of interfaces across Europe, will be vital to ensuring that the so-called fuel of the future has the universal availability and safety requirements necessary for wide availability.



Fluxys are also considering additional works in Antwerp, according to Mr Standaert: "In Antwerp, it is possible for truck to ship operations - and there will be further investments for LNG storage there. There will also be the option to go ship to ship. However, there is still a lot of idle time, and suppliers and contractors will be in a good position to negotiate for the foreseeable future."

Present in nine European countries, Fluxys is a high-pressure natural gas and LNG company with a three-part vision for the future: zero supply interruptions, an infrastructure lifetime of more than 50 years, and growth and acquisitions outside Europe. With 20 countries now exporting 300 million tonnes of LNG per annum, a 40 million tonne increase on the year before, and 35 countries importing LNG, part of the growth that Fluxys is aiming for will be in the LNG sector.

"Please don't wait for tomorrow's free beer - it's there today for you to take!"

Kwinten Standaert

Key Account Manager, Fluxys LNG

75 per cent of all imports are in the Japanese and Korean markets, with a significant proportion of the remainder (200 mtpa) being into Europe, which produces very little LNG at present. Fluxys are now capable of sourcing LNG fuel (from EDFT, ENI, Total, and Yamal LNG).



of all imports are in the Japanese and Korean markets

LNG in Europe: Vopak in Germany

The German port town of Brunsbüttel saw major development in 2016 with the construction of a large LNG import terminal. Part of a scheme to phase out Germany's reliance on nuclear energy to almost zero by 2022 (from 250 TWh), Vopak, which manages 300 facilities across the globe, in collaboration with Gasunie, operating in both Germany and the Netherlands, and Oiltanking, with 80 terminals worldwide, are operating a vast swathe of LNG infrastructure.

“So far, permits have been granted, but we are doing everything for the first time, and the integrated concept of LNG brings a lot of questions from the regulatory side, and hopefully that will be completed within a year. We have a building permit, and an environmental permit - basically, the whole package”

Guus Vogels

Sales Manager, Vopak

Brunsbüttel is the preferred location for an LNG terminal due to its proximity to a number of important features, including the port of Hamburg, its surrounding industrial zone, and the Kiel Canal - the busiest artificial waterway in the world, with 113 ships passing along it every day. There is also scope to promote LNG as a fuel for trucks, as Germany currently has three million diesel trucks in its road fleet. The local government both within the port of Brunsbüttel and the state of Schleswig-Holstein fully support these schemes, along with some tentative steps towards full rail linkages.

A range of terminals

Vopak look at both small- and large-scale terminals, and what they saw was that building of infrastructure is always a barrier, especially for facilities working with smaller volumes. They have plans to build a concept that gets the

best of both worlds, where other companies are able to bring larger volumes to north west Europe.

The site has direct access to areas covered by both Gaspool and NCG, which are due to merge next year. The link to this low/high pressure gas grid allows access to the local industry in order to evacuate boil off.

“We don't have any influence on the sourcing, we need to obey the law and get into the grid based on specs from our customers. We do have a ban on fracking LNG from the US in Germany, but if you look at the entire world LNG portfolio - LNG from the US is a small part of that, so therefore I think we shouldn't exclude it from the terminal but it is still up to our customers to make that decision.”

Guus Vogels, Sales Manager, Vopak

There is also an expectation that the terminal will adhere to a configuration featuring two large 240,000 cubic metre tanks, a large-scale jetty for (you guessed it) larger vessels, as well as a dedicated smaller one. Two truck loading bays will also be complemented by two rail car loading bays, an exciting development given that only five such facilities exist at the start of 2019.

Regulations and limitations

There were restraints, however, on jetties. If Vopak wanted to facilitate larger vessels, they would need at least one large jetty - but if they built two, then the cost would be higher. This layout is forecasted to handle around five billion cubic metres of LNG per year, with an option to scale up to seven over the next few years. The combined unloading rate of the jetties will be around 14,000 cubic metres per hour, and the loading rate is expected to exceed 2,500 m³ per hour. Again, there will be the opportunity for further expansion.

The project began in 2018, and operations are expected to begin in mid-2022, with a final investment decision in 2020. Discussions are underway with companies wanting LNG from the terminal, and agreements with LNG suppliers have begun.

LNG in Europe: Baleària in Spain

Currently operating out of 22 regional offices across five countries, with 24 routes in operation, Baleària is “an innovative, responsible, and citizen company - enthusiastic about our activity: connecting territories by sea to increase the development and wellbeing of the people,” according to Jesús Blanco Cedrón, Project Manager at Baleària.

Utilising their “3C culture” of conviction, convenience, and coercion, Baleària has made major steps in the LNG direction with their LNG ferries division, delivering the 880-person capacity Hypatia de Alejandria, the first LNG-powered ferry in the Med. Exciting developments are continuing over the next eighteen months, with the following projects currently in development:

The Armon Gijon fast ferry, operating with four engines with a capacity for 1,200 people and 257 cars

The Eleanor Roosevelt - the first and largest passenger fast ferry in the world, powered by dual natural gas engines

2018-2020 retrofit of six vessels: the Napoles, Abel Matutes, Sicilia, Baham Mama, Hedy Lamarr, and Martin i Soler.

Baleària fits into the larger Spanish market at a time when Spain is truly establishing itself as a major LNG player. Alongside the work done at Baleària, other companies such as Naturgy have been developing LNG infrastructure across the country.

