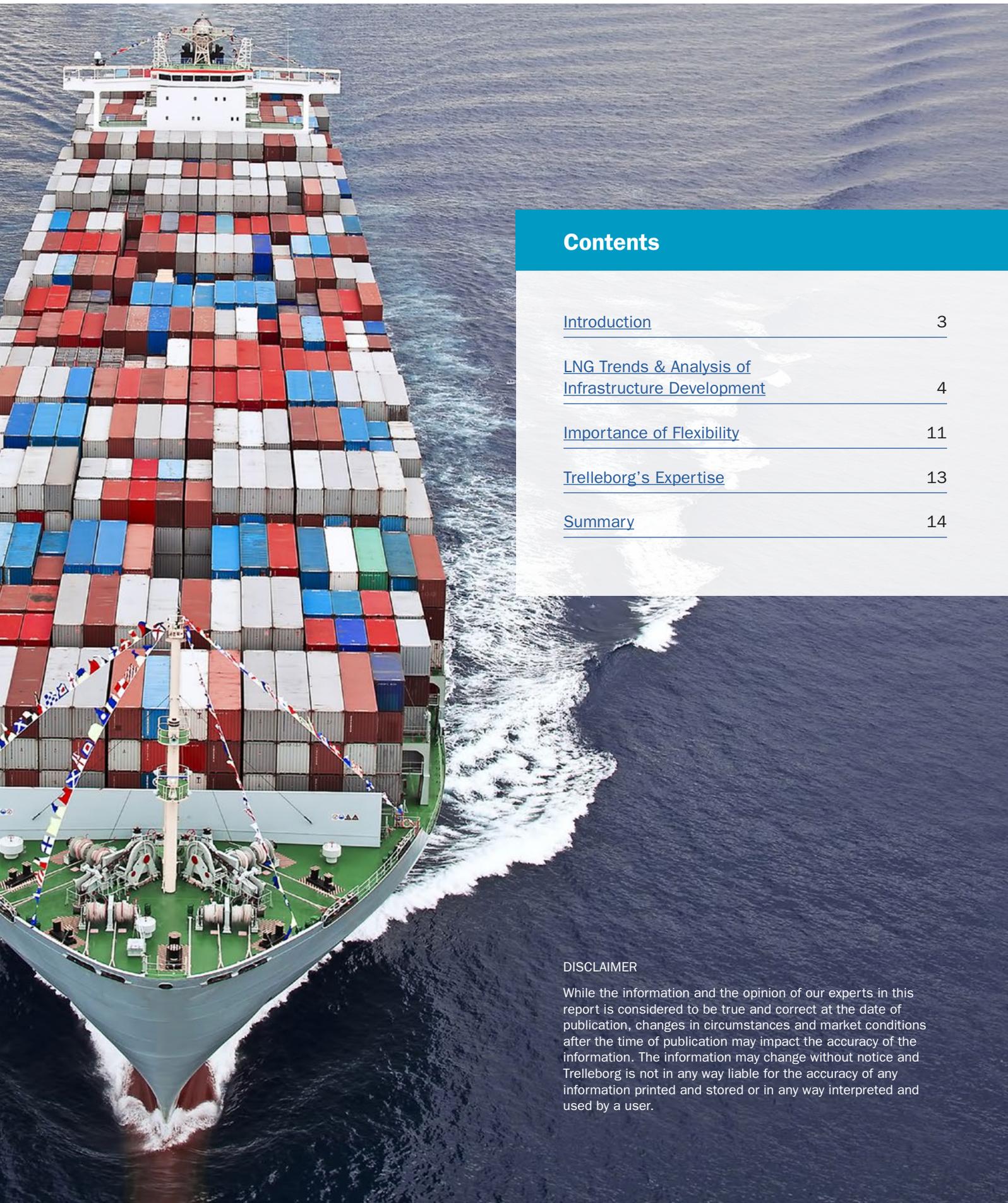


The Flexibility Factor: Energy Transfer Insights

**AN OVERVIEW OF LNG TODAY FOR MEETING
CHANGING INFRASTRUCTURE REQUIREMENTS**



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Introduction

THE ROLE OF LNG ON THE JOURNEY TO NET ZERO

The growing global climate crisis is driving the search for cleaner energy sources. Changes in market dynamics are spurring the evolution and growth of specific sub segments such as liquefied natural gas (LNG) as an alternative fuel source.

