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40 pages essential LNG news!
January 2017

In this issue:

IEA says inter-regional gas and LNG trade to grow 45 percent in 10 years

Paris-based body outlines its latest energy industry scenarios in World Energy Outlook.

Inter-regional natural gas and LNG trade is set to grow by 45 percent over the next 10 years and by 70 percent through 2040 as overcapacity is gradually absorbed, new players enter the stage, incumbents are challenged and the market rebalances.

The is the view of the International Energy Agency in its latest report in which various scenarios are put forward, including an over optimistic one whereby 60 percent of global power needs are met by wind and solar power by 2040.

"The concentration of import growth in Asia underpins a shift in trade flows towards the Asia-Pacific basin," the IEA said in the natural gas section of its 682-page World Energy Outlook.

"Over the outlook period, new pipeline connections are built and existing ones reinforced, complex pipeline projects generally find it harder to garner political and financial support in a market awash with LNG," the IEA said.

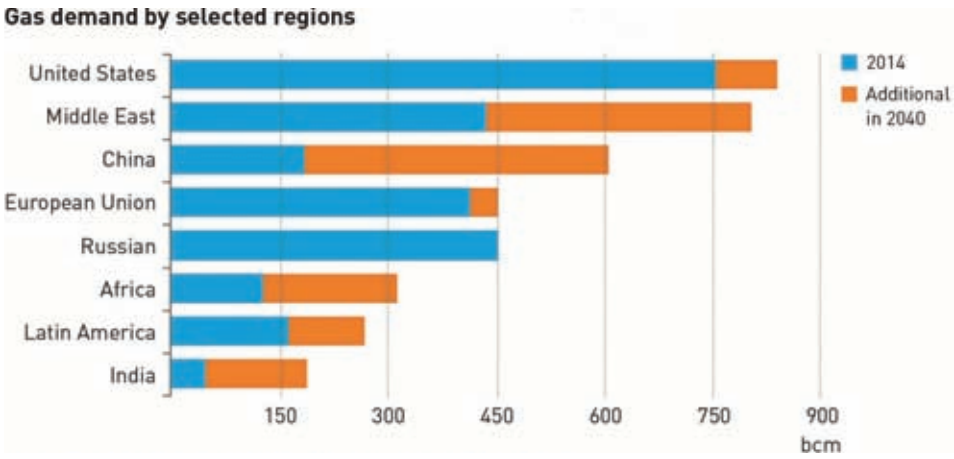
"Floating storage and regasification units help to unlock new and smaller markets for LNG and LNG captures around 70 percent of the additional gas trade and thus manages to increase its share in inter-regional gas trade from 42 percent in 2014 to 53 percent in 2040," it said.

Fundamentals

"Gas prices are increasingly determined by gas supply and demand fundamentals, including new trading hubs and the gradual removal of trade restrictions such as destination clauses limiting the buyer's right to resell the gas.

"With the LNG overcapacity gone by the mid-2020s, timely investment in new gas supply projects is needed to pre-empt price volatility," the IEA added.

The United States and Australia contribute two-thirds to gas production growth until 2020, but from the early 2020s onwards the global gas balance increasingly relies on output growth from a much broader range of producers.



Developing demand: natural gas dependent on government policies

Emerging

The IEA sees East Africa emerging as a new gas province and Argentina revived as an important gas producer, this time from shale.

"The Middle East, China and Russia respectively account for 24 percent, 13 percent and 8 percent of the incremental global gas production over the Outlook period," the IEA stated.

The report said global natural gas demand grows by nearly half over the period amid what it calls its "New Policies Scenario" whereby renewable energy source replace some fossil fuel over time.

"The annual growth rate of 1.5 percent is lower than the 2.3 percent observed over the past 25 years, but gas is nonetheless the fastest growing among the fossil fuels and increases its share in global primary energy demand from 21 percent today to 24 percent in 2040," the IEA said.

"We see clear winners for the next 25 years - natural gas but especially wind and solar - replacing the champion of the previous 25 years, coal," said Fatih Birol, the IEA's executive director.

"But there is no single story about the future of global energy: in practice, government policies will determine where we go from here," Birol added. The IEA report also said that Russia should be well placed to take advantage of the world's rising needs for natural gas, including from its Yamal LNG project in Siberia.

However, the IEA noted that the problems facing the country's gas industry are as big as the size of its resources.

Problems

"The country has vast gas resources, low production costs and more than 100 billion cubic metres spare production capacity since the new production facilities in the remote Yamal Peninsula came on stream," the IEA said.

"But, in practice, the problems facing the Russian gas industry are no less impressive than the size of its resources," the energy body stated.

The IEA pointed out that domestic consumption is plateauing as natural gas already accounts for more than half of Russian primary energy demand.

"In our projections, gas demand for power falls by some 20 Bcm over the projection period, while total consumption stays flat at around 450 Bcm.

Europe market

"Pipeline infrastructure ties Russian export opportunities at present to the vagaries of gas demand in Europe, but

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Maritime Content Ltd
1st Floor, 30 Warner Street
London EC1R 5EX
United Kingdom
www.LNGjournal.com
+44 (0)20 7253 2700

Publisher
Stuart Fryer

Editor
John McKay
editor@lngjournal.com

Advertising
David Jeffries
ONLY MEDIA LTD
Tel: +44 (0)20 8674 9444
Fax: +44 (0)20 8674 2743
djeffries@lngjournal.com

Subscriptions Sales Manager
Elena Fuertes
Tel: + 44 (0) 7017 3416
elena@lngjournal.com

Production
Vivian Chee
Tel: +44 (0) 20 8995 5540
chee@btconnect.com

Subscription

Print & online	£655/€810/US$1050
Online only	£595/€795/US$950

See website for more details
www.lngjournal.com
elena@lngjournal.com
hotline +44 (0)20 7017 3416

Printed by: Rabarbar s.c.,
Polna 44,
41-710 Ruda Śląska,
Poland

the opportunities there have been constrained," it said.

One of the problems is that neighbour Ukraine, hitherto one of the largest buyers of Russian gas, has cut direct imports of Russia to a minimum, though receives a growing volume of Russian gas through the backdoor via western nations.

Challenge

"Falling European production has been outpaced by the drop in gas demand in the European Union, meaning that the region's import needs have not grown as Russia anticipated," the IEA report said.

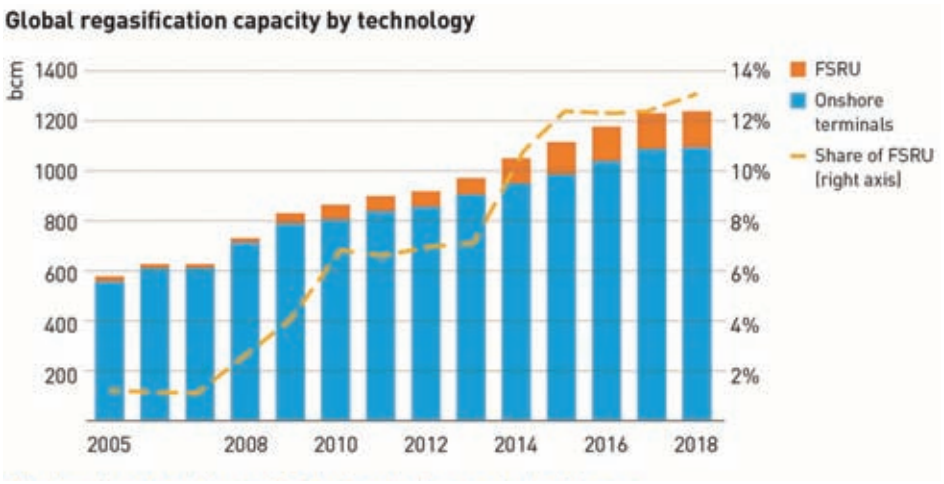
"At least for the medium term, Russia also faces strong competition in European markets from a well-supplied LNG market in which Europe is becoming the 'buyer of last resort' for excess LNG volumes," it added.

"We anticipate that, under these circumstances, Gazprom makes efforts to defend its market share in Europe and Russia's total exports rise back above 200 Bcm by the end of the decade.

"The key longer term challenge for the Russian gas industry is to unlock new export markets through the development of gas fields and the provision of pipelines to Asian markets, as well as LNG terminals that can provide Russia with more options in its export strategy.

"These upstream and infrastructure projects, which require huge upfront investments, need to be developed against the backdrop of lower revenue from oil and gas exports.

"In our projections, these new export arteries take time to develop but - starting with Novatek's Yamal LNG project and then the 'Power of Siberia' pipeline to China - they begin to lift the infrastructure constraint from the early 2020s.



Floating storage and regasification units are growing in significance

"As a result, Russia's net exports increase to over 300 Bcm in 2040, with the contribution from LNG rising from 8 percent today (the Sakhalin LNG project) to over 20 percent in 2040," the IEA added.

Floating LNG

While floating LNG liquefaction units are only now coming of age, floating storage and regasification units (FSRUs) have been in operation for about 10 years and their deployment continues to grow rapidly.

The number of units operating and under construction currently exceeds 20 worldwide. These floating units are either purpose-built vessels or converted LNG carriers.

"Lengthy permitting processes and land acquisition, which can delay the commissioning of onshore terminals, are usually by-passed through the use of FSRUs," the IEA said.

"This technology, therefore, caters well to emerging gas markets in developing countries, where financing can be a serious constraint. The scalability of the units also allows the import infrastructure to grow in step with the distribution network," it added.

"The main disadvantage of FSRUs is their relatively small size (typically between 4-8 Bcm), which makes them less suited for countries with a large and steady LNG demand.

"However, floating terminals are still an attractive technology for countries that want to increase flexibility (e.g. to meet seasonal demand swings) or diversify their gas import options," it stated.

In 2015, Egypt, Jordan and Pakistan started importing LNG deploying FSRUs while Colombia joined in 2016 and Uruguay will be one of the next nations to debut as an importer.

"In our Outlook, FSRU technology is an important enabler for gas demand growth in various smaller LNG markets in Africa, Latin America and developing Asia.

"FSRUs become increasingly influential in the medium term: their relatively short construction times allow for a quick ramp-up of LNG imports in times of low gas prices, thus gradually increasing the price responsiveness of gas consumption," the IEA explained.

Investment

According to the Paris-based organization, some $9.4 trillion of investment is needed in global gas supply through 2040.

"The regional distribution of capital expenditure by-and-large reflects the trends in production growth, with more than half of the cumulative investment needed over the period in those countries that lead gas production growth after 2025," it said.

"The large upstream capital expenditure cuts that many oil and gas companies have implemented in 2015 and 2016 would need to be reversed, at least in part, in order to meet the supply requirements," the IEA added.

The IEA has 29 members, including the leading global economies and the European Union, after being founded in 1974 to find policy responses to the oil crisis.

Its EU-led policies are now focused on global-warming and promoting renewable energy and the Paris Agreement on voluntary reductions in greenhouse-gas emissions. ■

Falling European production has been outpaced by the drop in gas demand in the European Union

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‘Dead Cow’ shale-gas play will cut future Argentine LNG demand and boost nation

South American resource plays can also look at the US for investment, production and cost guidance

Natural gas accounts for half of Argentina’s energy demand, though despite its resource wealth it became a net gas importer in 2008, by pipeline from Bolivia and via liquefied natural gas shipments.

South America holds significant natural gas resources, estimated at some 83 trillion cubic metres, of which two-thirds is unconventional shale gas.

The largest resource-holder is Argentina, which is second only to China (and above the United States) in the size of its recoverable shale-gas resources.

Vital play

Within Argentina, the most promising area is the Neuquén basin, and in particular the Vaca Muerta (Dead Cow) play, which has huge potential both as a source of tight oil and of shale gas.

It is a relatively new play and was the subject of a recent report by the International Energy Agency.

“The first shale-gas well that was hydraulically fractured and completed in 2010, but activity did not really pick up until 2013, when YPF, Argentina’s state-controlled oil and gas company, began a more intensive programme of appraisal and development,” the IEA explained.

“In total, around 600 wells have been drilled thus far, the majority of these by YPF, although several international majors (ExxonMobil, Chevron, Shell) and some smaller independent and Argentinian operators are also stepping up their presence,” the report added.

“Most of the initial wells drilled were vertical, but larger scale drilling of horizontal wells with hydraulic fracturing began in late 2014 and, by the end of 2015, around 10 percent of the producing wells were horizontal - a sign that the engineers were becoming increasingly confident about their knowledge of the reservoir and the location of some of the more productive areas,” it said.

Momentum

Shale gas currently accounts for less than 1 percent of Argentina’s 39 billion cubic metres of annual production, but some early signs of a shift in momentum are apparent.

“Our long-term assessment of Argentina’s shale-gas production is relatively upbeat, but it will take time for unconventional gas production to take-off.

“The size and apparent quality of the resource base is a critical factor for our long-term view: much remains to be discovered about the unconventional potential of the Vaca Muerta, but the information available thus far suggests that it bears comparison with some of the best performing US plays, such as the Eagle Ford in south Texas,” the IEA said.

The province where the Vaca Muerta play is located is sparsely populated, limiting the risk of disruption to existing communities, yet not too remote.

“There is reasonable access to water from the Neuquén and Limay Rivers, as well as Lake Nahuel-Huapi,” the report noted.

“Moreover, the basin has a long pedigree in conventional oil and gas (now in decline), and so has pipeline and other infrastructure already in place, alongside a well-established upstream and services industry.

Rationale

“In addition, there is a strong policy rationale and an increasingly favourable regulatory environment for Argentina to develop these resources,” the IEA said.

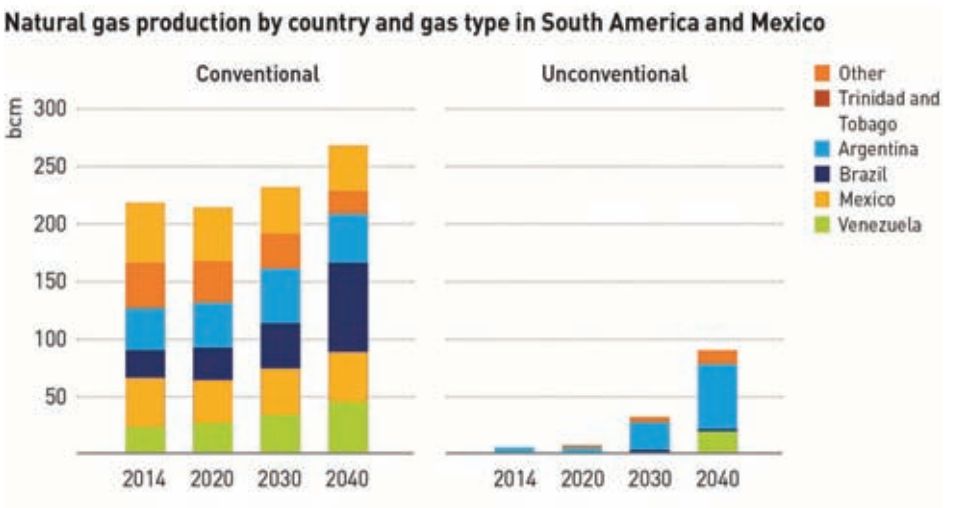
The desire to bring in new investment has brought forward changes in the upstream, including a fixed $7.5 per million British thermal units (MMBtu) wellhead price for domestic shale and tight gas.

The shale will provide a ready alternative source of gas to imported LNG.

However, the low price environment in global markets has taken a toll on capital availability for upstream spending by YPF and others.

The report noted that there were other limitations and uncertainties.

One immediate issue is the relatively weak supply chain for equipment, services and logistics.



Evolution seen in South American natural gas markets and resources

This means that for the moment, this still means the costs of production of Argentine shale gas is relatively high.

Cost estimates

The report estimated that the average costs are around $11 million for a typical horizontal well, still well above those in the US.

“More upstream players will be needed to spur the culture of innovation and learning-by-doing that has driven down costs and unlocked the potential of the US plays,” it added.

Over the longer term, uncertainty over future policies and regulation also clouds the outlook for Argentina, given the country’s history of government intervention in the oil and gas sectors.

“Last but far from least, the prospect of rapid population growth in the resource-rich areas and the need to develop a tailored permitting and compliance regime raise questions about the social and environmental aspects of unconventional resource development and the administrative capacity to handle it,” the report stated.

“Public authorities need to anticipate future strains on infrastructure and regulatory capacity and take advance action to alleviate them, or they run the risk of losing public confidence when problems occur,” the IEA explained.

“Despite the many hurdles to be overcome, Argentina is the only country in South America in our projections that succeeds in mobilising unconventional gas at scale, although Mexico also starts developing its large resources towards the end of the projection period,” it said.

“The big ramp-up in Argentina’s shale output is projected to start a little earlier, in the mid-2020s, and reaches over 40 Bcm by 2040.

It provides a major boost to overall South American gas output: between 2025 and 2040 and unconventional gas is responsible for 60 percent of the rise in regional gas production.

Mexico

In Mexico’s case, the proximity of a large and intensively developed resource in the US and the construction of large new cross-border pipeline capacity postpones the time at which indigenous resource development becomes commercially attractive.

The IEA forecasts Mexico’s shale-gas output starts to pick up only around 2030 and reaches some 15 Bcm in 2040.

The emergence of the US as a key LNG exporter is reshuffling the international gas order, though it remains to be seen how the main incumbents, such as Russia and LNG producer Qatar, will react to the more competitive international environment.

Uncertainties

Resource numbers for US shale gas are subject to considerable uncertainties, as reflected in the large range of estimates from different official and private sources.

While there are variations in the assessment of gas resources for all shale-

REMAINING TECHNICALLY RECOVERABLE NATURAL GAS RESOURCES BY TYPE AND REGION, END-2015 (TCM)							
	Conventional	Unconventional				Total	
		Tight Gas	Shale Gas	Coalbed methane	Sub-total	Resources	Proven reserves
OECD	78	24	81	16	121	199	22
Americas	51	11	55	7	73	124	14
Europe	17	4	13	2	19	37	4
Asia Oceania	10	8	13	8	29	39	4
Non-OECD	356	57	138	34	229	585	195
E. Europe/Europe	138	11	15	20	46	184	74
Asia	35	13	40	13	66	101	16
Middle East	104	9	4	-	13	117	80
Africa	51	10	39	0	49	100	17
Latin America	28	15	40	-	55	83	8
World	434	81	218	50	349	784	217

Recoverable global natural gas by type, including shale-gas reserves

gas plays, the Marcellus, the biggest US shale play, is at the heart of the uncertainty.

"Our analysis of the available estimates of US shale-gas resources points to a conceivable range of 14 trillion cubic metres to 34 Tcm.

"To demonstrate the marked impact of resource uncertainty on production trends, we have conducted an in-depth analysis of the production profiles of 27 shale-gas plays, with varying estimates of their technically recoverable resources," the IEA said.

Based on the price trajectory of its various forecasts, the range of resource estimates translates into a range of production levels between 470 Bcm and just over 900 Bcm in 2040.

Productivity gains, in terms of wells drilled per rig and ultimate recovery per well, improve the well economics and thus enable more marginal portions of any given play to be produced but the main parameter affecting productivity and gas produced is the assumed quality of the resource.

The productivity of a well is expressed in terms of the amount of gas that can be produced from it and the rate at which the gas flows to the surface.

The IEA noted that while the reservoir quality is the dominant factor in determining well productivity, the design of the US shale-gas wells play an important role too.

Well output

"The lateral length and the number of fracturing stages are the main determinants of cost and there is a trade-off between the additional cost of longer and more extensively fractured wells and the associated productivity gain," the IEA said.

"For example, operators in the largest shale gas play, the Marcellus, have increased lateral lengths and wells per pad for several years, but more recently the increases are levelling off,

suggesting that an economic optimum has been reached at current gas prices and well costs," the IEA noted.

Trade-off

"The number of wells on a pad, a proxy for how tightly wells can be spaced in the reservoir, illustrates a trade-off that operators need to make.

"More wells on a pad increase the total recovery of the volume of gas in place and provide for economies of scale, but if the well spacing becomes too tight, the wells often interfere with and cannibalise each other, resulting in a drop in the flow rate," the IEA explained.

"Several shale gas plays other than the Marcellus show a similar evolution of key parameters, such as lateral lengths and wells per pad, but the effect on productivity is not uniform.

"This is probably the result of the overriding impact of the quality of the reservoir and the ability to consistently optimise the productivity trade-off.

"Operators and service companies continue to push the limits of what is technically possible to boost productivity, until the gains and associated costs result in diminishing returns," the IEA said. ■

For the Record

AUSTRALIA is continuing to spend on developing the LNG sector. The Queensland coal-seam gas sector in eastern Australia has ongoing spending of more than A$2 billion (US$1.5Bln) per annum, though much of the CSG from the 7,331 wells drilled is required to service the three CSG-to-LNG plants, executives heard at a forum in Brisbane. The new plants, all completed within the past 18 months, will also have to cope with the LNG market trend towards shorter-term contracts as they ramp-up output on the combined six production Trains. Domestic natural gas demand in Queensland will still have to be met amid the continued uncertainty about the reliability in Australia of renewable energy projects. The Queensland LNG sector was the subject of a presentation and briefing at a forum and luncheon organised by Australian consulting firm EnergyQuest, whose Chief Executive is Dr Graeme Bethune. The EnergyQuest CEO is a former executive of Australian energy company Santos, operator of the Gladstone CSG-to-LNG plant. Bethune is also Chairman of the Australian Gas Industry Trust and represents Australia on a number of study groups of the International Gas Union. "CSG-to-LNG projects have been one of the true innovations in the Australian economy which has had a material impact on regions and the national economy," Bethune said. In addition to the more than 7,000 wells drilled there were 5,184 land access agreements with 2,188 landholders. The workforce on the three plants, all located on Curtis Island, near Gladstone, peaked at more than 40,000, with an ongoing operational workforce of up to 10,000 people. "The reserves and deliverability of CSG have shown remarkable growth, but it is still a work in progress and drilling rates will need to increase," Bethune said. "Queensland LNG is competing in the global marketplace, with the help of good joint venture and off-take partners, but the global market place is still adapting to new energy demand and investment requirements. Stable oil and LNG prices, even at lower levels, will enable business plans to be tailored to the 'new normal'," stated Bethune, who gave an overview and update on the three plants. The Queensland Curtis LNG plant, owned by Royal Dutch Shell, has two Trains operating with 8.5 million tonnes per annum of capacity, with 5.2 MTPA contracted to third-parties. Reserves are put at 11.3 trillion cubic feet. QCLNG cargoes are mainly shipped to Japan, China and Singapore. The Santos GLNG project is continuing active drilling and development. It has two Trains and 7.8 MTPA of capacity, with 7.2 MTPA contracted. Train 1 commenced production in October 2015 and Train 2 in March 2016. Reserves for GLNG are estimated to be 5.2 Tcf and deliveries are "widely dispersed". The Australia Pacific LNG project involves ConocoPhillips, Origin Energy and China's Sinopec. Its two Trains produce 9.0 MTPA, with 8.6 MTPA contracted. Train 1 commenced production in January 2016 and Train 2 started in the third quarter. Its main customers are Sinopec and Japanese utility Kansai Electric and reserves are estimated at 12.8 Tcf. Overall Australian LNG export volumes grew by an estimated 6.6 percent in October to 4.3 million tonnes, the equivalent of 65 cargoes, up from 4.0MT, or 61 cargoes, in September. EnergyQuest noted that despite what is supposed to be an oversupplied market, the LNG spot price in Asia was now at the highest it had been all year, rallying to more than US$7.00 per one million British Thermal Units.

CANADA is seeing at least limited progress on small projects in the province of British Columbia. The decision by the Asian-run Woodfibre LNG project to proceed and its full authorization means it will also be locked into using state-backed electricity and associated technology being pushed onto liquefaction and export ventures. The Government of BC and the provincial utility, BC Hydro, have announced a special electricity package for LNG export plants that connect to local utility BC Hydro and its integrated grid for the liquefaction process, including the powering of compressors to chill and liquefy natural gas. The Woodfibre development earlier in 2016 became the first LNG export project in Canada to receive its full environmental approval from the federal government in Ottawa under the new tougher legislation. It has now also taken a final investment decision to proceed. "Using electricity instead of natural gas to power LNG facilities will limit greenhouse gas emissions, helping the Province achieve its reduction targets," BC said. "LNG customers also will be required to contribute the full cost of connecting to the BC Hydro system and transmission upgrades required to serve their facilities, as set out in electricity supply and load interconnection agreements with BC Hydro," the government explained. The Woodfibre project is being developed by Indonesian billionaire Sukanto Tanoto and his Pacific Oil and Gas company. Planned for the site of a former pulp mill on the shores of Howe Sound in Squamish, north of Vancouver, Woodfibre is a mid-scale LNG facility with initial capacity of around 2.1 million tonnes per annum. The liquefaction plant and infrastructure is on the traditional lands of the Squamish First Nation and they have been given some in-put on environmental issues and the cleanest technology choices. BC said that the power package and rates for LNG projects will be available to proponents once they have announced their final decisions to proceed and use BC Hydro for the liquefaction process. The rate for LNG developers is also the same price as the standard industrial electricity rate for their ancillary power needs. "This creates an incentive for LNG developers to use electricity instead of natural gas for their compression needs, and supports actions under the Province's 'Climate Leadership Plan' to encourage electrification, reduce emissions, and enable the development of a new, low-carbon economy," said BC

CARIB ENERGY, a subsidiary of US shipping line Crowley Maritime Corp., has been given approval to export LNG in containers on board cargo ships to any country in Central America, South America or the Caribbean and with the fuel supplied by small-scale plants in three states in the US southeast. Carib said it would purchase the LNG for export from any of five existing small-volume natural gas liquefaction facilities, owned and operated by Pivotal LNG in the US states of Alabama, Georgia and Tennessee. The permits from the US Department of Energy authorize Carib to export the International Standardization Organization (ISO) containers over a 20-year period and amounting to around 1.3 billion cubic feet of US natural gas. The latest permit will increase LNG deliveries into the Caribbean and Latin American region where the ISO containers of LNG can be used for small-scale power plants or for fuel projects. ISO containers of LNG leaving the US have recently commanded the highest prices of around $10 per million British thermal units. The LNG will be sourced from affiliates of Pivotal LNG and exported on ships from the ports of Jacksonville and Port Everglades in Florida and Gulfport in Mississippi. The LNG ISO containers may also be shipped from other ports in the US southeast if they have the required infrastructure. Carib states that delivery of the LNG will be taken at the five facilities and the containers would then be transported on highways. The Crowley energy subsidiary Carib signed a sale and purchase agreement with Pivotal back in March 2014 and since then five small-scale liquefaction plants have been lined up to supply the containers. The five liquefaction facilities owned and operated by Pivotal include the Trussville LNG plant in Alabama. The facility has a liquefaction capacity of 1.82 Bcf per annum and is capable of loading 20 containers a day. The Trussville LNG Facility was built in 1974 and is subject to regulation by the Alabama Public Service Commission. Another plant is located in Chattanooga in the state of Tennessee. The Chattanooga liquefaction plant is a peak-shaving facility designed to supply gas to meet shortages during peak usage and is owned and operated by Chattanooga Gas Co. Its output is listed as 3.65 Bcf per annum. The facility, which was built in 1972 and is capable of loading 20 trucks per day, is overseen by the Tennessee Regulatory Authority and subject to safety regulation by the Federal Energy Regulatory Commission. The third plant supply ISO containers will be the Riverdale plant, a small-volume production facility located in Georgia, owned and operated by Atlanta Gas Light Co. It has a storage capacity equivalent to 2.5 Bcf per annum of natural gas. The fourth supply plant is the Cherokee LNG plant located in Ball Ground, Georgia, also owned and operated by Atlanta Gas Light. It has a storage capacity equivalent to 2 Bcf of natural gas. The plant was built in 1988 and is subject to regulation by the Georgia Public Service Commission. The fifth plant supplying the Carib export venture is the Macon facility, located in the town of Macon in Georgia and owned and operated by Atlanta Gas. It has storage capacity equivalent to 1.5 Bcf of natural gas and was built in 1978. It is also subject to regulation by the Georgia Public Service

Commission. The Crowley subsidiary behind the Carib-led venture is Crowley Petroleum Services, whose headquarters are in Jacksonville, Florida.

