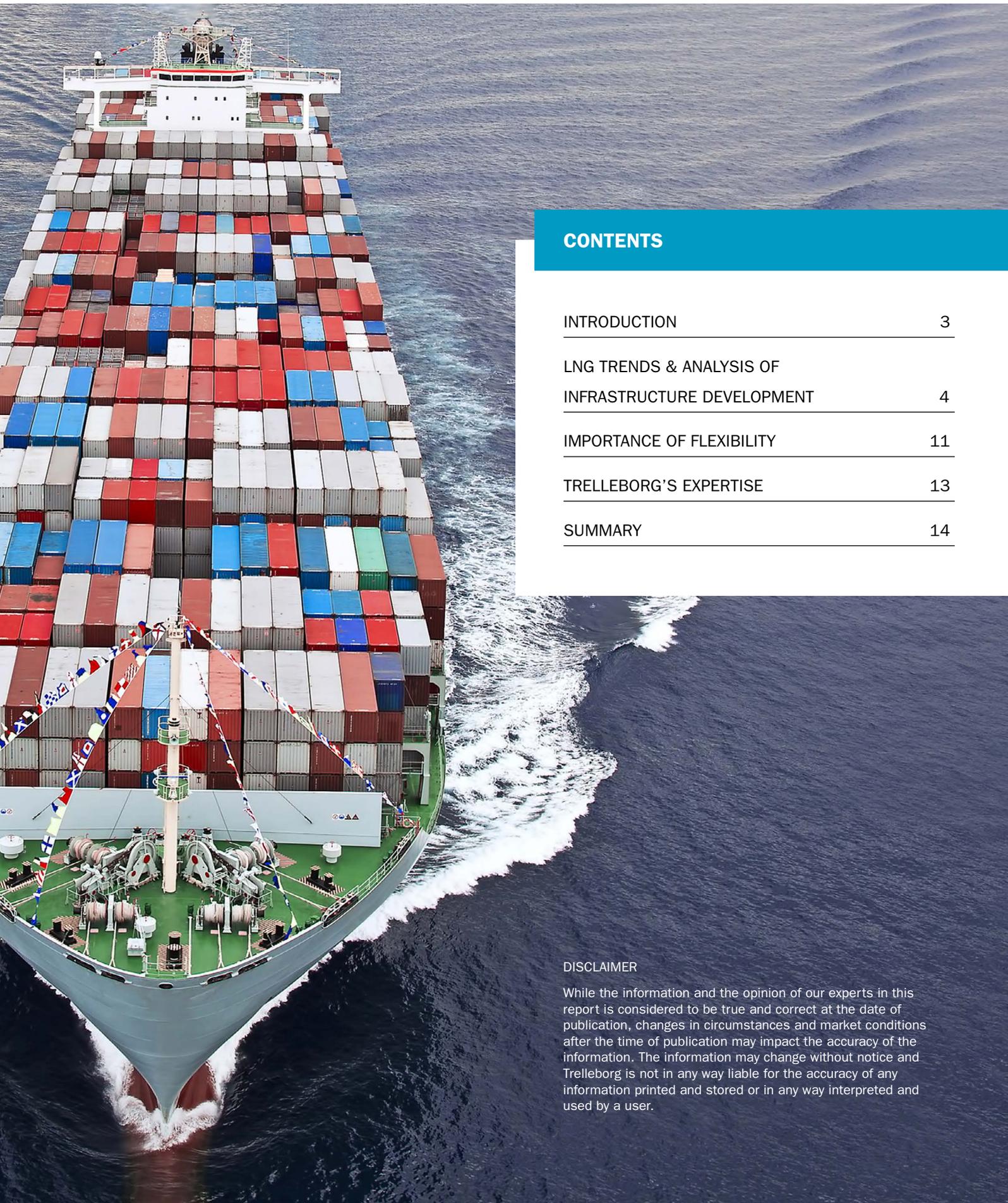




The Flexibility Factor: Energy Transfer Insights

**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 necessitating the search and need for cleaner energy choices. The changing market dynamics is driving evolution and growth within a number of sub segments such as liquefied natural gas (LNG) fueling.