LNG fueling is becoming an alternative choice for shipping lines wishing to reduce their carbon footprint with immediate impact. Today, there is around 20% less CO₂ and virtually zero NOx and SOx – this has contributed to the development of new markets within the LNG industry, initiating unprecedented levels of ship and bunker vessel building and new gas train construction.

Growing Demand for LNG Infrastructure

Developing economies are creating new markets and applications and driving demand for reliable and durable LNG infrastructure. This consists primarily of tankers, import and export terminals, floating storage facilities, bunker vessels, and inland storage plants.

The need to meet sustainability goals in more mature global markets is accelerating infrastructure changes. As LNG applications evolve, facilities must adapt innovative infrastructure and vessels to ensure they continue to operate safely, efficiently, cost-effectively, and timely.

As the move towards a carbon-neutral economy gains momentum, the demand for LNG and its related infrastructure will only increase.

Spot Contracts Demand Operational Flexibility

Driven by growth, the LNG industry has entered a mature-market phase. The LNG trade no longer revolves around long-term contracts that guarantee predictability. The market has instead expanded to include spot contracts and short-term contracts that are more flexible, requiring greater adaptability, as well as safety and efficiency.

The ability to adapt to spot contracts and also their operations in a safe and effective way across multiple jurisdictions is crucial for operators in both small- and large-scale LNG operations.



LNG Trends & Analysis of Infrastructure Development

THE EVOLUTION OF LNG APPLICATIONS

Operators are improving infrastructure by upgrading jetties to support bigger vessel types, using floating units as semi-permanent storage structures with on board liquid to gas conversion (FSRU), or using ship-to-ship transfers more regularly to meet demand. However, if paired with existing infrastructure that is no longer fit for purpose, all of these potential solutions will impact efficiency and – importantly – safety.

Globally, a growing number of ports and terminals are gradually upgrading their facilities to offer LNG bunkering services to prevent potential operational disruptions. These shore-based facilities are often strategically located in regions with stricter emissions control regulations and near LNG import terminals for efficient distribution.

However, due to its low capital investment and the limited infrastructure required, truck-to-ship is currently the most widely used configuration at terminals and ports today for LNG. The truck-to-ship configuration does, however, have flow rate limits and volume restrictions, limiting it to short sea-trade support. For international trading vessels, marine bunkering at sea will be required.

Alternative methods, such as ship-to-ship and shore-to-ship transfers, support larger storage capacity and higher bunkering rates. However, both involve substantial capital outlay in bunker vessels and fixed infrastructure, including storage tanks and specialized loading systems.

An alternative transfer method is to use hoses over loading arms. Hoses allow for a quick transfer of fuel to multiple LNG-powered vessels. Hoses are also versatile as they can accommodate various manifold locations.



INFRASTRUCTURE DEVELOPMENT

The global LNG infrastructure market is expected to witness significant growth in the near future. Although, it's predicted that the high cost of equipment will continue to hamper market growth.¹

The new global limit of 0.50% on sulfur content of ships' fuel – enforced by the International Maritime Organization (IMO) in January 2020 – is, however, poised to incentivize the investment into LNG. This stricter cap on marine bunker fuel is spurring the installation of new machinery (or conversion where possible) designed to operate on LNG, as well as the construction of related infrastructure to accommodate the switch to LNG-fueled vessels.