CENTRICA, the UK utility and energy company has entered into an agreement with Tokyo Gas, the third-largest LNG importer in Japan, to swap and share cargoes from the Atlantic and Pacific Basin volumes. Centrica and Tokyo Gas said their memorandum of understanding "establishes an alliance" between the two in their LNG activities. "A framework has been agreed whereby both companies will work together to optimise contracted volumes from both Atlantic and Asia-Pacific markets through location swaps, which would achieve LNG transportation savings and lower the overall cost of LNG procurement," they explained. Both companies said they intended to enter into a legally binding contract on the basis of this framework. "We are delighted to formalise our long-standing relationship with Tokyo Gas and we welcome the opportunity to expand our LNG activities in Asia Pacific," said Jonathan Westby, Centrica's Co-Managing Director of Energy, Marketing & Trading. "Building alliances, such as this, helps towards lowering LNG procurement costs and this can benefit customers around the world," Westby explained. According to senior Tokyo Gas executive Kentaro Kimoto, the collaboration will allow more flexible LNG diversions across the Pacific and Atlantic regions. "Through initiatives like this opportunity, we will make further efforts to lower LNG procurement cost in order to enhance our customer value," Kimoto said. Centrica signed a new five-year LNG supply agreement with Qatargas in September 2016 for up to 2 million tonnes per annum of cargoes supplied to the Grain import terminal, located southeast of London. The new LNG contract will start in January 2019, following expiry of Centrica's existing contract with Qatargas at the end of December 2018. The renewal of the Qatargas agreement gives the UK owner of British Gas a strong LNG portfolio going forward. Both Centrica and Tokyo Gas have volumes booked at US export projects under construction. Centrica was one of the early movers on booking US LNG supplies. In March 2013, it signed an accord with Cheniere Energy to receive shipments in the UK from the Sabine Pass plant in Louisiana from September 2018. Tokyo Gas will receive volumes from the US before Centrica as it has a tolling agreement with the Cove Point export plant in Maryland, set to come on stream in 2017. Centrica's future US LNG deliveries will amount to around 1.75 MTPA, the equivalent of the annual gas demand of around 1.8 million UK homes and is for an initial 20-year period. The Japanese volumes from Cove Point, located on Chesapeake Bay, will also be around 2 MTPA and could be more economic on a seasonal basis to ship across the Atlantic than through the Panama Canal and across the Pacific to Japan, analysts said.

CHENIERE ENERGY, owner of the Sabine Pass LNG plant in Louisiana, has started the pre-filing process with regulators for a fast-track greenfield pipeline project to bring shale-gas from the Woodford Shale in Oklahoma to export as LNG from the Gulf Coast. The US Federal Energy Regulatory Commission has agreed to initiate the pre-filing process for the Midship Project being backed by Cheniere affiliate Cheniere Midstream Holdings. "The scheduled in-service date for the Midship Project is June 2019," Cheniere said. In consideration of this schedule, Cheniere Midstream requested and received the initiation of its pre-filing permitting process before mid-November. The project is designed to transport up to 1.4 billion cubic feet per day of natural gas to LNG liquefaction plants in Louisiana and Texas and to other users, with interconnections also included to other pipelines. "The Midship Project is designed to meet the growing demand for new natural gas pipeline infrastructure for the anticipated continued ramp-up in production of the vast reserves from the Woodford Shale in Oklahoma," Cheniere said. "Current infrastructure for moving natural gas from this area is limited to serving mid-continent markets, is constrained and cannot accommodate the anticipated production growth from this region," Houston-based Cheniere stated. "The growing Gulf Coast LNG, Mexican and Southeast US power and export demand supports the development of infrastructure, such as Midship, to move gas southward and eastward to existing, non-constrained pipelines," the company added. The project would involve construction of around 200 miles of pipeline and related facilities in Oklahoma. Additionally, three new compressor stations are planned to be constructed in three counties of the state. Cheniere said it would also lease over 350 miles of existing pipeline capacity between Bennington, Oklahoma, and the Gulf Coast. Cheniere's venture is proposing a two-zone system that will transport gas out of the existing and "inadequate" system to access more desirable markets via deliveries to existing market hubs, such as TexOk near Atlanta, Texas, and Perryville, Louisiana. The project's Zone 1 will consist of around 200 miles of 36-inch-diameter newbuild pipeline that will begin at or near the Okarche processing plant in Oklahoma and end at Bennington, Oklahoma. "A majority of the project's newbuild mainline pipeline facilities (greater than 70 percent) will be collocated with existing pipelines, utilities and other rights-of-way," Cheniere said. Cheniere said the venture's Zone 2 would consist of 353 miles of existing pipeline capacity leased from the Midcontinent Express Pipeline and/or the Gulf Crossing Pipeline Co., operated by Kinder Morgan and Boardwalk Pipeline Partners respectively. The proposed leased capacity will begin at Bennington, Oklahoma, and end near Tallulah, Louisiana.

CHENIERE received a letter of authorization from the US Federal Energy Regulatory Commission to proceed with commissioning of its third production Train at the Sabine Pass export plant in Louisiana, opening the way for the selling of more spot cargoes on the LNG market. The FERC letter authorised the introduction of feed gas and refrigerants for commissioning of liquefaction Train 3 at its LNG export terminal in the state's Cameron Parish. "Based on review of the information filed above, we have also determined your filing is consistent with Environmental Conditions of the Order for introduction of feed-gas and refrigerants into Train 3 and Stage 2 OSBL facilities. Your filing is also consistent with Environmental Conditions of the August Order for the introduction of feed-gas and process fluids into the Heavies Removal Unit facilities within Train 3," the FERC letter added. Cheniere said that during the third quarter, Train 2 was completed and began selling commissioning cargoes that were offset against LNG terminal construction-in-process because these amounts were earned during the testing phase. "We expect sales of LNG cargoes from future liquefaction trains to be reported in the same manner," Cheniere added. During the three months to the end of September the Houston-based company said 18 cargoes were loaded and exported from the Sabine Pass facility, three of which were Train 2 commissioning cargoes. Cheniere noted that the start of operations had also increased operating costs and expenses. Cheniere is building a total of six Trains at Sabine Pass, each with a production capacity of around 4.5 million tonnes per annum. The company said Train 4 was about 92 percent complete and construction of Train 5 began in June 2015, and as of September 30, the overall project completion percentage for Train 5 was approximately 42.8 percent. Cheniere expects Train 5 to reach substantial completion in 2019 and Train 6 was currently under development, with all necessary regulatory approvals in place.

CONOCOPHILLIPS said it was in the process of selling its Kenai liquefied natural gas plant in the state of Alaska, the first US liquefaction and export plant to come on stream in 1969 and which went on to export cargoes to Japan for 46 years. ConocoPhillips said its move to sell the small-scale Kenai plant was consistent with the review process to sell assets not seen as a priority as the company refocuses and cuts costs. The US oil major said it would open a "data room" associated with the sale in January 2017. "Our current focus is on our North Slope operations," said spokeswoman Amy Burnett in reference to the huge natural gas resources that will be available for a new LNG export project majority-held by the state. LNG from Kenai had previously been shipped under long-term contract to Tokyo Electric Power Co. and Tokyo Gas though operations have gradually been cutback at the aging plant where the capacity is less than 900,000 tonnes per annum. That compared with the eventual 27 million tonnes per annum planned for the first US Gulf Coast LNG export plant to come on stream, Sabine Pass in Louisiana. Sabine Pass began operations in February 2016 and now has completed three liquefaction Trains with a combined 13.5 MTPA once they are ramped-up. More such large-scale export plants are currently being constructed on the Gulf Coast and two others on the east coast, including Cove Point in Maryland, scheduled to come on stream in 2017. The original investors in the Kenai plant were Marathon Oil and the predecessor

company of ConocoPhillips. Its start-up in 1969 came four years after the first full-scale LNG export plant began commercial operations at Arzew in Algeria. That Japanese contract with Kenai was signed in 1969 and the latest renewal expired in 2011. The Kenai plant was effectively mothballed in March 2013 because of uncertainty over whether Alaska's Cook Inlet had enough gas to meet local and export demand. Kenai was then given a short reprieve and during 2014 and 2015 exported about 10 cargoes to Japan, mostly on a spot basis to Japanese utilities, including Kansai Electric Power Co. The state of Alaska under the Alaska Gasline Development Corp. is currently taking over the new and larger Alaska LNG project using North Slope reserves to produce more than 20 million tonnes per annum. ConocoPhillips is among the stakeholders in this venture, though it is effectively on hold because of the downturn in the industry and the change in the economics of the original project. There have also been discussions on building a medium-sized LNG plant on Cook Inlet, near where the Kenai plant is located, though these have failed to advance beyond the study stage.

DELEK GROUP, the Israeli LNG project developer and natural gas producer in the Eastern Mediterranean, said third-quarter net income rose amid record production from the Tamar gas field. Group revenues for the three months were 1.6 billion shekels ($416M) compared with 1.7Bln shekels in the same period last year, though net profit and operating income increased. The Israeli company said the Tamar field produced record production of 2.6 billion cubic metres during the three months, with peak output reaching 1.0 billion cubic feet per day. Delek's main partner in its East Med operations centering on the Tamar field and the larger Leviathan field, set for a development project soon, is Noble Energy of the US. "Delek Group concludes a successful third quarter from a financial and strategic standpoint," said Asaf Bartfeld, President and Chief Executive Delek. "The third-quarter results demonstrate financial strength of the Group, which enables us to build upon the existing activities in the energy sector, whilst growing the Group in the international energy sector," Bartfeld added. Among quarterly highlights, the Israeli company said financing was secured for the Leviathan natural gas field development with a limited recourse loan of up to $1.75 billion and the company said it was progressing towards a final investment decision. Delek said another important landmark was an agreement worth an estimated $10 billion signed with Jordan's National Electric Power Company for the supply of natural gas from the Leviathan field. "Following the signing of our agreements with the Jordanian Electric Company as well as a number of other players in the domestic market, combined with the signing of the financing for the development of Leviathan, we see ourselves closer to the final investment decision to develop the Leviathan reservoir, based on our strategic plan," the CEO added. Additionally, the company leveraged its strong balance sheet to win a new international exploration licence in Newfoundland, Canada. Delek said net income for the three months rose to 85 million shekels ($22.1M) compared with 22M shekels in the year-ago period. Operating profit in the third quarter was 354M shekels ($92M) compared with 341M in the same period of 2015.

ENAGAS and Gas Natural Fenosa, the main Spanish natural gas and LNG companies, have launched a project with the state-run railway company Renfe to run Europe's first locomotives powered by LNG. "The test aims to analyse the potential environmental and financial advantages of natural gas in rail transport along non-electrified lines," said a statement from the three companies and other partners. The advantages are seen as being a reduction in environmental pollution and lower operating costs for LNG compared with oil-based fuels used on older trains. The project will also see the commercial companies working with the Associación para la Reconstrucción de Material Ferroviario (ARMF), the Institut Cerdà, which supports Spanish innovations, and French classification company Bureau Veritas. "This innovation project will assess the feasibility of adapting locomotives to run with LNG engines and tanks, and the relevant technical, legal, economic and environmental analysis for the Spanish and European rail network," they said. The project, coordinated by the Institut Cerdà and with ARMF as rail integrator, is in line with the European Union directive on the deployment of alternative fuels infrastructure in Europe. The agreement involves a pilot test being carried out with an LNG-powered engine on a locomotive from the Feve diesel train depot in northwest Spain along a 20 kilometres section between Trubia and Baiña stations, extending to Figaredo in Asturias. "For this purpose, the diesel engine on one of the two paired locomotive units will be replaced with one powered by natural gas, and tanks for storing LNG will be fitted, alongside other necessary auxiliary equipment," the statement explained. "The test will allow the results obtained for both diesel and gas technology to be compared, given that a locomotive running on each type of fuel will be used on the same train," it added. "This track test will be used to draw conclusions on technical requirements for space, weight, refrigeration, and autonomy for running on natural gas, as well as other considerations and comparative variables in emissions and operating economy," it said. Renfe, Gas Natural Fenosa and Enagas said they were also assessing the possibility of presenting a second phase in this project which could qualify for EU funding.

ENAGAS, the Spanish natural gas network and LNG terminal operator, has closed the acquisition of 20 percent of the Chilean import terminal company GNL Quintero from a subsidiary of Gas Natural Fenosa and has made a pledge of commitment to keep the South American nation supplied as the facility expands. The GNL Quintero regasification plant, located in Quintero Bay, was the first LNG terminal in the southern hemisphere. It has been in operation since 2009 and has been operating at full capacity since January 2011 and with an expansion now taking place. "With Enagas increasing its stake in the terminal, the company reinforces its long-term commitment to Chile. For Enagas, the priority is given to the development and future growth of GNL Quintero, which is a fundamental infrastructure for the security of the country's energy supply," Enagas stated. The transaction for the additional stake was valued at 175 million euros ($197M). With this purchase, Enagas increases its stake in the plant to 60.4 percent. This is comprised of a 40 percent stake in GNL Quintero and an indirect 20.4 percent stake through the affiliate company Terminal de Valparaíso. "This acquisition fits with the core business of the company and its profitability and objectives," Enagas added. GNL Quintero has a main ship docking area, three storage tanks, three vaporizers and a tank loading station. In addition, the terminal is planning to build a new LNG storage tank of 160,000 cubic metres capacity. The new tank will give GNL Quintero an increase in regasification to 833,000 cubic metres per hour. Enagas has been a shareholder in GNL Quintero since 2012. Enagas is already a stakeholder or has operatorship in the import and regasification facilities at Barcelona, Cartagena, Huelva, Bilbao and El Musel. The Enagas terminals in Spain have a total of 16 storage tanks around the country with capacity for 1.95 million cubic metres. They also have a total of nominal regasification capacity of 4.65 million cubic metres per hour. The ownership of GNL Quintero is now made up as follows: Enagas Chile, 40 percent; Terminal of Valparaíso, 40 percent (Enagas Chile, 51 percent, and Oman Oil Co. 49 percent) and Chilean company ENAP 20 percent.

ENI, the Italian energy company, has agreed to sell to BP a 10 percent stake in the Shorouk concession in Egyptian waters of the East Mediterranean for up to $500 million, making the UK company a partner in the "supergiant" Zohr field that will impact regional LNG supplies when it comes on stream in late 2017. Eni currently holds a 100 percent stake in the lock and said the agreed deal with BP includes a sum of $375M and a pro-rata reimbursement of past expenditures, which amount so far to $150M. The Italian company said that in addition, BP has an option to buy a further 5 percent stake under the same terms. The Zohr field when it comes on stream as early as the end of 2017 will affect regional LNG markets, especially for main player Egypt which was once an exporter and now imports LNG cargoes. "This transaction is in line with the Eni's 'dual exploration model' aiming at an early monetization of the value through the dilution of recent huge exploration discoveries owned with high participating interests," the Milan-based company said in announcing the deal. The Zohr field was discovered by Eni in August 2015 and is the largest offshore natural gas field in the East Med, with minimum resources in place of 30 trillion cubic feet and potentially much more. In February 2016, the Egyptian authorization process for the development of the Zohr field was completed and first gas is expected in about a year's time under a fast-track development plan. The Eni discovery will go some way to

satisfying Egypt's domestic natural gas needs, while possibly helping to revitalize its two LNG export plants and ending the need for LNG imports. Egypt has two Floating Storage and Regasification Units deployed at the port of Ain Sokhna in the Gulf of Suez to import cargoes and satisfy natural gas demand. So far in 2016, Egypt has taken delivery of almost 100 LNG cargoes from the spot and short-term market. "This interest in a truly world-scale asset will complement our existing Egyptian business," said Bob Dudley, BP Chief Executive, on the purchase of the Zohr field stake. "We already have a strong partnership with Eni in Egypt and look forward to working closely with them to efficiently bring these important resources to the Egyptian market. BP has now been in Egypt for over 50 years and we continue to see opportunities to further develop our extensive activities here. Beyond Zohr, the first phase of our major West Nile Delta project is on schedule to begin production next year and the fast-tracked development of the Atoll gas field is expected to come on stream in 2018," Dudley stated. However, BP's West Nile project is relatively small with 5 Tcf of gas, a fraction of the estimated resources in the Zohr field, located about 190 kilometres north of Port Said in water depths of 1,500 metres. Eni holds 100 percent of the Shorouk licence and operations are also being conducted with Petrobel, a joint venture between Eni and Egyptian state energy company Egyptian General Petroleum Corp. Petrobel awarded Italian energy engineering company Saipem the engineering, procurement, construction and installation contract for the accelerated start-up of the Zohr field. The scope of the Saipem subsea contract entails work on six gas wells and the installation of the umbilical systems. Eni said its East Med drilling campaign on Zohr will continue at a fast pace that will ensure the accelerated start-up production rate of 1 billion cubic feet per day. "The steady progress of the project execution is confirming the schedule expected to reach the first gas by the end of 2017," Eni stated.

ENI Italian energy company said its board has authorized the investment for the first phase of the Coral South floating LNG project in the Rovuma Basin offshore Mozambique in southeast Africa. The project involves the construction of 6 subsea wells connected to a Floating liquefied natural gas production facility with a liquefaction capacity of over 3.3 million tonnes per annum. Mozambique authorities approved the project development plan in February. "This project highlights Eni's technological leadership in the development of deepwater gas fields via FLNG facilities," the Italian company said. The Coral field, discovered in May 2012, is entirely located within the Rovuma Basin Area 4 licence area for which Eni is the operator and contains about 16 trillion cubic feet of gas in place. Eni estimates that the Area 4 resources amount to 85 Tcf. US energy company Anadarko Petroleum is the licence holder of the Area 1 zone, where large discoveries have been made and an onshore LNG project planned. The Italian company also explained that the move was still short of a final investment decision, though this would be decided soon by Eni and the other parties and partners involved. The Eni board's decision to go ahead with the first phase development of Coral FLNG comes after Mozambique and its project partners led by Eni on October 11 signed a 20-year LNG sales agreement with BP of the UK, opening the way for the venture to move forward. "The approval of this investment by Eni's Board of Directors is another fundamental step towards the Final Investment Decision on the project, which will turn effective once all Area 4 partners have approved it and the project financing, which is currently being finalized, has been underwritten," Eni said. Eni is the operator of Area 4 with a 50 percent indirect interest owned through the Eni East Africa subsidiary, which holds a 70 percent stake in Area 4. The other shareholders are Galp Energia of Portugal, Korea Gas Corp. and Mozambique state energy company Empresa Nacional de Hidrocarbonetos (ENH), who each hold 10 percent stakes. China National Petroleum Corp. (CNPC), the parent company of PetroChina, also has an interest through its 20 percent interest in Eni East Africa. Eni's Coral FLNG project will be located in waters more than 2,000 metres deep and about 80 kilometres offshore the northern Mozambican province of Cabo Delgado. The Eni plan of development, the very first one to be approved in the Rovuma Basin, foresees the drilling and completion of the six wells and the construction and installation of a floating production facility. Eni had previously been reluctant to move forward because of economic uncertainty in Mozambique following a state loans scandal. The shareholders in the Anadarko-led Area 1 licence include three Indian companies, ONGC Videsh, Oil India and Bharat PetroResources as well as Japan's Mitsui & Co. and Thailand's state-owned energy company PTT. Omar Mitha, the Chairman of state energy company ENH, said recently that his country was heartened by the rising clean-energy profile of LNG as a fuel. "The positive aspect that underlies the opportunities for Mozambique is that there are large reserves and the country offers security of energy supply to premium markets of East Asia, including new LNG importers," he said. "Mozambique has a strategic location, has economic advantages and a broad base of stakeholders from India, Thailand, South Korea, China and Japan," Mitha added.

EXXONMOBIL, the US major and a shareholder in the world's largest liquefied natural gas supply complex in Qatar, has joined a UK project to develop LNG bunkering infrastructure as well as storage and technical support in the north of Scotland. ExxonMobil is part of a joint venture, also including engineering company Babcock International, shipping services group Bernhard Schulte Shipmanagement (BSM), gas company Calor and the local council in the Orkney Islands. All will collaborate in what is called the Caledonia LNG project for development of the fuel in the North Sea and the northern UK, with building maritime refueling facilities seen as a key part of the planned activities. The parties have signed a memorandum of understanding to investigate opportunities to supply LNG for marine and land-based applications. As well as being a stakeholder in the Ras Laffan LNG liquefaction Trains in Qatar, ExxonMobil also has a stake in the UK South Hook import terminal at Milford Haven and is helping develop the US Golden Pass LNG export plant in Texas. "ExxonMobil will explore the potential for its global marine network to deliver LNG bunker fuel to customers in the region as well as providing technical support and expertise to enable safe LNG bunkering operations," a statement said. Babcock, one of the largest UK engineering services companies, will provide its experience of storage, handling and distribution of LNG, while BSM would be responsible for supervising the building, management and operation of the marine assets for the project. Calor will investigate opportunities to supply LNG to industrial and automotive sector customers, while the Orkney Islands Council would supply port services and security. "The Memorandum of Understanding is a clear indicator that ExxonMobil, Babcock International Group, Bernhard Schulte Shipmanagement (BSM) and Calor are determined to leverage their history and expertise with LNG to work with Orkney Islands Council to maximize the possibilities for customers," said Luca Volta, LNG Venture Manager at ExxonMobil Marine Fuels. "We will also draw upon our extensive global marine network to provide our customers in northern UK and the North Sea with LNG bunker fuel," Volta added.

FINLAND's natural gas utility and development company Gasum has opened the nation's second LNG filling station, located at the southwest port of Turku as it builds a nationwide network. The first Finnish LNG filling station serving heavy-duty road vehicles opened in August 2016 at Vuosaari Harbor, part of the Port of Helsinki. The Turku facility is the latest and will be followed by two others in 2017 in the towns of Jyvaskyla and Vantaa. Finland is joining the leaders in the LNG road fuel market such as the UK, Spain and the Netherlands, where station network build-outs are in progress targeting truck haulage companies as customers. "Gasum is committed to investing in the development of gas vehicle use and aims to construct two more gas filling stations in the Turku area next year," the company said. Vehicles at the Turku station can be filled up with LNG, compressed natural gas (CNG) or liquefied biogas (LBG). Gasum said its LNG and LBG fuels were suitable for heavy-duty road vehicles and in addition to reducing particulate emissions using the gas as an alternative to traditional diesel fuel helps reduce engine noise in trucks. The company is marketing CNG and LBG as a fuel for cars, delivery vehicles, waste management vehicles and buses. Gasum is also involved in the industrial LNG business through its ownership of the Norwegian company Skangas. Subsidiary Skangas is a leader in the Nordic region with LNG production plants in Risavika, Norway, and Porvoo, Finland, as well as LNG reception terminals in the Norwegian town of Ora, at Lysekil in Sweden and the newest at the port of Pori in Finland. Gasum is the leading supplier of biogas in Finland whereby it processes waste and produces biogas in the process. Demand for biogas produced from waste is increasing in the Nordic market where policy-makers and long-term targets are in favour of biogas production. The company has seven biogas plants located in the towns of Honkajoki, Huittinen, Kuopio, Oulu, Riihimaki, Turku and Vehmaa. Gasum also injects biogas into the Finnish national gas network from Espoo, Kouvola, Lahti and Riihimaki. "The development of the gas infrastructure plays a key role for the increased use of gas as a road vehicle fuel," said Gasum. The significance of the Turku filling station to the development of the Finnish gas infrastructure was pointed out by Gasum Chief Executive Johanna Lamminen. "I'm pleased that we're finally able to also provide southwest Finland with access to gas," Lamminen said. The CEO said Gasum was committed to investing in the development of the low-emission road fuel gas market by increasing the supply in the key demand areas in Finland. The Pori LNG import terminal is the first to operate in the country and recently began commercial operations with cargoes from Rotterdam. A second terminal is being developed at the port of Tornio with the opening scheduled for 2018.

FLOGAS BRITAIN, the UK liquefied natural gas provider, and a unit of Norwegian company Stolt-Nielsen are working on a joint project to bring small LNG shipments to the eastern Scottish Port of Rosyth. The shipments are scheduled to start by 2019 in small-scale LNG carriers and will supply customers not served by the existing natural gas grid. Stolt-Nielsen has already completed the permitting process for a similar project being developed for the Italian island of Sardinia. Flogas and Stolt-Nielsen said their initiative is a step towards reducing the cost of energy for homes and businesses in remoter areas. Under an initial plan LNG will be shipped by Stolt-Nielsen's LNG subsidiary via the small-scale vessels and stored in bulk at the Port of Rosyth, before being distributed by Flogas across

Scotland by road tanker, mainly to industrial customers. Flogas pointed out that Scotland's off-grid natural gas is delivered by road tanker from the Isle of Grain LNG import and fuel terminal in Kent, southeast England. "The costs associated with the long distances are high, forcing many off-grid businesses to use oil to power their industrial processes, or pay a premium for gas," Flogas said. "With a target completion date set for 2019, the bulk LNG solution will deliver LNG more cost effectively, making it cheaper and enabling users to switch to the more environmentally friendly fuel," Flogas added. "For the next phase of the project, a leading engineering firm has been engaged to support the preliminary engineering and permitting of the small-scale LNG terminal at the Port of Rosyth," Flogas explained. "Once permits are obtained, construction of the facility can begin on the site, which will generate over 100 local jobs during the 18-month construction phase, and 50 more following completion," said the UK company, based near Leicester. "This unique project is the beginning of Scotland's LNG future and a chance to establish Scotland as an even greener nation," said the Head of Sales of Flogas, Rob McCord. "It will encourage the development of a natural gas infrastructure in Scotland's remote regions and attract substantial investments from leading industrial groups," he added. "Flogas already supplies gas to many businesses and housing estates in Scotland, and the interest we have from potential new customers is huge. The demand is certainly there. We now need to work with the Scottish Government and our other stakeholders to bring the project to life," McCord added.

GOLAR LNG, the Norwegian fleet owner and project developer, said the shipping market shows positive signs with improving utilisation rates and the re-appearance of round-trip economics as it reported a narrowing of third-quarter operating losses. Golar said a total of around 300 spot fixtures were expected to

be concluded in the global market during all of 2016, a significant step up from around 190 voyages in 2015. "New LNG supply Trains are delivering on an almost quarterly basis, gradually eroding the overcapacity in the shipping market. There are clear signs of tightening in the spot market and this improvement is encouraging charterer interest in longer-term contracts," the company added. Golar reported that its quarterly losses narrowed to $28.2 million from $37.2M in the previous quarter. It explained that the third-quarter began in much the same way as the first half of the year with excess tonnage weighing heavily on rates. The company added that this was followed by increased activity in August that resulted in a step up in rates and utilisation, particularly for owners with open tonnage in the Atlantic Basin where spot rates in excess of $40,000 per day were achieved. "Both chartering activity and rates have since eased but levels remain well above the lows reached in the first half of 2016. The Pacific market continued to be typified by higher liquidity with an abundance of available shipping as well as spot demand from projects, utilities and traders," Golar said. "Spot charters have typically been for short durations, maintaining liquidity but limiting significant rate increases. Atlantic activity on the other hand has been more sporadic with thin tonnage availability and limited demand occasionally interrupted by sudden waves of requirements that clear out this available tonnage and result in improved rates," Golar stated. As regards its other activities in LNG and power development projects, Golar said it joined during the third quarter with oil and gas services company Schlumberger to form OneLNG to offer an integrated upstream and midstream solution for the development of low-cost gas reserves to LNG. UK company Ophir and OneLNG subsequently agreed to form a joint operating company to develop the 2.6 trillion cubic feet of gas reserves in the Fortuna field offshore Equatorial Guinea using floating LNG technology. Another subsidiary, Golar Power, closed a financing transaction with US equity fund Stonepeak to capitalise on downstream opportunities. Golar Power then reached a final investment decision on a Brazilian LNG-to-power project in the northeast state of Sergipe. Golar signed a 25-year deal to charter a Floating Storage and Regasification Unit to the Brazil venture and also entered into a long-term sale and purchase agreement for the supply of LNG. As regards its FSRU activities, Golar's existing fleet of six FSRUs all reside within the US-listed Golar LNG Partners affiliate but are managed by the shipping company. Golar said the FSRU fleet had maintained "operational excellence" during the past three months. The FSRU "Golar Tundra" remains at anchor off the coast of the West African nation of Ghana as part of a charter agreement with West Africa Gas Ltd (WAGL). However, Golar commenced legal proceedings in order to collect amounts due under the charter, though on November 29 the company received its first payment from WAGL for amounts outstanding under the charter. The company has not recognised any revenue from the Ghana charter in its latest income statement. The "Golar Tundra" will not now commence operations as an import facility in Ghana until 2017.