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 NO_x and SO_x – 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 toward 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. As a result, LNG trade no longer centers solely on long-term contracts accompanied by a level of predictability. Instead, it has broadened out to include short-term, more flexible spot contracts that bring a higher need for adaptability, as well as the undisputed need for safety and efficiency.

Taking advantage of opportunities in small- and large-scale LNG requires operators to be flexible, so that they can adapt not only to spot contracts, but also their operations in safe and effective ways – across multiple jurisdictions.



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's no longer fit for purpose, all of these potential solutions will impact efficiency and – importantly – safety.

One way foresighted ports and terminals are reducing disruption is by adding to, or modifying, their facilities to offer LNG bunkering services gradually over time. These shore-based facilities are often strategically located in regions with tighter emissions control regulations, and close to 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. This method does have its drawbacks; among other factors, it restricts flow rates – ultimately limiting bunkering operations to smaller-sized LNG-fueled vessels.

Alternative options, like ship-to-ship and shore-to-ship transfers, support larger storage capacity and higher bunkering rates, but both methods require significantly higher capital investments for bunker vessels and fixed infrastructure, such as storage tanks and specialized loading systems.



INFRASTRUCTURE DEVELOPMENT

The global LNG infrastructure market is expected to witness significant growth in the near future, due to lower LNG prices compared to other energy sources. 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.

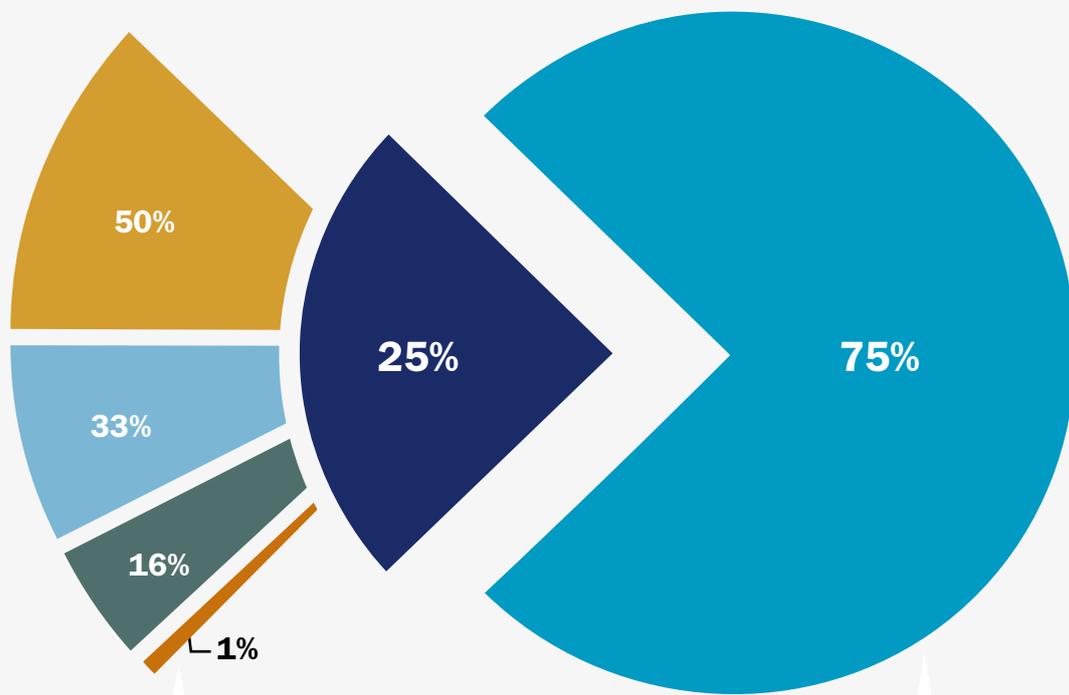
This standard is creating a self-reinforcing feedback loop, where the development of an efficient, secure, and competitive LNG supply chain and related bunkering infrastructure drives further adoption of LNG-fueled vessels.

