Chapter 2

Challenges and Initiatives for LNG Supply Security in Asia

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Chapter 2
Challenges and Initiatives for LNG Security in Asia

2-1. Why Is Supply Security Relevant in the Current LNG Market Context?

Supply security has been one of the major goals for all energy policy makers, particularly in import-dependent Asian countries; it is never a new nor unfamiliar topic in the region. Yet, under the ongoing LNG market developments, ensuring supply security is gaining more and more significance.

While the LNG market experiences unprecedented market expansion, serious discussions with consumers about supply have been nonexistent. Platforms such as Gastech, the World Gas Conference, and the LNG Producer–Consumer Conference have been used as an opportunity to discuss various issues, including gas supply security, but there is no platform that specifically deals with the issue.

Despite world LNG demand having grown by 1.7 times from 2007 to 2017, and the number of LNG importing countries having more than doubled from 17 to 39 during the same period, there is no official framework where LNG consumers can share the issues and countermeasures about gas supply security like the International Energy Agency in the oil market. The international LNG market is expected to be in a supply surplus condition where liquefaction capacity largely exceeds demand for the time being; any serious supply security issues have not emerged so far, despite rapid market expansion. Yet as the demand from China and other Asian emerging buyers has grown at an unexpected speed, the 'rebalancing' moment of the LNG market from supply surplus to supply shortage may come earlier than widely perceived, that is, in the early 2020s. Supply security risk will be recognised as a more acute issue amongst market players once the market is in a more strained condition. Policy makers in Asia now need to revisit supply security in the LNG market, identify the issues, and consider policy actions.

2-2. Investments in Value Chain

2-2-1. Growing Importance of Upstream and Liquefaction Investments

Supply security in the LNG market will be a function of two elements: value chain investments and market creation. Sufficient supply infrastructure must be in place to ensure security.

Sustained investment to the whole value chain from wellhead production, liquefaction, transportation, and, finally, to re-gasification, must also be secured. In the liquefaction capacity, after the oil price collapse in the summer of 2014, only a handful of projects had reached final investment decision (FID) per year. Since 2017, when crude oil prices began to recover, the conditions for FID have significantly improved because the balance sheet of the O&G industry has improved and the demand growth from emerging countries has become more evident.

Despite this improvement in the investment environment, only two projects (Corpus Christi Project Train 3 and LNG Canada) have achieved FID so far in 2018. While the nature of liquefaction projects requiring huge upfront investment and long-term recovery of investment remains the same, many buyers are willing to commit only to shorter-term purchases and are seeking more volume flexibility as part of longer-term purchase agreements. The divergence of interests between sellers and buyers has widened, which is contributing to the apparent slow pace of new FIDs. Traditional patterns of risk allocation are not adequate to get LNG development commitments from sellers. Buyers and sellers will need new strategies to allocate the long-term development risks to realise liquefaction capacity expansion as demand grows.

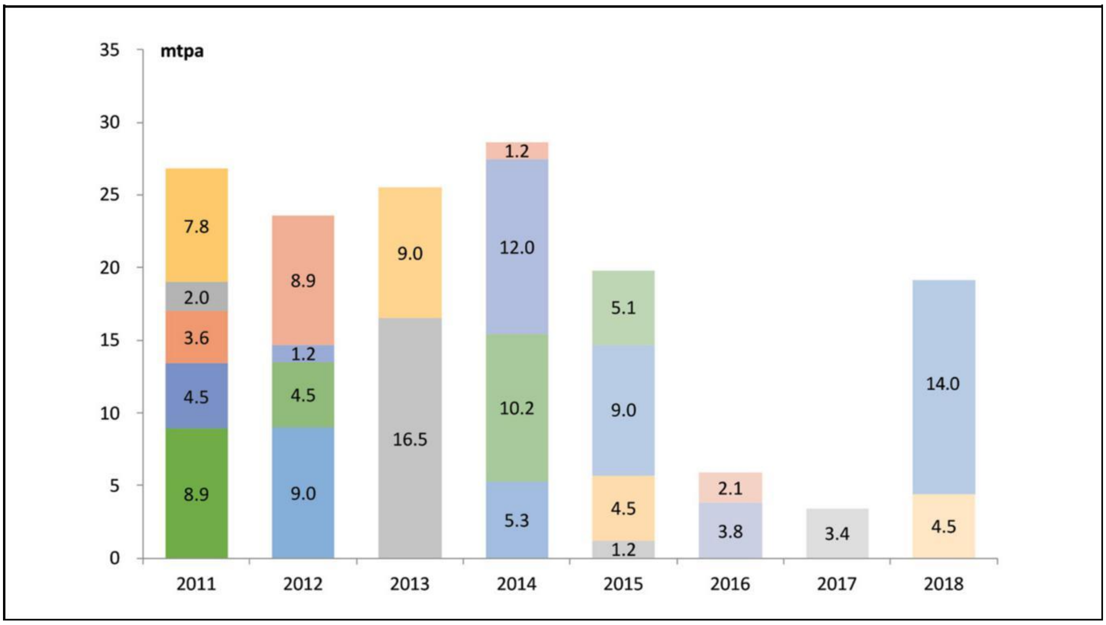
Some exporters plan to proceed without long-term purchase commitments. For example, Qatar announced plans to expand its liquefaction from 77 million tonnes per annum to 100 million tonnes per annum by 2024. Mr. Al-Kaabi, CEO of Qatar Petroleum, suggested the country's liquefaction capacity can be raised to 110 million tonnes per annum. These new supplies, if realised, will also help to meet growing LNG demand in Asia. Figure 2-1 shows FID for global LNG projects since 2011.