HOEGH LNG, the Norwegian fleet owner and floating storage and regasification unit charterer, posted a modest rise in third-quarter profits as the Latin American state of Colombia became an importer using the FSRU "Hoegh Grace" and a Chilean project prepared to take another ship. The Norwegian company is currently negotiating several long-term FSRU charters and said a project called Penco LNG in the South American nation of Chile was one of the ventures making progress. "The level of business development activity is currently high. Several new FSRU projects have been proposed lately, most of which have start-up dates in 2017 and 2018," Hoegh stated. Colombian companies Promigas and La Sociedad Portuaria El Cayao were the latest to initiate a joint venture LNG import project involving a Hoegh FSRU. The resulting LNG imports will give Colombia supplies for gas-fired generation to cover any shortfalls in electricity from hydropower. In addition to seeking US LNG cargoes, the new import facility at Cartagena will also be expecting to buy shipments from the Atlantic LNG export plant at Point Fortin in Trinidad. Hoegh has signed a contract for a minimum term of 10 years with Sociedad Portuaria and Promigas for the FSRU. "The Colombian FSRU project entered its start-up phase when 'Hoegh Grace' arrived in Cartagena early November 2016 and subsequently loaded its commissioning cargo," Hoegh said. "Commercial operation is expected to commence in early December 2016," the Norwegian company added. Hoegh said that it could transfer the "Hoegh Grace" to its US affiliate, a master limited partnership which already has four FSRUs under long-term contract. Next on the Hoegh FSRU agenda is Chile. Hoegh said that during the third-quarter all permits were issued by the Chilean regulatory authorities to Penco LNG. The Penco FSRU contract will be serviced by a newbuild vessel currently under construction at Hyundai Heavy Industries in South Korea. In its earnings, Hoegh posted a modest third-quarter profit of $3.33 million compared with $2.49M in the same three months of 2015. Total third-quarter income was $58.05M, little changed from the $58.31M of a year ago. Net cash flow for the quarter, a key measure of profitability, was $900,000 compared with a negative $41.8 million in the previous period. Hoegh President and Chief Executive Sveinung J. S. Stohle, said the company was continuing to focus on operational excellence and project execution. "With plenty of LNG being available at competitive prices, our customers continue to increase the throughput rate on our FSRU fleet, further reinforcing the economic attractiveness of FSRUs," the CEO stated. The company said it was "making progress on securing employment" for another FSRU due for delivery in March 2017, as well as for additional FSRUs under order or subject to conversions. "Hoegh LNG is participating in several tender and bi-lateral processes and has entered into a memorandum of understanding for exclusive negotiations for one project under development," it said. Hoegh said that at the end of September it had $269M in current cash and marketable securities and a net interest-bearing debt of $663M. The Group entered into four FSRU shipbuilding contracts with Hyundai in 2011 and 2012, all of which have been delivered, including the "Höegh Grace". Hoegh entered into two additional FSRU shipbuilding contracts with Hyundai in 2014 and 2015, with expected delivery during the first quarter of 2017 and 2018 respectively. As of the end of September, total remaining capital expenditures relating to these shipbuilding commitments were $534 million. "Hoegh LNG is currently in the final round of evaluating bids received from shipyards for its next FSRU newbuilding series. The terms and conditions of the offers received are very competitive, reflecting the current shipbuilding market. Given strong FSRU market fundamentals, Hoegh LNG is considering taking advantage of the current yard terms to further strengthen its competitive position as the leading provider of FSRU services," it stated.

IM SKAUGEN, the Norwegian operator of small-scale LNG carriers and other fuel vessels, reported a net loss of $13.36 million for the third quarter of 2016 compared with a profit of $4.27M in the year-ago period as it continued to pursue LNG projects. IM Skaugen said that there was underlying growth in seaborne transportation of all liquefied gases, including LNG and liquefied petroleum gas as well as petrochemicals. The company, which has offices in Oslo and Singapore, said it was seeking four additional LNG projects to supply power plants with shipments amid continued small-scale deliveries in Asia. IM Skaugen's Norgas unit is currently operating a fleet of 15 advanced gas carriers, in sizes from 6,000 cubic metres capacity to 12,000 cubic metres in capacity. "We have provided offers and we are participating in tenders where our services are critical for the success of the projects and which could materialize soon," the company said. The longer-term LNG contracts it is pursuing will allow it to improve its cash flow, which will enable a refinancing of the company's debts maturing in 2017. In the third quarter, Norgas carriers also continued to perform several LNG voyages in Asia. "These voyages confirm the versatility and flexibility our multigas carriers have in terms of loading LNG from any source," the company added. "Our long-term view is that small-scale LNG will substitute diesel and naphtha for use by smaller and stranded power plants," IM Skaugen said. "The delta between the diesel and LNG prices, which provides for the cost of shipping, conversion, storage and regas has thus started increasing recently. This has brought new life to some of our LNG projects which have previously been postponed or for other reasons delay," it added. "We remain cautiously positive that we can expect a gradual recovery of the trading opportunities in the longer-haul petrochemical gas markets. IMS is currently developing four additional specific LNG projects to supply power plants with LNG and on the back of these projects we could de-ploy the fleet of our

LNG capable vessels in 2016/2017. Our focus is on projects or countries with a required early start-up, and all such projects could enable the company to utilize the unique small-scale LNG competence and knowhow developed over the past 10 years," it stated.

JAPAN says the LNG market has not even begun to show signs of rebalancing in the midst of record oversupply and with more volumes to come on stream over the next three years in North America and the Asia-Pacific region. "Despite a historic supply glut, the liquefaction capacity of LNG will increase by yet another 50 percent (130 million tonnes per annum) by 2020," said the latest report from the Institute for Energy Economics in Japan. "Demand growth is accelerating in China, India and some new liquefaction plants have had troubles and delays in starting operations. Overall, however, supply remains excessive, with the LNG price for Asia remaining stable at $6-7 per million British thermal units," the report said. "The introduction of LNG is accelerating in many countries due to the current market situation and the increase in floating LNG terminals which have a shorter construction lead-time. In addition, the liquidity of the LNG market is improving as a result of the enormous increase in supply, particularly that of LNG exports without a destination clause such as American LNG. For sustainable development of the LNG industry, producer and consumer countries must work together to make LNG more cost-competitive and develop new demand for it," the IEEJ stated. Japan said recently that the average price of spot LNG delivered into Japan that was contracted in October cost $6.10 per MMBtu, a rise of $0.40 per MMBtu from the previous month. The latest contracted spot price is higher compared with the $5.70 per MMBtu price given for September 2016, but lower than the $7.60 per MMBtu logged a year ago by government officials. The Japanese Finance Ministry released figures in October showing that overall LNG shipments in September had dropped

after unexpectedly surging more than 9 percent in August. Japan said the drop came as the nation imported more thermal coal for power generation. It also took additional LNG shipments from Australia and Russia and fewer from the Middle East. Japan's overall shipments in September, the most recent monthly number available, amounted to 6.67MT, a decline of 3.5 percent compared with 6.91MT imported in the same month of 2015.

JAPANESE liquefied natural gas imports rose in October as did shipments of thermal coal for power generation as LNG cargoes from new production in Australia offset falls in volumes from the Middle East and Asia. The shipments to Japan's network of 34 terminals amounted to 6.28 million tonnes compared with 6.05MT in the same month of 2015, a rise of just over 3.7 percent. Thermal coal imports rose by 7.4 percent to 10 million tonnes, double the amount of the rise for LNG shipments. The monthly imports cost Japan 242.46 billion yen ($2.18Bln) compared with 357.02Bln yen ($3.21Bln) in October 2015. This means that LNG costs for Japan have fallen by around 32 percent in the past year as even long-term, oil-linked contract terms have softened. Current average prices paid by Japan are around $6.72 per million British thermal units compared with $10.28 per MMBtu a year ago, including oil-linked volumes and currency fluctuations. During September Japan imported a similar amount of thermal coal when the shipments increased by the corresponding amount of the fall in monthly LNG cargoes, rising 3.5 percent to 10.12MT. The import figures from the Ministry of Finance showed that total shipments of LNG from the Middle East dropped 13.1 percent year-on-year. Deliveries from countries like Qatar, the United Arab Emirates and Oman amounted to just 1.66MT. Asian deliveries in September plunged 24 percent from a year ago from nations such as Malaysia and Indonesia, Papua New Guinea and Brunei. The shipments last month amounted to 1.72MT. Russian imports were 27 percent higher at 657,000 tonnes compared with the year-ago figure of 516,000. The balance of other imports in the preliminary figures amounted to 2.24MT from exporting nations such as Australia and Nigeria and in the form of spot shipments. There were still no imports from the United States logged in Japan's trade figures during October Japan's government said on November 10 the average price of spot LNG imported into Japan that was contracted in October was $6.10 per million British thermal units, a rise of $0.40 per MMBtu from the previous month. The latest contracted spot price is higher compared with the $5.70 per MMBtu price given for September 2016, but lower than the $7.60 per MMBtu logged a year ago by government officials. The "Arrival-Based" price for October was given as $5.70 per MMBtu, while no price was given in September as the minimum of two required deals were not registered. However, the "Arrival-Based" price given in October 2015 was $7.90 per MMBtu. Spot cargo numbers come from the commerce division of the Japanese Ministry of Economy, Trade and Industry and are only issued if a minimum number of two trades are recorded. The ministry emphasizes that "spot LNG" refers to fuel traded on a cargo-to-cargo basis and does not mean shipments under contracts on a short-term, medium-term or long-term basis.

KOSMOS Energy, the US exploration and development company based in Dallas, said it was pushing ahead with developing its huge natural gas discoveries offshore Mauritania and Senegal with plans including two floating LNG production vessels and supplying gas-fired power plants in both West African nations. This would be based on the Tortue natural gas field and adjoining resources which have been appraised and delineated "and are expected to be the anchor for the first phase development." Kosmos said the project was moving forward based on a Floating LNG project offshore with two FLNG production units working in the field and with combined initial total production of 4.6 million tonnes per annum of LNG. In addition, domestic natural gas needs would also be provided for gas-fired power plants near the Mauritanian capital Nouakchott and Dakar, the capital of Senegal. The governments of both Senegal and Mauritania were supportive of the FLNG plans. "We anticipate the signing of an Intergovernmental Cooperation Agreement (ICA) by both governments," Kosmos said. The Texas-based company added that it was also evaluating "strategic partnering options" for the FLNG projects. Kosmos, a company listed on the New York Stock Exchange and with most of its operations centred in Africa, also gave an update on its activities and finances in its latest earnings for the third quarter of 2016. "Following our world-class gas discoveries offshore Mauritania and Senegal, we are currently designing a multi-well drilling program, to begin mid-2017, that we believe will target some of the largest un-drilled exploration prospects identified along the Atlantic Margins," said Andrew G. Inglis, Chairman and Chief Executive. Kosmos has said that its Mauritania-Senegal feed-gas assets amounted to between 25 trillion cubic feet and 50 Tcf of discovered and de-risked gas resources. The US company is also producing oil at its venture offshore the West African state of Ghana. The Tweneboa, Enyenra and Ntomme (TEN) project is the second major oil development in Ghana and is progressing despite challenges. Production from its oil finds started in August 2016 and was impacted by downtime associated with turret issues on the Jubilee Floating Production, Storage and Offloading (FPSO) vessel earlier in the year. "This issue required the implementation of new operating procedures, including the use of tug boats for heading control and a dynamically positioned shuttle tanker and a storage vessel for offloading," the company said. "These new operating procedures are working effectively, underpinning the operator's guidance for gross sales volumes from the Jubilee field of 85,000 barrels of oil per day in the second half of 2016," it added. "With the delivery of first oil from the TEN project and progress toward restoring full operating capability at Jubilee, our asset in Ghana has reached an important inflection point," Inglis added. "We are now generating the free cash flow that will enable Kosmos to continue to grow organically. In addition, the quality of our exploration portfolio has never been stronger," the CEO stated. Analysts said that the LNG plans for Senegal and Mauritania put forward by Kosmos show the benefits of its strategy of exploration focused on frontier and emerging areas along the Atlantic Margin. "In the Gulf of Mexico, our position in Mauritania and Senegal would stretch from Louisiana across the Mexican border," the US company explained. Its current assets include existing production and development projects offshore Ghana, other large discoveries offshore Mauritania and Senegal, as well as exploration licenses with significant potential offshore Portugal, Sao Tome and Principe, Suriname, Morocco and the Western Sahara. The company generated a third-quarter net loss of $59.8M compared with net income of $60.3M in the same period last year. During the quarter, Kosmos said it successfully concluded its semi-annual bank re-determination process on our reserves-based lending facility which resulted in a $40M increase to the borrowing base. The E&P company said the borrowing base is now around $1.46 billion with $617M of undrawn availability. Kosmos said it exited the third quarter of 2016 with around $1.1Bln of liquidity and $1.2Bln of net debt.

MODEC, the Japanese maker of oil and natural gas production platforms and other energy industry equipment, has developed a floating power plant that uses liquefied natural gas as the fuel for electricity generation. Modec said its floating LNG-fueled power plant can be moored to a jetty or anchored offshore. The LNG-fueled floating generators are expected to be marketed in nations such as the Philippines and Indonesia, where there are many island areas without their own power plants. It works the same as an LNG Floating Storage and Regasification Unit (FSRU), with an LNG carrier coming alongside and offloading LNG that can be regasified and then used to generate electricity for transmission to an onshore power grid via an undersea cable. While FSRUs are viewed as a fast track to LNG imports compared with building an onshore terminal, so the Modec floating LNG power plants can also lower costs and shorten permitting processes. Modec said it would be taking orders in 2017 and power companies would be able to deploy the vessels by 2019. The 300-metre LNG power generation units will be offered in versions ranging from 84,000 kilowatts to 720,000kW. A 250,000kW system meeting the needs of roughly 150,000 people will cost a total of some 40 billion yen ($350 million), including design, materials procurement and construction. "Customers can opt for a gas turbine combined-cycle system that uses gas and steam turbines to generate electricity and a desalination system can be added to the plant to turn seawater into freshwater," a statement said. Floating electricity plants already exist using diesel generators, though these cause more pollution. "The LNG-based vessels are more efficient at generating electricity and do so with a smaller carbon footprint," Modec said.

OIL SEARCH, the Australian-listed energy company with a stake in Papua New Guinea LNG and in natural gas resources to underpin a second project, said annualized production at the liquefaction facility near Port Moresby amounted to 89 cargoes shipped at the end of October. During a field trip for investors to the Oceania nation, Oil Search said the PNG LNG plant, operated by ExxonMobil, was now capable of 7.9 million tonnes per annum of output, above its nameplate capacity of 6.9 MTPA. Oil Search said of the 89 cargoes delivered so far in 2016, 75 were shipped under long-term contract and 14 were sold on the spot market. A total of 6.6 MTPA of PNG contractual volumes are supplied to Tokyo Electric Power Co., Osaka Gas, China's Sinopec and CPC of Taiwan. The company noted that there was "consistent demand for spot volumes reflecting high heating-value gas well suited to the Asian" natural gas networks. Oil Search said the PNG plant was also expanding its customer base beyond the foundation customers, with nine of the 14 spot cargoes sold so far in 2016 going to buyers in Japan. The company said the PNG plant was continuing to optimize production and the Angore gas field tie-in is scheduled for 2018. About 20 percent of the PNG LNG feed-gas is sourced from the Oil Search-operated onshore oil fields in the form of associated gas. Oil Search said it was now working closely with its co-venture partners on the next phase of LNG development in PNG, focused on commercialising discovered gas resources. Appraisal and development activities are underway in the North-West Highlands, including the P'nyang gas field operated by ExxonMobil, to back the potential expansion of the existing plant The Gulf Province of PNG is also seeing appraisal activities centred on the Elk-Antelope natural gas fields, operated by French energy company Total SA, to support the proposed Papua LNG project, which could also share existing facilities. Oil Search executives told the investors that whatever the final decision on the additional natural gas resources, there was enough proven feed-gas to more than double production. "The material PNG resource base, underpinned by Elk-Antelope and P'nyang, is sufficient for at least a two-Train expansion," Oil Search said. "Project cooperation and/or integration is likely, making the next phase of LNG from PNG one of the most competitive in the region," the company added. "Various commercial models can be applied to ensure fair sharing of significantly increased value between Elk-Antelope, P'nyang and PNG LNG owners," Oil Search stated. "The aim is to deliver two new 4 MTPA Trains constructed together at the existing PNG LNG site. The spectrum of options range from full unitisation of the upstream fields (Elk-Antelope and P'nyang) and new downstream Trains," it added. Oil Search said the additional 8 MTPA of LNG output in PNG is targeting Japanese customers. "Quality Asian buyers require volumes post-2020 that can more than underpin 8 MTPA of expansion from PNG and its proximity is ideal for North-East Asian buyer requirements. LNG buyers continue to sign new long-term LNG Sales and Purchas Agreements with oil-price linked slopes," it said. Japan was also seen as being highly supportive of PNG's economic development. "The supply of additional LNG from PNG can support Japan's goal of supply source diversification and Elk-Antelope gas field heating values meet Japan domestic requirements," the company said.

OPHIR Energy of the UK has signed a joint venture agreement to develop the Fortuna floating liquefied natural gas project offshore Equatorial Guinea in West Africa with shipping company Golar and oil services firm Schlumberger to produce free-on-board cargoes priced at around $6 per million British thermal units. The accord was signed by a unit of the UK explorer and producer called Ophir Holdings and OneLNG, a joint venture between subsidiaries of Golar LNG and Schlumberger. The binding Shareholders' Agreement establishes a joint operating company to develop the Fortuna FLNG from feed-gas resources in Block R offshore Equatorial Guinea using Golar's production hull technology. OneLNG and Ophir will have 66.2 percent and 33.8 percent ownership of the joint venture entity. The Fortuna FLNG company will now facilitate the financing, construction, development and operation of the integrated project and, from the final investment decision, will own Ophir's share of the Block R licence and the "Gandria" FLNG vessel. "This innovative structure aligns investment across the value chain and provides a framework to promptly deliver a fully financed project" said a statement. The Fortuna FLNG accord is subject amongst other things to final terms and execution of project debt financing, approval by the shareholders of Ophir Energy and by the government of Equatorial Guinea. A final investment decision is now expected to take place in the first half of 2017 and first gas is scheduled for three years later. "Initial offtake is expected to be 2.2-2.5 million tonnes per annum for a duration of between 15 and 20 years which will monetise around 2.6 trillion cubic feet of the discovered resource. The expected total capital expenditure for the integrated project is approximately $2 billion to reach first gas," the companies added. "Prior to FID, a decision will be taken as to the final offtake pricing mechanism. Shortlisted proposals from potential offtakers will be evaluated on the basis of value maximisation," they said. "At an assumed FOB gas price of $6.00 per million British thermal units, the joint venture company will generate approximately $560 million in cash flow per annum," they stated.

PETRONET LNG, the Indian regasification terminal operator and importer, posted a drop in quarterly revenues to less than $1 billion, though its latest earnings still managed to boost its shares on the prospects of more imports and the company's involvement in a project for more LNG use in the country's mass transportation system. Petronet said total income from operations during the fiscal second quarter dropped about 12 percent to 6,614 crore rupees ($971 million) compared with 7,545 crore rupees ($1.1 billion) in the same three months a year ago. The company's net profit jumped 82 percent to 460 crore rupees ($67.5M) for the quarter ended September 30 compared with profit of 253 crore rupees ($37.1M) in the 2015 quarter. The results pleased energy investors on the Bombay Stock Exchange where Petronet shares traded up 6.4 percent on November 18 to 369.45 rupees. Petronet said work was completed during the quarter for expanding its Dahej terminal, located north of Mumbai, to handle 5 million tonnes per annum more LNG, with capacity at the facility now 15 MTPA. Dahej is the most widely used terminal. The Shell-operated import terminal at Hazira, also on the West Coast near Mumbai, has 5 MTPA of capacity. The Dabhol facility, south of Mumbai, still only has the capacity to handle 1.7 MTPA of cargoes because of a lack of breakwater infrastructure. The fourth West Coast terminal at Kochi in the southwest state of Kerala, also owned by Petronet, is little used because of inadequate pipeline connections, though it can handle 5 MTPA of imports. Around half-a-dozen east coast LNG import ventures are planned, including the use of floating storage and regasification units, to increase the nation's much-needed LNG supplies for industrial development. Petronet is one of the companies that hosted the November 8 launch of India's first bus to run on LNG. A ceremony was attended by India's Minister of Petroleum and Natural Gas, Dharmendra Pradhan, and the companies behind the project, also including Indian Oil Corp. and auto and truck maker Tata Motors. The LNG technology was provided by Chart Industries of the US. "As it is a pilot project, the LNG-driven bus will run on a trial basis before it can be certified for commercial application," Petronet said. "The bus is part of a plan of the Ministry of Petroleum and Natural Gas to use LNG directly for mass transportation and to reduce carbon emissions in the country," Petronet added.

PETROCHINA, the Chinese energy company and liquefied natural gas terminal owner, has commissioned new storage and regasification facilities at the Rudong import terminal, previously visited by British Columbia Premier Christy Clark. While in China in late 2013 as part of an Asian tour to promote LNG exports, Clark visited the Rudong terminal, located in the eastern province of Jiangsu. The visit was arranged by the development company of the Woodfibre export plant at Squamish, north of Vancouver, which has a 35 percent stake in the Chinese terminal. Woodfibre is now the only BC LNG liquefaction plant moving forward after receiving all its permits with 25 conditions attached, being supported by the Squamish First Nation and taking its own final investment decision to proceed. Rudong could be the only Chinese import terminal to handle regasified Canadian LNG in 2020 and beyond as most others among 20 originally planned for BC have been shelved for economic reasons or have been ground to a halt by ever stricter Canadian environmental policies. The minority Rudong stake is held by Asian energy company Pacific Oil & Gas Co. of Indonesian billionaire Sukanto Tanoto, owner of Woodfibre LNG. The regasification terminal is now one of the largest in China after being upgraded by China Huanqiu Contracting & Engineering, a unit of PetroChina's

parent company, China National Petroleum Corp. Huanqiu Contracting said it had commissioned the new storage tank with just over 200,000 cubic metres of additional capacity, as well as more regasification equipment and adjoining pipelines, Rudong LNG has been in operation since 2011 and the new storage adds to the existing two tanks, each with 160,000 cubic metres of capacity. The Chinese facility can now handle 6.5 million tonnes per annum of LNG shipments. However, the Woodfibre project is also the smallest international venture put forward in BC and will only produce 2.1 MTPA of LNG, about one third of the annual handling capacity of the Rudong terminal, one of 14 operating on the Chinese coast. In contrast to the tiny Woodfibre project, the postponed Royal Dutch Shell-led venture, LNG Canada, and the Pacific NorthWest LNG project of Petronas of Malaysia would each ship roughly 10 times that amount and bring 30 times more investment.

PETRONAS, the Malaysian energy company, said the world's first floating liquefied natural gas production plant has received its first feed-gas from the Kanowit field it is deployed over in an area 180 kilometres offshore Sarawak and the commissioning process is well underway as the project advances towards start-up. The Malaysian production hull, named "PFLNG Satu", received its feed-gas from the central processing platform at the field, igniting the production vessel's flare tower at the height of 130 metres. The Petronas acting Vice President for LNG Assets, Development and Production, Adnan Zainal Abidin, said the receipt of first gas signified the beginning of the commissioning and start-up processes. "We have come a long way with our partners to deliver a game-changer in the global LNG business. The shared vision for 'PFLNG Satu' to monetize gas resources, uneconomical to develop via conventional means, is an achievement all can be proud of," said Adnan. The production hull started its 2,120 nautical mile journey from Okpo, South Korea, to the Kanowit gas field in May 2016 for its offshore phase of commissioning. "Fitted with an external turret for water-depths of between 70 metres and 200 metres deep, 'PFLNG Satu' will extract natural gas via a flexible subsea pipeline for the liquefaction, production, storage and offloading processes of LNG at the offshore gas field," Petronas explained. "Designed to last up to 20 years without dry-docking, 'PFLNG Satu' has the flexibility to be redeployed to multiple locations to better access marginal and stranded gas fields of Malaysia," the company added. "It introduces a new type of play to complement Petronas's global LNG portfolio and enhance its reputation as a preferred and reliable LNG supplier," it stated. The Petronas FLNG plan has advanced at a time when both Malaysia and neighbour Indonesia, who are Asia's leading LNG producers, are trying to meet their own rising domestic demand for natural gas. Both Malaysia and Indonesia are following a twin-track of gaining revenue from LNG exports while at the same time as distributing regasified LNG, mainly for use by power plants and industries. The Kanowit FLNG hull was constructed at the Daewoo Shipbuilding and Marine Engineering yard in Korea and is scheduled to produce 1.2 million tonnes of LNG per annum. However, a second FLNG project planned by Petronas, the Rotan FLNG facility for offshore Sabah, has been postponed as part of cost-cutting measures. The French LNG and energy engineering company Technip oversaw the building of the topside and production facilities. The "PFLNG Satu" weighs about 125,000 tonnes and is 365 metres in length. It is also the first vessel to use the dual row cargo containment system to ensure limited sloshing within the hull.

QATAR's liquefied natural gas marketing company will supply 1.3 million tonnes per annum of cargoes to the largest gas power plant in Latin America being built in Sergipe, the smallest state in Brazil, located in the northeast of the country. The Qatari cargoes will come from a new marketing arm called Ocean LNG, established by Qatar Petroleum and its production partner in Ras Laffan, ExxonMobil, in response to the increased completion for global customers. The Ocean LNG shipments will begin in 2020 and come from Qatar Petroleum's future international LNG supply portfolio sourced from outside of the State of Qatar. The volumes for Brazil will be supplied on an ex-ship basis whereby the Qatari side assumes responsibility for the shipping in what is Brazil's first long-term LNG contract. Brazil-based Sergipe Electric Power Plant SA (Celse) is the buyer of the cargoes. The Qatari contract comes at a time when Brazil is a growing destination for cargoes from the first US Gulf Coast LNG export plant built at Sabine Pass in Louisiana. Celse and its Brazilian joint venture partners are chartering a Floating Storage and Regasification Unit (FSRU) from a Golar LNG affiliate to supply regasified LNG for a combined-cycle gas-fired power plant being built in the region to generate over 1,500 megawatts of electricity. Located near Aracaju, the state capital of Sergipe state, the power station will be the largest gas power plant in Latin America, according to the builder of the plant under a $900 million contract, General Electric of the US. The Sergipe project will supplement hydropower during dry seasons and help to meet growing demand for electricity in the region. Qatar Petroleum President and Chief Executive Saad Sherida Al-Kaabi hosted a signing ceremony in the Qatari capital Doha for the long-term LNG sale and purchase agreement between its Ocean LNG affiliate and Brazil's Celse. "This is the first SPA to be entered into by Ocean LNG, making it the first supplier to deliver LNG to Brazil under a long-term contract," said Al-Kaabi. "It represents another step towards enhancing our position as a global LNG leader and extending our reach to all markets," Al-Kaabi added. "Brazil is an important LNG market and we are proud to contribute to meeting Brazil's gas demand," the CEO added.
Celse CEO Eduardo Malan said the agreement with Ocean LNG was a landmark in the development of the Porto de Sergipe power plant. "Celse is proud to partner with LNG industry pioneers Qatar Petroleum and ExxonMobil and their newly formed Ocean LNG joint venture as its long-term fuel supplier," Malan added. The Sergipe gas-to-power project is scheduled to deliver power to 26 committed off-takers for 25 years from 2020 in accordance with previously executed contracts. Golar is supplying the FSRU through its Golar Power subsidiary and plans to deploy the vessel "Golar Nanook". Golar Power will own 50 percent of the Sergipe project and 100 percent of the associated FSRU to be deployed in Brazil.