LNG in Europe: Naturgy in Spain

LNG is seen as a medium-term commitment in the region, and more and more commentators and companies are realising that to meet zero per cent emissions targets in 2050, LNG will have to be phased out. To manage the transition to and from LNG, operators and engineers need to have a deep understanding of vessel operational profiles and know how to balance operational flexibility and logistic stability. With two operational LNG bunkering vessels at present, Naturgy is now working with the Valencia port authority, the major authority on LNG bunkering in Spain, to develop a third vessel.

Naturgy’s LNG learning curve has required constant cross-departmental communication, agreement on technical and operational requirements, clearly-defined procedures, and the establishment of clear responsibilities. It has been especially trying, as Naturgy works in both the container ship and ferry market, which are commonly held to be totally different.

The firm has also been involved in the SamuelLNG project, the “first phase of the global project towards a blue Atlantic arch by 2025”, running the demand analysis, defining the solution, building the logistics platform, and running a risk assessment. They collaborated on the project that is now an effective low-capex system that supplies the expected demand and aggregates new customers to maximise investment in new infrastructures.

Focusing just on Naturgy, which operates in 30 countries in addition to Spain, and is also the main LNG player in the Atlantic Basin, one gets an idea of the upscaling taking place in Spain in recent years. With three of the five main ports in the Mediterranean, Spain is vital to LNG growth. Barcelona is the first cruise ship port in Europe, Valencia the main Ro-Ro port, and Algeciras operates with more than 4.5 million TEU per annum. LNG will provide a “bridge to the future” according to Naturgy, taking the region into the 2020s and 2030s.

Global LNG footprint

LNG in Europe: Rolls Royce in Norway

The firm's history with LNG in Norway began in 2000 with truck bunkering using tanks between 100 and 200 m³ in volume, but has been driven further by the NOx fund, the development of more infrastructure, and the resulting support provided to ship owners. Rolls Royce now owns 18 facilities across Norway and can provide ship-to-ship bunkering. On the back of LNG success, there are now plans to bring LBG, or liquified bio gas, to Norway to achieve full GHG neutrality in operations. As with every other LNG ship within EU waters, all Norwegian FLNGs are assisted by government subsidies.

LNG in Europe: The Port of Rotterdam Authority in Belgium

To ensure that STS bunkering is always safe, operational safety is a paramount concern for every LNG operator. Organisations such as the Port of Rotterdam Authority have a responsibility to maintain environmental safety with regards to distance to populated areas, nautical safety, and mooring distances and distances to passing vessels. Rotterdam has also introduced simultaneous operations systems (SIMPOS) and more general safety management procedures.

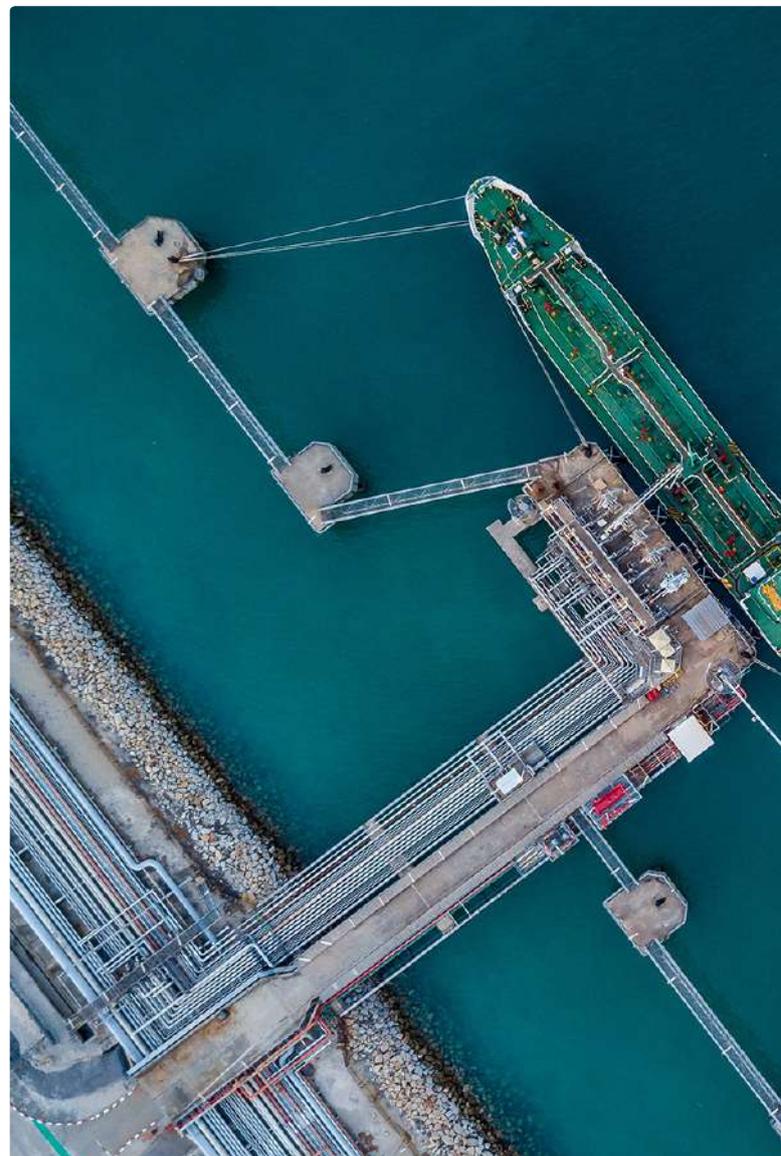
Mr Cees Boon, Sector Coordinator for the Harbour Master Policy Department in Rotterdam describes the effect of environmental and maritime legislation, European regulations, and port bye-laws on managing marine traffic. "There is an interaction with different ships - there is a safety concern area around the bunker ship during the process, for example. Existing regulations about passing distances is already in place, and we just use that now: you can pass within a shorter distance, but you have to be in contact with them, but otherwise it is a 50m distance to other ships.