Due to the physical nature of natural gas, supply infrastructure (pipelines) must be built to each individual consumer; thus, the creation of natural gas demand has the same meaning as investment in the downstream sector in an emerging natural gas market. As last year's report shows (ERIA, 2018), US$80 billion downstream investment is required to meet the growing natural gas demand in Asia.[3] Natural gas demand has been growing in Asia, but growth is still checked by the limits of downstream investment so that demand potential is

[3] Countries in this category include members of the Association of Southeast Asian Nations (ASEAN), and India.

not fully realised. Accelerated investment in the downstream sector is equally required to develop the LNG market.

Figure 2-1. Final Investment Decision for Global LNG Projects Since 2011
(capacity in million tonnes per annum: mtpa)



Note: Different color shows different project capacities
Source: IEEJ based on corporate press releases

2-2-2. Ensuring Legitimacy in an Investment Project

Securing a project's legitimacy during its formation and development becomes increasingly important. Understanding the rationale for the project, why a specific developer is chosen from several other companies, and why the location was selected must be determined in a transparent and convincing manner. In Asia, LNG-related projects such as Gas to Power or FSRU installment sometimes have been done on a private and bilateral basis. Such a negotiation style may enable the host government and prospective project developer to have close and intensive discussions and to share more privileged information with each other to fast-track the project. The development process, however, may be perceived as lacking transparency, and thus the project may lack legitimacy in the host country. Perceived lack of legitimacy may cause interruption or even cancellation depending on the political and economic conditions of the host country. Some of the ongoing negotiations of the project development therefore may contain an inherent risk of interruption or cancellation. The project developer is required to ensure the project's legitimacy to manage such risk.

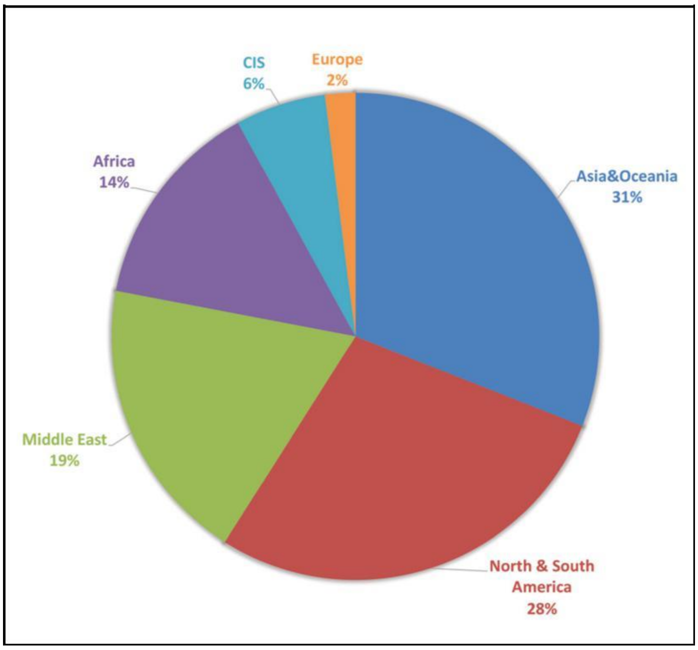
2-2-3. Export Credit Assistance and Other Official Assistance Programmes

The Japan–US Strategic Energy Partnership (JUSSEP) consists of a wide range of joint projects across the energy value chain. Of special importance is the joint effort to expand natural gas electric power generation and re-gasification facilities in Asia and US LNG export facilities, for which export credit or other official assistance programmes are key, as last year's report (ERIA, 2018) pointed out. Official credit and financial assistance for these programmes includes direct involvement of export credit and trade development agencies of both governments. These agencies address political or commercial risks inherent in building out power generation and re-gasification facilities. Government-supported agencies such as the Export-Import Bank of the United States, OPIC, US Trade Development Administration (USTDA), Japan Oil Gas and Metals National Corporation (JOGMEC), JBIC, and NEXI have all been directly involved in LNG projects in the US and throughout Asia.

Several initiatives are worth noting. JOGMEC has provided financial assistance through equity capital and loan guarantees of US$5.8 billion for oil and gas upstream development (including LNG export projects) worldwide. The distribution of equity capital by region is shown in Figure 2-2. JOGMEC's Value Chain Training Program, beginning in 2018, provides capacity building for nine local industry experts and regulatory officials in energy policy, legal structures, facilities development, and transportation solutions for the development of electric power stations, natural gas distribution networks, and LNG re-gasification facilities.