QATARI LNG production company RasGas said it had delivered its first cargo to the newest French import terminal in the Channel port of Dunkirk as the facility ramps up its regasification capabilities for the European winter season. Once in full operation, the Dunkirk terminal is expected to be able to regasify 13 billion cubic metres per annum, 9.6 million tonnes per annum of LNG. The Dunkirk facility is 65 percent owned by French utility Electricite de France and 10 percent by energy major Total. The remaining 25 percent is held by Belgian natural gas company Fluxys, owner of the Zeebrugge LNG import terminal. France's other three import terminals are operated by a subsidiary of France utility and energy company Engie. The Dunkirk cargo was delivered by the 145,000 cubic metres capacity "Maran Gas Asclepius" for the EDF Group. "RasGas is proud to support the start-up operations of this new LNG regasification terminal in France through the delivery of this cargo," said RasGas Chief Executive Hamad Mubarak Al-Muhannadi. "We look forward to the successful start-up of commercial operations at the terminal and commencing deliveries in 2017 under our recently executed medium-term Sales and Purchase Agreement," added Al-Muhannadi. RasGas signed a medium-term agreement in July 2016 to supply 3 MTPA of LNG to EDF at the Dunkirk terminal. That accord was in addition to three existing long-term SPAs between RasGas and EDF group subsidiaries for the delivery of up to 4.6 MTPA to Edison in Italy and up to 3.5 MTPA to EDF Trading in Belgium. Marc Benayoun, an executive vice president of the EDF gas division and head of its Italian unit Edison, said the RasGas

Diary of events

Gastech Conference and Exhibition
April 4-7, 2017
Makuhari Messe International Convention Complex, Chiba City, Japan
www.gastechevent.com

LNG 2nd International Summit
April 24-25, 2017
Cannes, France
http://lngsummit.org

Flame Natural Gas & LNG Conference
May 2017 (dates to be confirmed)
Hotel Okura, Amsterdam, the Netherlands
https://energy.knect365.com/flame-conference

shipment would allow the final stages of the commissioning tests to be performed. "This is another example of the excellent relationship between RasGas and the EDF Group. This long-term partnership started 13 years ago with the signing of a long-term LNG SPA with Edison and the construction of the offshore Adriatic LNG regasification terminal in Italy," Benayoun explained.

ROTTERDAM said it would soon begin using a liquefied natural gas-powered dredging vessel, currently being built at the Barkmeijer shipyard in Friesland in northwest Holland, for service in basins of the port, one of Europe's main LNG import terminals. The ship called "Ecodelta" is a key component of the new contract entered into by dredging company Van der Kamp and the Port Authority. In this agreement, the Zwolle-based dredging company will be responsible for keeping Rotterdam's port basins at the correct depth until 2023. Rotterdam Port said the LNG-fueled vessel would begin operations during 2018 by which time LNG bunkering vessels will have been deployed to boost LNG fuel needs in the maritime market of Northwest Europe. "The introduction of the LNG-powered dredging vessel is in line with the Port Authority's policy to make Rotterdam the most sustainable port in its class," a statement said. "To this end, the Port Authority is promoting the transition from fuel oil to LNG as a transport fuel for the shipping sector. In addition, it strives to establish the Rotterdam Port as a leading European LNG hub. By adopting LNG as a transport fuel, inland vessels, coasters and ferries can reduce their carbon dioxide emissions by up to 20 percent and nitrogen oxides by up to 85 percent. Sulfur and particulate emissions are more or less eliminated altogether," the Port said. The Port Authority said it was encouraging the development of additional services and wider distribution of the fuel by the Gate LNG import terminal, owned by Dutch storage giant Vopak and natural gas utility Gasunie. "All in all, the contracted work for dredging company Van der Kamp concerns an annual volume of 5 million cubic metres of dredged material," the Port said. "Dredging is currently done by a number of vessels, including the 'Hein' and the 'Rijndelta', which are 36 and 30 years old respectively. The 'Rijndelta' will be handling the main share of the maintenance work, while the 'Hein' will 'step in' when activities need to be scaled up due to excess siltation. The 'Ecodelta' is expected to replace the 'Rijndelta' in the longer term," it explained.

SANTOS, the Australian energy company, has signed an agreement in Papua New Guinea to buy a stake in an exploration licence from ExxonMobil and Oil Search, both shareholders in the PNG LNG plant and a second liquefaction venture planned for the Oceania nation. The licence, known as Petroleum Prospecting Licence (PPL) 402, covers 510 square kilometres of onshore prospects and is 40km northwest of the Hides gas field that feeds the PNG LNG plant, operated by ExxonMobil. Analysts said the transaction was a shuffling of assets among energy companies operating in PNG amid continued debate about whether the country should have a second LNG export plant or expand its existing facility. The deal gives PNG LNG plant stakeholder Santos participation in the recently spudded Muruk 1 exploration well. The well is targeting gas resources of around 2 trillion cubic feet near the existing Hides and Juha gas fields that supply the PNG LNG plant. Santos Chief Executive Kevin Gallagher said Santos had a long and successful working relationship with both Oil Search and ExxonMobil in PNG. "The agreement demonstrates our commitment to growing our position in Papua New Guinea and working with our long-term partners to explore and develop," said Gallagher, who declined to divulge the value of the transaction. When the deal is completed ExxonMobil will still hold 42.5 percent of PPL 402 and Oil Search 37.5 percent. The shareholders in the existing PNG LNG, located northwest of the capital Port Moresby, in addition to ExxonMobil and Santos are Oil Search, JX Nippon Oil of Japan and the PNG Government. A second LNG project for PNG called Papua LNG is being developed by French energy company Total and ExxonMobil, which became a stakeholder after acquiring InterOil Corp. for $2.5 billion after out-bidding Oil Search for the company. Papua LNG is being developed with resources from the Elk-Antelope field, one of the largest onshore resource discoveries in the Asia-Pacific region. The existing PNG LNG project is a development that includes gas production and processing facilities in the Southern Highlands, Hela, Western, Gulf and Central provinces of PNG. More than 700 kilometres of pipelines connect the facilities, which include a gas conditioning plant in Hides, and liquefaction and storage facilities near the capital with plant capacity of 6.9 million tonnes per annum of LNG and there are plans for expansion. Oil Search, after losing the takeover battle for InterOil to ExxonMobil, has since explained its preference for three new production Trains centred on the existing PNG liquefaction plant rather than the Papua LNG venture. ExxonMobil's takeover of Papua LNG stakeholder InterOil was initially opposed by Total because of InterOil's big stake in the Elk-Antelope gas field that will underpin the Total-led Papua project. The Total-ExxonMobil feed-gas assets for Papua LNG are contained in the Elk-Antelope licence known as PRL 15 joint venture. Oil Search Managing Director Peter Botten said the sale of 20 percent stake of PPL 402 to Santos was a transaction consistent with its strategy. "The company's strategic approach is to work with selected partners to balance risk while holding appropriate participation levels in opportunities that have the potential to add material gas resources to the company's portfolio," said Botten.

SEMPRA ENERGY, developer of the US Cameron liquefied natural gas export project in Louisiana with European and Japanese partners, has filed with regulators to proceed with a second LNG export joint venture located in Texas and involving Woodside of Australia. Sempra, whose LNG assets also include the Costa Azul import terminal on the Pacific coast of Mexico, said its application for permits had been sent to the Federal Energy Regulatory Commission for the Port Arthur project. The San Diego, California-based utility and energy company has formally sought authorization to site, construct and operate the Port Arthur liquefaction plant along the Sabine-Neches Waterway in Southeast Texas. The FERC application for the proposed project includes two processing Trains producing a total of 13.5 million tonnes per annum of LNG, the equivalent of 698 billion cubic feet of natural gas. Sempra and Woodside are also planning three LNG storage tanks, natural gas liquids and refrigerant storage, a feed-gas pre-treatment facility and an export terminal with two berths to load LNG carriers. Sempra said a separate application was filed with the FERC seeking authorization to construct natural gas pipelines to deliver natural gas to the project. "We are pleased to continue advancing the Port Arthur LNG project," said Octavio Simoes, President of the Sempra LNG and Midstream division. "Our experience in developing, building and operating energy infrastructure will help us deliver a cost-competitive project to the global LNG market," Simoes added. Sempra's partner Woodside is one of the world's most experienced LNG plant operators and currently runs the Northwest Shelf and Pluto LNG plants in Western Australia, supplying customers all over the Asia-Pacific region. Sempra and Woodside signed a project development agreement in February 2016 that provides a framework for the sharing of costs related to the development, technical design, permitting and marketing of the proposed liquefaction project. Port Arthur will also have truck-loading and unloading areas to participate in the growth of the LNG fuel market for ships and trucking. Sempra's existing US LNG import terminal is being transformed into a liquefaction plant on the shore of the Calcasieu Ship Channel at Hackberry, Louisiana. The liquefaction project team is led by the engineering, construction and procurement contract joint venture comprising CB&I of the US and Chiyoda Corp. of Japan. Sempra is developing the Cameron plant with Japanese partners Mitsui & Co. and Mitsubishi Corp. and French utility and LNG and energy player Engie. The Cameron facility and its initial three Trains is scheduled to start up in 2018. The FERC in May 2016 authorized the Cameron project to build two additional liquefaction Trains and five in total for almost 25 million tonnes per annum in production. The new FERC order will allow Sempra to build Train 4 and Train 5 as well as a fifth LNG tank with 160,000 cubic metres of storage.

TELLURIAN Investments, the development company of former Cheniere Chief Executive Charif Souki and his Driftwood LNG project, said General Electric's oil and gas subsidiary had made a $25 million preferred equity investment in Tellurian. Tellurian recently entered into a merger agreement with Magellan Petroleum Corp., a small oil and gas exploration company listed on the Nasdaq stock exchange, and expects the agreement to close before the end of December, giving Tellurian listed status. Under the Tellurian-Magellan merger agreement each share of Tellurian will be converted into the right to receive 1.30

shares of Magellan. Magellan will issue about 122 million shares of common stock to Tellurian shareholders, representing about 95 percent of Magellan's outstanding shares. The Souki company said the GE Oil & unit investment has a common stock value of $5.94 per share. "This investment represents another step forward in the development of Driftwood LNG, where we are working together with GE to design the lowest cost liquefaction for the global market," said Tellurian President and Chief Executive Meg Gentle. "GE Oil & Gas has provided technology for LNG facilities worldwide for over 25 years and is a pioneer in innovation and a leader in reliability," she added. "We look forward to a long and beneficial partnership with the GE team," Gentle said. Tellurian and the Driftwood LNG project were set in motion by Souki after he left Cheniere just before the Houston-based company's Sabine Pass LNG export plant in Louisiana came on stream in February 2016. The former Cheniere CEO aims to replicate Sabine Pass with the Driftwood venture, currently in the engineering design and pre-filing phase of the Federal Energy Regulatory Commission permit process. Tellurian expects construction of Driftwood LNG to begin in 2018 and the project to become operational in 2022. The Driftwood venture would export up to 26 million tonnes per annum of cargoes from its proposed liquefaction plant to be located on the west side of the Calcasieu River, near Carlyss in Louisiana's Calcasieu Parish.

TOTAL, the French energy company, said it had now formally become the operator of the planned floating liquefied natural gas import terminal venture being developed for the West African nation of the Ivory Coast. The Ivory Coast LNG consortium led by Total with a 34 percent stake has now finalized all agreements and has been awarded the rights to build and operate the facility with a planned capacity of 3 million tonnes per annum. Total said it would use the terminal to supply LNG volumes from its global portfolio in proportion to its participating interest in the project. The regasification and import facility is expected to become operational by mid-2018. The project involves the construction of infrastructure connected to a floating storage and regasification unit in the Vridi area of the capital Abidjan. An associated pipeline will also be constructed to connect the FSRU to existing and planned power plants, as well as to regional markets to be supplied by the Ivorian network. "This will enable the Ivory Coast to become the first regional LNG import Hub in West Africa and to meet both regional and domestic demand," Total stated. "This project illustrates Total's strategy to develop new gas markets by unlocking access to LNG for fast-growing economies," said Philippe Sauquet, President of Gas, Renewables and Power at Total. "Working closely with our partners enabled us to put together an integrated proposal combining LNG supply and import infrastructure through a floating storage and regasification unit," said Sauquet. "We are very pleased to have been selected by the Ivorian authorities to manage this project, which will meet growing domestic and regional needs for gas and power," the French company executive stated. The joint venture partners in addition to Total include SOCAR, the state energy company of the former Soviet state of Azerbaijan, with a 26 percent share and Royal Dutch Shell with 13 percent. The Ivory Coast state company Societe Nationale d'Operations Petrolieres de la Côte d'Ivoire (Petroci) has 11 percent of the venture, Norwegian LNG FSRU supplier Golar LNG has 6 percent and a US utility investment group Endeavor Energy and the local utility CI Energies each have 5 percent.

TOTAL has been chosen by Iran to operate the renewed development of the South Pars gas field, the largest in the world with the adjoining offshore North Field owned by Qatar and used for LNG production. Total's preliminary contract is with the National Iranian Oil Company and includes a shareholding for China National Petroleum Corp. Total had previously initiated development of South Pars but all work in Iran was later suspended for various reasons. "This is an agreement in principle. The final contract will be signed early 2017," said a statement from the project company Petropars. The Total contract has no LNG production element, though there were previously three LNG projects in Iran. Total said the natural gas produced would be fed into Iran's gas network. Analysts said that although there is no LNG element for the post-sanctions project, the development of the field will produce a bonanza of subsea and related contracts for global players to bid for in tenders. "Total will launch engineering studies and a call for a tender process so that construction contracts can be awarded immediately upon signature of the final agreement," Total added. "The South Pars project will be developed in two phases. The first phase, with an estimated total cost of around 2 billion dollars equivalent, will consist of 30 wells and 2 well head platforms connected to existing onshore treatment facilities by 2 subsea pipelines," the French company explained. "At a later stage, a second investment phase, involving the construction of offshore compression facilities, will be launched once required by the reservoir conditions," it added. As yet Iran has no liquefaction plants to make its own LNG, though its passed projects were called Pars LNG, Persian LNG and Iran LNG. However, these ventures were abandoned. Firstly because of the interference in the projects by the extremist Iranian Revolutionary Guards and later because of Western sanctions that prohibited investments in Iran because of the nuclear issue, now resolved. Total said it would operate the next phase of the South Pars project in which it has a 50.1 percent stake. Petropars, a subsidiary of the NIOC, will own 19.9 percent stake while China's state-owned CNPC would have a 30 percent share in the venture. The South Pars 11 project will have a production capacity of 1.8 billion cubic feet per day, or 370 000 barrels of oil equivalent per day. "This project fits with the group's strategy of expanding its presence in the Middle East, where the origins of the group lie, and growing its gas portfolio by adding low unit cost, long plateau gas assets," said Total Chairman and Chief Executive Patrick Pouyanne. "In parallel, Total will launch engineering studies and a call for tender process so that construction contracts can be awarded immediately upon signature of the final agreement," Total added. Total said the contract is a Heads of Agreement. "Following Total's successful development of phases 2 and 3 of South Pars in the 2000s, the Group is back to Iran to develop and produce another phase of this giant gas field," said Pouyanne. "Total is delighted to have been selected by NIOC - it is a recognition of both our technical expertise and the partnership the Group has built with Iran over the years," added Pouyanne. "Total is pleased that the discussions with NIOC resulted in an attractive commercial framework," the CEO said. "Total will develop the project in strict compliance with national and international laws and looks forward to working alongside the Chinese state-owned company CNPC in this additional international partnership," it added. Under the terms of the HoA, NIOC and the project partners will conduct exclusive negotiations to finalize a 20-year contract in accordance with the technical and economic terms recently approved by the Iranian Parliament.

WOODSIDE Petroleum, operator of two liquefied natural gas production plants in Western Australia, has completed the transaction with Australian resources company BHP Billiton worth up to US$400 million to acquire half of its gas assets in the offshore Scarborough field and the Carnarvon Basin for future LNG production. The acquisition was completed for a purchase price of $US250M and with an additional US$150M added after a final investment decision to monetize the resources. Woodside operates the Northwest Shelf LNG production plant at Karratha in Western Australia, where BHP is one of five other shareholders, also including BP of the UK, Chevron Corp., Royal Dutch Shell and Japan-Australia LNG. The nearby Pluto LNG liquefaction plant is 90-percent owned by Woodside with Japanese utilities Kansai Electric and Tokyo Gas each holding five percent. The Woodside resource estimate for the Scarborough area resources, including the Scarborough, Thebe and Jupiter gas fields is 8.7 trillion cubic feet. On completion of the BHP sale, Woodside's net share will be 2.6 Tcf. The Woodside contingent resource estimate for the Scarborough area resources are based on a potential development involving Floating LNG. The Carnarvon, Browse and Bonaparte basins offshore Western Australia have proven resources of around 133 Tcf. The Browse Basin, offshore the northwest coast of Western Australia, is the subject of the Woodside-led Browse FLNG project, which is currently on hold. The Woodside acquisition from BHP includes a 25 percent interest in WA-1-R and a 50 percent interest in WA-62-R, which together contain the Scarborough gas field. Woodside will also acquire a 50 percent interest in WA-61-R and WA-63-R which contain the Jupiter and the gas fields. Woodside will operate WA-61-R, WA-62-R and WA-63-R. ExxonMobil is the operator of WA-1-R. After the Scarborough deal 462 million barrels of oil equivalent were added to Woodside's contingent resources. ■

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Approaches for testing structural integrity during cryogenic spillage on FLNG hulls

Sebastien Viale, New Materials R&D Manager and Nadia Elkhodja, Modelling Engineer, Technip France, and Laurent Pomie, Integrity Assurance Manager, Technip UK

The planned operation of natural gas liquefaction units offshore has raised many new safety issues. Cryogenic spillage is among the most critical as load bearing structures cannot be designed to resist such accidents.

In order to propose better protection at manageable cost, to enhance structural integrity and to lower the risks associated with cryogenic spillage on marine structures, Technip as FLNG market leader, has run an extensive physical test program to support the development of tailor made numerical modeling tools.

Screening

In a first step, numerous protective materials were screened and then tested to assess their performances. We found that all products currently available in the market display limitations.

During the test campaign, alternate product designs were investigated to improve structural design and avoid the need for human intervention "Inspection Maintenance and Repair" during service lifetime.

Secondly, we developed a numerical methodology using thermal and mechanical analysis to simulate the spillage process physics and the risk for marine structures.

In this paper, a summary of the test campaign and full-scale simulations on a generic Epoxy will be presented and analyzed.

We will focus on investigations done to properly assess the resistance of this material during rapid cooling following an accidental cryogenic release as per ISO 20088-1.

Operating LNG liquefaction units in offshore conditions has raised new safety considerations.

As generally accepted, carbon steel displays a tendency to become brittle when its temperature rapidly decreases.

Grades

Even special grades such as Low Temperature Carbon Steel (LTCS) used for LNG decks exhibit a ductile-brittle transition temperature (DBTT).

Feedback from spillage incidents on LNG carriers indicates that cryogenic spillage is a real risk to take into account during design.

In offshore facilities, cryogenic spillage is a common risk where passive fire protection materials are used to protect steel items avoiding them to reach their DBTT.

With this feedback wet applied epoxies are the current materials of choice when it comes to cryogenic spillage protection for FLNGs.

It is important to mention that tailor-made materials are readily available in the market.

Moreover, today there is no international standard or recommended practice to test material performances in case of rapid temperature decrease.

Feedback from spillage incidents ...indicates that cryogenic spillage is a real risk to take into account during design.

Quantified

Therefore, Technip in 2012 proposed a more quantified approach to the different stake holders through a Joint Industrial Project, involving operators, original equipment manufacturers and engineering contractors.

The objectives of this project were multiple:

- To determine accidental exposure criteria to rank protection material performance (i.e. type of cryogenic threat - liquid or vapor, protection duration and threshold temperature, to maintain stability of the exposed items).
- Promoting the emergence of a wider range of materials for cryogenic spillage protection, including new application/deployment methods.
- To screen and to assess the performance of alternate protection technologies.
- Leading an international committee responsible for drafting ISO 20088-1 on testing materials in cryogenic pool conditions.

OPEX evaluation of alternate solutions have been included in the evaluations by the JIP. New product designs that reduce IMR (Inspection/Maintenance/Repair) during service life have been also investigated.

As the selection of Cryogenic Spillage Protection (CSP) material is both design and project dependent, the JIP undertook numerous sample tests from different suppliers. The tests consist of performance under cryogenic conditions and general mechanical resistance.

Results presented below were obtained on a generic Passive Fire Protection (PFP) Epoxy A from mechanical test to cryogenic exposure as defined by ISO 20088-1. Based on the results, we were able to start mechanical and thermal simulation of the coating response. This enabled us to predict sample degradation.

Project

First, we needed to define what a cryogenic release is. For the JIP, the definition of cryogenic liquid release is: a cryogenic liquid (with temperature below -160°C) in rapid contact with a substrate. We have used in tests only liquid nitrogen rapid exposure. Liquid nitrogen was dumped onto the sample substrate in less than 60 seconds.

As previously introduced, CSP materials are usually wet applied epoxy resins. Such materials are directly sprayed onto the substrate via special pumps and spray guns.

The main advantage of epoxy is the strong adhesion to the substrate. As an indicator, adhesion test on cured resin should display a minimum range of 5 MPa according to ISO 4624. Moreover, spray application is well suited to complex geometries. But this great feature is also its major drawback when it comes to inspection, maintenance and repair (IMR). It is almost impossible to easily remove material slabs without damaging large surfaces.

Moreover, in terms of safety, applying material on yard requires full personal protection equipment for operators and handling large quantity of chemicals. To be complete, those systems need at least 24 hours to fully cure on the basis that safety is key.

Emerging

The JIP favored emerging solutions using prefabricated panels. Casting in this case is performed at the supplier's factory. This approach has several advantages that can be summarized as follow:

- Reduce installation time
- Improve quality (fabrication done at supplier's plant)
- Highly tunable (possible to apply anti-skid coating at paint shop stage)
- HSE: overall improvement, reduce risk at the yard
- Improve IMR

Installation at the yard is done with commercially available epoxy glues that require 4 hours to cure. Glue application is similar to wet applied epoxy coating with less quantity. The same applicators can perform similar job with the exact same equipment as previously without extended training reducing job cuts at the shipyard.

Joints and sealants can be a major issue with this new technology and the JIP looked at this particular point.

Technologies tested during the JIP :

On FLNG, fire is the principle hazard for decks and steelwork. Accidental cryogenic release is a secondary hazard such that CSP material must be PFP as well.

Inspired by solutions used onshore for cryogenic application, the JIP focused on four different technologies:

- Wet applied epoxy
- Prefabricated epoxy panels
- Prefabricated Sandwich panels
- Prefabricated Wood panels

During 2013, thirty different samples

Epoxy A	Thermal diffusivity m²/sec	Specific heat J/kg°C	Volume density kg/m³	Thermal conductivity W/m°C
20°C	1.9e-7	1749.5	1159	0.281
0°C	1.65e-7	1562	1161	0.304
-40°C	2.08e-7	1316.5	1166	0.322
-196°C	5.63e-7	264.3	1200	0.178

Table 1: Thermal parameters from Epoxy A at selected temperatures

from the above mentioned technologies were exposed to 500L of liquid nitrogen in a 1*1m sample size. Backface temperatures were recorded during 120min total test duration. Backface temperatures should remain above to -40°C defined as the embrittlement temperature of marine carbon steel. The tests were performed at Technip's Cybernetix facility in Compiegne, France.

Wet applied epoxies can be segregated as follow:

- PFP: Homogenous epoxy resin comprising a sole layer with an intumescent charge with or without midlayer mesh.
- CSP + PFP: Heterogeneous or duplex system with CSP syntactic material layer (containing glass microsphere to improve thermal insulation) applied on the metal substrate protected with a PFP upper layer (containing intumescent charge such as: sodium silicates and graphite). Both layers are separated by a mesh.

Duplex system wet applied epoxies displayed better behavior in terms of thermal protection compared to the homogenous system. Most of the time, they showed good thermal insulation and backface temperature reached -40°C in 45~60min on average thanks to the good thermal barrier from the syntactic layer.

The PFP homogenous system provide a certain degree of cryogenic insulation despite not being design for it.

Systems

Since both systems have PFP as a top layer, they have in common the same general surface deterioration around the liquid nitrogen release point. Hairline cracks were observed in sample with reinforcement mesh, while, more consequential cracks were obtained in samples with no reinforcement mesh.

At the time of the JIP tests, few suppliers were able to provide prefabricated samples. Nevertheless, two samples were tested with non-epoxy resins used as PFP active material.

They displayed good thermal protection superior to 120min and no surface degradation were observed. The panels were easy to install and the jointing done at the test lab used a commercially available fire proof material.

Sandwich samples were also tested. Different core foams were tested such as, PU, fluoropolymer or PVC to name a few. All skins were polyester based resins. Such technology has been used for decades in the insulation business.

They displayed outstanding thermal protection. No samples reached negative temperature within 120min. a few hairline cracks were observed on the top skin. Unfortunately, polyester is not suitable as a top layer as it is not a fire proof.

Found

Compressed wood was tested. Such material can be found nowadays inside offshore LNG tank bottom insulation. They displays excellent thermal insulation proprieties without surface degradation. They were not further tested due to the significant water uptake during ageing tests.

In addition, mechanical tests were performed on all samples. The major area of concern was compression resistance since the main application is the main deck.

The JIP determined that samples should display a minimum 7MPa resistance in compression in order to accommodate the use of forklift trucks. Unfortunately, most sandwiches did not survive this test and were excluded from the rest of test campaign.

Since, the objective was to develop an in-house numerical model capable of predicting coating thermal response as well as its integrity with time, we focused our characterization on a pure PFP specimen: Epoxy A.

We selected this sample since it has a high probability of cracking and because its homogeneity would simplify the simulation.

Material Characterization of Epoxy A - Thermal properties under cryogenic conditions

The thermal properties of Epoxy A were studied by the JIP. We looked at the following parameters: of thermal diffusivity, thermal conductivity, specific heat, and density in the temperature range from -196°C to +25°C.

Specific heat was measured according to ASTM E2584, thermal diffusivity was tested according to ASTM STP 1320. The thermal conductivity was determined as a product of thermal diffusivity, volume density, and specific heat. The results summarized in Table 1, are in good agreement with published data for common epoxy formulations.

Subsequently, Epoxy A was tested by being exposed to a sudden drop of temperature simulating an accidental cryogenic release.

The aim of the test was to monitor the material survivability when exposed to thermal shock and its ability to thermally insulate the substrate.

Geometry

This was done according to the ISO 20088-1 with the geometry of the sample holder taken from PFP ISO standard 22899-1 with multiple vertical surfaces in order to accommodate jet fire test. There is a central beam that separates the sample into two identical basins.

The sample is placed immediately below a 500L spillage tank as seen in Figure 4. The test started with the release of 250L of LIN from the spillage tank at a height of 1000mm from the substrate surface resulting of an initial LIN pool of 5cm depth.

The test bench is presented in the figure below. The substrate back face was instrumented with thermocouples as described in ISO 20088-1.

Two types of substrates were investigated. Bare substrate where only carbon steel was used and coated substrate composed of carbon steel piece with 18mm of Epoxy A.

All substrates were constructed from the same carbon steel material with a thickness of 10 mm. The Epoxy A included a reinforcement mesh at 6mm under the surface.

We incorporated two thermocouples on the mesh one within each basin to record the temperature within the sample.

Standards

This additional feature is not part of the two ISO standards that rely only on backface temperature measurements.

The following figure displays the temperatures of Epoxy A with the two thermocouples inside the sample's thickness as well as thermocouple localization.

Figure 1 displays a typical curve for epoxy when exposed to rapid decrease in temperature, only thermal conductivity and thickness played a role.

The two dotted lines correspond to the thermocouples installed inside the sample, they clearly show a rapid decrease toward cryogenic temperature without reaching -196°C.