"The bunker vessel also has to fly a 'B' flag, people on board have to be aware of any danger mitigation, alarm procedures must be clear, and all of that is the responsibility of the bunker office. For STS distance to the public, we apply the system of the environmental legislation - the EU Seveso directive."

Mr Boon also sees the value in the process of conducting

external safety studies for environmental safety and public health. The process begins with a calculated quantitative risk assessment, followed by a more qualitative gauge of whether or not the area within the 10-6 contour is sufficiently populated to rule out further development or operation of fuel bunkering. There is an accepted level of societal risk, and this is reflected in the final stage: an LNG bunker map with green, yellow, and red zones.

This method differs in every port and is unique to Rotterdam.



LNG in Europe: Dunquere LNG in France

Dunkirk is the first European LNG terminal to be fully connected to two markets – in the UK and Germany, through Zeebrugge. Dunkirk is a hugely impressive LNG facility, boasting a capacity of 13 billion m3 per annum, and currently meets 20 per cent of French and Belgian demand. It boasts a flexible connection design, and there are 157 unloading slots per year.

Since its commercial start up on the 1st January 2017, and its first cargo on the 23rd, the Dunkirk facility has been working with a range of send-out cargoes between 14,000 and 1.9 m3 per hour. However, the number of cargoes is still relatively low, with 11 in the first year of operation, growing to 14 in 2018. With the inclusion of a fast reloading service and truckloading capabilities of Q1 this year, it is expected that the number of cargoes will increase to between 30 and 40 by January 2020.

“The port of Dunkirk is very important, but 3,000 hectares are still free to expand it yet further. It is one of France’s most important ports, connected with all the networks in Europe. It is also the first French port with an inland waterway connection.”

Cécile Grégoire-David

Business Development & External Relations,
Dunkerque LNG SAS

In the past year, Dunkerque LNG SAS has invested €200,000 in improving their environmental shipping index standing and has developed a new tax break system. Under the new system, ships coming into port will access electricity at a reduced rate – as opposed to the previous shore tax on accessing electricity. The European parliament is currently aiming at a zero per cent tax on electricity consumed by ships in port.

Partnerships and long-term plans

The Dunkirk LNG facility currently has contracts with Engie (5,000 m3), Shell (6,800 m3), Coralius (5,800 m3), and Nauticor (7,500 m3) amongst others. If they all reload twice a week, this will equate to a total volume of at least 100,000 m3 at the most conservative.

The port’s long-term plan is to support the growth of LNG as a viable marine fuel, to become the main port of LNG supply for the northern French coast and southern England, and to supply power stations across the north and east of France. If Dunkerque LNG achieves this ambition, it will cement the port town as one of the most important centres of LNG in all Europe.

With direct access to the North Sea, a nearby north/south motorway, multiple inland waterways and the major Seine-Nord canal, the position of Dunkirk lends itself perfectly to extremely proactive LNG market proliferation.

Bringing with it an annual capacity of 3,000 trucks, the first of three truck-loading bays is now operational. The facility is also adapting its main jetty, due for completion in mid-2019, to accommodate small-scale ships between 3,000 and 30,000 m3 whilst allowing the two main prongs of the port to be used for larger vessels. This will allow three ships to bunker simultaneously in the basin by 2020.



Dunkirk is a hugely impressive LNG facility and currently meets 20 per cent of French and Belgian demand

LNG in Europe: Nauticor in the Netherlands

The Linde Group, a “blue chip” company on the DAX 30, operates in more than 100 countries, and started with the world’s first LNG vessel – the SEAGAS – having now completed 15,000 safe bunkers. Nauticor has also worked on the world’s first retrofitted LNG ferry, the first newbuild LNG ferry in Germany, the first Ro-Ro ferry with a mobile LNG tank, the first retrofitted chemical tanker with LNG, the first LNG-engine-enabled dredger, and the first retrofitted container vessel with an LNG tank.

Developing new ship-to-ship solutions is the next step in global LNG strategy, according to Sales & Business Development Senior Manager Jan Schubert, as evidenced by the recent launch of the world’s largest bunker supply vessel, the Kairos. Mr Schubert goes on:

“I would like to see the role of Nauticor translated into the work of other companies. However, we sometimes have to explain to terminals and suppliers that the large scale way of doing business does not scale-up as you would expect. You have to be flexible – everything is not transposable to LNG because the specifics of the fuel and the commercial reality is not identical. However, we are working to find ways to make it commercially sensible to both parties to transfer to LNG.”

Main price drivers

Operating primarily in the Netherlands, Nauticor works with the Title Transfer Facility (TTF), the Dutch virtual trading point. The price of LNG through the TTF is determined mainly by pipe gas across North West Europe and FOB

premium. Location, drop, size, total volume, and contract term will also drive prices. In the downstream, the bunker location and distance to the LNG terminal, along with the drop size and the total volume per contract can drastically alter unit value. Flexible bunker schedules will help, but the duration of the commitment, and the volume of fuel need to be guaranteed to maximise this.