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. 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.³ 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.⁴

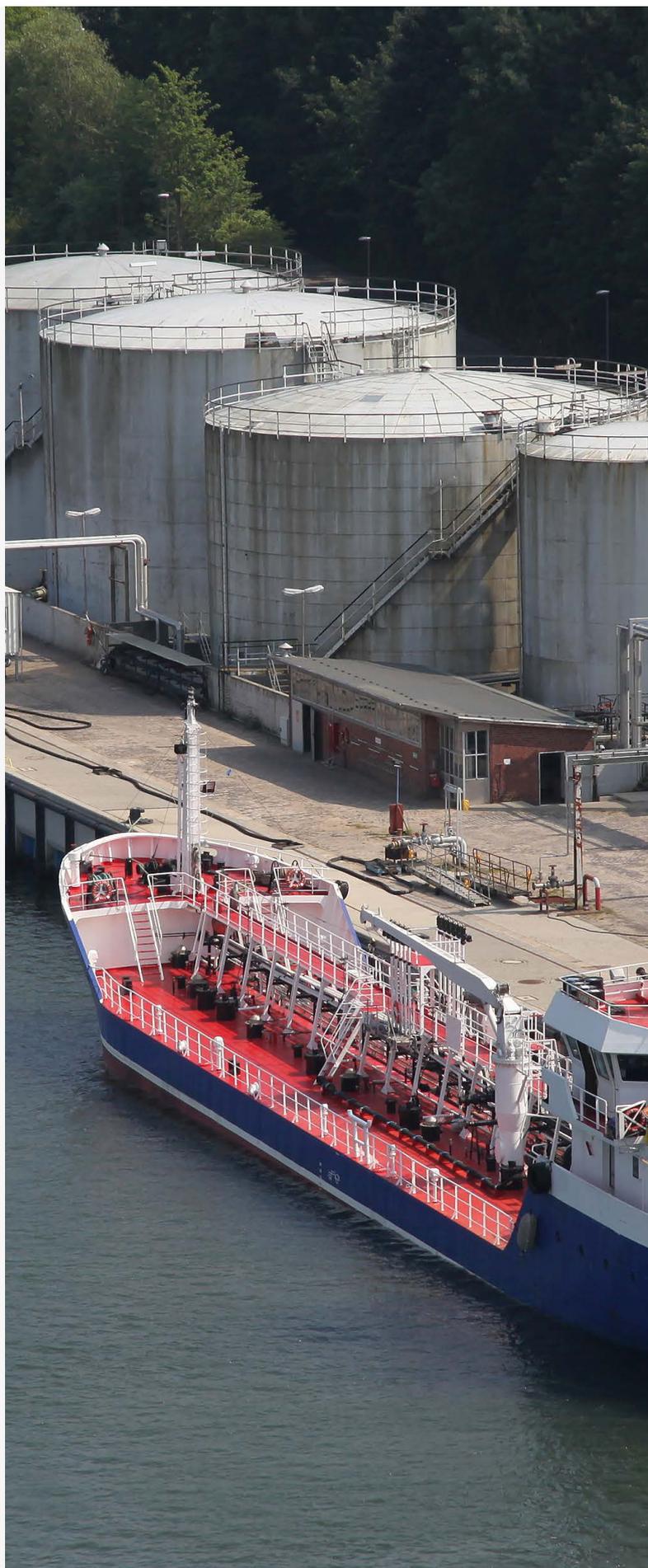
Europe currently boasts the majority of LNG bunkering ports, although similar facilities are starting to flourish in Southeast Asia and the United States.⁵

With 226 LNG-powered ships currently existing around the world – and another 432 on order⁶ – an increasing number of bunkering facilities is gearing up to support the demand for LNG as a fuel into the future.