JBIC has been active in supporting LNG projects, and has extended project finance to the Cameron and Freeport LNG projects. For these, JBIC has also extended financing for vessels to bring LNG to Asian markets. These projects have been deemed important for Japan as they contribute to the ability of Japanese utilities to manage LNG price spike risks. Also, as destination restrictions are absent in US projects, they improve the competitive market for LNG in Asia. JBIC played an important role in financing for expansion of the Panama Canal as well, a critical low-cost transport route to Asian markets.

Figure 2-2. JOGMEC-Supported Equity Capital for Upstream Oil and Gas Projects by Region



CIS = Commonwealth of Independent States, JOGMEC = Japan Oil Gas and Metals National Corporation.
Note: The total amount for the equity capital is US$5.3 billion.
Source: JOGMEC.

NEXI has also been active in providing political risk insurance for both Japanese and US businesses that are jointly undertaking LNG projects. Amid international consensus on the benefits of developing LNG markets, NEXI has also shifted its mandate from supporting infrastructure projects only if they supplied LNG to Japan to supporting the projects if they involve Japanese companies (such as Japanese exporters, equity investors, operators, or off-takers). NEXI has provided insurance guarantees for several LNG import projects in the Indo-Pacific region, which have contributed to the regional gas supply security, as well as to US LNG projects. Table 2-1 shows recent projects where NEXI is participating, along with the amount of financial insurance.

Table 2-1. Recent NEXI-Insured Projects

Year	Country	Project	Insurance Amount (US$m)
2016	Indonesia	Tangguh LNG Project Expansion	Non-disclosure
2014	Indonesia	Donggi-Senoro LNG Project	382
2014	US	Freeport LNG Project	1,150
2014	US	Cameron LNG Project	2,000
2012	Australia	Ichthys LNG Project	2,750
2009	Russia	Sakhalin II LNG Project	1,400
2009	Papua New Guinea	PNG LNG Project	950

LNG = liquefied natural gas, NEXI = Nippon Export and Investment Insurance, PNG = Papua New Guinea.
Source: NEXI.

The Japanese government and Japanese companies have a strong interest in developing LNG and power projects in the Indo-Pacific region, since a growing LNG market provides fuel diversity and energy security. The Asian LNG market is on a trajectory to more than double by 2030; this growth will require over US$80 billion in infrastructure investments. In particular, Asia is set to play a larger role in global gas-to-power demand by 2030.

US government agencies, including USTDA and OPIC, have also launched several initiatives aimed at developing gas and LNG markets in the Asia-Pacific region. USTDA announced the US Gas Infrastructure Exports Initiative, which is designed to connect American companies to new export opportunities across the gas value chain in emerging economies. As part of the initiative, the USTDA has identified project sponsors in high-growth emerging markets for gas-related project proposals for US companies.

OPIC, which provides financing through loan guarantees to allow American businesses to take advantage of commercially attractive opportunities in emerging markets, has also launched an initiative to promote LNG markets in the Indo-Pacific region. OPIC expressed its intent to support Virginia-based AES for construction of an LNG receiving terminal and a 2,250-MW, combined-cycle power plant in Viet Nam, which would provide around 5% of the country's power generation capacity and support its continued economic development. This initiative is a step to facilitate critical investment into Viet Nam's energy infrastructure and gas supply chain.

2-3. Market Creation

2-3-2. Making the Market Work

Ensuring the LNG market works is the other critical element of gas supply security. In cases where an unexpected supply disruption happens or an unexpected demand surge occurs, as was observed in Japan after the great earthquake in 2011, marginal supply must be shipped to the highest priority buyers through market mechanisms and price signals. As in the international oil markets, if several spot cargoes are actively traded, and enough liquidity exists in the market, an emergency demand can be absorbed by such market transactions, with limited impacts to the price level.

Under the current LNG trading system, flexible allocation of cargoes is not easy due to the existence of destination restrictions in the traditional long-term contracts. Even if diversion is allowed with the consent of the seller in the contract, cumbersome procedures may have a chilling effect for the buyers to divert the cargo. The LNG market is still too inflexible to allow for optimal allocation of LNG cargoes in an emergency. While the removal of destination restrictions is often cited as essential to realise a more transparent LNG price discovery, as well as to create a more reliable LNG price benchmark, it has another imperative to ensure supply security to LNG importers. Promoting such developments and urging the market player to be more active in spot trading are needed to enhance and strengthen the resilience of the world LNG market.

Increased exports of US LNG, which provides Asian buyers with another supply source besides the Middle East, Oceania, and Russia, is expected to play a major role in enhancing supply security. Although there is relatively low dependence on geopolitically unstable countries for world LNG supply, emergence of new and large-scale supply capacities in the US will bring numerous supply security benefits for Asian importers. Another advantage of the US LNG supply is that it does not have destination restriction, and therefore can forego any process to obtain seller's consent to redirect the cargo destination, thus making it a convenient and effective source.