Global LNG footprint

LNG in North America: Seaspan in Canada

Seaspan is a ferry and petro-bulk operator based in Vancouver which also manages multiple shipyards and drydocks. Mr Harly Penner, Engineering Superintendent of the Ferries Corp. within Seaspan, describes the structure of his vessels, featuring two engines with a single LNG tank, an engine room, and a very large battery compartment.

“We read all of these news stories about sustainability and started to challenge ourselves because we actually had gaps in our knowledge: fugitive emissions, unaccounted natural gas, methane slip. We wanted to build an inventory in terms of what our vessels were delivering as a green project. We don’t advertise as being green, but all of our key stakeholders are constantly checking how green we are.

“We needed to look at how our natural gas was produced, as in British Columbia where we are based it is produced in an electrified liquefaction facility. As our LNG programme developed, we made some promises – and a big one was the commitment to our stakeholders that we would reduce greenhouse gas emissions.”

LNG in South America: Balearia across the continent

Balearia is the leading shipping line for passengers and services to the Balearic Islands – and also Spain, Morocco, Algeria, the United States and Bahamas. From November 2018, they started a route from south Spain to the Canary Islands and they are opening more and more routes. LNG as a fuel is a major commitment both in an economic and profitable area, but also compliance. Balearia are also undertaking six LNG retrofit projects.

LNG in South America: Total in Panama

Total’s LNG group will offer “worldwide multi-energy bunkering solutions to shipowners”, supported by the

second largest LNG portfolio amongst the majors, overlapping major marine hubs. The next wave of vessels are due to come in before the IMO 2020 regulations, as is the completion of projects in both Panama and the Dominican Republic.

The Panama LNG terminal started up in June 2018 with a floating storage unit (FSU). Within the next few months, an additional 180,000 m³ LNG storage tank will be completed, and the facility will have the ability to reload small-scale vessels from 3,000 m³ up. Truck loading will be introduced in 2020.

Total’s LNG activities are rounded out by continual development of the Dominican Republic facility which began in 2003. It currently has a storage capacity of 160,000 m³, with two loading bays capable of handling vessels of 10,000 m³ or larger.

LNG in Asia: CNOOC in China

CNOOC, the China National Offshore Oil Corporation, employs nearly 100,000 people, and has an annual turnover in excess of \$160 billion. Within this is CNOOC's Gas and Power Group, the third-largest importer of LNG in the world – at just under 21 million tonnes per year – with the third-largest global contract volume.

CNOOC has been working in vehicle bunkering for more than a decade and is now making serious inroads into vessel bunkering – covering vehicles from heavy trucks and intercity buses to tankers and container ships.

“Chinese LNG development can influence Japan and other parts of Asia due to the size of its GDP and the strength of its ports. Hopefully, Europeans will use the fuel more in future.”

Qiao Yu

CM of LNG bunkering projects,
CNOOC

Qiao Yu, CNOOC's GM of LNG bunkering projects, has described a major push within the group to fully gasify the Yangtze river – the longest river in China at over 6,000km long. With a GDP exceeding 90 trillion RMD in 2018, and seven of the 10 largest ports in the world, China may well emerge as the premier LNG superpower within the next few years – despite the majority of activity currently sitting within Western Europe.

Bunkering plans: 2020 and beyond

As part of its drive to cement itself as a global LNG player, CNOOC's Gas and Power Group is developing two new LNG bunkering vessels at present, as well as 76 platform supply vessels between 2020 and 2025. There are also plans to build several shore-based LNG bunkering vessels, although exact numbers are not yet available.

Despite being by far the biggest player in Chinese LNG, CNOOC is not the only player in China – so more LNG development could stem from other companies.

“The Chinese shipyards are competitive, but until recently many LNG have chosen Korean shipyards. However, all new CNOOC vessels will be built in Chinese shipyards.”

Qiao Yu

CM of LNG bunkering projects,
CNOOC

With the Ministry of Transport already entering the ECA sulphur limit of no more than 0.5 per cent mass by mass, restrictions are set to tighten yet further. From January 2020 all vessels entering China's inland river ECA must use marine fuel oil of less than 0.1 m/m, and from January 2022 this limit will apply to the whole ECA.

Global LNG footprint

2018: the start of a long-term LNG focus

Going into 2019, CNOOC expect a complete LNG bunkering system to be in place along the Yangtze river, the Beijing-Hanzhou canal, and the Xijiang river by 2025. Within that time, it is expected that PTS (port-to-ship) and STS (ship-to-ship) bunkering stations will also develop in other waterways in China, with the Yangtze leading the way with 45 stations. Mr Yu describes CNOOC's approach as the "Four Part Strategy", referring to LNG carrier ships along China's river systems, LNG STS transfer, LNG STS bunkering, and LNG bunkering SIMPS.

By the end of 2018, CNOOC had built 163 new LNG-powered vessels and renovated a further 117 - primarily in the Yangtze, Pearl, and Huangpu rivers. There were also 21 completed LNG stations, although only five were in operation due to "a lack of demand" according to Mr Yu. As of early 2019, CNOOC forecast bunkering volumes of between 0.32 and 0.58 million tonnes in 2020, between 1.24 and 2.53 million tonnes in 2025, and between 2.96 and 4.97 million tonnes by 2030.

A history of LNG

At present, there are 20 LNG receiving stations operating across China, and receiving 68.4 million tonnes per annum. However, the first LNG bunkering vessel - with a capacity of 14,000 m³ - was only delivered in May of last year.

There have also been some inroads made into LNG-powered passenger craft, with a small 3 m³ ferry starting operations in Dongjiang Lake "to preserve its natural beauty". CNOOC have also explored the LNG conversions of old fishing boats and cargo vessels, with between 80 and 90 per cent of the costs covered by government subsidies, and the bunkering of international fuels along the coastal region.