FSRUs

Historically, much of the world's gas reserves have been commercially inaccessible. Floating storage and regasification units (FSRUs) are 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 FSRU development. 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 2025.⁷



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.⁸

As large ports continue to adopt LNG fueling infrastructure, there is a clear opportunity for large-scale distribution of LNG to be made more accessible throughout the world's markets.

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.⁹ At the same time, LNG-powered rail could lower fuel costs, although the Energy Information Administration expects the uptake to be relatively slow.¹⁰

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 2030.¹¹

To help meet that demand, Qatar Petroleum earlier this year gave the go-ahead for the world's biggest LNG project, a 32 mtpa expansion of its North Field LNG, while Gazprom started construction of the 13 mtpa Baltic LNG project in Russia.

In addition, Australia's Santos Ltd has given the go-ahead for its Barossa gas project off northern Australia to backfill the 3.7 mtpa Darwin LNG plant.¹²

Opportunity #4: Technology as a Catalyst

As LNG markets evolve, there are many opportunities for technology to bridge the gap between buyers and sellers, to enable flexibility, transparency and efficiency.

The cost of technology can be high and integrating the technology with existing infrastructure can be challenging – though rewarding.



Challenge #1: COVID-19

The COVID-19 pandemic has brought delays to construction of new LNG infrastructure due to both mandatory and voluntary work stoppages, as well as supply chain disruptions.¹³

As a result of COVID-19, global LNG prices hit a record low in 2020, but reached record high levels in January 2021 due to winter demand, supply outages and infrastructural constraints.

Even before the COVID-19 pandemic, the LNG market was set for oversupply in 2021, as new projects continued to grow capacity well beyond steady demand growth.¹⁴ Reduced gas demand because of the pandemic has added to excess supply, creating market volatility. And a sustained period of lower oil prices and increased competition among gas supply sources as new supply reaches the market have combined to erode margins, putting pressure on gas and LNG producers.¹⁵

European wholesale gas prices hit record high levels in the summer of 2021, driven partially by an increase in demand as the pandemic eased.¹⁶

Challenge #2: Alternative Fuels

The lower emission benefits of LNG are well understood.¹⁷ However, it can never be carbon-free. There is therefore significant development in the field of alternate fuels. The main alternatives are ammonia and hydrogen, which are both proven as technically viable, however, not yet commercially available at scale.¹⁸

Use of hydrogen as a fuel directly will either require compression, for limited range applications, or liquefaction to be able to store larger volumes for typical trade patterns. There is also the engineering challenge of being able to contain large volumes of the smallest and most flammable atom at -260C without leakage.

Ammonia may be the preferred option as containment is simpler. It is, however, highly toxic, and therefore a severe hazard to life. 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 roll-out can be undertaken. Despite these challenges there are many serious trials underway.¹⁹

With all alternate fuels, including LNG, the energy density needs to be addressed, to carry the equivalent fuel volumes compared to HFO or diesel. Larger fuel tanks are required, which naval architects need to balance in either a reduction of range, as the same volume of fuel won't allow the ship to sail as far, or a reduction of cargo carrying capacity, as larger fuel tanks will reduce cargo space.

Challenge #3: Contract Issues

Differences in a project's 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.²⁰

Challenge #4: Climate Change

Today's existing LNG infrastructure is required to withstand the world's rising sea levels and harsher weather patterns. This puts increased strain on ports, facilities and vessels and can cause catastrophic damage to infrastructure.

NATURAL GAS GROWTH ACROSS DIFFERENT REGIONS

In 2020, global LNG trade increased to 360 million tons.²¹ As energy consumption rises and the world shifts toward cleaner fuels, global demand for LNG is expected to double to 700 million tons by 2040.²² This increase in volume reflects the resilience and flexibility of the global LNG market in 2020.