We will see later that crack initiation appears at around 10s however after that,

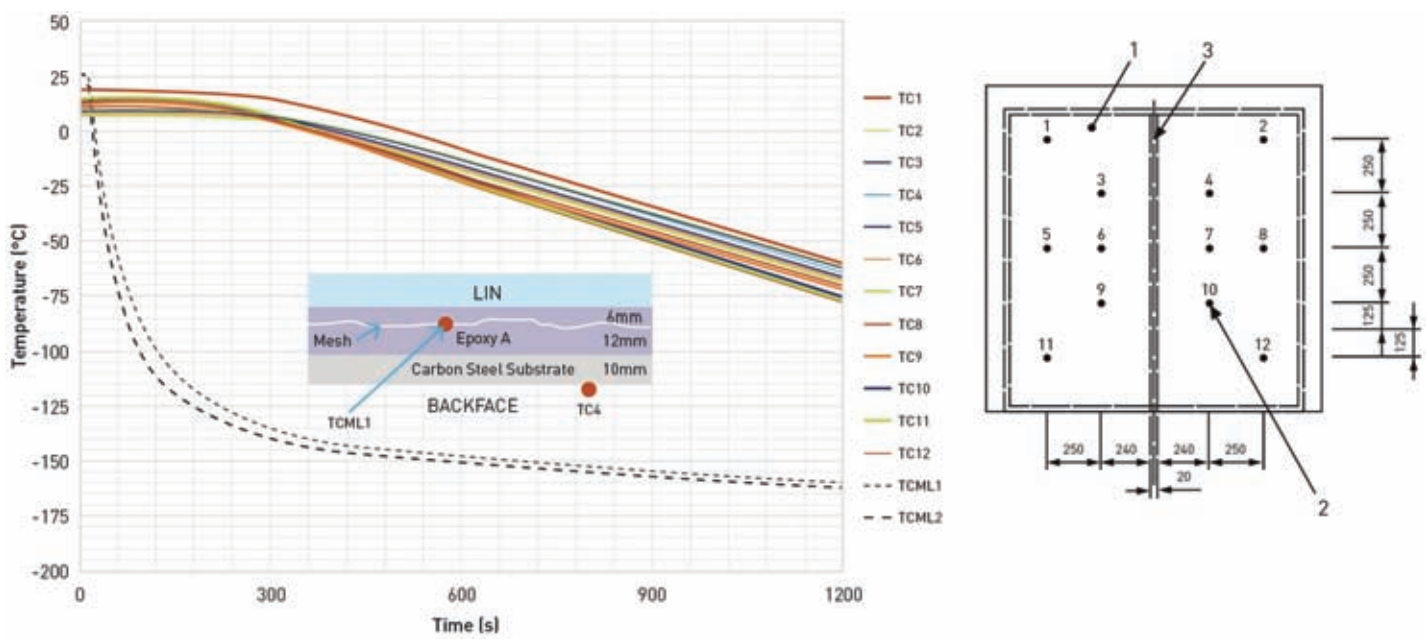

Figure 1: (LHS) Epoxy A ISO 20088-1 experimental result, (RHS) Thermocouple localization

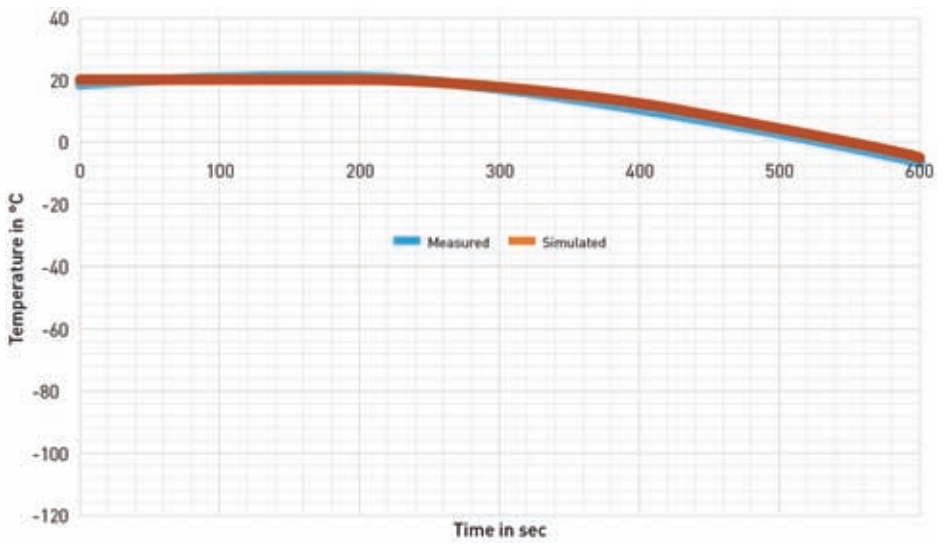

Figure 2: Comparison of calculated and measured temperature under the LIN release point in a sample without 6mm upper layer.

no abrupt change of slope was observed meaning that Epoxy A did not suffer any major surface rupture.

Mechanical tests

The mechanical tests performed were designed to establish: compression and tensile strength at room temperature.

The Epoxy A formulation was historically developed for fire protection and a mesh is present at mid layer. The compression test was performed according to ISO 604 at a speed of 10mm/min and at 23°C.

In compression, Epoxy A performed well. A curve is linear across a broad range of strain revealing a quasi-elastic behavior.

The materials obey Hooke's law and Young's modulus can be extrapolated to about 0.58MPa in this region. The samples displayed barreling and start to crush at roughly 10 MPa stress and this can be seen on the curve with the little shoulder at 16-20% of relative strain.

Machining

Tensile tests were also preformed but it is to be noted that during machining of the sample the mesh was excluded to avoid destruction. The tests were done according to ISO 527 with specimen size 1A and at a test speed of 2mm/min at 23°C.

From the curve above, we obtained an elasticity modulus of around 37 MPa. The maximum tensile stress is around 2.79 MPa on average. The specimen exhibited a brittle facture at very low strain around 1% and no plastic deformation was observed.

Material Simulation of Epoxy A1 : Modeling a structure subject to LNG spillage is a very challenging task due to the complexity of the various physical phenomena (thermal, mechanical), the heterogeneity of the different elements (insulation, structure) and associated materials (carbon steel, epoxy, and reinforced mesh).

This section described the modeling of Epoxy A coated on a carbon steel structure submitted to a thermal load. A 3D thermal and mechanical Finite Element (FE) model of a coated structure was developed to reproduce tests that had been performed according to the ISO test configuration.

Coating: FE analysis aims to predict coating integrity in case of cryogenic spillage and the critical criterion for crack initiation in epoxy A.

FE analysis was carried out in two steps. Step one was first to perform a thermal simulation of one ISO test case using realistic thermal boundary conditions.

Numerical results were compared with experimental measurement data. Then, we performed mechanical analysis using a loading derived from the first thermal analysis. A critical criterion for crack initiation in Epoxy A will be identified numerically.

Calculation methodology: Modeling a thermal-mechanical problem requires two sequential FE analysis:

1. A transient heat transfer analysis dedicated to the determination of the temperature field in the substrate as a function of time. For this analysis, only heat conduction is considered.
2. And a static nonlinear (material and geometric nonlinearities) mechanical analysis using thermal loading derived from the first heat transfer analysis, to compute the thermal stress induced by the cryogenic spill.

A 3D finite element model of the test case with coated substrate was developed and several comparisons of numerical results with measurements are presented below.

Thermal analysis: This section describes the strategy used to identify model inputs such as the thermal boundary conditions for the thermal analysis simulation. The case studied is a LIN pool applied suddenly on the top face of Epoxy A left and during 10 min.

To accurately model tests with a coated substrate, the thermal boundary conditions are a crucial input. The coated substrate top face is subjected to a sudden thermal load, induced by LIN spillage.

To define the temperatures input, one possibility is to use the temperatures measured in trials with bare substrate. Indeed, given the high conductivity of carbon steel, temperatures measure on bare substrate back face are representative of temperatures on the top face of the tests with Epoxy A.

The temperature of the Epoxy A top face is obtained by linear interpolation in space and time of temperature measured on the bare substrate back face.

Other surfaces are supposed to be perfectly insulated: no thermal exchange is considered on these surfaces. No discontinuities, voids or cracks are considered in the Epoxy A.

The thermal analysis was performed with ABAQUS v6.13 software. The FE model uses a very fine mesh size 1mm in the thickness axis both in 18mm epoxy A and 10 mm carbon steel to capture temperature gradients. The simulation provides substrate temperature.

Thermal results: A figure illustrates a snapshot of the resultant temperature fields at 60s. The epoxy remaining at a temperature below -40°C is represented in black (see original paper).

After 60 seconds, Epoxy A surface under the LIN release point reached -40°C where epoxy started to be brittle. This observation indicates a high probability of Epoxy A crack initiation during this period.

Comparison between experimental and calculation results: To reconcile the numerical and the experimental results, the reference used is the backface temperature.

The nearest thermocouple from the LIN release point was selected and temperature versus time was plotted.

The trend is acceptable but a difference of 10°C (overall ΔT of more 200°C) after 600seconds was observed.

One explanation can be that LIN diffuses into surface discontinuities formed at the sample surface lowering locally the temperature.

Structure

Since simulation assumed no loss of structural integrity during the test, no perfect fit can be observed. We tried to experimentally check this hypothesis by measuring crack morphology without success due to sample destruction during machining.

Therefore, in order to verify this hypothesis, a second set of simulations was performed excluding the 6mm upper layer considering that cracks covered all surface and that LIN reached 6 mm depth on average corresponding to the embedded mesh.

In Figure 3, the fit is perfect without the 6mm upper layer. We can conclude two important points: (a) the lack of fit in a previous figure indicates surface degradation must be taken into account, (b) the perfect fit in Figure 3 indicates that the crack depth corresponds to the bottom of the mesh at mid layer which seems to hinder further crack propagation.

From experimental measurements, carbon steel cooldown is much slower when coated with Epoxy A.

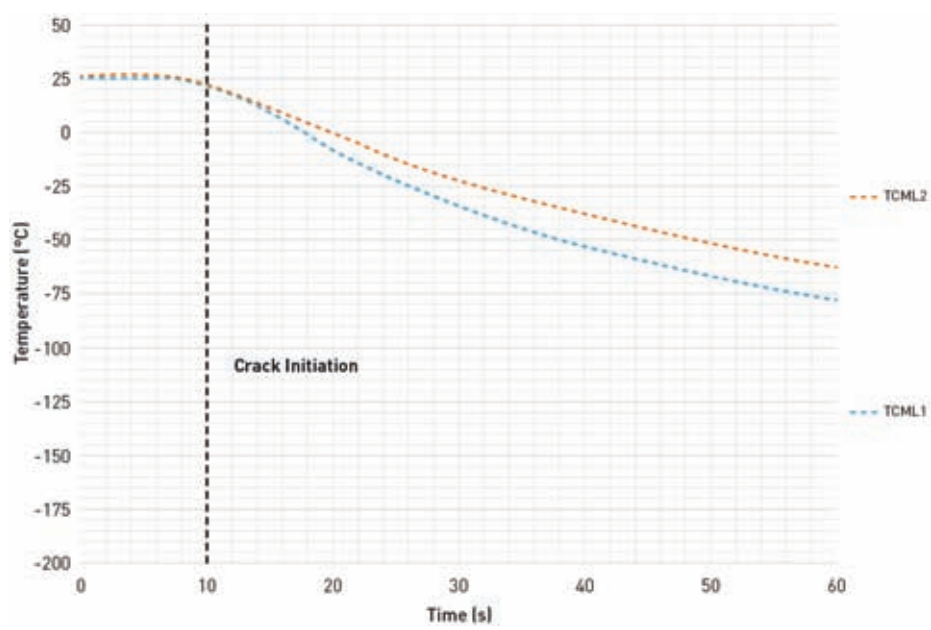

Figure 3: Temperature recorded at the at 2/3 of the epoxy layer

For example at 300seconds, thermocouple TC6 on bare carbon steel displays -75°C while with the Epoxy A coating the temperature is around 0°C.

The backface carbon steel temperature with Epoxy A is always warmer than for the bare sample thanks to the thermal insulation of Epoxy A.

Mechanical analysis

Mechanical calculations were performed with ABAQUS v6.13 software. The substrate was clamped on the rear face and submitted to a thermal loading. Thermal loading were derived from a heat transfer calculation (first thermal analysis).

Material laws were implemented in the different substrate components by using material properties presented in section above. A 3D FE model was defined with a very refined mesh to capture stresses/strains gradients in the epoxy.

Model is defined with a mesh of 20-node quadratic brick, hybrid with linear pressure elements (C3D20H). The element sizes were around 1 mm sufficiently fine to give an accurate numerical solution.

All the connections between the different components of the substrate were tied connections.

Mechanical results

The mechanical simulation performed on the substrate, showed that the maximum stress induced by combining mechanical and thermal loadings, at t=10 seconds after LIN deposit, occurred in a critical area located under the release point.

According to the calculation results, just after the initiation of cracking (at 10 seconds after LIN deposit), the surface temperature observed was approximately equal to -30°C under the release point, and the maximum principal stress was approximately σmax = 9MPa.

Therefore, failure occurs when the maximum principal stress reached the critical criterion σmax in Epoxy A.

On Figure 13 (RHS), we observed that maximal principal stress remain close the surface (2mm in depth), indicating a superficial damage. This result has been correlated by the presence of the hairline cracks on the specimen surface.

Conclusions

In this paper, we presented some of the CSP JIP main results such as: extensive materials test campaign and ISO 20088 work. Since 2012, new technologies have emerged giving the opportunity to the FLNG market to broaden the range of CSP materials and now alternate technologies are starting to be mature.

PFP epoxies have a tendency to display limitations when exposed to liquid nitrogen. Some minor surface degradations of the CSP coating were observed with low impact on the fire protection behavior.

Future ISO 20088-1 was used to evaluate CSP material behavior when subjected to rapid exposure to cryogenic liquid.

It is now the industry preferred protocol for CSP material testing with cryogenic liquid condition.

We also presented our calculation methodology used to support both Technip's FLNG design teams and material suppliers for predicting structural integrity in case of LNG spillage. The model can perfectly predict surface cracking of the CSP coating.

Temperature measurement analysis allowed us to detect and define the moment of initiation of surface discontinuity and showed no carbon steel integrity loss.

The main observation indicated that the reinforcing mesh embedded in epoxy coating is mandatory to reduce the risk of cryogenic surface rupture.

By computing a mechanical FE Analysis, a critical criterion for predicting the initiation of cracks in Epoxy A was identified. ■

The article is based on extracts from the paper "New approaches for testing and predicting structural integrity during cryogenic spillage on FLNG" by Sebastien Viale, Ph.D., New Materials R&D Manage and Nadia Elkhodja, Senior Numerical Modelling Engineer, Technip France, and Laurent Pomie, Integrity Assurance Group Manager, Technip UK. Because of space limitations not all figures could be published and others were renumbered for typographical reasons.

Acknowledgment:

The authors would like to thanks JIP sponsors: BG group, Chiyoda, ConocoPhillips, EDF, Emco Wheaton, ENGIE, Exxon Mobil, Fives Group, Saipem, Statoil, Total as well as Technip Management for funding this project. The authors would like to thanks R. Legent at Cybernetix for conducting flawlessly all tests.

Denmark-based company Kosan Crisplant aims to turn gas expertise into profits in LNG fuel sector

Joint ventures will see company operating in South Korean bunker market and Nordic liquefaction

Kosan Crisplant, an independent company with Middle East ties operating out of Denmark, has been working in the gas business for 65 years, mainly within liquefied petroleum gas and it is now broadening its horizons and entering the liquefied natural gas sector where its experience will be valuable.

LNG is still a new and growing business for the Aarhus-based company. The company benefits from its Danish HQ, while the principal shareholder of Kosan Crisplant remains the Bahrain-based Seera Investment Bank.

Strengths

The company's strength is its LP gas cylinder filling business worldwide where it supplies around 3,000 plants and is aiming to make an impact in the same LNG sectors from maritime bunkering to small-scale distribution.

Kosan Crisplant will aim in the LNG sector to offer engineering, manufacturing and installation solutions for LNG as a fuel.

The company's main LNG joint venture is with Korea LNG Solution (KLS), aimed at supplying fuel and equipment to the bunkering market.

After having signed a memorandum of understanding in June 2016, Kosan Crisplant and KLS followed up with a detailed co-operation agreement that was signed during the Marine Tech Korea 2016 conference in Gyeongnam, Korea at the end of September 2016.

The co-operation agreement requires Kosan Crisplant and KLS to co-operate on the development, manufacture and sale of LNG bunkering equipment for small-scale LNG as bunker fuel for ships in South Korea over a four-year period.

Initiation

The collaboration between the two LNG experts was initiated in Copenhagen in June 2016 when they first signed an accord with the intention of mutually exploring and benefitting from each other's strengths within the LNG market.

"Now that the co-operation is expanding and becoming more specific, both parties are looking forward to reaping the benefits that the agreement may bring," they said.

"LNG is without doubt a clean, safe, practical and economically viable fuel, and KLS aims to create a safe, efficient and cost-effective infrastructure to supply LNG to both power plants and the shipping industry," says KLS.

"The target of this co-operation agreement is to complete the first project within a year or two, and expand from there on," it added.

Kosan Crisplant at present is a project-oriented corporation that supplies equipment, plants and systems for filling and maintenance of LP gas cylinders and offers after-sales and engineering services, facility management, and supply of components for the gas industry.

Customers

To date, the customer base consists of large international corporations, state-owned enterprises, national oil and gas companies and small and large private businesses.

"Profiting from more than 65 years of experience in the gas business - the gas company has entered the market for small-scale projects within the LNG segment, introducing a unique fully automatic zero-emission LNG bunkering facility for ships," it explained.

For the time being, KLS will focus on three main target businesses:

1) LNG bunkering
2) Transportation and supply of LNG to islands with ISO LNG containers
3) Research & Development for starting new LNG businesses

KLS is operated by a small staff and a couple of associates. The five key persons have long-term experience within the field of energy, the LNG market, power plants and LNG fuelling.

The start-up business will be a supplier of LNG to islands, backed by shareholders and partners.

Network

Kosan Crisplant says it is excited about this new collaboration and is eager to find a position in the LNG industry among the world's biggest players.

The long-term gas company has a lot to gain from this collaboration in the Korean market as it builds up its LNG distribution network.

One of Kosan Crisplant's infrastructure offerings for LNG

During the past few years, Korea has placed a bigger focus on LNG and the benefits represented by cleaner fuel.

"Some ship owners have now started to take advantages of these opportunities, resulting in new LNG ships and retrofits on the drawing board.

At the same time, the Korean government has to deal with pollution issues and is therefore trying to find alternative ways to reduce the emission of sulfur dioxide (SOx), Nitrogen oxides (NOx) and carbon dioxide (CO2).

Invention

Kosan Crisplant has already invented a fully automatic and flexible small-scale LNG bunkering facility in Denmark.

The zero-emission LNG bunkering facility is located in the port of Hou near Aarhus, making it possible to fuel the ferry "Samsø" for a whole day's operations in less than 15 minutes.

The bunkering facility is fully automatic and requires no permanent staff on shore. With its modular design, the LNG bunker¬ing facility can be dismantled and moved to another location in less than a week.

Kosan Crisplant acts as a bridge between the ferry crew who uses the LNG on the one side and the suppliers of the LNG on the other.

The company helps LNG users build their bunkering solutions to fit their specific needs. It operates in terms of modularized standard equipment, which means it has the building blocks to put together an order to fit the specific requirements of each client without costs going through the roof. This goes for both bunkering and liquefaction as well.

Fuel needs

If you are operating a ferry, a short sea or inland ship on LNG, you will typically need to bunker anything from 20-300 cubic metres of LNG per hour. In the low end of this continuum, you can bunker directly out of a tank trailer or an ISO tank. It would be time consuming, though.

If you require faster bunkering, or more volume than one tank trailer can offer, this is where Kosan comes in.

"We offer different solutions to bunker directly from one to six trailers at the same time or from an intermediate tank on the quayside with flow rates up to 150-300 cubic metres per hour," the company says

"We can do this with a very high level of safety, with no fixed staff to operate the system and with no emission of LNG," it adds.

"There are quite a lot of ships in this segment, some with projectable sailing routes for which a fixed land-based bunkering installation is suitable. Others are a bit more unpredictable in their sailing patterns, and we can supply them with a movable solution instead," it explains.

"We continuously work on our visions and solutions for bunkering. This means that we can offer solutions with higher volumes in a much shorter time by

connecting more trailers and more pumps," it says.

"Common for our solutions is and will be that they need to be flexible, automatic and based on our zero-emission technology. The latest addition to our portfolio is a completely movable solution that may be transported on a truck thus avoiding permanent installations at the port," it adds.

Liquefaction

In terms of liquefaction, Kosan has developed a small-scale liquefaction plant that is able to draw natural gas directly from the gas grid or from a bio plant.

This equipment is modularized to produce LNG or liquefied biogas in modules of 50 ton/day.

Kosan said it made sense to combine up to five to six of these to reach the capacity needed or as demand rises in order to "grow as you go".

"The scalable system invented by Kosan Crisplant enables customers to easily increase their supply as demand rises making it possible to start small and upgrade when needed.

"The liquefaction process can be started or stopped in only 30 minutes, which makes it possible to balance production with power price variations and short term market demands," the company states.

Best sense

In countries with a dense natural gas grid, it is not practical to drive a tank trailer to a terminal far away to pick up LNG.

"We believe it makes better sense to liquefy the gas locally, thereby minimizing the distance between the source of the LNG and the consumer.

"This would entail faster delivery times and in countries where biogas is produced and sent into the natural gas grid, it opens a whole new market for CO2 neutral LNG - or LBG as it would be called in that case," says Kosan.

In Denmark, the small island of Samsoe is already 100 percent fossil-fuel free in its electricity production. Now they have their eyes on the transport sector.

The islanders are currently investigating the possibility of using local waste in the biogas production and subsequently liquefying the biogas to make fuel for their municipal vehicles and their new dual-fuel LNG ferry, "Isabella", which connects the island to the mainland.

"We believe we will see more of these examples in the future and we predict a huge latent market for liquefaction plants," adds Kosan.

Environmental

"More and more companies are focusing on lowering the CO2 footprint and reducing their impact on the environment, and a way to cope with these challenges it to use greener fuels in the logistical supply chain or in the production.

"In Denmark, we are starting to upgrade the biogas plants, and subsequently connecting them to the natural gas grid, enabling gas consumers to use biogas instead of natural gas," it says.

Kosan offers the following benefits from its liquefaction plants:

- Modular design allowing you to "grow-as-you-go"
- Production of 50, 100, 150 etc. tons/day
- Production of LNG and LBG
- Fully automatic facility - no staff necessary to run the plant
- High flexibility - the plant can be started or stopped in less than 30 minutes and set to run with variable output
- Low power consumption - reduction of OPEX
- Possible to benefit from low energy and gas prices - produce LNG/LBG when electric and/or gas prices are low
- Hedging - reduce the risk of adverse price movements by producing to stock
- Fast and easy export - self-service truck loading point
- Versatile solution > excess heat can be used in the district heating network
- Limited footprint > approximately 10,000 square metres.

Kosan is also planning a highly efficient LNG liquefaction plant in Northern Denmark, ensuring maximum operational flexibility, fully automated operation and low energy consumption.

The company has joined a project that aims to establish the plant in the North of peninsular Denmark with easy access to the Port of Frederikshavn.

Kosan's contribution will be the technology needed for such a facility to turn natural gas from the local natural gas grid or a biogas plant into a liquid. ■

How modularized building methods were refined in Australian LNG production and export plants

Part II of an article by Geoff Byfield, Technology Development Manager, and Eric Pegrum, Construction Manager, Woodside Energy, Perth, Western Australia

We are expanding the technology and methods from construction of the then new Train 5 at the North West Shelf plant in Western Australia, the first base-load Train constructed using a modularised approach.

Although the construction method was different to NWS LNG Train 4, the layout of the earlier stick-built train was retained.

The modularised Pluto LNG train followed a similar approach. Since then Woodside has embarked upon a journey of continuously improving the state-of-the-art modularised LNG train design.

NWS Train 5 was built to the replicate the layout of the earlier NWS Train 4 stick-built design, inclusive of the Acid Gas Removal Unit (AGRU).

Method

Using the AGRU as an example, this was largely located within a single module. However the lean amine cooler and regenerator condenser were located in the separate air cooler module forming part of the spine.

The objective of placing the entire dehydration system in the same module had similarly not been met.

The regeneration gas cooler was located in a separate module. The fractionation system (integral to each LNG train for this project) was primarily contained within a single module, but the air cooled depropaniser and debutaniser condensers were located in a separate module.

Unwittingly the desire to keep the air coolers in a contiguous bank and to minimise the number of air cooler modules in the spine had led to complete segregation of the air coolers from all other equipment.

Air coolers had been treated as mutually exclusive to all other equipment items. No “process” module had any air coolers. No “air cooler” module had any other process equipment.

Exceptions

With the exception of mercury removal, every unit included some air coolers, and therefore they were not contained within a single module.

Although this particular train did not feature and end-flash system, this represents an extreme example of how the fish-bone layout could result in far more connections at site than necessary.

An end-flash gas system is only relatively small and could very easily fit with a single module.

Installation order

Yet by adopting the fish-bone layout conventions, there would be three site connections required between the compressor and inter/aftercoolers and another three recycle lines coming back to the compression module.

All of these site connections would be unnecessary when the whole system could easily fit in a single module.

The fish-bone layout consisted of three rows of equipment. The anticipated installation sequence relied upon two principles:

- The air cooler modules were in the middle row and therefore needed to be installed first. This was not seen as a major concern, as these relatively simple modules could be constructed first, and didn’t have any highly specialised equipment that might suffer from unexpected late delivery.
- The remaining modules would be installed from either side, after the air cooler modules

In order to allow flexibility of the installation of the process modules, it was necessary to have at least a module’s width around three sides of the LNG train.

The fourth side would typically be obstructed early in the construction phase by the main interconnecting piperack.

It was important that the overall site layout avoided having piperacks at both end of the LNG train, as this would block the installation path for modules.

If a train only had access on one side and one end of the train, then this would dictate that the modules on the blocked side be installed in order.

Worse still, if the main gas turbines were installed on that side, then the only way to install module No. 1 would be to do it before the adjacent air cooler module. Driving SPMTs over the gas turbine foundations was not acceptable to the construction team.

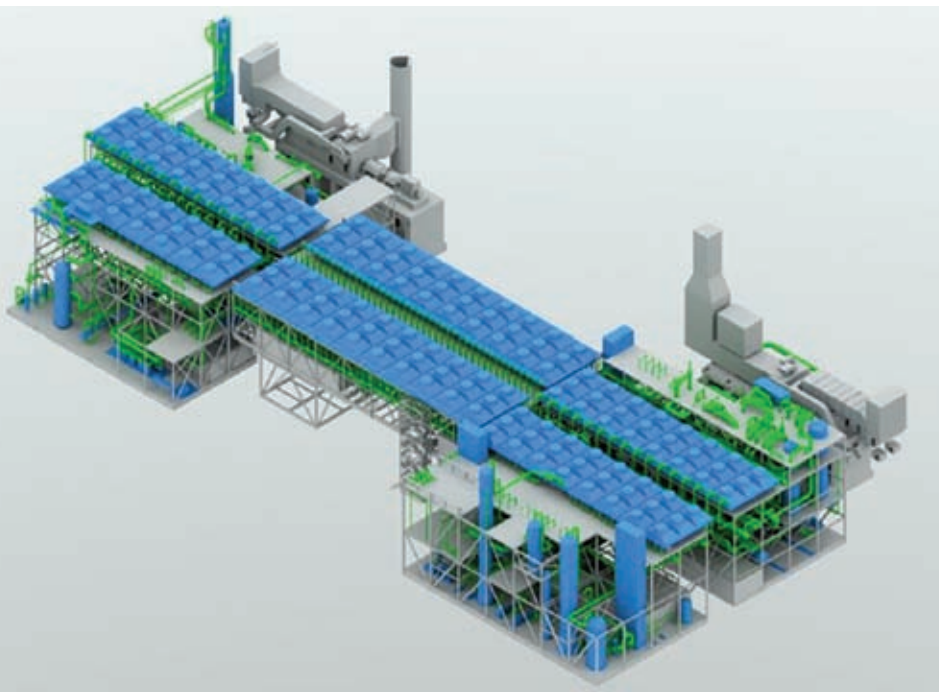

Figure 1: Woodside’s ‘Next Generation’ LNG design concept For 5 MTPA of capacity and using the C3MR processing system

If the site did not have access on either end of the train, such as if piperacks were connected to both ends of the train, then this would be even more restrictive. The process modules on the side away from the haul road would have to be installed before their adjacent air cooler module(s) and the process module on the other side.

‘Air’ modularisation

At the conclusion of FEED, comparison with the original modularised LNG trains, NWS Train 5 and Pluto, revealed that the quantity of structural steel used for a fish-bone design was significantly higher.

There was in fact a great volume of empty space underneath the air coolers. Conventional air-cooled LNG train design leverages the piperack structure to support the air coolers.

NWS Trains 1, 2 and 3, the first air cooled LNG trains, used this approach, but they used a much narrower piperack with only a single row of air coolers.

NWS Trains 4 and 5 and Pluto featured two rows of air coolers, but have located the two main compression strings and also the end-flash gas compressor underneath the second row to ensure that this space did not go to waste.

In the fish-bone design, the air cooler “piperack” modules are far wider than they need to be to function as a piperack.

Yet this large volume of air remains underutilised. Furthermore most of the pipes are being supported by separate structural steel in the process modules.

As a result, there is a lot of duplication in the structural steel - one set to support the pipes and another set to support the air coolers.

Whilst there may be some safety concerns with placing some equipment underneath air coolers, locating benign equipment (e.g. heated water expansion drum and circulation pumps) under the air coolers to create integrated modules, will assist in keeping the size and weight of the modules to a minimum.

Third generation

In 2011 Woodside commenced a study investigating the sort of LNG trains that would be in use by the year 2020, with the intention of making some step change improvements.