LNG in Asia: Total in Singapore

Total has also been developing a major LNG project in Singapore, featuring three 180,000 m³ storage tanks as well as a larger 260,000 m³ tank. There are currently plans for two jetties, with the FID upcoming on the second.



Major players

Total

According to Xavier Pfeuty, LNG Manager of Total's Marine Fuel Global Solutions group, the oil giant is committed to promoting LNG as a viable marine fuel. Speaking at the recent LNG Bunkering Summit, Mr Pfeuty related the "real improvement" in Total's LNG presence as they passed the six million tonnes mark. Selling in three main markets (Africa, Asia, and Europe), Total's LNG division has bunkering hubs in France, Hamburg, Singapore, South Korea, Oman. They are also investigating opportunities in the Gulf of Mexico and the Panama Canal.

"The main and most challenging point for LNG worldwide remains the low-carbon roadmap, and the reduction of greenhouse gases by 50 per cent by 2050."

Xavier Pfeuty

LNG Manager, Total Marine Fuel Global Solutions

As the IMO's regulatory framework moves on apace, firms like Total are switching some focus onto LNG as a bridge fuel to take them into the 2020s and 2030s. LNG, when compared to marine fuel oil, can provide a 20 per cent reduction to CO₂ emissions, an 85 per cent reduction to NO_x, 90 to SO_x, and an almost complete elimination of particulates. These reductions put LNG firmly on Total's low-carbon roadmap - but there are some issues.

At the end of 2018, with all these projects in the pipeline, Total was operating a 28 million tonnes per annum LNG portfolio (representing a 10 per cent market share) across their 10 import terminals, with the capacity for 24 million tonnes of liquefaction.

Rolls Royce

Rolls Royce's VP of LNG Systems, Oscar Kallerdahl has recently discussed the three-pronged approach to LNG that Rolls Royce have been taking towards LNG, focussing on ship design, system integration, and the selling of those

products. They have 55 vessels currently powered by LNG, 29 LNG systems, and have sold more than 100 LNG engines.

Painting a picture by numbers

Rolls Royce have three new licenses due to come in from 2021 onwards, and are expect to reduce GHG emissions in their Norwegian operations by 25 per cent. Over the duration of the ten year contract, they aim to have a ship at every port, with 34 port calls north bound, and 33 port calls south bound. This would require 11 ships in total. Other projects include:

- > A retrofit of six vessels with Hurtigruten, a cruise company
- > A new build contract for four vessels, all using an LNG system supplied by rolls, batteries, efficient propulsion, power management systems, and heat recovery systems
- > A pure gas engine project in Bergen, with the following reductions against fuel oil: NO_x - 92 per cent, CO₂ - 30 per cent, Sox - 99 per cent, particulates - 99 per cent, GHG - 20 per cent

Holistic efficiency savings

Rolls Royce have developed a multifaceted approach to efficiency savings in shipping, combining to achieve a 40 per cent total reduction. Mr Kallerdahl has admitted that there are additional savings to be made, but that the changes already made represent the "low-hanging fruit".

- > Wavepiercing technology, for a five to eight per cent efficiency saving
- > Gas engines for an 18 to 22 per cent saving
- > Hybrid shaft generators for 4 to 6 per cent savings
- > Promas propulsion and manoeuvring system for a five to eight per cent saving
- > Design - and engineering-integrated ship system for a four to six per cent saving

According to Tom Strang, Senior Vice President of Maritime Affairs, at Carnival: "One per cent of our fuel is LNG in 2018, shortly rising to two per cent. We've invested in exhaust gas cleaning systems, instead. There's going to be a lot of uncertainty - I'm not even going to talk about pricing - we just have to deal with it as it comes. We just have to be prepared, which means making decisions in due course. If, today, you've yet to make a decision regards to LNG or cleaning systems, then you have not made a decision in the best timescale.

"There's also an enforcement issue. What's going to happen when a ship sails into an area in which the fuel it's running is non-compliant?"

AIDAnova: a world first for LNG

Stuart Carpenter, LNG Project Director for Carnival, has also spoken on the process of working on the world's first LNG-powered cruise ship - the hugely-impressive AIDAnova, powered by an on-board arrangement of four 16 cylinder 46 DF MaK engines:

"We have had great collaboration with Meyer Werft on our initial operations, and a great opportunity for the crew to get the best preparations for seamless operations in service.

"On the 12th of December, the vessel was delivered in Northern Europe and undertook the first cruise bunkering in Tenerife. The size difference between our huge vessel and the bunker vessel was difficult, and we're seeing an operation currently take in the region of 10-12 hours. This was the start of our regular operations."

The AIDAnova has completed four bunkerings to date, with the most recent taking place on the 30th of January over 10 ½ hours. "It is not yet business as usual, but we are moving towards regular operations now," said Mr Carpenter, "with one of the key items being understanding how to keep track of the process of the bunkering from the control room." With the bunker areas being a maze of pipes and potentially lethal leaks, the entire operation has to be viewed through an extensive CCTV system.

Bunker stations and issues

There are two bunker stations on the cruise ship, giving this difficult-to-maneuvre vessel the capability to bunker from either side. However, there are still a vast number of compatibility factors to consider before bunkering can be safely undertaken - most of which are physical factors. These factors include moorings, manifolds, transfer systems, and the manoeuvring of obstacles. The AIDAnova also has overhanging lifeboats that were initially seen as a major problem for bunkering - however, pontoons acting as separators have been developed to keep bunkering vessels at a safe and consistent distance.