Saudi Arabia

Natural gas plays a key role in Saudi Arabia's long-term economic growth and diversification plans but, lacking any import infrastructure to adapt to the growth of the LNG industry, demand is wholly constrained by supply.³¹

Central, South and East Asia

In the first five months of 2021, WwAsian LNG demand firmly returned to growth,²³ with China and India leading the recovery in demand for LNG by increasing their LNG imports by 11% each.²⁴ China's target to become carbon neutral by 2060²⁵ is expected to perpetuate its LNG demand through the key role gas can play in decarbonizing hard-to-abate sectors. Likewise, India increased imports, taking advantage of lower-priced LNG to supplement its domestic gas production. Japan, on the other hand, has suffered a deterioration in their economic outlook as a result of COVID-19.²⁶

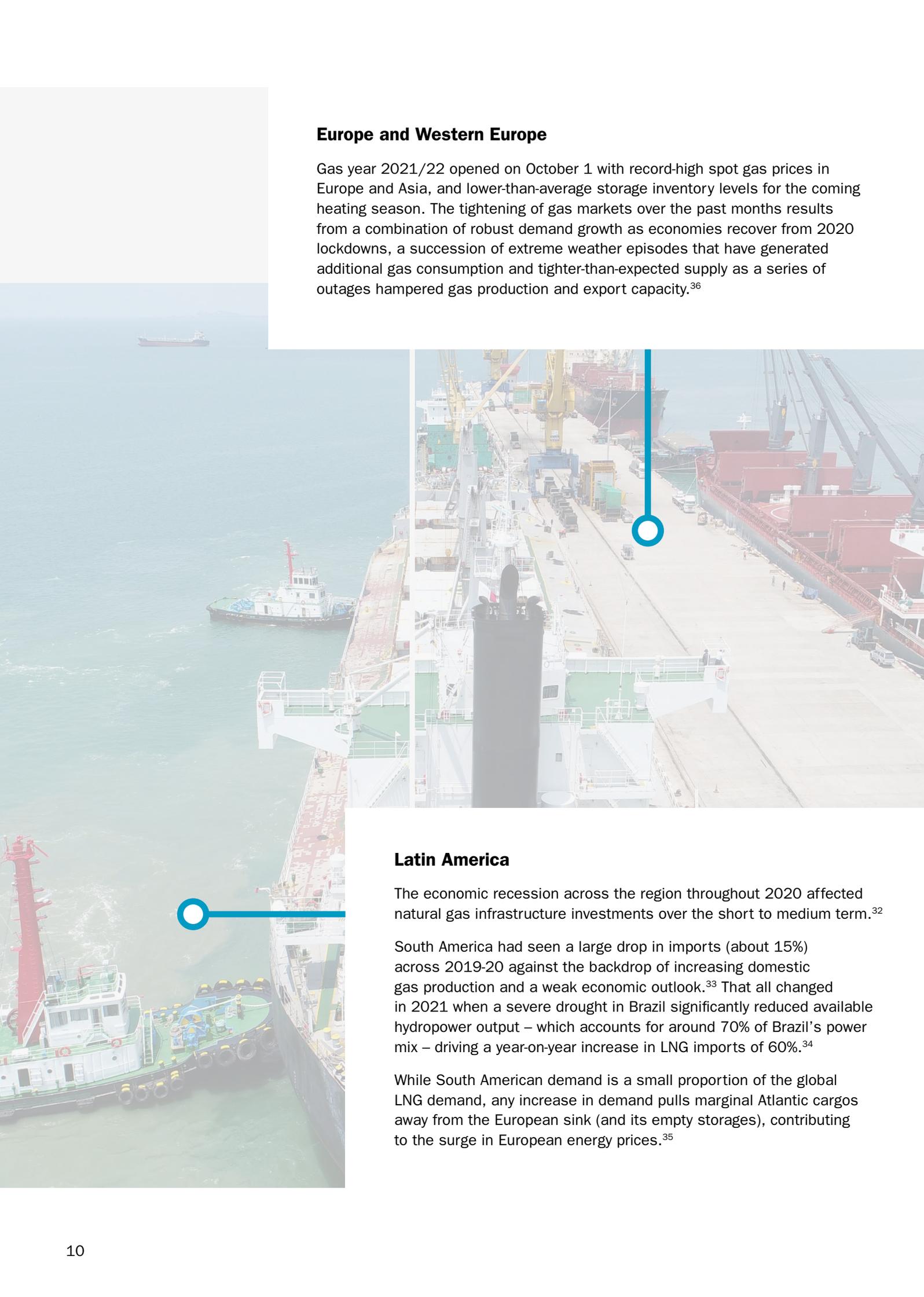
China witnessed blistering growth in the first half of 2021, after 28% year-on-year growth in the first six months of the year.²⁷