Enhancing the modularisation approach was a key part of this strategy.

The third generation of modularisation considered by Woodside was intended to address some of the shortcomings of the second generation and to extend the redesign for modularisation philosophy further.

Rather than simply arrange the equipment, the approach was to deliberately select the most compact equipment available, equipment that would be easy to modularise, even if that equipment cost more than standard equipment.

The other fundamental change introduced by this third generation was to use modules that were partially covered by air coolers.

The second generation fish-bone design used only modules with 100 percent coverage of air coolers or 0 percent coverage of air coolers. In order to avoid concerns with hot air recirculation, the intention was to continue to arrange the air coolers as a single contiguous bank.

Layout changes

Thus the layout concept changed from fish-bone to a "domino" arrangement, with some modules rotated perpendicular to the main axis of the train in order provide module space to the side of the air coolers.

The desire for more compact equipment, and construction feedback that complex 3D compressor suction piping took a lot of effort to complete at site, led to the selection of aero-derivative main refrigerant drivers.

This in turn led to slightly smaller capacity trains, with fewer modules. Finally the desire for better maintenance access to all equipment led to the uncovered space in the modules being split on both sides of the air coolers.

This prevented any equipment being enclosed by the air coolers and outer equipment.

The train layout then took on the shape of a barbell or "dog-bone".

Using space

The space underneath the air coolers was utilised for small, safe equipment – the boiler feed water system to support the steam heating medium.

In the mixed refrigerant (MR) compression module the low pressure mixed refrigerant (LPMR) suction scrubber was also placed underneath the air coolers, as a low pressure vessel normally containing zero liquid and therefore minimal hydrocarbon inventory.

In contrast the main MR chillers were stick-built to keep the large hydrocarbon inventory in the open, assist with drainage of propane scrubbers and avoid concerns over module flexing affecting the specialised gaskets between butted kettles.

Care was taken over the module delivery sequence. The two compression modules were expected to be the last installed, due to the turbine delivery to the fabrication yard.

The MR compression module deliberately placed on the end of the train, whilst extra space was allowed to be able to slot the propane compression module in between the adjacent modules.

'Next' generation

Commencing in 2013, further modularisation studies were given the name of "Next Generation" modularisation. The objectives were to continue the LNG2020 approach of using modules partially covered with air coolers to:

- Extend to different process designs
  - Train sizes
  - Driver types (industrial GT vs aero GT vs combined cycle)
  - Liquefaction technologies
- Explore various module orientations
- Drive down the module weight by concentrating upon more efficient structural designs to reduce the structural steel weight to <<50% of the total module weight.

Alternative designs

A total of six different air-cooled LNG train designs were produced. The base case was taken as a standard 2×Frame 7, C3MR design, to confirm that the LNG2020 modularisation approach would work effectively at this train size, even though the main gas turbine drivers could not be modularised.

An industrial gas turbine combined cycle design was also developed, and an improved aero-derivative design with even fewer modules.

Different liquefaction cycles were also considered to evaluate which best suited the modularised construction approach.

Module orientation

The end modules in the LNG2020 dog-bone design only had direct contact with the adjacent module, whilst the central modules contacted two.

Some of the alternative arrangements explored as part of the Next Generation study deliberately featured modules that had edges against more than one module, and up to four in the case of the revised dog-bone design.

This further reduces the number of module interconnections, as there are less situations where a pipe has to travel from one module and then on to the next.

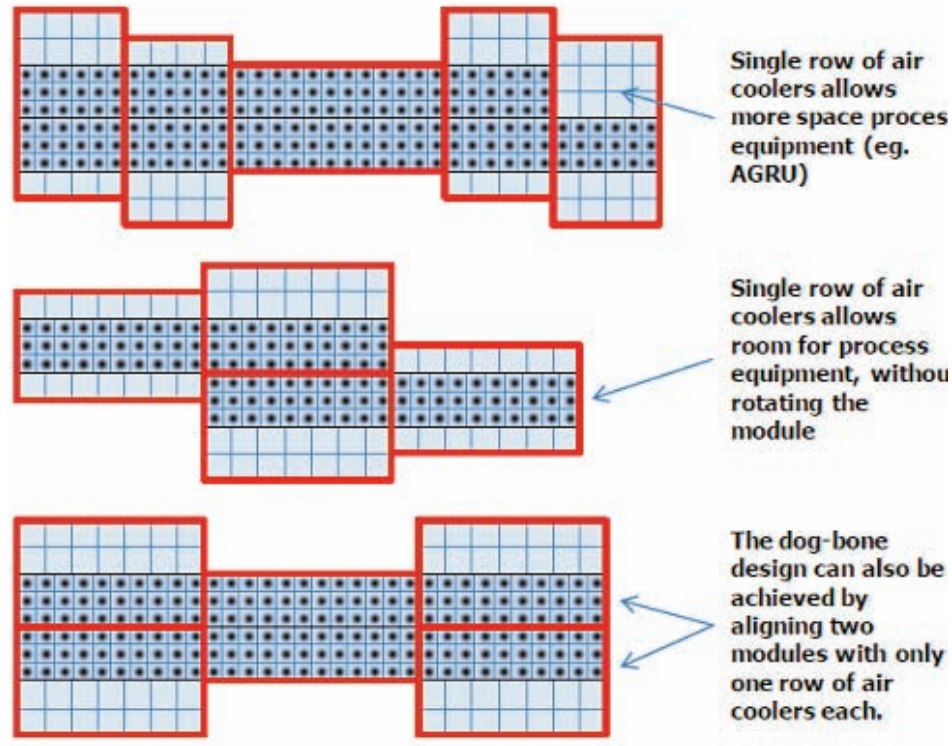

Figure 2: Alternative ways to arrange modules partially covered with air coolers

The latter arrangements also facilitate fewer connections for the main lines that run the length of the train, such as the flare header.

The base case Next Generation design adopted this modified dog-bone module arrangement. As the two Frame 7 gas turbines were too large to fit inside a module with all of their related systems, the main gas turbine strings were stick-built adjacent to the end modules.

The propane condenser, which consumes a large proportion of the air cooler bank was retained in the middle of the train as a single module (after optimising the air cooler design to minimise the footprint).

This design provides a unique advantage in relation to the flexible installation of modules.

By accepting the one restriction of installing the propane condenser (slightly longer than the other modules) as the last piece of the jigsaw, there is effectively a haul road channel through the centre of the train, through which all of the other modules (and gas turbines) may be installed with complete flexibility.

Furthermore, this ability is retained even when both ends of the train are completely blocked off by other systems, such as piperacks.

Further enhancements

The Next Generation base case using 2×Frame 7s to achieve 5 MTPA was developed for a warm climate, similar to Pluto.

Woodside has future opportunities in different environments, including areas with the benefit of a significantly cooler climate. This significantly alters the power balance, and allows the same 5 MTPA capacity to be achieved using only a single Frame 7 gas turbine driver with assistance of electric motors for the balance of the refrigerant driver power.

The electric motor driven compressors <25 MW may be fully modularised, leaving just the single Frame 7 (or H-100) gas turbine to be stick-built.

With only one gas turbine string, this can be placed adjacent to the propane condenser module, allowing a more compact train layout.

The train width has been reduced back to only 65 metres, similar to the LNG2020 study, whilst retaining the capacity of the Next Generation base case.

Quantification

By deliberately placing all of the stick-built elements on one side of the train, this design retains the ability to install any module in any order (including the propane condenser), without needing any access from the ends of the train.

In order to minimise overall plot space, the electrical substation and transformers have been incorporated into the train footprint to form a neat rectangle with laydown space for specific maintenance activities (e.g. molecular sieve changeout).

Due to the narrow train footprint, this layout could be adapted for a nearshore barge-mounted application with only minor modifications.

Based upon the studies completed by a major LNG engineering contractor, the cost savings between a second generation fish-bone design and a Next Generation

design were estimated to be in the order of 20%.

Furthermore, the deliberate attention given to minimising the interconnections to be completed at site resulted in a four-fold decrease on a diameter-inch basis.

This has flow-on effects to the number of workers required, and therefore to the size of the construction camp that has to be built to accommodate the construction workforce.

Conclusions

Woodside's Next Generation modularised LNG technology can improve the construction of modularised LNG facilities by minimising the amount of module interconnection work to be completed at site.

In addition, the flexible construction sequence incorporated into the Next Generation layouts mitigates some of the execution risks.

There is reduced exposure to the fabrication of a single module running late and causing a range of problems:

- delays in the installation of other sequence dependent modules
- multiple handling of modules
- additional laydown space being required to park modules
- shipping of modules before they are adequately complete, leading to costly carryover work at site.

For sites with restricted plot space, the ability to install modules without using the space at either end of the train as a module haul road will be critical to allowing other elements such as piperacks to be constructed ahead of the modules.

The family of Next Generation layouts, all employing integrated modules, partially covered with air coolers, has been shown to be flexible to various LNG train designs, with different train sizes, driver types and different liquefaction technologies.

Woodside has selected this technology as the construction approach that would be applied to a future onshore development at Grassy Point in Canada, and has shared some of the Next Generation technology with joint venture partners for other opportunities. ■

World LNG Carrier Fleet

LNG carrier	Capacity m^3	Owned or Ordered by	Builder	Delivery Date	Flag	Power Plant	Cargo System	No. of tanks	Ship built for Export plant
Aamira	266,000	QGTC	Samsung	Dec-10	Liberia	DRL	TZ Mk. III	5	Qatargas IV
Abadi	135,000	Brunei Gas Carriers	Mitsubishi Nagasaki	Jun-02	Brunei	S	Moss	5	Brunei LNG
Adam LNG	162,000	Oman LNG	Hyundai	Dec-14	Marshall Is.	DFDE	TZ Mk. III	4	Oman LNG
Al Aamriya	210,100	J5 Consortium	Daewoo	Feb-08	Marshall Is.	DRL	GT NO 96	4	Qatargas
Al Areesh	151,700	Teekay LNG	Daewoo	Jan-07	Qatar	S	GT NO 96	4	Ras Gas II
Al Bahiya	266,000	QGTC	Samsung	Oct-09	Liberia	DRL	TZ Mk. III	5	Qatar-Atlantic
Al Biddah	135,275	J4 Consortium	Kawasaki Sakaide	Nov-99	Japan	S	Moss	5	Qatargas
Al Daayen	151,700	Teekay LNG	Daewoo	Apr-07	Qatar	S	GT NO 96	4	RasGas II
Al Dafna	266,000	QGTC	Samsung	Oct-09	Marshall Is.	LR DRL	GT NO 96	4	Qatar-Atlantic
Al Deebel	145,000	Peninsular LNG	Samsung	Dec-05	Bahamas	S	TZ Mk. III	4	Qatargas
Al Gattara	216,200	OSG/Nakilat	Hyundai	Oct-07	Marshall Is.	DRL	TZ Mk. III	4	Qatargas II
Al Ghariya	210,100	ProNav	Daewoo	Feb-08	Bahamas	DRL	GT No. 96	4	Qatargas
Al Gharaffa	216,200	OSG/Nakilat	Hyundai	Jan-08	Marshall Is.	DRL	TZ Mk. III	4	Various
Al Ghashamiya	216,000	QGTC	Samsung	Mar-09	Liberia	DRL	TZ Mk. III	4	Qatar-Atlantic Basin
Al Ghuwairiya	261,700	QGTC	Daewoo	Aug-08	Marshall Is.	DRL	GT NO. 96	5	Qatar-Atl'c Basin
Al Hamla	216,000	OSG	Samsung	Feb-08	Marshall Is.	DRL	TZ Mk. III	4	QatarGas
Al Hamra	137,000	National Gas Shipping	Kvaerner-Masa	Jan-97	Liberia	S	Moss	4	ADGAS
Al Huwaila	217,000	Teekay	Samsung	May-08	Bahamas	DRL	TZ Mk. III	4	RasGas III
Al Jasra	137,100	J4 Consortium	Mitsubishi Nagasaki	Jul-00	Japan	S	Moss	5	Qatargas
Al Jassasiya	145,700	Maran-Nakilat	Daewoo	May-07	Greece	S	GT No 96	4	RasGas
Al Kharaitiyat	216,200	QGTC	Hyundai	May-09	Liberia	DRL	TZ Mk. III	4	Qatargas III
Al Kharaana	210,000	QGTC	Daewoo	Oct-09	Marshall Is.	DRL	GT NO 96	4	Qatargas IV
Al Kharsaah	217,000	Teekay	Samsung	May-08	Bahamas	DRL	TZ Mk. III	4	RasGas III
Al Khattiya	210,000	QGTC	DSME	Oct-09	Marshall Is.	DRL	GT No. 96	4	Qatargas IV
Al Khaznah	135,500	National Gas Shipping	Mitsui Chiba	Jun-94	Liberia	S	Moss	5	ADGAS
Al Khor	137,350	J4 Consortium	Mitsubishi Nagasaki	Dec-96	Japan	S	Moss	5	Qatargas
Al Khuwair	217,000	Teekay LNG	Samsung	Jul-08	Korea	DRL	TZ Mk. III	4	RasGas
Al Mafyar	266,000	OSG/Nakilat	Hyundai	Oct-07	Marshall Is.	DRL	TZ Mk. III	4	Qatargas II
Al Marrouna	151,700	Teekay	Daewoo	Nov-07	Bahamas	S	GT NO 96		Ras Gas I
Al Mayeda	266,000	QGTC	Samsung	Jan-09	Liberia	DRL	TZ Mk. III	5	Qatar-US/Var.
Al Nuaman	210,000	QGTC	DSME	Dec-09	Marshall Is.	DRL	GT No. 96	4	Qatargas IV
Al Oraiq	210,000	J5 Consortium	Daewoo	Apr-08	Marshall Is.	DRL	GT No. 96	4	Various
Al Rayyan	135,360	J4 Consortium	Kawasaki Sakaide	Mar-97	Japan	S	Moss	5	Qatargas
Al Rekayyat	216,200	QGTC	Hyundai	Jun-09	Bahamas	DRL	TZ Mk.III	4	Qatar-Atlantic
Al Ruwais	210,100	ProNav	Daewoo	Nov-07	Germany	DRL	GT NO 96	4	Qatargas II
Al Sadd	210,100	QGTC	Daewoo	Mar-09	Liberia	DRL	GT NO 96	4	Qatar-Atlantic Basin
Al Safliya	210,100	ProNav	Daewoo	Dec-07	Bahamas	DRL	GT NO 96	4	Qatargas II
Al Sahla	216,200	J5	Hyundai	Jun-08	Japan	DRL	TZ Mk. III	4	Ras Gas III
Al Samriya	261,700	QGTC	Daewoo	Sep-08	Marshall Is.	DRL	GT NO. 96	5	Qatargas II
Al Sheehaniya	210,100	QGTC	Daewoo	Feb-09	Liberia	DRL	GT NO 96	4	Qatar-Atlantic Basin
Al Shamal	217,000	Teekay LNG	Samsung	Jun-08	Qatar	DRL	TZ Mk. III	4	RasGas
Al Thakhira	145,000	Peninsular LNG	Samsung	Sep-05	Bahamas	S	TZ Mk. III	4	Qatargas
Al Thumama	216,000	J5 Consortium	Hyundai	Apr-08	Japan	DRL	TZ Mk. III	4	Rasgas
Al Utouriya	215,000	J5	Hyundai	Sep-08	Panama	DRL	TZ Mk. III	4	RasGas
Al Utourma	215,000	J5	Hyundai	Sep-08	Panama	DRL	TZ Mk. III	4	Ras Gas III
Al Wajbah	137,350	J4 Consortium	Mitsubishi Nagasaki	Jun-97	Japan	S	Moss	5	Qatargas
Al Wakrah	135,360	J4 Consortium	Kawasaki Sakaide	Dec-98	Japan	S	Moss	5	Qatargas
Al Zhubarah	137,570	J4 Consortium	Mitsui Chiba	Dec-96	Japan	S	Moss	5	Qatargas
Alto Acrux	147,000	LNG Marine Transport	Mitsubishi	Mar-08	Bahamas	S	Moss	4	Various
Amali	148,000	Brunei-Shell	DSME	Jul-11	Brunei	DFDE	GT No. 96	4	Brunei LNG
Amanl	154,800	Brunei-Shell	Hyundai	Nov-14	Brunei	DFDE	TZ Mk. III	4	Brunei LNG
Aman Bintulu	18,928	Perbadanan / NYK Line	NKK Tsu	Oct-93	Malaysia	S	TZ Mk. III	3	Petronas
Aman Hakata	18,800	Perbadanan / NYK Line	NKK Tsu	Nov-98	Malaysia	S	TZ Mk. III	3	Petronas
Aman Sendai	18,928	Perbadanan / NYK Line	NKK Tsu	May-97	Malaysia	S	TZ Mk. III	3	Petronas
Arctic Aurora	160,000	Dynagas	Hyundai	Jul-13	Marshall Is.	DFDE	TZ Mk. III	4	Various
Arctic Discoverer	140,000	K Line	Mitsui Chiba	Jan-06	Bahamas	S	Moss	4	Various
Arctic Lady	147,200	MOL/Hoegh LNG	Mitsubishi Nagasaki	Apr-86	Norway	S	Moss	4	Various
Arctic Princess	147,200	MOL/Hoegh LNG	Mitsubishi Nagasaki	Jan-06	Norway	S	Moss	4	Various
Arctic Sun	89,880	Arctic LNG Shipping	IHI Chita	Dec-93	Liberia	S	IHI SPB	4	ConocoPhillips/Marathon
Arctic Voyager	140,000	K Line	Kawasaki	Jul-06	Bahamas	S	Moss	4	Statoil
Arkat	148,000	Brunei-Shell	DSME	Feb-11	Brunei	DFDE	GT. No. 96	4	Brunei LNG
Arwa Spirit	165,000	Teekay LNG	Samsung	Sep-08	Marshall Is.	DFDE	TZ Mk. III	4	Various
Asia Endeavour	160,000	Chevron	Samsung	Dec-14	Bahamas	DFDE	TZ Mk. III	4	Various
Asia Energy	160,000	Chevron	Samsung	Sept-14	Bahamas	DFDE	TZ Mk. III	4	Various
Asia Excellence	160,000	Chevron	Samsung	Sept-13	Bahamas	DFDE	TZ Mk. III	4	Various
Asia Vision	160,000	Chevron	Samsung	June-14	Bahamas	DFDE	TZ Mk. III	4	Various
Barcelona Knutsen	173,400	Knutsen	Daewoo	May-10	N.I.S.	DFDE	GT NO 96	4	Various
Bebatic	75,060	Brunei Shell Tankers	Atlantique	Oct-72	Brunei	S	TZ Mk. I	6	Brunei LNG
Beidou Star	172,000	MOL	Hudong	Oct-15	Hong Kong	DRL	GT NO. 96	4	Various
Berge Arzew	138,088	BW Gas	Daewoo	Jul-04	Norway	S	GT NO 96	4	Sonatrach
BW GDF-Suez Boston	138,059	BW Gas	Daewoo	Jan-03	Norway	S	GT NO 96	4	Suez LN
BW GDF Suez Everett	138,028	BW Gas	Daewoo	Jun-03	Norway	S	GT NO 96	4	Suez LNG
Bilbao Knutsen	138,000	Knutsen / Marpetrol	IZAR Sestao	Jan-04	Spain	S	GT NO 96	4	Atlantic LNG
Bilis	77,730	Brunei Shell Tankers	La Seyne	Mar-75	Brunei	S	GT NO 82	5	Brunei LNG
Bishu Maru	162,000	K Line-Transpacific	Kawasaki Sakaide	Dec-15	Panama	S	Moss	4	Australia-Japan
British Diamond	155,000	BP Shipping	Hyundai	Sep-08	IOM	DFDE	TZ Mk. II	4	Indonesia-Various
British Emerald	155,000	BP Shipping	Hyundai	Jun-07	UK	DFDE	TZ Mk. III	4	Tangguh LNG
British Innovator	138,200	BP Shipping	Samsung	Jul-03	Isle of Man	S	TZ Mk. III	4	Various
British Merchant	138,000	BP Shipping	Samsung	Apr-03	Isle of Man	S	TZ Mk. III	4	Various
British Ruby	155,000	BP Shipping	Hyundai	Jan-08	U.K.	DFDE	TZ Mk. III	4	Various
British Sapphire	155,000	BP Shipping	Hyundai	Sep-08	IOM	DFDE	TZ Mk. III	4	Tangguh
British Trader	138,000	BP Shipping	Samsung	Dec-02	Isle of Man	S	TZ Mk. III	4	Engas

Broog	135,466	J4 Consortium	Mitsui Chiba	May-98	Japan	S	Moss	5	Qatargas
Bu Samara	266,000	QGTC	Samsung	Dec-08	Qatar	DRL	TZ Mk. III	5	Qatargas
BW Suez Paris	162,400	BW Gas	Daewoo	May-09	N.I.S.	DFDE	GT NO 96	4	Yemen-Atlantic
BW Suez Brussels	162,400	BW Gas	Daewoo	May-09	N.I.S.	DFDE	GT NO 96	4	Yemen-Atlantic
Cadiz Knutsen	138,826	Knutsen / Marpetrol	IZAR Puerto Real	Jun-04	Spain	S	GT NO 96	4	Engas
Castillo de Santisteban	173,600	Elcano	STX	Aug-10	Malta	S	GT NO. 96		Various
Castillo de Villalba	138,000	Elcano	IZAR	Nov-03	Spain	S	GT NO 96	4	Sonatrach
Catalunya Spirit	138,000	Teekay LNG Partners	IZAR Sestao	Mar-03	Liberia	S	GT NO 96	4	Atlantic LNG
Celestine River	145,000	KLNG	Kawasaki	Dec-07	Bahamas	S	Moss		Various
CESI Gladstone	174,100	MOL-China LNG	Hudong	Oct-16	Hong Kong	S	GT No 96	4	Australia-China
CESI Qingdao	174,100	MOL-China LNG	Hudong	Nov-16	Hong Kong	S	GT No 96	4	Australia-China
Cheikh Bouamama	75,500	Skikda LNG Transport	USC	Jul-08	Bahamas	S	TZ Mk. III	4	Sonatrach
Cheikh El Mokrani	75,500	Med LNG Corp	USC	Jun-07	Bahamas	S	TZ Mk. III	4	Sonatrach
Clean Energy	150,000	Dynagas	Hyundai	Mar-07	Marshall Is.	S	TZ Mk. III	4	Various
Clean Force	150,000	Dynagas	Hyundai	Jan-08	Marshall Is.	S	TZ Mk. III	4	Various
Clean Ocean	155,900	Dynagas	Hyundai	Mar-14	Marshall Is.	DFDE	TZ Mk. III	4	Various
Clean Planet	155,900	Dynagas	Hyundai	Mar-14	Marshall Is.	DFDE	TZ Mk. III	4	Various
Clean Vision	160,000	Dynagas	Hyundai	Jun-15	Marshall Is.	DFDE	TZ Mk. III	4	Various
Cool Explorer	160,000	Thenamaris	Samsung	Oct-13	Bermuda	DFDE	TZ Mk. III	4	Various
Cool Runner	160,000	Thenamaris	Samsung	May-14	Bermuda	DFDE	TZ Mk. III	4	Various
Cool Voyager	160,000	Thenamaris	Samsung	Oct-13	Bermuda	DFDE	TZ Mk. III	4	Various
Corcovado LNG	160,106	TMSC Gas	Daewoo	Jun-14	Malta	TFDE	GT No 96	4	Various
Creole Spirit	174,000	Teekay	Daewoo	Jan-16	Bahamas	MEGI-DF	NO. 96 GW	4	Cheniere
Cubal	160,400	Mitsui/NYK/Teekay	Samsung	Jan-12	Bahamas	DFDE	TZ Mk. III	4	Various
Cygnus Passage	145,400	Cygnus LNG	Mitsubishi	Feb-09	Panama	S	Moss	4	Various
Dapeng Moon	147,000	China Ships	Hudong	Jul-09	China	S	GT NO 96	4	Various
Dapeng Star	147,000	China Ships	Hudong	Nov-09	China	S	GT NO 96	4	Various
Dapeng Sun	147,000	China Ships	Hudong	Jul-07	China	S	GT NO 96	4	Woodside Energy
Disha	136,000	Petronet LNG Ltd.	Daewoo	Jan-04	Malta	S	GT NO 96	4	Qatargas
Doha	137,350	J4 Consortium	Mitsubishi Nagasaki	Jun-99	Japan	S	Moss	5	Qatargas
Duhail	210,100	ProNav	Daewoo	Jan-08	Germany	DRL	GT NO 96	4	Various
Dukhan	135,000	J4 Consortium	Mitsui Chiba	Oct-04	Japan	S	Moss	4	Qatargas
Dwiputra	127,385	Humpuss Consortium	Mitsubishi Nagasaki	Mar-94	Bahamas	S	Moss	4	Pertamina
Ebisu	147,547	Golar LNG	Kawasaki	Sep-08	Bahamas	S	Moss	4	Various
Ejnan	145,000	4J	Samsung	Jan-07	Bahamas	S	TZ Mk. III		RasGas
Ekaputra	136,400	Humpuss Consortium	Mitsubishi Nagasaki	Jan-90	Liberia	S	Moss	5	Pertamina
Energy Advance	145,000	Tokyo LNG Tankers	Kawasaki Sakaide	Mar-05	Japan	S	Moss	4	Darwin
Energy Atlantic	159,924	Alpha	STX Jinhae	Sep-15	Malta	DFDE	No. 96	4	Various
Energy Confidence	155,000	Tokyo LNG Tankers	Kawasaki	Apr-09	Panama	S	Moss	4	Various
Energy Frontier	147,600	Tokyo LNG Tankers	Kawasaki Sakaide	Sep-03	Japan	S	Moss	4	Darwin
Energy Horizon	177,000	Tokyo LNG Tankers	Kawasaki	Jul-11	Japan	S	Moss	4	Pluto LNG
Energy Navigator	147,000	Tokyo LNG Tankers	Kawasaki Sakaide	May-08	Japan	S	Moss	4	Various
Energy Progress	145,000	MOL	Kawasaki	Nov-06	Japan	S	Moss	4	Bayu Undan LNG
Esshu Maru	162,000	K Line-Transpacific	Kawasaki Sakaide	Dec-14	Panama	S	Moss	4	Australia-Japan
Excalibur	138,200	Exmar/ Excelerate	Daewoo	Oct-02	Belgium	S	GT NO 96	4	Various
Excel	138,106	Exmar/ MOL	Daewoo	Sep-03	Belgium	S	GT NO 96	4	Various
Excelerate	138,000	Exmar/Excelerate	Daewoo	Oct-06	Belgium	S	GT NO 96	4	Various
Excellence	138,000	GKFF Ltd.	Daewoo	May-05	Belgium	S	GT NO 96	4	Excelerate Energy
Excelsior	138,000	Exmar	Daewoo	Jan-05	Belgium	S	GT NO 96	4	Various
Exemplar	150,900	Excelerate	Daewoo	Jun-10	Belgium	S	GT NO 96	4	Various
Expedient	151,000	Excelerate	Daewoo	Nov-09	Belgium	S	GT NO 96	4	Various
Experience RV	174,000	Exmar/Excelerate	Daewoo	Jul-14	Marshall Is.	DFDE	GT NO 96		Various
Explorer	150,900	Exmar/Excelerate	Daewoo	Mar-08	Belgium	S	GT NO 96	4	Excelerate
Express	151,000	Exmar/Excelerate	Daewoo	May-09	Belgium	S	GT NO 96	4	Various
Exquisite	150,900	Excelerate	Daewoo	Sep-09	Belgium	S	GT NO. 96	4	Various
Fraiha	210,100	J5 Consortium	Daewoo	Sep-08	Marshall Is.	DRL	GT NO 96	4	Qatargas
FSRU Independence	170,000	Hoegh	Hyundai	Feb-14	NIS	DFDE	TZ Mk. III	4	Various
FSRU Lampung	170,000	Hoegh	Hyundai	May-14	Indonesia	DFDE	TZ Mk. III	4	Various
Fuji LNG	147,895	TMSC Gas	Kawasaki	Jun-04	Malta	S	Moss	4	Various
Fuwairit	138,000	Peninsular LNG	Samsung	Jan-04	Bahamas	S	TZ Mk. III	4	RasGas II
Galea	134,425	Shell Shipping	Mitsubishi Nagasaki	Oct-02	Singapore	S	Moss	5	Shell
Galicia Spirit	140,620	Teekay LNG Partners	Daewoo	Jul-04	Liberia	S	GT NO 96	4	Engas
Gaselys	153,500	GdF/NYK	Atlantique	Mar-07	France	DFDE	CS 1	4	Engas
Gallina	134,425	Shell Shipping	Mitsubishi Nagasaki	Oct-02	Singapore	S	Moss	5	Shell
GasLog Chelsea	153,000	GasLog	Hanjin Korea	Dec-09	Panama	TFDE	TZ Mk. III	4	Various
Gaslog Geneva	174,000	GasLog	Samsung	Sept-16	Bermuda	TFDE	TZ Mk. III	4	Shell charter
Gaslog Gibraltar	174,000	GasLog	Samsung	Oct-16	Bermuda	TFDE	TZ Mk. III	4	Shell charter
Gaslog Glasgow	174,000	GasLog	Samsung	Jun-16	Bermuda	TFDE	TZ Mk. III	4	Shell charter
Gaslog Greece	174,000	GasLog	Samsung	Mar-16	Bermuda	TFDE	TZ Mk. III	4	Shell charter
GasLog Salem	165,000	GasLog	Samsung	Apr-15	Liberia	TFDE	TZ Mk. III	4	various
GasLog Santiago	155,000	GasLog	Samsung	Mar-13	Liberia	TFDE	TZ Mk. III	4	Various
GasLog Saratoga	155,000	GasLog	Samsung	Dec-14	Bermuda	TFDE	TZ Mk. III	4	Various
Gaslog Savannah	155,000	GasLog	Samsung	May-10	Bermuda	DFDE	TZ Mk. III	4	Various
GasLog Seattle	155,000	GasLog	Samsung	Oct-13	Bermuda	TFDE	TZ Mk. III	4	Various
GasLog Shanghai	155,000	GasLog	Samsung	Jan-13	Liberia	TFDE	TZ Mk. III	4	Various
Gaslog Singapore	155,000	GasLog	Samsung	Jul-10	Bermuda	DFDE	TZ Mk. III	4	Various
Gaslog Skagen	155,000	GasLog	Samsung	Oct-13	Bermuda	DFDE	TZ Mk. III	4	Various
Gaslog Sydney	155,000	GasLog	Samsung	May-13	Bermuda	DFDE	TZ Mk. III	4	Various
GDF-Suez Global Energy	74,000	Gaz de France	Chantiers	Dec-06	France	DFDE	CS1	4	Sonatrach
GDF-Suez Cape Ann	145,000	Hoegh LNG/MOL	Samsung	May-10	Liberia	DFDE	TZ Mk. III	4	Various
GDF-Suez Neptune	145,000	Hoegh LNG/MOL	Samsung	Dec-09	Liberia	DFDE	TZ Mk. III	4	Various
GDF-Suez Point Fortin	154,200	LNG Japan	Imabari/Koyo	Feb-10	Panama	DFDE	TZ Mk. III	4	Various
Gemmata	138,100	Shell Shipping	Mitsubishi Nagasaki	Mar-04	Singapore	S	Moss	5	Shell
Ghasha	137,510	National Gas Shipping	Mitsui	Jun-95	Liberia	S	Moss	5	ADGAS
Gigira Laitebo	177,000	MOL-Itochu	Hyundai	Feb-09	Panama	DFDE	TZ Mk. III	4	Various
Golar Arctic	140,645	Golar LNG	Daewoo	Dec-03	Marshall Is.	S	GT NO 96	4	Shell Spot
Golar Bear	160,000	Golar	Samsung	Mar-14	Bermuda	DFDE	TZ Mk. III	4	Various