There are also procedural issues such as communication between teams and the remote issues endemic to remote CCTV monitoring of a dangerous procedure. Hose handlings can also cause accidents and loss of fuel, but both of these issues can be successfully mitigated by early engagement and good collaboration with the supplier.

Bunkering with Shell's Cardissa, the hoses used on the AIDAnova are protected with cryojackets which insulate and impact-proof the fuel when in transit. The liquid hoses are clearly colour-coded and marked, matching the manifolds, and whilst it isn't often executed in the cruise industry, a full mooring analysis has been undertaken to ensure the AIDAnova can still be bunkered in port. As to crew competency, all Mr Carpenter had to say was "don't reinvent the wheel - use industry best practice."

Consistency in operations and fleet expansion is a long-term goal for Carnival, and with three vessels currently on order, the proof will soon be in the pudding. These vessels will be aesthetically different to the AIDAnova, but their LNG capabilities will be the same. "What we didn't want was a different way to do the operations in Barcelona, the US, Tenerife, and Northern Europe - we don't want a different level of safety in each port," according to Mr Carpenter.

Over the next 12 months, the world LNG cruise industry is set for decent levels of growth - with the Costa Smeralda, the second vessel in Carnival's fleet, due in October, followed by the P&O Iona, and Mardi Gras in 2020.

Important aspects

Banking and finance

Speaking on behalf of Societe Generale CIB, Paul Taylor, Global Head of Shipping & Offshore has what many would consider a novel perspective on the emerging LNG market.

“As a banker, perhaps my approach is a little different. These ships have such a huge role to play in IMO 2020 - firstly in terms of doing the right thing - we have a responsibility to lobby the sector, support our clients, and innovate. People take 60,000 commercial ships on the waters today, and we actually have a very strong voice in the global banking economy to enforce change. So far, we have committed \$100 million to change.

“We want to make huge changes - not just in lending, but in lobbying. We are members of the CLNG consortium - we are the first bank to join, but we don't want to be the only one any longer.

“LNG is a key area for us - not just as a fuel, but across the chain, and across banking.”

“Yes, but the costs are not as much as people think - you hear stuff like more than 15 per cent for an LNG vessel - it just isn't that. Scrubbers, on the other hand, are even more expensive than you hear on the grapevine. The difference between regular ships and LNG is closer to seven or eight per cent. We are supportive of LNG as a fuel, and we fully expect banks to be supportive of the major liner companies that will be investing.”

Paul Taylor

Global Head of Shipping & Offshore,
Societe Generale CIB

According to Peter Keller, Executive Vice President at Tote Inc., it is really important that this infrastructure continues to develop because if a company cannot bunker, not only can it not refuel, but LNG will not grow: “A lot of people keep talking about the economics of LNG, and as a recently retired ship owner - we do in fact look at the environmental benefits and try to put a financial bias onto it. At the end of the day, this industry needs to do the right thing - this is the way the world is going, whether we like it or not.

“So, what are the other alternatives we see looking ahead 10, 20, 30 years? What do we see that is out there? What do we see that's out that that's viable? The cost of ships - an ocean-going LNG ship will be far more expensive, due to insurance and risk - are the banks ready to support investing into these vessels?”

Alternative fuels

23 per cent of the German market currently relies on renewable energy, with the same proportion dependent on nuclear energy. German LNG therefore has the potential for a huge share of the market in the next few years. Germany also depends on 836 TWh of energy produced from coal, so major shifts in energy make-up are needed.

According to Tom Strang, Senior Vice President of Maritime Affairs at Carnival, long-term fuel solutions are still up in the air: “We see a lot of questions about hydrogen, ammonia - and we don't know. Most of us know LNG as a fuel that meets and exceeds all regulations and demands. When it comes to the carbon discussion, clearly all of us know that LNG will have a significant role to play. As we then move to 2050 and on to zero per cent emissions, and for all its great performance, LNG... let's say we are looking at alternatives for the future. Is it hydrogen? Ammonia?

“One thing I will say - if you thought LNG was challenging, look at ammonia. It kills people if released in an uncontrolled manner. Hydrogen is another order of magnitude - its functional pressure for one thing. But I am confident that we will triumph.”

Another thing that frequently arises in these discussions is the availability of this newer fuel type in the supply chain. It

Important aspects

has always been a challenge, but can you imagine what it would be like getting a volume of hydrogen and ammonia to places like the Canary Islands in a volume that is usable?

Clearly, LNG has a role to play – it has the best-in-class performance that has been seen to date. There are also other pathways – biomethane, gasification of waste, liquefaction of that. If one looks at deep sea shipping, or at large ships in general, it is difficult to see any reliable solutions there – yet.

“We have a number of ships that are difficult to retrofit so we have to embrace alternative tech. As we move into the future, where are we going to see LNG fit in? We have the largest fleet of ships ready for shore-fuelling, there are only 2 ports in Europe where that fleet can fuel. We have to look at investing in infrastructure and energy improvements.”

Tom Strang

Senior Vice President of Maritime Affairs,
Carnival

There’s a lot that can be done with LNG, but it is not the answer to those distant zero per cent targets.

Hydrogen

Further criticism of hydrogen as a viable transitional fuel comes from Sjaak Klaap, VP of Business Development at Spliethoff, whose main concern is the volume of fuel required for longer journeys.