As a result of China's blistering LNG growth, it is expected to become the world's largest LNG market, with the nation expected to account for over 18 million tons of the global LNG demand forecasted for 2021.²⁸

Sub-Saharan Africa

Various projects in the Sub-Saharan Africa region have been progressing steadily, although today's focus on LNG in the region will most likely shift to further development of existing projects, rather than the sanctioning of new developments.

In South Africa, there is currently no LNG import infrastructure in existence,²⁹ although an electricity plan has been approved by the Cabinet in order to alleviate current electricity supply constraints. The increased electrification and the expansion of natural gas infrastructure presents key countries in the region with the potential for attractive LNG regasification investment,³⁰ giving operators the flexibility to meet the demands of short-term contracts in the Sub-Saharan Africa region.



Europe and Western Europe

Gas year 2021/22 opened on October 1 with record-high spot gas prices in Europe and Asia, and lower-than-average storage inventory levels for the coming heating season. The tightening of gas markets over the past months results from a combination of robust demand growth as economies recover from 2020 lockdowns, a succession of extreme weather episodes that have generated additional gas consumption and tighter-than-expected supply as a series of outages hampered gas production and export capacity.³⁶

Latin America

The economic recession across the region throughout 2020 affected natural gas infrastructure investments over the short to medium term.³²

South America had seen a large drop in imports (about 15%) across 2019-20 against the backdrop of increasing domestic gas production and a weak economic outlook.³³ That all changed in 2021 when a severe drought in Brazil significantly reduced available hydropower output – which accounts for around 70% of Brazil's power mix – driving a year-on-year increase in LNG imports of 60%.³⁴

While South American demand is a small proportion of the global LNG demand, any increase in demand pulls marginal Atlantic cargos away from the European sink (and its empty storages), contributing to the surge in European energy prices.³⁵

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. Purchasers recognize the surplus of LNG in the market and are more willing to commit to short-term contracts as the desire for long-term contracts lessens.

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. On top of vessels that can have multiple options for docking to onboard/offboard fuel and ports needing to provide options for these transfers, smart navigation and piloting solutions can help make the flexibility ports and vessels need for dockings, safer.

Improving Interface Management

Given the global scope and myriad applications of the LNG industry, diversity is 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 the various stages of the LNG supply chain is critical to supporting the business model of every transfer operation. Interface optimization means consistent communication and standardized processes at every transfer point.



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.