This standard is creating a self-reinforcing feedback loop, where the development of an efficient, secure,

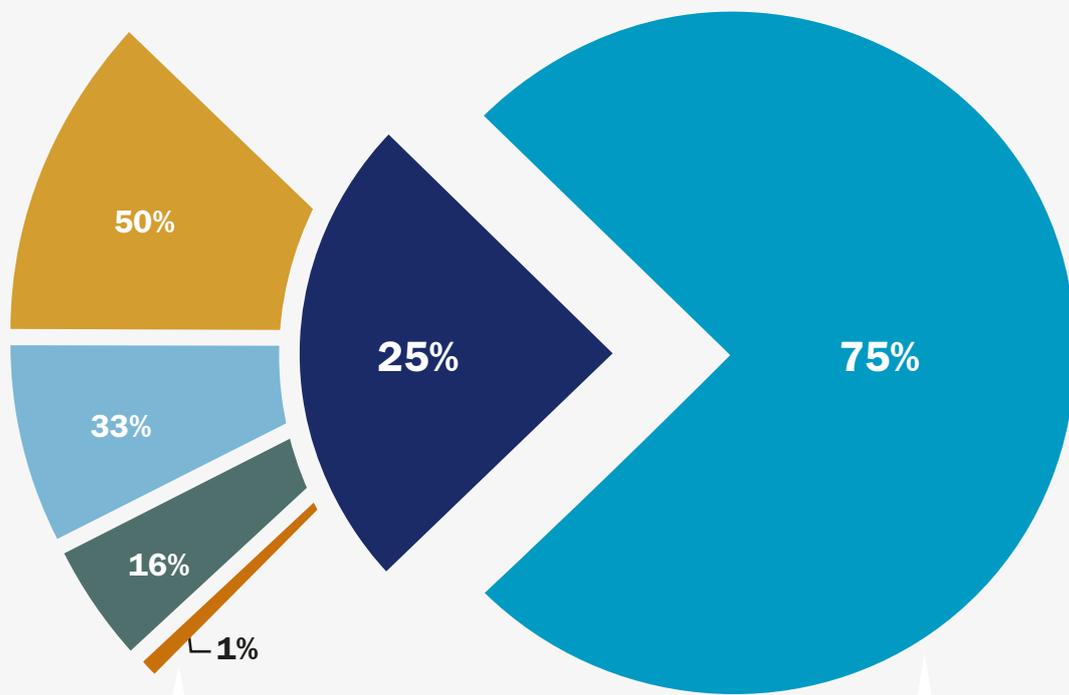
and competitive LNG supply chain and related bunkering infrastructure drives further adoption of LNG-fueled vessels.

LNG Supply Chain

The LNG supply chain is a carbon-intensive process. Uptake in gas demand will be met by LNG in many countries without domestic gas production or pipeline gas from nearby countries.

By its very nature, the LNG supply chain spans the globe and involves different industry processes. Up until now, however, the emissions from LNG, such as shipping and regasification, have been considered on a more segmented basis. With the growth of the LNG fueling market, there is an increased focus on the lifecycle emissions of the whole LNG supply chain – from 'well-to-wake' emissions to final combustion.²

CARBON INTENSITY OF THE LNG SUPPLY CHAIN



- Upstream gas production, processing and transportation emissions
- Liquefaction emissions

- Shipping emissions
- Regasification emissions

- Downstream emissions
- Other emissions (excluding downstream combustion)

PROJECTS ATTRACTING INVESTMENT

LNG is a global commodity with 21 countries exporting to 42 importers.³ The bunkering infrastructure to support LNG as a marine fuel continues to snowball.

LNG Bunkering

To meet growing demands, LNG infrastructure has shown clear signs of growth, with 124 ports now providing LNG bunkering facilities.⁴ In early 2019, there were just six LNG bunkering vessels in operation: five in Europe and one in North America. As of July 2020, this has more than doubled, growing to 13 in service, with a further 28 on order and/or undergoing commissioning.⁵

Europe currently boasts the majority of LNG bunkering ports, although similar facilities are starting to flourish in Southeast Asia and the United States.⁶

SGMF data suggests that over 318 LNG-fueled ships are operating across the globe with 532 more on order.⁷ The data also suggests that 31 LNG bunker ships are operating globally – with 24 more on order – while 98 ports are offering LNG as a fuel.

LNG Exports

Political instabilities in Europe in 2022 have resulted in bunkering activity being driven away from Russia as shipowners avoid Russian-origin cargoes.

These instabilities have resulted in high LNG prices in 2022, which will, however, boost investments in LNG export capacity in the medium to long term.

FLNG and FSRU Technology

Historically, much of the world's gas reserves have been commercially inaccessible. Floating liquefied natural gas (FLNG) technology is helping to open up connections, driving the emergence of new geographic markets.