“Hydrogen is often spoken about, but the fact that it has to be manufactured is not. Most of it is produced from natural gas, and the carbon from that is released. So, when people talk about zero per cent, it just isn’t sustainable. Scalability

is also an issue – we are using more than 300 million tonnes of fuel on the world shipping fleets. And we aren’t even talking about commercial issues yet. Fuels like hydrogen – forget about it – it isn’t going to work! If we go to hydrogen on intercontinental routes – there would be no space left for cargo.

“So, let’s stop talking about hydrogen in deep sea shipping, because it’s pointless. I see very encouraging developments in the marine sector and the energy sector – electricity, that’s where we should focus. Whatever you call this fuel, there will be a place for everything – biofuel, cooking oil, whatever. We could go to McDonald’s three times a day, and we still wouldn’t have enough cooking oil. We cannot simply say that whatever we do on a small scale can be scaled up.”

Pricing systems

Following a conversation with Kwinten Standaert, the Key Account Manager at Fluxys LNG, Oil & Gas IQ learnt about the current ship-to-ship bunkering operations at Zeebrugge. What was particularly interesting was the transparency of tariffs, which put some small-scale numbers into the equation. An overview of those prices is below:

- > €1.1 per MWh for ship loading
- > €50 per m3 LNG storage per annum
- > €500 per truck loading

Working primarily with vessels of a capacity less than 30,000 m3, Mr Standaert believes that for vessels with smaller cargoes in particular - LNG will provide the best alternative to soon-to-be banned fuels.

“Certain options of fuel are no longer an option - such as heavy fuel oil, currently used for two thirds of shipping. It will suddenly be no option. Also, in terms of scrubbers, they will also no longer be allowed.”

Kwinten Standaert

Key Account Manager, Fluxys LNG

LNG is unequivocally seen as an equivalent for diesel or LPG and has a high energy density per kilogram and per litre. However, the price of LNG is not as clear, with “advancements being made by data providers all the time”, & the relative size of the market creating significant volatility.

Flow measurement

Speaking at a recent European event, Daniel Kemp of Emerson discussed the challenges of LNG measurement, from bunkering issues and custody transfer certification, to application and system complexity to energy content measurement.

Mr Kemp’s comments have been edited for brevity and clarity.

“In any automation process we are seldom looking at just the hardware, especially when you’re talking about bunker systems, where there is a whole process, or rather a whole series of processes taking place.

“First of all, a solid accurate measurement is vital. The end goal is to have an accurate mass delivery, and this conversion of volume to mass is where lots of errors occur. The Coriolis principle uses the movements caused by flow to work out the mass flow measurement.

“LNG bunkering is not new technology, it is simply a new application - in fact, it isn’t even that: all we’re doing is providing a flow of mass, something we’ve been doing forever!

“We encounter more and more companies prioritising energy content. One of the main things we are looking at is additional insight - a gas analyser provides that insight, far more useful than simply monitoring mass. This gives visibility on energy content throughout the bunkering process.

“The main variations in the process that we see are as follows: the bunker barge generating boil off and being returned to the bunker barge during offloading; the movement of gas, no longer liquified, that has returned as boil off to the bunker barge; and the content of the LNG.

“We then have to analyse the actual piping layout of the vessel itself. Any bypass valves are monitored to ensure there is an integrity all the way up to the receiving vessel. We then move on to what is really important!

“So, you’ve designed a system looking at mass flow, and you’ve looked at the layout of the piping, bypass valves, and so on. Now, you have this system going out to transfer and receiving vessels. This needs to be verified independently. MID is one such system that is an established certifying body ensuring wide acceptance of bunker delivery.

Pricing systems

"Titan LNG has a flex vessel that can bunker various quantities of between 30 and 450 m³ per hour. It has two independent certified systems: one very small line, and a larger flow meter on the stern. There is also a third, used for the boil off. They can monitor their jobs with small vessels with or without boil off, and the same with large vessels.

"The other vessel is the Karios, a large LNG bunker vessel owned by Nauticor LNG. On the bunker delivery note is the gas make-up, mass, and energy content of the cargo you are receiving.

"We started on land and we've continued to work on land. Enagas is a company we work with, using a MID standard when loading trucks. They can do complete measurements of cargo and boil off, and these sort of measures are vital to the future of LNG."



MAN Energy Solution's Dietmar Zutt has shed further light on developments to LNG engines by describing engines now being installed that can jump between a liquid fuel mode and a gas mode. This is just one way to deal with the "over-dimensioned" nature of many engines that have a certain operational mode requiring extra power, but therefore have to carry that extra size and bulk across all other operations. The nature of the work that MAN carries out is to get "more power with fewer cylinders".

There is also talk of a hybrid battery that will be validated in the next two to three years, and will offer zero omissions.

Diesel: a popular problem fuel?

The most popular fuel in many markets, including British Columbia's shipping industry, is ULSD or ultra-low-sulphur diesel. When switching to LNG, current estimates state that around 5,700kg of CO₂ emissions per day can be saved per vessel, or around 22 per cent. However, this astonishing saving can only be capitalised upon when vessels are at least 75 per cent capacity; with lower loads, the gap is much smaller - almost negligible at very low loads. So, what to do?

Working with Wärtsilä on the development of a new low load feature for their engines, Seapan has developed a feature that enables engines to cut off three cylinders, from nine down to six, when working on a small load. This allows the vessel to benefit from the environmental advantages of alternative fuels such as LNG without needing to be at over 75 per cent load.