2-3-3. Updates on Destination Clause Removal

Japan Fair Trade Commission's (JFTC) study on the trading practices of the LNG market in June 2017 reviewed three provisions in the long-term LNG contract, namely, destination restriction, profit sharing, and take-or-pay (JFTC, 2017). The findings are:

- Destination restrictions in the contract are likely to violate Japan's Anti-Monopoly Act (AMA) for Free on Board contracts. As for delivered ex-ship contracts, these types of restrictions are likely to violate the AMA when a seller refuses to consent to diversion, even if a buyer's request is necessary and reasonable.
- Profit share clauses are regarded as unfair trade practice for Free on Board contracts. As for delivered ex-ship contracts, they are likely to violate the AMA when they cause unreasonable profit sharing with a seller, or when they discourage a buyer from reselling because of the seller's request to disclose the deal information.
- On take-or-pay, the study finds that imposing the clause may limit competition when a seller's negotiation position is stronger than that for buyers, as they may unilaterally impose the clause without enough negotiations after the investment is already recovered.

The study urges Japanese buyers not to accept the above clauses in the new and renewed long-term contract, and to review competition-restraining practices for the existing contracts.

The study had a triggering effect on several new developments in the LNG market. Several Japanese buyers succeeded in removing destination restriction clauses from new long-term contracts (JERA, 2017; Tokyo Gas, 2018). As a similar development in other regions, DG Competition announced that it will start reviewing the existing LNG long-term contract by EU member countries with Qatar to check whether it has a clause to limit free movement of natural gas (European Commission, 2018). Similar studies by anti-monopoly authorities of other countries, such as the US Federal Trade Commission or the Korea Fair Trade Commission, if conducted, would deepen the discussion about the appropriateness of destination restrictions in the context of fair market competition.

LNG development is inherently risky for both sellers and buyers because of the large, long-term financial commitments necessary to bring a project to FID. Destination restrictions remove a major risk diversification option for buyers who might be willing to make such a commitment as long as they have an alternative outlet for contracted LNG shipments. A likely outcome of persistent destination restrictions is lower volumes of worldwide LNG exports and a more expensive and smaller market for natural gas power development and re-gasification facilities.

2-3-4. Development of a Reliable LNG Benchmark and Pricing Indices

An established and widely used price benchmark will facilitate active spot trading, which, in turn, will solidify the position of the benchmark. Physical trading activities reinforce the reliability of price benchmarks as observed in the international crude oil market. The LNG market is unique amongst commodities for which a spot benchmark is not referenced in the price formula of the term contract pricing. Creation of a reliable benchmark is an important task for making LNG a more commodified product.

Several benchmarks have been proposed by futures markets, price reporting agencies, and online trading platform companies, but none have been established in the LNG market like the West Texas Intermediate Crude Oil Benchmark Price or Brent benchmarks in the crude oil market. One of the reasons behind the gap in pricing is insufficient spot transactions and stakeholders' reluctance to disclose the price level of their own transactions in a timely manner. Although the spot activities per se have grown significantly in the last decade, they have not reached the level that causes a sustainable influence on the long-term contract prices.

2-3-5. Connection with Atlantic (European) Markets

Interactions with Atlantic natural gas markets will be one of critical features of the future Asian LNG market. The European natural gas market in particular is regarded as a 'balancing place' for the world LNG market, and active cargo transactions will enhance Asian market supply flexibility. This is because the European market has various supply sources, such as domestic gas production and pipeline imports from Russia and North Africa, alongside LNG. Europe also has a large storage capacity at around 5.0 trillion cubic feet (Tcf), as compared to 1.4 Tcf in Asia, and this can absorb seasonal demand fluctuation. This flexible supply generated from the removal of destination restrictions or increased exports from the US liquefaction capacity will enable more intense cargo transactions amongst LNG markets in the world, particularly with European markets. This will improve supply flexibility and secure Asian market supply.

2-4. New Demand Creation: LNG Bunkering

2-4-1. Overview

Bunkering had its origins during the early nineteenth century when the earliest commercial steamships began to be developed. The first fuel for these steam-powered vessels was primarily coal that was stored at ports in large fixed containers known as bunkers. With the expansion and shift in marine fuel types, bunkers and bunkering broadened to reference all aspects of storage, handling, and delivery of fuels used by marine vessels.

From 1907 to 1909, per direction of President Theodore Roosevelt, a portion of the US Navy dubbed 'The Great White Fleet,' sailed the world. Separate from its political goals, it sought to make an operational assessment of the readiness and requirements of its capabilities. Refueling at ports along the way to acquire coal took place every two weeks. Because the coal at these different ports had inconsistent energy content, coupled with a large amount of soot, ash, and other debris, the US decided to shift its fleet from coal to petroleum products that were cleaner-burning and whose energy content was more uniform and predictable.

Similar concurrent determinations were made elsewhere that together augured the global shift from coal to petroleum-derived fuels for marine vessels. Just as steamships were shown to have greater dependability and timeliness than sail, so too did steam-powered ship propulsion systems begin in the 1930s to be displaced by motor ones because of their ability to move larger ships at higher speed. During the mid-1960s, more than half of the world's fleet was motor-driven; by the beginning of the twentieth-first century, this proportion had risen to 98%.