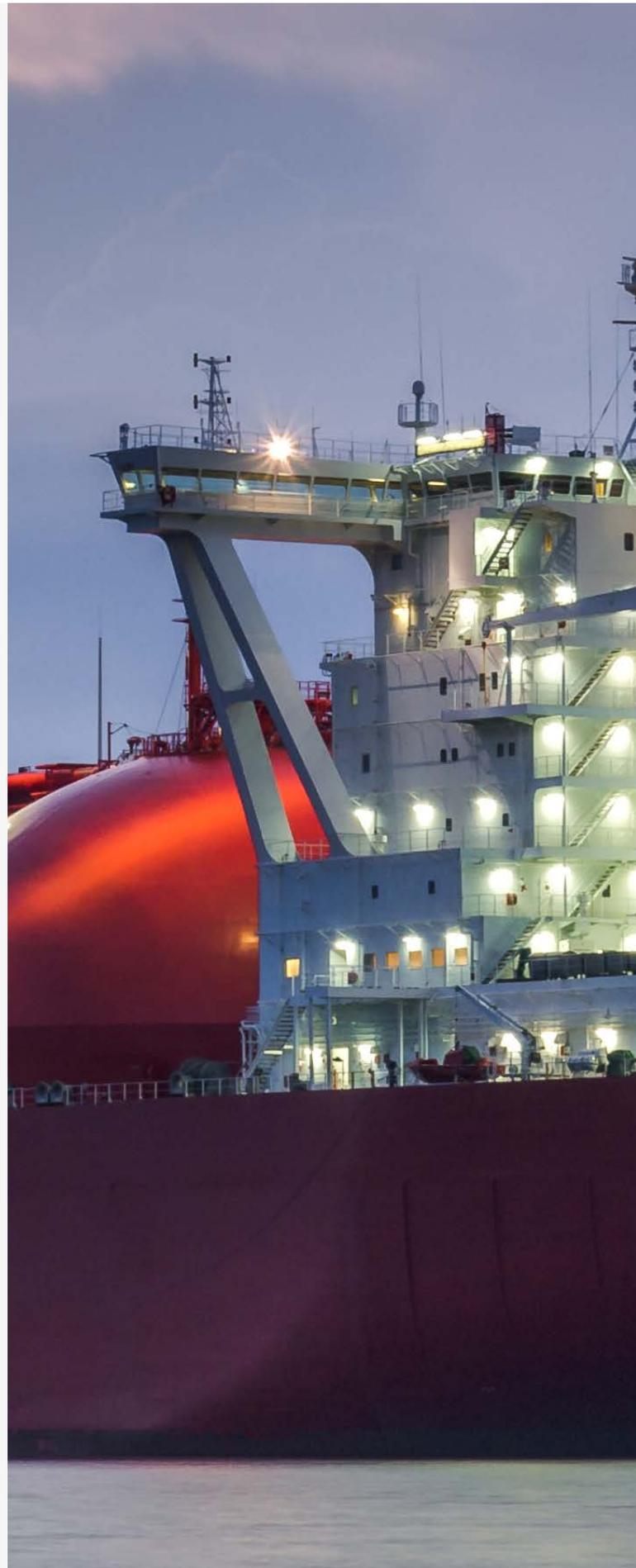
Conversely, fragmentation creates inefficiencies and safety issues, and reduces the opportunity to implement flexible business models. A standardized approach across facilities opens up opportunities for all stakeholders through common requirements and systems. Standardization of systems improves operational 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 requires robust system architecture design at the outset. In turn, this requires oversight between stakeholders and an understanding of cross-party requirements.

The Role of Specification

Every port and terminal is unique. It is important to identify the correct specifications needed at the early stages of a project to ensure long-term performance, and the safety of the project. The ability to understand materials and applications plays a large part in optimizing safety and performance, and ensuring the right solution for the job.

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. To ensure all specifications and services are considered, you need a supplier that has the knowledge, experience and technical know-how to get you up and running anywhere in the world.



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. With our understanding of country-specific safety and technical needs, we deliver solutions that meet your exacting quality and safety standards. And, our global network of technology is also supported by a global aftersales team that provide 24/7 support and service as required.

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.