"We had to manage a continual cultural change," said Mr Harley Penner, Seapan's Engineering Superintendent, "and work with captains and navigators to convince them that they could run with these new engines - and just the one." The engines used by Seapan have cylinder deactivation loads that can save over 15,000 kg CO₂ per day, which when combined with their emphasis on one engine wherever possible can save over 30,000kg per day. There are talks about a possible theoretical move to CH₄, but "whilst we do recognise that there are some changes which can be made to push on with our mission for efficiency, you've got to grab the low-hanging fruit first."

Fleet and regulations

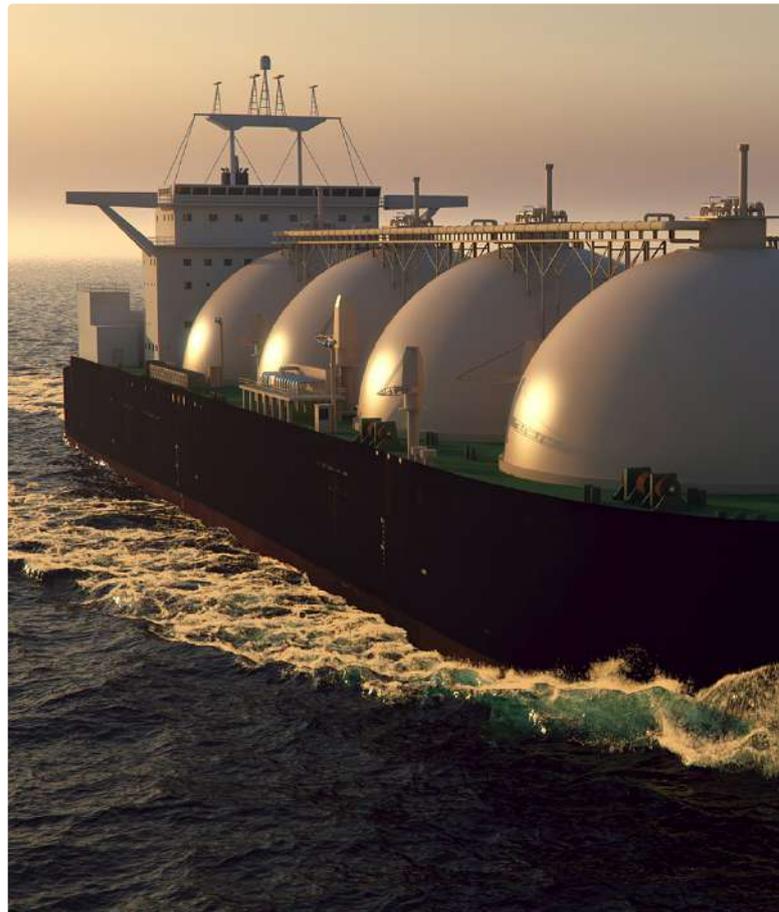
LNG is seen as the best solution to addressing the stringent IMP regulations in the mid-term, making the option especially appealing for a newbuild. However, to reduce global emissions by 50 per cent from their 2008 levels and lowering CO2 emissions per transport work by at least 70 per cent by 2050 will require the development of alternative fuels, as LNG will not be able to meet those deadlines.

“It’s nice to see so much interest in LNG. We started with shipping in 1946 with a single vessel but have now expanded into what we are today. We have vessels with Spliethoff, Biglift, and Sevenstar Yacht Transport, and of our whole fleet - only 0.0001 per cent is not on liquid fuel (including LNG). LNG is indeed the fuel of the future - I mean, we are 99.9 per cent on liquid fuel. All we need to do is to get more customers on board.”

Sjaak Klaap

VP Business Development, Spliethoff

However, with 10 per cent of the global fleet now older than 20 years, and more than a quarter older than 11 years, both retrofits and newbuilds will abound.



Conclusion

LNG is an important part of the future energy mix – perhaps not the catch-all solution it is often thought of as being in the sector, but nevertheless worth pursuing. Its proliferation worldwide is increasing apace, and ever-stricter regulations will continue to drive change. The price gap between LNG and more conventional fuels will most likely widen, but success stories such as those featured in this report should encourage further investment in this growing field.

“We are predicting steady growth in the sector – there will be no gold rush, no free beer tomorrow. We expect 23 per cent of fuel usage to be LNG by 2050, up from less than one per cent in 2015.”

Oscar Kallerdahl

Vice President of LNG Systems, Rolls Royce

Frank Hartevelde, Director of Sales & Marketing at Wärtsilä describes the outlook brilliantly: “When we talk about the future, are we actually thinking enough about our future – are we thinking about what will the world look like in 2050? If we don’t know the answers, then how can we expect our children to? But there is a call to action – so we should start developing zero emissions solutions instead of sticking our heads in the sand. Many questions are now immediately showing up: if we have to invest in all this new technology, when will it start paying back?”

If we are talking about clean energy and clean environments, the Paris agreement is very important to drive this business. But on the other side we do see the depletion of resources as a major question mark over it all. It is also worth mentioning the IMO ballast water convention, despite it being delayed.

Major players in the industry have to shape this market, and there is a need for another way of thinking because at the moment we are still thinking as we have thought for the last 40 years. Now, when we are constructing a ship, we

need to be innovative and prepare a ship for the future. In 2005 or 2006, vessels were ordered en masse, but last year it was under two thousand. So, ship producers are so eager to get the contract, the shipyards have to say “we have a specification that matches that” because otherwise they won’t win this project. But companies are not actually pushing the fact that their vessels, which will last for 25 or 30 years, may still be around in 2050.

The availability of LNG at present is a fraction of what we need for this long-term plan. It is nevertheless an exciting time.