At the same time, recent and emerging LNG markets are driving the demand for offshore and terminal floating storage and regasification unit (FSRU) development. FSRU technology enables the import of LNG to countries without the infrastructure. As operators capitalize on FSRU development, the FSRU market size is estimated to grow by a CAGR of 8%, with 81.92 MT between 2021 and 2025.⁸



LNG CHALLENGES AND OPPORTUNITIES

Opportunity #1: Economic Growth

Economic challenges remain, including emerging market currency concerns, but growth has proven resilient in key markets like China, providing cyclical headwinds for the LNG industry.⁹

Increasing adoption of LNG fueling infrastructure by large ports presents a clear opportunity for LNG distribution to become more widespread around the globe.

Opportunity #2: New Types of End Users

Some applications, like LNG fueling, have developed significantly over the last few years, but the longer-term upsides remain to be seen. There is increased use of LNG in trucking, especially in China, while floating import terminals offer flexibility and access to smaller markets such as Egypt, Jordan, Pakistan, and potentially Australia.¹⁰ At the same time, LNG-powered rail could lower fuel costs, although the Energy Information Administration expects the uptake to be relatively slow.¹¹

These new types of end users provide a faster route to market than building shore-based gas facilities for power stations.

Opportunity #3: Investment in Global LNG Infrastructure is Recovering

Global LNG demand is expected to grow by 53% to 560 million tonnes per annum (MTPA) by 2030.¹²

In response to the rising demand, Qatar Petroleum Company recently announced that it would expand its North Field LNG facility by 32 million tonnes per annum. Moreover, Gazprom is in the process of building the 13 million tonnes per annum Baltic LNG facility in Russia.

In addition, Australia's Santos Ltd has approved its Barossa gas project off northern Australia to backfill the 3.7 MTPA Darwin LNG plant.¹³

Opportunity #4: Technology as a Catalyst

In a rapidly evolving LNG market, the use of new technologies can facilitate greater flexibility, transparency, and efficiency between buyers and sellers, thus bridging the gap between them.

The challenges of implementing new technologies in the existing infrastructure can be significant. However, its benefits outweigh the disadvantages.



Challenge #1: Political Instabilities

Political instabilities have caused an increase in natural gas prices, casting longer-term uncertainty on the prospects of natural gas, particularly in developing markets where the gas was set to play a fundamental role in energy transitions. This uncertainty means that natural gas demand is expected to remain subdued up to 2025.¹⁴

To relieve price competition, quicker development of clean energy transition policies is key, and would help emerging markets access supplies that can generate positive changes in air quality and carbon intensity.

Challenge #2: Alternative Fuels

LNG has the advantage of generating lower carbon emissions than other conventional fuels.¹⁵ However, it can never be carbon-free. A significant amount of progress has been made in the field of sustainable alternative fuels. There are currently several alternatives in development and production, including ammonia and hydrogen, which have proved technically feasible, although not yet commercially available.¹⁶

Using hydrogen as a fuel directly requires either compression, for limited range applications, or liquefaction to store larger volumes for typical trade patterns. It is also a challenge to contain large volumes of the smallest and most flammable atom at -260°C without leakage.

It may be preferable to use ammonia since containment is simpler. There are, however, severe life risks associated with it because of its high toxicity. As well as tank and pipeline containment, the combustion cycles of engines or inefficient SCR (Selective Catalytic Reduction) may release ammonia via 'ammonia slip' which needs addressing before any large-scale rollout can be undertaken. Despite these challenges there are many serious trials underway.¹⁷

With all alternative fuels, including LNG, the energy density needs to be addressed, to carry the equivalent fuel volumes compared to HFO or diesel. Consequently, larger fuel tanks are required. The result is either a reduction of range or a reduction of cargo carrying capacity, since larger fuel tanks limit cargo space.

Challenge #3: Contract Issues

Differences in value chain can derail a project. For example, different cost recovery systems complicate the allocation of costs to infrastructure, the LNG liquefaction or regasification plant, and any separate pipeline project. The extent to which downstream infrastructure costs can be recovered through upstream production is often an issue, alongside differing timelines for licensing, relinquishment and investment.