Golar Celsius	160,000	Golar LNG	Samsung	Sep-13	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Crystal	160,000	Golar LNG	Samsung	Oct-13	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Eskimo (FSRU)	160,000	Golar LNG	Samsung	Jan-15	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Freeze	125,850	Golar LNG	HDW	Feb-77	UK	S	Moss	5	Various
Golar Glacier	162,000	Golar LNG	Hyundai	Sep-14	Marshall Is.	DFDE	TZ Mk. III	4	Various
Golar Grand	145,880	Golar LNG	Daewoo	2006	IoM		GT NO 96	4	Various
Golar Ice	160,000	Golar LNG	Samsung	Feb-15	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Igloo (FSRU)	160,000	Golar LNG	Samsung	Oct-13	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Kelvin	160,000	Golar LNG	Samsung	Jan-15	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Maria	145,950	Golar LNG	Daewoo	2006	Marshall Is.		GT NO 96	4	Various
Golar Mazo	135,225	Golar LNG/CPP	Mitsubishi	Jan-00	Liberia	S	Moss	5	Pertamina
Golar Penguin	160,000	Golar LNG	Samsung	Mar-14	Marshall Is.	DFDE	TZ Mk. III	4	Various
Golar Seal	160,000	Golar LNG	Samsung	Aug-13	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Singapore (FSRU)	160,000	Golar LNG	Samsung	June-15	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Snow	160,000	Golar LNG	Samsung	Jan-15	Bermuda	DFDE	TZ Mk. III	4	various
Golar Tundra (FSRU)	160,000	Golar LNG	Samsung	Dec-15	Bermuda	DFDE	TZ Mk. III	4	Various
Golar Viking	140,000	Golar LNG	Hyundai	Jan-05	Marshall Is.	S	Moss	4	Various
Golar Winter	138,250	Golar LNG	Daewoo	Apr-04	Marshall Is.	S	GT NO 96	4	Petrobras
Grace Acacia	150,000	Algaet Shipping	Hyundai	Jan-07	Japan	S	TK MK III	4	Various
Grace Barleria	150,000	Swallowtail Ship	Hyundai	Oct-07	Japan	S	TZ Mk. III	4	Various
Grace Cosmos	150,000	AGH Shipping	Hyundai	Mar-08	Japan	S	TZ Mk. III	4	Various
Grace Dahlia	177,000	Tokyo Gas	Kawasaki	Oct-13	Japan	S	Moss	4	Various
Gracilis	138,830	Golar LNG	Hyundai	Jan-05	Marshall Is.	S	TZ Mk III	4	Shell BG
Granatina	140,645	Shell Shipping	Daewoo	Dec-03	Singapore	S	GT NO 96	4	Shell
Grand Aniva	147,200	Sovcomflot/NYK	Mitsubishi	Jan-08	Japan	S	Moss	4	Various
Grand Elena	147,200	Sovcomflot/NYK	Mitsubishi	Oct-07	Japan	S	Moss	4	Various
Grand Mereya	147,200	Primorsk/MOL/K Line	Chiba	May-08	Japan	S	Moss	4	Sakhalin II
Hanjin Muscat	138,200	Hanjin Shipping	Hanjin	Jul-99	Panama	S	GT NO 96	4	Oman Gas
Hanjin Pyeong Taek	130,600	Hanjin Shipping	Hanjin	Sep-95	Panama	S	GT NO 96	4	Pertamina
Hanjin Ras Laffan	138,214	Hanjin Shipping	Hanjin	Jul-00	Panama	S	GT NO 96	4	QatarGas
Hanjin Sur	138,333	Hanjin Shipping	Hanjin	Jan-00	Panama	S	GT NO 96	4	Oman Gas
Hispania Spirit	140,500	Teekay LNG Partners	Daewoo	Sep-02	Spain	S	GT NO 96	4	Atlantic LNG
Hoegh Gallant FSRU	170,050	Hoegh LNG	Hoegh Hyundai	May-14	Marshall Is.	DFDE	TZ Mk. III	4	chartered
Hoegh Grace FSRU	170,050	Hoegh LNG	Hoegh LNG Hyundai	May-15	Marshall Is.	DFDE	TZ Mk. III	4	various
Hyundai Aquapia	135,000	Hyundai MM	Hyundai	Mar-00	Panama	S	Moss	4	Oman Gas
Hyundai	135,000	Hyundai MM	Hyundai	Jan-00	Panama	S	Moss	4	RasGas
Hyundai Ecopia	145,000	Hyundai	Hyundai	Nov-08	Panama	S	TZ Mk. III	4	Various
Hyundai Greenpia	125,000	Hyundai MM	Hyundai	Nov-96	Panama	S	Moss	4	Pertamina
Hyundai Oceanpia	135,000	Hyundai MM	Hyundai	Jul-00	Panama	S	Moss	4	Oman Gas
Hyundai Technopia	135,000	Hyundai MM	Hyundai	Jul-00	Panama	S	Moss	4	RasGas
Hyundai Utopia	125,182	Hyundai MM	Hyundai	Jun-94	Panama	S	Moss	4	Pertamina
Iberica Knutsen	138,000	Knutsen OAS	Daewoo	Aug-06	Norway	S	GT 96	4	Gas Natural
Ibra LNG	147,100	Oman Gas	Samsung	Jun-06	Panama	S	TK Mk. III	4	Oman LNG
Ibri LNG	145,000	Oman Gas	Mitsubishi	Jul-06	Panama	S	TK Mk. III	4	Oman LNG
Ish	137,540	National Gas Shipping	Mitsubishi Nagasaki	Nov-95	Liberia	S	Moss	5	ADGAS
K Acacia	138,017	Korea Line	Daewoo	Jan-00	Panama	S	GT NO 96	4	Oman Gas
K Freesia	135,256	Korea Line	Daewoo	Jun-00	Panama	S	GT NO 96	4	RasGas
K Jasmine	145,700	Korea Line	Daewoo	Mar-08	Panama	S	GT NO 96	4	Kogas offtake
K Mugungwha	152,000	K Line	Daewoo	Nov-08	Panama	S	GT NO 96	4	Various
Kita LNG	160,106	TMSC Gas	Daewoo	Jun-14	Malta	TFDE	GT No 96	4	Various
Kotawaka Maru	125,200	J3 Consortium	Kawasaki Sakaide	Jan-84	Japan	S	Moss	5	Darwin
Lala Fatma N'Soumer	145,000	Algeria Nippon Gas	Kawasaki Sakaide	Dec-04	Japan	S	Moss	4	Sonatrach
Larbi Ben M'Hidi	129,750	SNTM-Hyproc	La Seyne	Jun-77	Algeria	S	GT NO 85	5	Sonatrach
Lijmilya	261,700	QGTC	Daewoo	Sep-08	Marshall Is.	DRL	GT NO. 96	5	Various
LNG Abuja	126,530	Bonny Gas Transport	GD Quincy	Sep-80	Bahamas	S	Moss	5	Nigeria LNG
LNG Adamawa	141,000	Bonny Gas Transport	Hyundai	Jun-05	Bermuda	S	Moss	4	Various
LNG Akwa Ibom	141,000	Bonny Gas Transport	Hyundai	Nov-04	Bermuda	S	Moss	4	Various
LNG Aquarius	126,300	MOL/LNG Japan	GD Quincy	Jun-77	Marshall Is.	S	Moss	5	Various
LNG Barka	153,000	NYK	Kawasaki	Jan-09	Bahamas	S	Moss	4	Various
LNG Bayelsa	137,500	Bonny Gas Transport	Hyundai	Feb-03	Bermuda	S	Moss	4	Nigeria LNG
LNG Benue	145,700	BW Gas	Daewoo	Mar-06	Bermuda	S	GT NO 96	4	Nigeria LNG
LNG Bonny	177,000	Bonny Gas Transport	Hyundai	Oct-15	Bermuda	DFDE	TZ Mk III	4	Nigeria LNG
LNG Borno	149,600	NYK Line	Samsung	Aug-07	Japan	S	TZ Mk. III	4	Nigeria LNG
LNG Capricorn	126,300	MOL/LNG Japan	GD Quincy	Jun-78	Marshall Is.	S	Moss	5	Pertamina
LNG Cross River	141,000	Bonny Gas Transport	Hyundai	Sep-05	Bermuda	S	Moss	4	Various
LNG Dream	145,000	Osaka Gas	Kawasaki	Sep-06	Japan	S	Moss	4	Woodside Energy
LNG Ebisu	147,500	MOL	Kawasaki	Sep-08	Bahamas	S	Moss	4	Various
LNG Edo	126,530	Bonny Gas Transport	GD Quincy	May-80	Bahamas	S	Moss	5	Nigeria LNG
LNG Enugu	145,000	BW Gas	Daewoo	Oct-05	Bermuda	S	GT NO 96	4	Nigeria LNG
LNG Fimina	175,000	Bonny Gas Transport	Samsung	Oct-15	Bermuda	DFDE	TZ Mk III	4	Nigeria LNG
LNG Flora	127,700	J3 Consortium	Kawasaki Sakaide	Mar-93	Japan	S	Moss	4	Pertamina
LNG Fukurokuju	165,000	MOL	Kawasaki	June-15	Japan	S	Moss	4	Various
LNG Gemini	126,300	MOL/LNG Japan	GD Quincy	Sep-78	Marshall Is.	S	Moss	5	Pertamina
LNG Imo	148,300	BW Gas	Daewoo	Jun-08	Bermuda	S	GT NO 96	4	Nigeria LNG
LNG Jamal	135,330	Osaka Gas/J3 Consortium	Mitsubishi Nagasaki	Oct-00	Japan	S	Moss	5	Oman Gas
LNG Jupiter	145,000	NYK Line	Kawasaki	Jul-09	Bahamas	S	Moss	4	Various
LNG Jurojin	155,300	MOL	MHI Nagasaki	Nov-15	Japan	S	KM	4	Various
LNG Kano	148,471	BW Gas	Daewoo	Jan-07	Bermuda	S	GT No. 96	4	NLNG
LNG Lagos	177,000	Bonny Gas	Hyundai	Oct-15	Bermuda	DFDE	TZ Mk III	4	Nigeria LNG
LNG Leo	126,400	MOL/LNG Japan	GD Quincy	Dec-78	Marshall Is.	S	Moss	5	Pertamina
LNG Lerici	65,000	Exmar	Italcantieri Sestri	Mar-98	Italy	S	GT NO 96	4	Sonatrach
LNG Libra	126,400	Hoegh LNG	GD Quincy	Apr-79	Marshall Is.	S	Moss	5	Various
LNG Lokoja	148,300	BW Gas	Daewoo	Dec-06	Bermuda	S	GT No. 96	4	Nigeria LNG
LNG Ogun	148,300	NYK Line	Samsung	Aug-07	Japan	S	TZ Mk. III	4	Nigeria LNG
LNG Ondo	148,300	BW Gas	Daewoo	Sep-07	Bermuda	S	GT NO 96	4	Nigeria LNG
LNG Oyo	140,500	BW Gas	Daewoo	Dec-05	Bermuda	S	GT NO 96	4	Nigeria LNG
LNG Pioneer	138,000	MOL	Daewoo	Jul-05	Bahamas	S	GT No 96	4	Idku

LNG Port Harcourt	175,000	Bonny Gas	Samsung	Oct-15	Bermuda	DFDE	TZ Mk III	4	Nigeria LNG
LNG Portovenere	65,000	Exmar	Italcantieri Sestri	Jun-96	Italy	S	GT No 96	4	Sonatrach
LNG River Niger	141,000	Bonny Gas Transport	Hyundai	May-06	Bermuda	S	Moss	4	Various
LNG River Orashi	145,910	BW Gas	Daewoo	Nov-04	Bermuda	S	GT No 96	4	Nigeria LNG
LNG Rivers	137,231	Bonny Gas Transport	Hyundai	Jun-02	Bermuda	S	Moss	4	Nigeria LNG
LNG Saturn	153,000	MOL	MHI	Nov-15	Japan	S	Moss	4	Various
LNG Sokoto	137,231	Bonny Gas Transport	Hyundai	Aug-02	Bermuda	S	Moss	4	Nigeria LNG
LNG Taurus	126,300	MOL/LNG Japan	GD Quincy	Aug-79	Marshall Is.	S	Moss	5	Various
LNG Venus	155,000	Osaka/MOL	MHI	Oct-14	Japan	S	Moss	4	Various
LNG Vesta	127,547	Tokyo Gas Consortium	Mitsubishi Nagasaki	Jun-94	Japan	S	Moss	4	Pertamina
LNG Virgo	126,400	MOL/LNG Japan	GD Quincy	Dec-79	Marshall Is.	S	Moss	5	Pertamina
Lobito	160,400	Mitsui/NYK/Teekay	Samsung	Oct-11	Bahamas	DFDE	TZ Mk. III	4	Various
Lusail	138,000	Peninsular LNG	Samsung	May-05	Bahamas	S	TZ Mk. III	4	Qatar
Madrid Spirit	138,000	Teekay LNG Partners	IZAR Puerto Real	Jan-05	Spain	S	GT No 96	4	Engas
Magellan Spirit	165,500	Teekay LNG Partners	Samsung	Sep-08	Denmark	DFDE	TZ Mk. III	4	Various
Malanje	160,400	Mitsui/NYK/Teekay	Samsung	Jul-11	Bahamas	DFDE	TZ Mk. III	4	Various
Maran Gas Achilles	174,000	Maran	Hyundai Samho	Feb-16	Greece	DFDE	GT No 96	4	Various
Maran Gas Agamemnon	174,000	Maran	Hyundai Samho	May-16	Greece	DFDE	GT No 96	4	Various
Maran Gas Alexandria	161,870	Maran	Hyundai Samho	Sep-15	Greece	DFDE	TZ Mk. III	4	Various
Maran Gas Amphipolis	173,400	Maran	Daewoo	Aug-16	Greece	DFDE	GT No 96	4	Various
Maran Gas Apollonia	161,870	Maran	Daewoo	Jan-14	Greece	DFDE	GT No 96	4	Various
Maran Gas Asclepius	145,000	Kristen Navigation	Daewoo	Jul-05	Bermuda	S	GT No 96	4	Qatar
Maran Gas Coronis	145,700	Maran	Daewoo	Sep-07	Greece	S	GT No 96	4	Rasgas II
Maran Gas Delphi	159,800	Maran	Daewoo	Feb-14	Greece	DFDE	GT No 96	4	Various
Maran Gas Efessos	159,800	Maran	Daewoo	Jun-14	Greece	DFDE	GT No 96	4	Various
Maran Gas Hector	174,000	Maran	Hyundai Samho	Nov-16	Greece	DFDE	GT No 96	4	Various
Maran Gas Lindos	159,800	Maran	Daewoo	Jun-15	Greece	DFDE	GT No. 96	4	Various
Maran Gas Mystras	155,900	Maran Gas	Daewoo	May-15	Greece	DFDE	GT No 96	4	various
Maran Gas Pericles	174,000	Maran	Hyundai Samho	June-16	Greece	DFDE	GT No 96	4	Various
Maran Gas Posidonia	161,870	Maran	Daewoo	May-14	Greece	DFDE	GT No 96	4	Various
Maran Gas Sparta	161,870	Maran	Hyundai Samho	April-15	Greece	DFDE	G TZ Mk. III	4	Various
Maran Gas Troy	155,900	Maran Gas	Daewoo	May-15	Greece	DFDE	GT No 96	4	various
Maria Energy	174,000	Tsakos	Hyundai	Mar-15	Marshall Is.	TFDE	GTT Mk II	4	Various
Marib Spirit	165,000	Teekay LNG	Samsung	May-08	Marshall Is.	DFDE	TZ Mk. III	4	Various
Matthew	126,540	Suez LNG Shiping	Newport News	Jun-79	Bahamas	S	TZ Mk. I	6	Atlantic LNG
Mekaines	266,000	Naklilat	Samsung	Mar-09	Liberia	DRL	GT No 96	4	Qatar-Atlantic Basin
Meridian Spirit	165,500	Teekay LNG	Samsung	Jan-10	Denmark	DFDE	TZ Mk. III	4	Various
Mesaimeer	210,100	Naklilat	Hyundai	Mar-09	Liberia	DRL	GT No 96	4	Qatar-Atlantic Basin
Methane Alison Victoria	145,000	GasLog	Samsung	Aug-07	Bermuda	S	TZ III	4	Eq.Guinea LNG
Methane Becki Anne	170,000	GasLog	Samsung	Sep-10	Bermuda	TFDE	TZ Mk. III	4	Various
Methane Heather Sally	145,000	GasLog	Samsung	Jul-07	Bermuda	S	Tz Mk. III	4	Eq.Guinea LNG
Methane Jane Elizabeth	145,000	GasLog	Samsung	Jun-06	Bermuda	TFDE	TZ Mk. III	4	Engas
Methane Julia Louise	170,000	GasLog	Samsung	Dec-09	Bermuda	TFDE	TZ Mk. III	4	Various
Methane Kari Elin	138,200	Shell	Samsung	Jun-04	Bermuda	S	TZ Mk. III	4	Various
Methane Lake Charles	145,000	Shell	Samsung	Feb-07	Bermuda	S	TZ Mk. III	4	Marathon Oil
Methane Lydon Volney	145,000	Shell	Samsung	Aug-06	Bermuda	S	TZ Mk. III	4	Engas
Methane Mickie Harper	170,000	Shell-GasLog	Samsung	Nov-10	Bermuda	TFDE	TZ Mk. III	4	Various
Methane Nile Eagle	145,000	Shell-GasLog	Samsung	Dec-07	Bermuda	S	TZ Mk. III	4	Engas
Methane Patricia Camila	170,000	Shell-GasLog	Samsung	Oct-10	Bermuda	TFDE	TZ Mk. III	4	Various
Methane Princess	138,159	Golar LNG	Daewoo	2003	UK	S	GT No 96	4	Spot BG
Methane Rita Andre	145,000	GasLog	Samsung	Mar-06	Bermuda	S	TZ Mk. III	4	Engas
Methane Shirley Elizabeth	145,000	GasLog	Samsung	Apr-07	Bermuda	S	TZ Mk. III	4	Marathon Oil
Methane Sprit	165,000	Teekay LNG	Samsung	Mar-08	Singapore	DFDE	TZ Mk. III	4	Various
Methania	131,230	Distrigas	Boelwerf	Oct-78	Belgium	S	GT No 85	5	Sonatrach
Milaha Qatar	145,000	Milaha	Samsung	Apr-06	Denmark	S	TZ Mk. III	4	Qatar
Milaha Ras Laffan	138,270	Milaha	Samsung	Mar-04	Denmark	S	TZ Mk. III	4	RasGas II
Min Lu	147,000	China Ships	Hudong	Aug-09	China	S	GT No 96	4	Various
Min Rong	147,000	China LNG Ships	Hudong	Feb-09	Hong Kong	S	GT No 96	4	Australia-China
Mostefa Ben Boulaid	125,260	SNTM-Hyproc	La Ciotat	Aug-76	Algeria	S	TZ Mk. I	6	Sonatrach
Mourad Didouche	126,130	SNTM-Hyproc	Atlantique	Jul-80	Algeria	S	GT No 85	5	Sonatrach
Mozah	266,000	QGTC	Samsung	Aug-08	Qatar	DRL	TZ Mk III	5	Qatargas II
Mraweh	137,000	National Gas Shipping	Kvaerner-Masa	Jun-96	Liberia	S	Moss	4	ADGAS
Mubaraz	137,000	National Gas Shipping	Kvaerner-Masa	Jan-96	Liberia	S	Moss	4	Various
Muraq	210,100	J5-K Line	Daewoo	May-08	Marshall Is.	DRL	GT No 96	4	Qatar-Atl'c Basin
Murwab	210,100	J5 Consortium	Daewoo	May-08	Marshall Is.	DRL	GT No. 96	4	Qatargas
Muscat LNG	149,170	Oman Gas/MOL	Kawasaki Sakaide	Mar-04	Japan	S	Moss	4	Oman Gas
Neo Energy	149,700	Tsakos	Hyundai	Feb-07	Liberia	S	GTT Mk II	4	Various
Nizwah LNG	145,000	Oryx LNG Carriers	Kawasaki Sakaide	Dec-05	Japan	S	Moss	4	Oman Gas
Northwest Sanderling	127,525	Australia LNG	Mitsubishi Nagasaki	Jun-89	Australia	S	Moss	4	NWS
Northwest Sandpiper	127,500	Australia LNG	Mitsui Chiba	Feb-93	Australia	S	Moss	4	NWS
Northwest Seaeagle	127,450	Australia LNG	Mitsubishi Nagasaki	Nov-92	Bermuda	S	Moss	4	NWS
Northwest Shearwater	127,500	Australia LNG	Kawasaki Sakaide	Sep-91	Bermuda	S	Moss	4	NWS
Northwest Snipe	127,747	Australia LNG	Mitsui Chiba	Sep-90	Australia	S	Moss	4	NWS
Northwest Stormpetrel	127,600	Australia LNG	Mitsubishi Nagasaki	Dec-94	Australia	S	Moss	4	NWS
Northwest Swallow	127,708	J3 Consortium	Mitsui Chiba	Nov-89	Japan	S	Moss	4	NWS
Northwest Swan	138,000	Australia LNG	Daewoo	Mar-04	Australia	S	GT NO 96	4	NWS
Northwest Swift	127,590	J3 Consortium	Mitsubishi Nagasaki	Sep-89	Japan	S	Moss	4	NWS
Ob River	150,000	Lance Shipping	Hyundai	Oct-07	Marshall Is.	S	TZ Mk. III	4	Various
Onaiza	210,100	Nakilat	Daewoo	Apr-09	Liberia	DRL	GT NO 96	4	Qatar-Atlantic Basin
Pacific Arcadia	147,200	NYK Line	MHI	Oct-14	Bahamas	S	KM		Various
Pacific Enlighten	145,000	LNG MT	Mitsubishi	Mar-09	Japan	S	Moss	4	Various
Pacific Eurus	137,000	LNG Marine Transport	Mitsubishi Nagasaki	Mar-06	Bahamas	S	Moss	4	Darwin
Pacific Notus	137,006	Pacific LNG Shipping	Mitsubishi Nagasaki	Sep-03	Bahamas	S	Moss	5	Darwin
Palu LNG	160,106	TMSC Gas	Daewoo	Jun-14	Malta	TFDE	GT No 96	4	Various
Papua	171,800	MOL-China	Hudong	Jan-15	Hong Kong	DFDE	SSD	4	PNG LNG
Polar Eagle	89,880	Polar LNG	IHI Chita	Jun-93	Liberia	S	IHI SPB	4	ConocoPhillips/Marathon
Provalys	153,500	Gaz de France	Chantiers	Nov-06	France	DFDE	CS1	4	ELNG