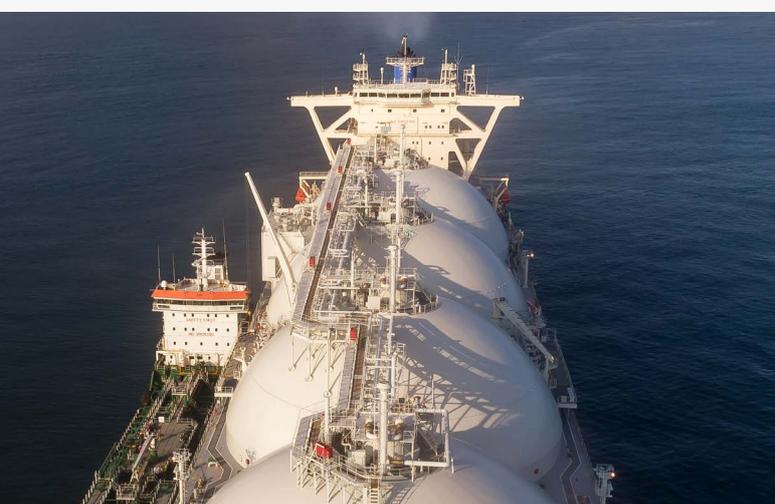
Discover Global Solutions Showcase

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

REFERENCES

- ¹ Allied Market Research, Liquefied Natural Gas (LNG) Infrastructure Market by Type (Liquefaction Terminal, and Regasification Terminal), and End-User Industry (Heavy-Duty Vehicles, Electric Power Generation, and Marine Transport) – Global Opportunity Analysis and Industry Forecast, 2021
<https://www.herbertsmithfreehills.com/latest-thinking/decarbonisation-of-the-Ing-supply-chain-challenges-and-the-wayforward>
- ² SEA LNG, 2021 Outlook for LNG – a View From the Bridge, 2021
- ³ SEA LNG, LNG – The Only Viable Fuel, 2020
<https://www.ship-technology.com/features/Ing-bunkering-facilities-around-the-world/#:~:text=While%20Europe%20boasts%20the%20majority,Asia%20and%20in%20the%20US.>
- ⁴ <https://www.sgmf.info/>: Accessed November 12, 2021
- ⁵ Global Floating Storage Regasification Unit (FSRU) Market 2021-2025
- ⁶ Deloitte, Remodel, reinvent: How technology and changing business models are impacting the future of LNG, 2019
- ⁷ Energy Information Administration, Liquefied natural gas shows potential as a freight locomotive fuel, April 14, 2014, <https://www.eia.gov/todayinenergy/detail.cfm?id=15831>, 2014: Accessed February 1, 2016.
- ⁸ <https://www.reuters.com/article/global-Ing-investments-idUSL4N2P32XV>
- ⁹ <https://www.mckinsey.com/industries/oil-and-gas/our-insights/the-future-of-liquefied-natural-gas-opportunities-for-growth>
- ¹⁰ Fitch Solutions, LNG: Global Industry Trends, 2020
<https://www.forbes.com/sites/uhenergy/2021/09/24/as-Ing-resources-stall-prices-are-set-to-rise-until-2025/?sh=63cbeb8e4af0>
- ¹¹ <https://www.fortisbc.com/est/marine/environmental-benefits-of-Ing-fuelled-marine-vessel>
- ¹² <https://www.lr.org/en-gb/insights/articles/decarbonising-shipping-ammonia/>
- ¹³ https://www.nyk.com/english/news/2021/20210422_01.html
- ¹⁴ SEA LNG, LNG – The Only Viable Fuel, 2020
- ¹⁵ International Gas Union, LNG World Report, 2018
<https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-Ing/Ing-outlook-2020.html#iframe=L3dlYmFwcHMvTE5HX291dGxvb2sv>
- ¹⁶ <https://www.Ingindustry.com/special-reports/22062021/woodmackenzie-china-to-overtake-japan-as-worlds-largest-Ing-market/>
- ¹⁷ <https://www.climateaction.org/news/china-pledges-carbon-neutrality-by-2060>
- ¹⁸ <https://www.reuters.com/business/energy/chinas-Ing-imports-surge-cool-winter-high-prices-bite-2021-08-25/>
- ¹⁹ <https://www.nortonrosefulbright.com/en-za/knowledge/publications/89977412/global-Ing-outlook-2021>
- ²⁰ <https://timera-energy.com/south-american-Ing-imports-rebound-in-2021/>
- ²¹ <https://www.iea.org/reports/gas-market-report-q4-2021>





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