Investing in new downstream infrastructure, however, is needed to realize growth potential. Today, with midstream energy infrastructure projects virtually drying out, infrastructure investors are venturing downstream in search of assets structured to fit their investment profile.

Between 2008 and 2017, spot and short-term LNG offtake contracts grew from 20% to 30% of volumes exported. 76% of respondents believe that these contracts will grow faster than overall LNG trade.¹⁸

Challenge #4: Climate Change

Increasing sea levels and worsening weather patterns pose a threat to LNG infrastructure today. It puts an increased strain on ports, facilities, and vessels, as well as posing a risk for catastrophic damage to infrastructure.

NATURAL GAS GROWTH ACROSS DIFFERENT REGIONS

Global LNG trade grew by 4.5% from 2020 to 2021, reaching an all-time high of 372.3 MT. A strong post-pandemic recovery resulted in a surge in LNG imports, even though the annual growth rate of 4.5% remains far from pre-COVID-19 levels of 13.0% in 2019.¹⁹

Global natural gas consumption is expected to contract and grow slowly over the following years as political instabilities continue to push prices up, fueling fears of supply disruptions.²⁰

Central, South and East Asia

In the first five months of 2021, Asian LNG demand firmly returned to growth,²¹ with China and India leading the recovery in demand for LNG by increasing their LNG imports by 11% each.²² China's target to become carbon neutral by 2060²³ is expected to perpetuate its LNG demand through the key role gas can play in decarbonizing hard-to-abate sectors. Japan, meanwhile, has suffered a deterioration in their economic outlook as a result of COVID-19.²⁴

China witnessed blistering growth in the first half of 2021 after 28% year-on-year growth in the first six months of the year.²⁵

Saudi Arabia

Natural gas plays a critical role in Saudi Arabia's long-term growth and diversification, but the lack of import infrastructure keeps demand dependent on supply.²⁶

Sub-Saharan Africa

Although the project pipeline in Sub-Saharan Africa has been steadily developing, the focus of LNG in the region today is most likely to be on refining existing projects rather than initiating new ones.

An electricity plan has been approved by the Cabinet to relieve current electricity supply constraints in South Africa.²⁷ However, there is currently no LNG import infrastructure in place. Increasing electric power generation and the development of natural gas infrastructure provide key countries in the region with an attractive opportunity for LNG regasification investment,²⁸ giving operators the flexibility to meet short-term contract requirements in the Sub-Saharan Africa region.

Europe and Western Europe

LNG demand from Europe is being met by diverting cargoes bound for other destinations. This is due to the political instabilities in 2022, which have caused a supply crunch that will last for years.

As Europe aims to reduce its dependence on Russian natural gas, it's estimated that Europe's consumption of LNG will double in 2022. Even if producers could increase production immediately, Europe does not have the infrastructure to absorb the LNG necessary to completely avoid using Russian gas before 2024.

However, if the US and Qatar build additional capacity as planned, the transition from Russian LNG exports will be achievable in the longer term.²⁹

Latin America

The economic recession across the region throughout 2020 affected natural gas infrastructure investments over the short to medium term.³⁰

The period 2019-2020 saw South America's imports fall by around 15% owing to growing domestic gas production and weak economic conditions.³¹ The situation changed in 2021 when a severe drought in Brazil resulted in a substantial reduction in available hydropower capacity – responsible for roughly 70% of Brazil's power needs – causing LNG imports to rise 60%.³²

While South American demand is a small proportion of the global LNG demand, any increase in demand pulls marginal Atlantic cargoes away from the European sink (and its empty storages), contributing to the surge in European energy prices.³³

Importance of Flexibility

Flexible LNG Solutions

Across international markets, LNG is traded as a commodity. In international shipping, it is used as a fuel. Each market requires flexible solutions to ensure safety, efficiency, cost effectiveness, and, ultimately, the success of the business model – from ship-shore links for FSRUs to hybrid-GEN3 solutions for bunker vessels. New projects need to find fast return on investment (ROI), while established facilities must keep pace with today's changing demands.