Long-haul commercial global maritime traffic has developed into two general forms:

- liner shipping, the primary one, which operates on fixed schedules and routes with established ports of call; and
- the 'tramp trade,' which has no fixed schedules or list of ports of call.

The largest bunkering hubs by sales volume are Singapore (42.4 million mt), Fujairah (24 million mt), Rotterdam (10.6 million mt), Hong Kong (7.4 million mt), and Antwerp (6.5 million mt). They account for almost 60% of global bunker sales. Coinciding with the development of liner shipping, these bunkering hubs prospered by being both port facilities along major maritime routes, as well being close to major refining centres. Their location has ensured that long-haul liner vessels deviate little, if at all, from their respective voyages, avoiding time and financial costs when bunkering. Refinery proximity means that there is minimal fuel transportation cost and little chance of shortages. Bunkering (refueling) can be done while cargo loading and unloading takes place. Tables 2-2 and 2-3 below offer summary views on bunker markets, vessel numbers and sizes, and fuel requirements.

Table 2-2. Global Shipping Fleet by Category and Tonnage for 2017

Category	Number of Vessels	DWT (million)	% of Total DWT	Average DWT/Vessel
Oil Tankers	10,152	535	28	52,685
Bulk Carriers	10,884	797	43	73,188
General Cargo	19,601	75	4	3,817
Container Ships	5,154	246	13	47,654
Other	47,370	210	12	4,433
Total	93,161	1,862	100	19,985

DWT = dead-weight tonnage.

Source: United Nations Conference on Trade and Development.

Table 2-3. Global Fuel Consumption by Ship Type in 2015

Category	Fuel consumed (mte LNG)	Number of vessels	Average consumption (mte LNG)
Container	52.5	5,009	10,491
Bulk carrier	43.6	10,650	4,097
Oil tanker	31.6	6,395	4,938
Chemical cargo	14.2	4,720	2,999
General cargo	13.2	10,973	1,202
LPG/LNG tanker	12.7	1,687	7,509
Cruise	9.6	477	20,170
Ferry (ro-ro and pax)	10.2	5,288	1,933
Vehicle/co-co	11.4	2,236	5,658
Service	8.8	25,317	397
Refrigerated	3.8	4,876	779
Offshore	3.5	785	4,477
Other + Unclassified	23.0	21,021	1,094
Total	238.1	99,434	2,393

LNG = liquefied natural gas, LPG = liquefied propane gas, ro-ro = roll on/roll off.

Source: DNV & ICCT Data from OIES

2-4-2. Regulatory Shifts

Currently, the array of bunkering fuels is on the cusp of a major shift. While it might not be as disruptive as the transition from sail to steam, it is as significant as the transition from coal to petroleum-derived fuels. The primary driver is the International Maritime Organization's (IMO) decision to drastically curtail sulfur emissions in bunker fuels.

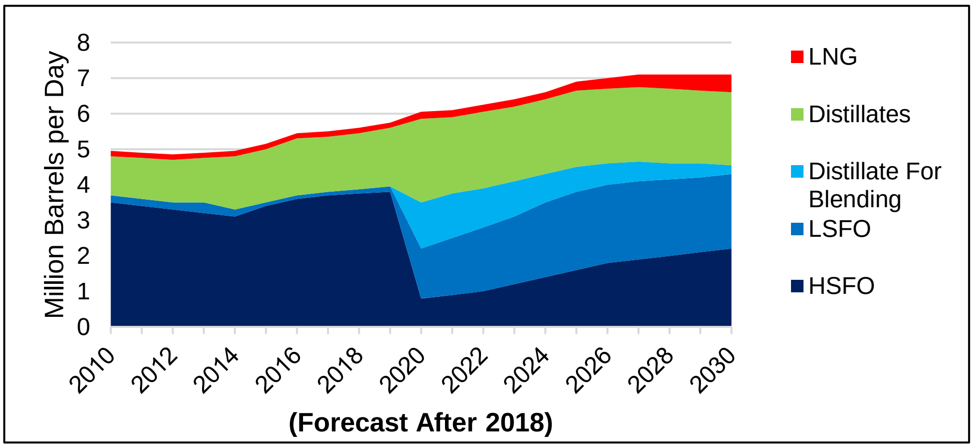
On 27 October 2016, the IMO, an agency of the United Nations, announced that it would require marine fuels' maximum sulfur levels to be reduced to 0.5% from current maximum limits of 3.5%; this rule is set to be binding on 1 January 2020.

There are two reasons for the mandate:

- to protect human health, given that marine vessels are a major source of sulfur pollution in coastal cities (ships contribute about 13% of total sulfur-dioxide emissions; this is more than 2,000 times the level allowed for motor vehicles on US highways); and
- to protect the global environment.

This ruling is the most recent in a series that began with the first IMO rule enacted in 1983. Currently, there are over 90,000 marine vessels; all are subject to the IMO decision. Each of the constituencies that are involved and/or subject to this rule agree that there will be major impacts on all fossil-derived fuels. However, there is no consensus amongst forecasts on the demand size of different marine fuel types after this rule goes into effect.

Figure 2-3. Potential Displacement of HSFO with Other Fuels



HFSO = high-sulfur fuel oil, LNG = liquefied natural gas, LSFO = low-sulfur fuel oil,
Note: Analysis based on various sources.

2-4-3. Overview of Bunker Markets, IMO Compliance, and EmCAs

Currently, marine fuel demand is approximately 6 million barrels per day (MBD). Of this, about 3.3 MBD is high-sulfur heavy fuel oil (HSFO), 2.5 MBD is low-sulfur heavy fuel oil (LSFO) and middle distillates, and 0.2 MBD-equivalent (or 3% of 6 MBD) is LNG. Breaking this down further, about 2 MBD of the 3.3 MBD of HSFO will have to be displaced by other low- or non-sulfur fuels. Currently, there are four foreseeable solutions:

- use LSFO;
- install or purchase vessels with scrubbers, devices that are attached to exhaust systems to remove polluting matter such as sulfur;
- use variants of middle distillates such as marine gas oil (MGO) or marine diesel oil (MDO);
- convert to or purchase LNG-fueled vessels.

Already, high-sulfur marine fuel consumption is restricted in certain continental coastal areas; these are known as Emission Control Areas (EmCAs). Since 1 January 2015, only fuels with a maximum of 0.1% sulfur content are allowed in EmCAs, which include:

- the Baltic Sea EmCA (adopted 1997, enforcement began in 2005);
- the North Sea EmCA (adopted 2005, enforcement began in 2006);
- the North American EmCA, including most of Canada and the US (adopted 2010, enforcement began in 2012); and,
- the US Caribbean EmCA, including the US Virgin Islands and Puerto Rico (adopted 2011; enforcement began in 2014).

China has its own EmCA, where a 0.5% sulfur limit came into effect in 2018.

2-4-4. IMO 2020 Policy Compliance Options

LSFO

LSFO requires no fundamental capital change from a shipping operator’s perspective. However, additional desulfurisation is costly, thereby raising consumers’ overall fuel prices.

Scrubbers

Scrubbers allow shipping operators to continue using HSFO. However, the retrofitting costs average about US$4.5 million per vessel, with the possibility of reaching as high as US$10 million. Operators are then faced with the dilemma of disposing of the sulfur-contaminated residue: release it into the sailing waters or store it onboard for port disposal.

Looking at the business case, scrubber investment becomes compelling if the HSFO-LSFO price differential is wide enough. By example, a typical Aframax vessel consumes almost 100,000 barrels of fuel oil per year. If the differential is such that HSFO costs US$5.5 million less per year than LSFO, then a US$4.5 million scrubber investment is economically prudent.

MGO/MDO

Low-sulfur MGO and MDO offer another alternative to satisfying IMO 2020 compliance. However, like LSFO, these fuels will be costlier because of the need for more desulfurisation, as well as to divert refinery streams from other fuel production and markets, notably the heating oil, diesel, and jet fuel pools. Furthermore, there is concern regarding the availability of low-sulfur MGO and MDO. In anticipation of the IMO ruling, fuel producers have tested several MGO and MDO fuel formulations, but have not announced their respective commitment to which one to use. This elevates the uncertainty of what types of fuels will be available when the IMO ruling comes into effect.

LNG

Of all the available fuels, LNG produces no meaningful sulfur-dioxide pollution. It also contributes significantly to the reduction of particulate and nitrous oxide emissions. While on an energy basis natural gas is considerably less costly than petroleum-derived fuels, LNG's critical drawback is that it has less energy density than fuel oil. Therefore, LNG-fueled vessels require larger onboard tank capacity, and the need for more bunkering facilities along maritime routes because of the necessity to refuel more frequently. In addition, current estimates put the cost of LNG-fueled vessels at US$8 million to US$12 million higher than comparable oil-fueled ones with a longer investment recovery period than scrubbers (up to 3 years).

2-4-5. Possible IMO 2020 Compliance Scenarios

The whole supply chain sees the IMO implementation challenge as perplexing. With fuel representing between 60% to 80% of a shipping operators' costs, the lowest cost alternative is obviously the most appealing. Since three of the compliance alternatives require some sort of capital investment, the challenge then becomes to estimate the direction of fuel prices (as one headline correctly summarises the situation: '[The] Multibillion-Dollar Quandary: Buy Cleaner Fuel or a Fuel Cleaner?'). The most likely compliance path is expected to be greater reliance on low-sulfur fuels, whether they are LSFO, low-sulfur MGO, or MDO. Nevertheless, scrubber and LNG alternatives are expected to be significant.

Currently, the IMO expects there to be 3,600 vessels with scrubbers by 1 January 2020. Most market analysts see this forecast as being aggressive with the general view being closer to between 1,500 and 2,000 vessels. However, once the IMO 2020 sulfur rule compliance modalities become clearer, and fuel price spreads return to stability and clarity after 2020, these same market analysts expect scrubber installations to increase to approximately 8,000 in 2025, and another 50% above the 8,000 units by 2030, or about 15% of marine vessels.