Volume Flexibility

Volume flexibility is one solution that gives purchasers the ability to reduce the annual contract volume and, as a result, their take-or-pay obligation. A surplus of LNG supply on the market is prompting purchasers to opt for short-term rather than long-term contracts.

Docking Flexibility

It is important for vessels and ports to be designed for compatibility with multiple types of docking to enable the safe transfer of fuel during ship-to-ship, ship-to-shore, or single-point mooring operations. With vessels having multiple docking options to onboard/offboard fuel and ports having to accommodate these options, smart navigation and piloting solutions can help make docking operations and transfer of fuel safer.

Improving Interface Management

LNG's global scope and varied applications make diversity the norm. From traditional terminals to bunker barges and everything in between, project requirements vary substantially, inviting varied solutions and complicating interface management at transfer touchpoints.

Optimizing the interface at all stages of the LNG supply chain is integral to supporting every transfer operation, and can only be assured through the adoption of consistent communication and standardized processes.



Efficient Equipment Delivers Flexibility

Adopting easily configurable and compatible equipment systems delivers several benefits such as an enhanced overview of operations, improved productivity, reliability, safety, and, ultimately, faster ROI to all stakeholders. Efficient systems that offer these benefits are able to provide support to LNG operators that require operational flexibility to adapt to spot contracts.

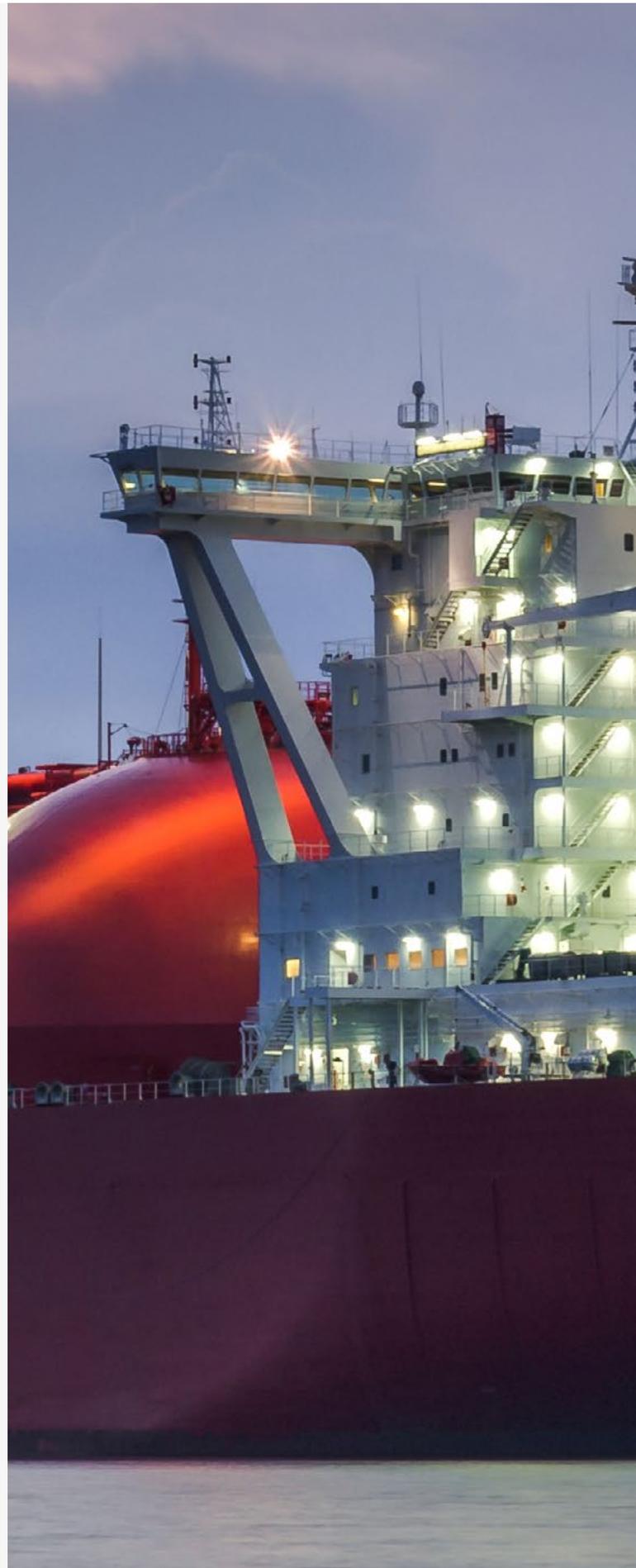
Conversely, fragmentation creates inefficiencies and safety issues, and reduces the opportunity to implement flexible business models. A standardized approach across facilities opens up opportunities for all stakeholders through common requirements and systems. Standardization of systems improves operational control. At the same time, data sharing between parties is enhanced, enabling effective communications, fast response to potential issues, and empowered long-term decision making.