Unequivocally, all forecasts of LNG marine consumption show that demand growth will be spurred the most by the IMO 2020 sulfur rule. However, the range of forecasts varies considerably. Conservative estimates foresee LNG comprising 7% of global bunker demand by 2030; more aggressive ones project 30% in this same interval. Currently, there are about 650 vessels that can use LNG. However, most of these ships (about 525) are involved in the LNG supply chain—tankers, bunker vessels, or floating, production, storage, and offloading vessels) and consume 'boil-off' (LNG which gasifies while vessels are in transit). About 70 LNG-consuming vessels are medium-to-large ships, including tankers, containerships, and bulk carriers. They account for about 1 million LNG tonnes of consumption per year. The balance are smaller intra-regional ships, the bulk of which are car/passenger ferries in the EmCAs, primarily the Baltic and North Sea ones, the areas with the strictest EmCAs.

There are currently approximately 135 LNG-fueled vessels on order for near-term delivery. Of the large, long-haul variety, this includes 33 tankers, 23 cruise ships, and 20 container ships. Altogether, these additional LNG-fueled vessels represent between 1.2 and 3 Mtpa of new LNG demand, as shown in Table 2-4.

Table 2-4. LNG-Fueled Vessels in Use or Under Construction as of May 2018

	In Operation	Under construction	Proportion of total fleet (in %)	Potential LNG consumption ('000 tonnes)
Container	3	21	0.48%	251.8 to 609.3
Oil + Chemical tanker	10	33	0.40%	176.9 to 553.2
Bulk carrier	3	3	0.06%	24.6
Ferry & ro-ro	41	25	0.98%	149.8 to 466.9
General cargo	4	2	0.05%	7.2
Liquefied gas tanker	18	0	1.07%	135.2
Service/tug/psv	31	9	0.13%	16.3
Cruise	0	18	4.82%	463.9 to 1,154.7
Vehicle	2	2	0.49%	31.1
Other	9	17	0.12%	16.4
Total	121	135	0.26%	1,273 to 3,015

LNG = liquefied natural gas, psv = platform supply vessel, ro-ro = roll on/roll off.
Source: DNV & ICCT Data from OIES

With the IMO 2020 sulfur ruling, bunker fuel markets are set to become fragmented: no longer is there a simple choice between a small number of hydrocarbon fuels. Now, the choice has expanded, and this has raised questions regarding fuel availability across all bunkering hubs.

Furthermore, and critically, it is important to add that the IMO 2020 sulfur rule will not be IMO's last. Currently, there are continuing discussions and meetings regarding a subsequent ruling regarding greenhouse gas (GHG) emissions. IMO ruling discussions and negotiations can go on for years and are of indefinite length. This creates considerable uncertainty for entities that are subject to IMO's rulings regarding managing compliance issues. Some entities have short investment time horizons of 5 years. Others have longer ones that go out to 30 years.

IMO's GHG ruling will seek significant reductions in emissions. While the timing of the final ruling is uncertain, already the IMO has committed to a 7-year evaluation plan, with a three-step approach: data collection, data analysis, and decision-making on what further measures may be required. The goal is to have an objective, transparent, and inclusive policy debate regarding the implementation of targeted emission limits.

Those maritime operating entities that have long-term horizons already are factoring future IMO rulings, especially with regard to GHG emissions, into their investment decisions. In these contexts, LNG becomes particularly advantaged; not only does it offer strict compliance with the IMO 2020 sulfur rule, as well as low nitrous oxide and particulate emissions, it has half the GHG emissions of petroleum-derived fuels. Lastly, LNG has operating cost advantages. For example, given that LNG is cleaner than fuel oil, engines and associated equipment will need less maintenance and last longer.

2-4-6. Additional LNG Considerations - Operations, Policy, and Case Studies

For LNG-fueled ocean-going vessels to be possible, existing ports need LNG bunkering capabilities. As previously mentioned, bunkering hubs are located at major ports along key maritime routes. Given that LNG has lower energy density, LNG-fueled vessels will either need larger tanks (thereby displacing valuable cargo-carrying capacity) or more bunkering hubs on long-haul routes.

There are two ways that LNG bunkering can take place: ship-to-ship fueling; and shore-to-ship. LNG bunkering vessels store LNG and travel to ships so that they can be refueled. This is particularly useful with large vessels such as containers that have difficulty maneuvering in tight ports or getting to shore-based fueling. Appendix Table 1 (LNG Bunkering Vessels – Current and Planned) lists all current and planned LNG bunkering vessels. Many of these listed were commissioned in 2017 and 2018.

The overwhelming majority of shore-to-ship fueling is in northern Europe. Thanks to longstanding Baltic and North Sea EmCA initiatives (see earlier discussion on EmCAs in this section) targeting not only sulfur oxide, but also nitrous oxide and particulate emissions, demand was increased for ships to have alternative fueling options, including LNG along with accompanying infrastructure. All coastal vessels voyaging within these EmCAs cannot deviate from these rigorous requirements.

TEN-T initiative

Furthermore, the EU has the Trans-European Transport Networks (TEN-T) initiative. Started in 1996, TEN-T seeks to coordinate, integrate, and improve all transportation systems within the EU, including ports and coastal waterways. With EU Directive 94 promulgated in 2014, all TEN-T core ports need to be equipped with some combination of LNG bunkering and shore power facilities by 2025. This would include not only ports within the Baltic and North Sea EmCAs, but also those along the Atlantic Coast and Mediterranean. In 2017, this directive was extended to include all EU Eastern Partnership countries.

The Singapore Initiative

In October 2016 at the Singapore International Bunkering Conference, representatives from the port authorities of seven major trading countries (Belgium, Japan, Norway, Netherlands, Korea, Singapore, US-Jacksonville, Florida) signed an MOU on the Development of LNG as a Marine Fuel. The goal of this MOU is to form a network of terminals to promote LNG bunkering, as well as to harmonise standards and specifications. This network has since been expanded to include French, Canadian, and Chinese port authorities.

2-4-7. Case Studies

Japan

Several factors favor Japan's ports and LNG facilities as key components to foster the development of LNG bunkering in Asia. First, Japan has 35 LNG terminals along its coasts, each of which has sizeable storage facilities. Second, as Japan's domestic LNG demand plateaus and possibly softens with the restart of its nuclear-powered plants, excess storage capacity can be directed to LNG bunkering uses. Third, Japan's geographic location, and, more specifically, the port of Keihin (comprised of Yokohama, Tokyo, and Kawasaki), is optimally situated on the North Pacific route between Asia and North America. Keihin is the first discharging port for westbound long-haul vessels, and the last loading port for eastbound ones. Furthermore, the port can accommodate a variety of vessel types and sizes. Last, weather conditions at Keihin are rarely adverse; therefore, the port is safely accessible year-round.

Already, a consortium comprised of Sumitomo Corporation, Uyeno Transtech, and Yokohama Kawasaki International Port are taking the initial steps to begin LNG bunkering operations. Via joint venture, this consortium is set to commission ship-to-ship LNG bunkering in Tokyo Bay (port of Keihin) projected to start in 2020. Established in May 2018, another joint venture made up of Chubu Electric Power, Toyota Tsusho, and NYK Line hopes similarly to start ship-to-ship LNG bunkering in 2020 at the port of Nagoya in the Chubu (Central) region of Japan.

China

In August 2018, China's Ministry of Transport issued a draft timetable for developing LNG bunkering. The timetable requested commentary from parties of interest including maritime operators and authorities, trade groups, and NOCs. The draft specified few details, but was aggressive in delineating specific milestones: by 2020, the Ministry hopes to have basic operating standards and the foundation for future infrastructure development in place; by 2025, it seeks to develop a comprehensive and technologically advanced water transportation for LNG.

The latter would include a minimum of 15% of new state-owned vessels and 10% of new vessels operating on major inland waterways. Under the initiative, key regions to be targeted are the Beijing-Tianjin-Hebei (Bohai waters) metropolitan region and the Yangtze River Delta. In addition, the plan seeks to establish two international LNG bunkering hubs. Also, in August 2018, China's Ministry of Finance issued directives granting tax exemptions to LNG-powered ships, as well as directing local authorities to reduce transit fees and prioritise port access for LNG-powered vessel operators. Combined, these regulations seek to establish a broad, commercially viable LNG bunkering market.

Most of the construction and retrofitting of LNG-fueled vessels has been financed by national gas companies such as China Gas Holdings, Kunlun Energy, CNOOC, and China Changjiang Bunker, a subsidiary of Sinopec. As of March 2018, China has 275 LNG-fueled ships, of which 160 are new builds and the rest are diesel retrofits. There are also 19 bunkering stations, of which three are operational. Developers of bunkering infrastructure include state-backed entities such as China Gas, CNOOC, and Hubei Energy Group, as well as private companies such as ENN and Jiangsu Haiqi Ganghua Gas Development. In April 2018, Hubei Energy Group announced plans to develop a RMB2.5 billion LNG storage and bunkering project on the Yangtze River with partial financing from the city of Zhijiang, Hubei province.

Singapore

In 2017, Singapore's Maritime and Ports Authority invested SGD12 million to accelerate LNG bunkering in its port. One part of the funding is allocated for new LNG bunkering vessels; the other is to facilitate investment in LNG-fueled ships. There are some conditions required by

Singapore for this funding, including being registered as a Singapore carrier; in return, Singapore is offering 5-year exemptions on port charges.

Fujairah

As the second-largest bunkering port after Singapore, Fujairah is planning to install LNG storage facilities with no set deadline. Located on the ocean side of the United Arab Emirates, Fujairah is strategically located on major maritime routes, making LNG storage facilities critical ahead of the IMO 2020 rule, as well as future IMO GHG-reducing bunkering initiatives.