This level of compatibility necessitates robust system architecture design from the outset, as well as cooperation between stakeholders and an understanding of cross-party requirements.

The Role of Specification

Every port and terminal is unique. Identification of the correct specifications and a comprehensive understanding of materials and applications early on in a project are crucial to ensure its long-term performance and safety.

At the same time, products must meet differing regulatory requirements globally, and suppliers must understand and integrate all necessary standards into their solution – and be prepared to provide first-class 24/7 support when it's needed to ensure downtime is kept at a minimum. An experienced, knowledgeable and technical supplier is essential to ensure that all specifications and services are met anywhere across the globe.



Trelleborg's Expertise

For over 50 years, Trelleborg has been central to the LNG industry, shaping and taking action as it's evolved. With a reputation for thought leadership, innovation, product design, and providing effective business solutions, we work with industry bodies to set industry standards. We understand that it is critical that our systems are designed to work effectively in different locations around the globe and in different jurisdictions.

The LNG industry demands integrated solutions rather than individual products, so our primary focus is engineering LNG solutions that offer configurability, compatibility, and flexibility for your bespoke operational requirements. Our comprehensive knowledge of the safety and technical requirements of different countries allows us to offer state-of-the-art solutions that meet the highest safety and quality standards. In addition to our global technology network, we also have a worldwide aftersales team available to provide support 24/7.

Trelleborg has been leading the way in integrated ship-shore link technology development and the design for liquefied natural gas carriers (LNGCs), shore terminals, FSRUs and floating LNG applications such as Shell Prelude.

More recently, Trelleborg has taken this knowledge and expertise into the emerging LNG bunkering market with development of our GEN3 SSL/USL hybrid ship-shore link systems, which allow bunker vessels to replenish their tanks from a large-scale LNG terminal and then service a global fleet of smaller, LNG-fueled vessels.

Trelleborg will help you understand the opportunities for LNG infrastructure at your port or terminal and will create bespoke solutions to meet your operational needs in LNG. Our solutions include navigation and piloting technologies that will help you navigate to within 1 cm of accuracy, as well as advanced docking and mooring equipment and bespoke fender systems, which are all designed to increase the safety, efficiency, and sustainability of your operations.

In addition, Trelleborg also offers after-sales services. These services include comprehensive training and maintenance programs, which enable management teams to provide first-line support to staff, while our 24/7 maintenance and repair programs offer regular preventative maintenance of your bespoke equipment in order to reduce downtime and prevent costly repairs.



Summary

IN CONCLUSION

Demand for cleaner fuels is set to propel LNG fueling into a mature market phase – where spot contracts are utilized, rather than solely long-term contracts. In addition to developing economies driving new markets, the global LNG infrastructure market is expected to witness significant growth in the near future.

However, LNG infrastructure must be able to keep up with demand. Accelerating LNG fueling to meet sustainability demands requires LNG infrastructure that can cope with demand by berthing more and more LNG-powered vessels safely and efficiently.

In order to respond to LNG's various challenges and opportunities, LNG leaders must adapt to the needs of spot contracts, changing environments, and transfer scenarios. To do this and help ensure your LNG operations take place safely and efficiently, operational flexibility is crucial.

Discover Global Solutions Showcase

Trelleborg's innovative and pioneering solutions have been meeting the demand for LNG from the outset. Read how our LNG solutions are increasing the safety, sustainability, and overall efficiency of LNG operations across the globe today.

EXPLORE CASE STUDIES



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