Puteri Delima	130,400	MISC	Atlantique	Jan-95	Malaysia	S	GT NO 96	4	Petronas
Puteri Delima Satu	137,100	MISC	Mitsui Chiba	Apr-02	Malaysia	S	GT NO 96	4	Petronas
Puteri Firuz	130,400	MISC	Atlantique	May-97	Malaysia	S	GT NO 96	4	Petronas
Puteri Firuz Satu	137,100	MISC	Mitsubishi Nagasaki	Sep-04	Malaysia	S	GT NO 96	4	Petronas
Puteri Intan	130,400	MISC	Atlantique	Aug-94	Malaysia	S	GT NO 96	4	Petronas
Puteri Intan Satu	137,100	MISC	Mitsubishi Nagasaki	Dec-01	Malaysia	S	GT NO 96	4	Petronas
Puteri Mutiera Satu	137,100	MISC	Mitsui Chiba	Apr-05	Malaysia	S	GT NO 96	4	Petronas
Puteri Nilam	130,400	MISC	Atlantique	Jun-95	Malaysia	S	GT NO 96	4	Petronas
Puteri Nilam Satu	137,100	MISC	Mitsubishi Nagasaki	Sep-03	Malaysia	S	GT NO 96	4	Petronas
Puteri Zamrud	130,400	MISC	Atlantique	May-96	Malaysia	S	GT NO 96	4	Petronas
Puteri Zamrud Satu	137,100	MISC	Mitsui Chiba	Apr-87	Malaysia	S	GT NO 96	4	Atlantic LNG
Raahi	136,000	Petronet LNG Ltd	Daewoo	Dec-04	Malta	S	GT NO 96	4	Qatargas
Ramdane Abane	126,130	SNTM-Hyproc	Atlantique	Jul-81	Algeria	S	GT NO 85	5	Sonatrach
Rasheeda	266,000	QGTC	Samsung	Jun-10	Liberia	DRL	TZ Mk. III		Various
Ribera del Duero Knutsen	173,400	Knutsen	Daewoo	Nov-10	Nor-NIS	DFDE	GT NO. 96	4	Various
Salalah LNG	147,000	Oman Gas/MOL	Samsung	Dec-05	Japan	S	TZ Mk. III	4	Oman
SCF Polar	71,500	Sovcomflot	Kockums	Aug-69	Liberia	S	GT NO 82	6	Sonatrach
Seishu Maru	162,000	K Line-Transpacific	Kawasaki Sakaide	Jan-15	Panama	S	Moss	4	Australia-Japan
Seri Alam	138,000	MISC	Samsung	Oct-05	Malaysia	S	TZ Mk. III	4	Yemen LNG
Seri Amanah	145,000	MISC	Samsung	Mar-06	Malaysia	S	TZ Mk. III	4	Yemen LNG
Seri Anggun	145,000	MISC	Samsung	Nov-06	Malaysia	S	TZ Mk. III	4	Yemen LNG
Seri Angkasa	145,000	MISC	Samsung	Feb-07	Malaysia	S	TZ Mk. III	4	Petronas
Seri Ayu	145,000	MISC	Samsung	Oct-07	Malaysia	S	TZ Mk. III	4	Various
Seri Bakti	152,300	MISC	Mitsubishi	Mar-07	Malaysia	S	GT NO 96	4	Petronas
Seri Balhaf	152,000	MISC	Mitsubishi	Sep-08	Malaysia	S	GT NO 96	4	Various
Seri Balquis	152,000	MISC	Mitsubishi	Dec-08	Malaysia	S	GT NO 96	4	Various
Seri Begawan	152,300	MISC	Mitsubishi	Dec-07	Malaysia	S	GT NO 96	4	Various
Seri Bijaksana	152,300	MISC	Mitsubishi	Feb-08	Malaysia	S	GT NO 96	4	Petronas
Seri Camellia	150,000	MISC	Hyundai	Nov-16	Malaysia	S	Moss	4	Petronas
Sestao Knutsen	138,000	Knutsen	IZAR Sestao	Jan-07	Spain	S	GT NO 96	4	Atlantic LNG
Sevilla Knutsen	173,400	Knutsen	Daewoo	Jun-10	N.I.S.	DFDE	GT NO 96	4	Various
Shahamah	135,500	National Gas Shipping	Kawasaki Sakaide	Oct-94	Liberia	S	Moss	5	ADGAS
Shangra	266,000	QGTC	Samsung	Nov-09	Liberia	DRL	TZ Mk. III	5	Qatargas IV
Shen Hai	147,100	China LNG	Hudong Zhonghua	Sep-12	China	AB/CC Steam	GT NO 96	4	Various
Simaisma	147,700	Maran Gas Maritime	Daewoo	Jul-06	Greece	S	GT No 96	4	Qatar
SK Splendor	138,375	SK Shipping	Samsung	Mar-00	Panama	S	TZ Mk. III	4	Oman Gas
SK Stellar	138,375	SK Shipping	Samsung	Dec-00	Panama	S	TZ Mk. III	4	RasGas
SK Summit	138,000	SK Shipping	Daewoo	Aug-99	Panama	S	GT NO 96	4	RasGas
SK Sunrise	138,306	I. S. Carriers	Samsung	Sep-03	Panama	S	TZ Mk. III	4	RasGas
SK Supreme	138,200	SK Shipping	Samsung	Jan-00	Panama	S	TZ Mk. III	4	RasGas
Sohar LNG	137,250	Oman Gas/ MOL	Mitsubishi Nagasaki	Oct-01	Malta	S	Moss	5	Oman Gas
Solaris	155,000	GasLog	Samsung	Jul-14	Bermuda	TFDE	TZ Mk. III	4	Various
Sonangol Benguela	160,500	Sonangol	Daewoo	Sep-11	Bahamas	S	GT No. 96	4	Angola LNG
Sonangol Etosha	160,500	Sonangol	Daewoo	Sep-11	Bahamas	S	GT No. 96	4	Angola LNG
Sonangol Sambizanga	160,500	Sonangol	Daewoo	Sep-11	Bahamas	S	GT No. 96	4	Angola LNG
Southern Cross	172,000	MOL	Hudong	May-15	Hong Kong	DRL	GT NO. 96	4	Various
Soyo	160,400	Mitsui/NYK/Teekay	Samsung	May-11	Bahamas	DFDE	TZ Mk. III	4	Various
Spirit of Hela	177,000	MOL	Hyundai	Oct-09	Panama	DFDE	TZ Mk. III	4	Various
Stena Blue Sky	145,700	Stena	Daewoo	Jan-06	Panama	S	GT No 96	4	Various
Stena Clear Sky	171,800	Stena	Daewoo	Sep-10	Panama	DFDE	GT NO 96	4	Various
Stena Crystal Sky	171,800	Stena	Daewoo	Jul-10	Panama	DFDE	GT NO 96	4	Various
STX Kolt	145,700	STX Panocean	Korea Hanjin	Nov-08	Panama	DFDE	TZ Mk. III	4	Various
Suez Point Fortin	154,200	Trinity LNG	Koyo Japan	Nov-09	Panama	S	TZ Mk. III	4	Yemen LNG
Taitar No. 1	145,000	NYK Line	Mitsubishi	Oct-09	Liberia	S	Moss	4	Various
Taitar No. 3	145,000	NYK Line	Mitsubishi	Jan-10	Liberia	S	Moss	4	Various
Taitar No. 4	145,000	NYK	Mitsubishi	Jan-10	Liberia	S	Moss	4	Various
Tangguh Batur	145,700	Sovcomflot/NYK	Daewoo	Dec-08	Cyprus	S	GT NO 96		Tangguh
Tangguh Foja	155,000	K Line	Samsung	Jul-08	Panama	DFDE	TZ Mk. III	4	Tangguh LNG
Tangguh Hiri	155,000	Teekay LNG	Hyundai	Nov-08	IOM	DFDE	TZ Mk. III	4	Tangguh
Tangguh Jaya	145,700	K Line	Samsung	Nov-08	Panama	DFDE	TZ Mk. III	4	Tangguh
Tangguh Palung	155,000	K Line	Samsung	Mar-09	Panama	DFDE	TZ Mk. III	4	Tangguh
Tangguh Sago	155,000	Teekay LNG	Hyundai	Mar-09	IOM	DFDE	TZ Mk. III	4	Tangguh LNG
Tangguh Towuti	145,700	Sovcomflot/NYK	Daewoo	Oct-08	Cyprus	S	GT NO 96	4	Tangguh
Tembek	216,200	OSG/Nakilat	Samsung	Sep-07	Marshall Is.	DRL	TZ Mk. III	4	Qatargas II
Tenaga Satu	130,000	MISC	Dunkerque	Sep-82	Malaysia	S	GT NO 88	5	Petronas
Trinity Arrow	154,900	K Line	Imabari Shipbuilding	Mar-08	Panama	S	TZ Mk. III	4	Various
Umm Al Amad	210,100	J5	Daewoo	Aug-08	Marshall Is.	DRL	GT NO 96	4	Ras Gas III
Umm Al Ashtan	137,000	National Gas Shipping	Kvaerner- Masa	May-97	Liberia	S	Moss	4	ADGAS
Umm Bab	145,000	Kristen Navigation	Daewoo	Nov-05	Bermuda	S	GT NO 96	4	Qatargas
Umm Slaal	266,000	QGTC	Samsung	Nov-08	Qatar	DRL	TZ Mk. III	5	Qatargas
Valencia Knutsen	173,400	Knutsen	Daewoo	Sep-10	Nor-NIS	DFDE	GT NO. 96	4	Various
Velikiy Novgorod	170,200	SovComFlot	STX	Feb-14	Liberia	DFDE	GT No. 96	4	Various
Wakaba Maru	125,000	J3 Consortium	Mitsui Chiba	Apr-85	Japan	S	Moss	5	Pertamina
WilEnergy	125,500	Awilco LNG	Mitsubishi	Oct-83	NIS	S	Moss	5	Various
WilForce	156,000	Teekay LNG	Daewoo	Aug-13	NIS	DFDE	GT NO 96	4	Various
WilGas	125,500	Awilco LNG	Mitsubishi	Jul-84	NIS	S	Moss	5	Various
WilPower	125,500	Awilco LNG	Mitsubishi	Jul-84	NIS	S	Moss	5	Various
Woodside Cheney	174,000	Maran	Hyundai Samho	March-16	Greece	DFDE	GT No 96	4	Various
Woodside Donaldson	165,500	Teekay LNG	Samsung	Dec-09	Singapore	DFDE	TZ Mk. III	4	Various
Woodside Goode	159,800	Maran	Daewoo	Jul-14	Greece	DFDE	GT No. 96	4	Various
Woodside Rogers	155,900	Maran Gas	DSME	Jul-13	Greece	DFDE	GT NO 96	4	Various
Yari LNG	159,983	TMSC Gas	Daewoo	Jun-14	Malta	TFDE	GT No 96	4	Various
Yenisei River	155,000	Dynagas	Hyundai	Jul-13	Marshall Is.	DFDE	TZ Mk. III	4	Various
YK Sovereign	127,125	SK Shipping	Hyundai	Dec-94	Panama	S	Moss	4	Pertamina
Zarga	266,000	QGTC	Samsung	Dec-09	Liberia	DRL	TZ Mk. III	5	Qatar-Atlantic
Zekreet	135,420	J4 Consortium	Mitsui Chiba	Dec-98	Japan	S	Moss	5	Qatargas

Any observations, additions or suggested revisions to the LNG journal World LNG Carrier Fleet list should be sent to editor@lngjournal.com

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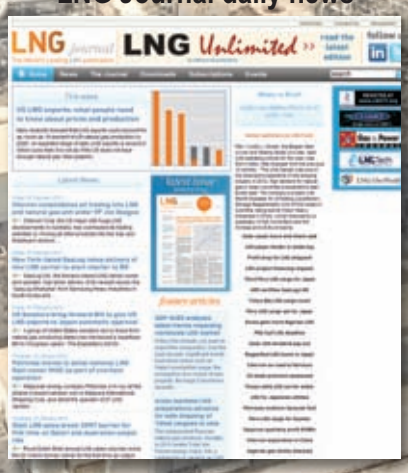

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Subscriptions | **Elena Fuertes**
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E: elena@lngjournal.com

LNG Import Terminals

Explanatory Notes

- The tables do not include the following types of LNG facilities :
  - Small marine satellite terminals receiving LNG from liquefaction plants in their own country (such as exist in Norway) or which receive LNG transhipped from nearby reception terminals in their own country (such as in Japan)
  - Satellite LNG storage facilities that receive LNG transported only by road or rail
- Expansions of LNG reception terminals are only shown if they involve new storage tanks
- Where there is a blank in the table the information is uncertain or unknown.

Any comments on the tables, and corrections / additional information from terminal shareholders and project developers would be most welcome, and should be sent to John McKay e-mail editor@lngjournal.com

Country	Location (Project)	Owners	Start up	Storage Tanks	Storage Capacity
Belgium	Zeebrugge	Fluxys	1987	4	380,000
Canada	Canaport Saint John	Irving Oil, Repsol	2009	3	480,000
Chile	Quintero	ENAP, Metrogas, Enagas	2009	3	334,000
	Mejillones	Engie, Codelco	2010	1	175,000
China	Beihai LNG, Guangxi	Sinopec	2015	2	320,000
	Dalian	PetroChina	2011	3	480,000
	Dongguan, Guangdong	Jovo Group	2013	2	160 000
	Fujian LNG (Xiuyu)	CNOOC, Fujian I&D Corp.	2008	2	640,000
	Guangdong	CNOOC,BP	2006	3	480,000
	Haikou, Hainan LNG	CNOOC	2014	3	480,000
	Ningbo, Zheijang	CNOOC, Zhejiang Energy	2012	3	480,000
	Qingdao, Shandong	Sinopec	2014	3	480,000
	Rudong	PetroChina	2011	3	530,000
	Shanghai	CNOOC, Shenergy Group	2009	3	495,000
	Shanghai, Mengtougou	Shanghai Gas	2008	3	120 000
	Tangshan, Hebei	PetroChina	2013	3	480,000
	Tianjin FSRU	CNOOC	2014	1	60,000
	Zhuhai, Gaolan	CNOOC	2013	3	480,000
Dominican Republic	Punta Caucedo	AES Andres	2003	1	160 000
Finland	Pori	Gasum Skangas	2016	1	30,000
France	Fos Tonkin	Elengy	1972	3	150,000
	Montoir-de-Bretagne	Elengy	1980	3	360,000
	Fos Cavaou	Engie, Total	2010	3	330,000
	Dunkirk LNG	EDF, Fluxys, Total	2016	3	570,000
Greece	Revithoussa	DEPA	2000	2	130,000
India	Dabhol	GAIL, NTPC (Ratnagiri Gas & Power)	2009	3	480,000
	Dahej	Petronet LNG	2004	4	592,000
	Hazira	Shell India, Total	2005	2	320,000
	Kochi, Kerala	Petronet LNG	2013	2	320,000
Indonesia	Arun	Pertamina	2015	5	507,000
Italy	Panigaglia	Snam	1969	2	100,000
	Porto Levante (offshore GBS)	ExxonMobil, Qatar Petroleum, Edison Gas	2009	2	250,000
Japan	Negishi	Tokyo Gas	1969	14	1,180,000
	Sodegaura	Tokyo Gas	1973	35	2,660,000
	Ohgishima	Tokyo Gas	1998	4	850,000
	Higashi-Ohgishima	Tokyo Electric	1984	9	540,000
	Futtsu	Tokyo Electric	1985	10	1,110,000
	Yokkaichi LNG	Chubu Electric	1988	4	320,000
	Kawagoe	Chubu Electric	1997	6	840,000
	Yokkaichi Works	Toho Gas	1991	2	160,000
	Chita LNG Joint	Toho Gas, Chubu Electric	1978	4	300,000
	Chita LNG	Toho Gas, Chubu Electric	1983	7	640,000
	Chita - Midorihama	Toho Gas	2001	2	400,000
	Senboku I	Osaka Gas	1972	4	180,000
	Senboku II	Osaka Gas	1977	18	1,585,000
	Himeji	Osaka Gas	1984	8	740,000
	Himeji LNG	Kansai Electric	1979	7	520,000
	Yanai	Chugoku Electric	1990	6	480,000
	Niigata	Nihonkai LNG, Tohoku Electric	1984	8	720,000
	Oita	Oita Gas, Kyushu Electric	1990	5	460,000
	Tobata	Kitakyushu LNG	1977	8	480,000
	Fukuoka	Saibu Gas	1993	2	70,000
	Sodeshi	Shizuoka Gas	1996	3	337,200
	Hatsukaichi	Hiroshima Gas	1996	2	170,000
	Kagoshima	Nippon Gas	1996	2	136,000
	Shin-Minato	Sendai City Gas	1997	1	80,000
	Nagasaki	Saibu Gas	2003	1	36,000
	Sakai	Kansai Electric, Cosmo OIl	2006	3	420,000
	Mizushima	Nippon Oil, Chugoku Electric	2006	2	320,000
	Sakaide	Shikoku Electric, Cosmo Oil	2011	1	180,000
	Ishikari LNG	Hokkaido Gas, Hokkaido Electric	2012	2	380,000
	Okinawa	Okinawa Electric Power	2012	2	280,000
	Naoetsu	Inpex	2013	2	360,000
	Joetsu	Chubu	2011	3	540,000
	Hachinohe LNG	Nippon Oil	2015	2	280,000
	Hitachi LNG	Tokyo Gas	2015	1	230,000
Korea	Incheon	Kogas	1996	20	2,880,000
	Kwangyang	POSCO	2005	4	530,000
	Pyeong-Taek	Kogas	1986	23	3,360,000
	Samcheok	Kogas	2014	3	600,000
	Tong-Yeong	Kogas	2002	17	2,620,000
Mexico	Altamira	Vopak, Enagas	2006	2	300,000
	Energia Costa Azul	Sempra LNG	2008	2	320,000
	Manzanillo	Samsung, Kogas, Mitsui	2012	2	300,000
Netherlands	Gate LNG	Gasunie, Royal Vopak	2011	3	540,000
Poland	Swinoujscie	Baltic Gaz System	2015	2	320,000
Portugal	Sines	REN Atlantico	2004	3	390,000

LNG Import Terminals (continued)

Country	Location (Project)	Owners	Start up	Storage Tanks	Storage Capacity
Puerto Rico	Penuelas	EcoElectrica	2000	1	160,000
Singapore	Singapore	Singapore Energy Authority	2013	3	540,000
Spain	Barcelona	Enagas	1969	8	840,000
	Huelva	Enagas	1988	5	610,000
	Cartagena	Enagas	1989	5	587,000
	Bilbao	Enagas, EVE	2003	3	450,000
	Sagunto	GNF, Osaka Gas, Oman Oil	2006	4	600,000
	Reganosa, Ferrol	Galicia, Sonatrach, Tojeiro	2006	2	300,000
	El Musel, Gijón,	Enagas	2013	2	300,000
Taiwan	Yung-An	CPC	1990	6	690,000
	Tai-chung	CPC	2009	3	480,000
Thailand	Map Ta Phut	PTT LNG	2011	2	320,000
Turkey	Marmara Ereglisi	Botas	1994	3	255,000
	Izmir	EgeGaz	2006	2	280,000
USA	Everett	Suez LNG NA	1971	2	155,000
	Lake Charles	Shell, ETE	1982	4	425,000
	Elba Island	Kinder	2001	5	535,000
	Cove Point	Dominion	2003	5	530,000
	Freeport	Freeport LNG Development	2008	2	320,000
	Cameron	Sempra LNG	2009	3	480,000
	Golden Pass, TX	Qatar Petroleum, ExxonMobil	2010	5	775,000
	Pascagoula, MS	Gulf LNG, Kinder	2012	2	320,000
UK	Isle of Grain	National Grid	2005	8	1,000,000
	South Hook	ExxonMobil, Qatar Petroleum,Total	2009	5	775,000
	Dragon LNG, Milford Haven	Shell, Petronas	2009	2	310,000

LNG Import Terminal Projects

Country	Location/Project	Owners/Project Developers	Start up	Storage Tanks	Storage Capacity
China	Swatuo, Guangdong	CNOOC	2017	2	320,000
	Yingkou, Liaoning	CNOOC	2017	2	320,000
	Qidong, Jiangsu	Shell-Guanghui	studies		
Finland	Yuedong LNG, Jieyang, Guangdong	CNOOC	2017	2	320,000
India	Tianjin North	Sinopec	2017	2	320,000
	Tornio	Gasum Skanga	2018	1	30,000
	Ennore	Indian Oil Corp	2017	2	320,000
	Mundra	Gujarat State Petroleum, Adani Group	2017	2	320,000
Indonesia	FSRU Andhra Pradesh	Engie, Andhra Pradesh Gas	2017	1	135,000
Japan	Pipovav LNG (FSRU), Gujarat	Swan Energy	2017	2	320,000
Malaysia	Labuhan Maringgai	Perusahaan Gas Negara	2017	1	135,000
Philippines	Soma, Fukushima	Japan Petroleum	2017	1	230,000
UK	Lahad Datu LNG, Sabah	Petronas	2017	studies	
Uruguay FSRU	Pagbilao LNG	Energy World Corp.	2017	1	130,000
	Port Meridian, Barrow-in-Furness	Port Meridian Energy Ltd.	2017	1	150,000
	Montevideo	Gas Sayago, Mitsui Osk Lines	2017	1	230,000

LNG FSRU Import Facilities

Country	Location (Project)	Owners	Start up
Argentina	Bahia Blanca GasPort	Excelerate/YPF Repsol	2008
	Escobar GasPort	Excelerate/Enarsa	2011
Brazil	Pecem, FSRU	Petrobras	2009
	Guanabara Bay FSRU	Petrobras	2009
	Salvador, Bahia FSRU	Petrobras	2013
Colombia	Cartagena FSRU	Promigas, Sociedad Portuaria El Cayao	2016
Egypt	Ain Sokhna, Suez	EGAS, Hoegh	2015
	Ain Sokhna, Suez	EGAS, Golar	2015
Indonesia	Lampung	Hoegh LNG, PGN LNG	2014
	Nusantara (Jakarta Bay)	Golar LNG, Pertimana	2012
Italy	Livorno	OLT Offshore LNG Toscana	2013
Jordan	Aqaba, Jordan	Golar LNG	2015
Kuwait	Mina Al-Ahmadi	KPC	2009
Lithuania	Klaipeda	Klaipedos Nafta Hoegh LNG	2014
Malaysia	Malacca FSRU	Petronas	2012
Pakistan	Port Qasim	Excelerate, Engro Corp	2015
UAE	Ruwais, Abu Dhabi	Gasco (UAE)	2016
	Jebel Ali Port, Dubai	DSA (UAE)	2010
UK	Teesside GasPort	Excelerate	2007

LNG Export Projects

Country	Location/Project	Project Developers	Planned Start Up	Number of Trains	Capacity In MTPA
AUSTRALIA	Browse LNG	Woodside, BHP, BP Chevron, Shell, Mitsubishi, Mitsui	2018+	2	10.0
	Ichthys LNG	INPEX, Total	2017	2	8.4
	Prelude FLNG	Shell, Inpex, Kogas CPC	2017	1	3.5
	Sunrise LNG	Woodside, Osaka Gas, ConocoPhillips, Shell	2020+	1	3.5
	Wheatstone LNG	Chevron, Apache, Shell , Kuwait FPEC	2017	2	9.0
CANADA	Aurora LNG BC	CNOOC, Inpex Corp. and JGC Corp.	2021	4	24.0
	Bear Head LNG, Nova Scotia	LNG Ltd.	2021	4	8.0
	Cedar 1, 2, 3, Kitimat area	LNG Export Ltd (Haisla)	2021	studies	
	GNL Quebec, Saquenay	Freestone Capital and Breyer Capital	2021	4	10.0
	Goldboro LNG, Nova Scotia	Pieridae Energy	2021	2	10.0
	Grassy Point LNG	Woodside Petroleum	2021	studies	
	Kitimat LNG, BC	Woodside, Chevron	2021	2	10.0
	LNG Canada, BC	Shell, Mitsubishi, Kogas, PetroChina	2021	2	12.0
	Melford LNG project, Nova Scotia	H-Energy Hiranandani Group	Studies		
	Pacific Northwest LNG, BC	Petronas, Japex, Sinopec, Indian Oil, Brunei Petroleum	2021	2	12.0
	Shell Prince Rupert LNG,BC	Shell	2021	3	21.0
	Steelhead LNG, Bamfield	Steelhead LNG Corp	2021	2	12.00
	Vancouver Tilbury	WesPac Midstream	2021	1	3.25
EQ.GUINEA	Equatorial Guinea Fortuna FLNG	Ophir and Golar LNG	2019	1	2.0
INDONESIA	Sengkang LNG	Energy World Corp.	2017	4	2.0
MALAYSIA	Bintulu Train 9	Petronas	2016	1	3.6
	Kanowit FLNG (Sarawak)	Petronas	2016	1	1.2
	Rotan FLNG (Sabah)	Petronas	2017	1	1.5
MOZAMBIQUE	Area 1 Onshore	Anadarko Petroleum and partners	2021	2	10
	Area 4 Onshore	Eni and partners	2021	2	10
	Area 4 FLNG	Eni and partners	2019	1	2.5
NIGERIA	NLNG Train 7	NNPC, Shell, BP, Total	2020+	1	8.4
PAPUA NEW GUINEA	Elk-Antelope LNG	Total, InterOil, Oil Search, Petromin	Studies		
RUSSIA	Yamal LNG Siberia	Novatek, Gazprom, Total	2018	3	16.5
	Sakhalin II expansion	Gazprom, Shell, Mitsui, Mitsubishi	2021	studies	
	Vladisvostok LNG	Gazprom, Itochu, various	2021	2	10.0
USA	Alaska LNG Nikiski	ExxonMobil, BP, ConocoPhillips, Alaska State	2021	3	20.0
	Annova LNG, Brownsville	Exelon Corp.	2021	6	6.0
	Cameron LNG, Louisiana	Sempra	2018	5	24.92
	Corpus Christi Liquefaction, Texas	Cheniere	2019	5	22.5
	Cove Point LNG, Maryland	Dominion	2018	1	5.25
	Delfin LNG, Louisiana	Delfin, Hoegh	2021	3	9.0
	Driftwood LNG, Louisiana	Tellurian Investments	2022	6	26.0
	Freeport LNG, Texas	Freeport LNG	2018	4	20.4
	Golden Pass, Texas	Qatar Petroleum, ExxonMobil	2021	3	15.6
	Jordan Cove Energy	Veresen Inc.	2021	2	6.8
	Lake Charles, Louisiana	Shell, ETE	2021	3	15.0
	Magnolia LNG	Louisiana LNG Ltd.	2021	4	8.0
	Port Arthur LNG	Sempra	2021	2	10.0
	Rio Grande LNG	NextDecade	2021	6	27.0
	Sabine Pass LNG, Louisiana	Cheniere	2016-19	5	22.5
	Southern LNG	Kinder Morgan	2019	4	2.0
	Texas LNG Brownsville	Chandra, Meyer, Samsung, others	2021	2	4.0
	VG LNG (Cameron Parish)	Venture Global	2019	10	10.0
	VG LNG (Plaquemines)	Venture Global	2021	10	20.0

LNG Exporters

Country	Location/Project	Shareholders	Start up	Liquefaction		Storage	
				Trains	capacity (nominal) mtpa	No. of tanks	Total capacity m^3
ABU DHABI (UAE)	Das Island (Adgas)	ADNOC, Mitsui, BP, Total	1977	2	3.2	3	240,000
			1994	1	2.5		
ALGERIA	Arzew	Sonatrach GL4Z	1964	3	1.1	3	35,000
	Arzew	Sonatrach GL1Z	1978	6	7.8	3	300,000
	Arzew	Sonatrach GL2Z	1980	6	8.0	3	300,000
	Arzew	Sonatrach	2014	1	4.7		
	Skikda	Sonatrach GL1K II	1980	3	3.0	5	308,000
	Skikda	Sonatrach (rebuild)	2013	1	4.5		
ANGOLA	Soyo	Sonangol, Chevron, BP, ENI, Total	2012	1	5.2	2	370,000
AUSTRALIA	Karratha	NWS Woodside, Shell, BHP	1989	2	5.0	4	260,000
		(BP, Chevron	1992	1	2.5	1	130,000
		(Mistubishi/Mitsui)	2004	1	4.4	1	130,000
		NWS partners	2008	1	4.4	1	130,000
	Darwin	Darwin (Bayu Undan) ConocoPhillips, Santos, Eni, Inpex, TEPCO, Tokyo Gas	2006	1	3.5	1	188,000
	Australia Pacific LNG	ConocoPhillips, Origin Energy, Sinopec	2016	2	7.5	2	320,000
	Gladstone LNG	Santos, Petronas, Total, Kogas	2015	2	7.8	2	280,000
	Gorgon LNG	Chevron, Shell, ExxonMobil	2016	3	15. 6	2	360,000
	Pluto LNG	Woodside, Tokyo Gas, Kansei	2012	1	4.8	2	240,000
	QCLNG	Shell, CNOOC	2014	2	8.0	2	280,000
BRUNEI	Lumut	Brunei/Shell/Mitsubishi/Total	1972-74	5	7.2	3	176,000
EGYPT	Damietta	Union Fenosa, EGPC, EGAS	2004	1	5.0	2	300,000
	Idku	EGPC, EGAS, Shell, Engie, Petronas	2005	2	7.2	2	280,000
EQ.GUINEA	Bioko Island	Marathon, Sonagas, Mitsui, Marubeni	2007	1	3.4	2	272,000
INDONESIA	Bontang I	Pertamina, VICO, JILCO, Total	1977	2	5.2	5	635,000
	Bontang II		1983	2	5.2		
	Bontang III		1989	1	2.8		
	Bontang IV		1993	1	2.8		
	Bontang V		1997	1	2.8		
	Bontang VI		1999	1	3.0		
	Sulawesi LNG	Medco Energi, Pertamina, Mitsubishi	2015	1	2.0	1	170,000
	Tangguh	BP, MI Berau, CNOOC, Nippon, LNG Japan	2008	2	7.6	2	340,000
MALAYSIA	Bintulu (MLNG Satu)	Petronas, Sarawak, Mitsubishi	1983	3	8.1	4	260,000
	Bintulu (MLNG Dua)	Petronas, Shell, Sarawak, Mitsubishi	1995	3	7.8	1	65,000
	Bintulu (MLNG Tiga)	Petronas, Shell, Sarawak, Mitsubishi, Nippon Oil	2003	2	6.8	1	120,000
NIGERIA	Bonny Island	NNPC, Shell, Total, Eni	1999	2	6.4	2	168,400
		Nigeria LNG (formed by above)	2002	1	3.2	1	84,200
		Nigeria LNG	2006	2	8.2		
		Nigeria LNG	2008	1	4.1	1	84,200
NORWAY	Snøhvit/Melkoya Island	Statoil, Total, GDF-Suez, Petoro	2007	1	4.2	2	280,000
OMAN	Oman LNG	Oman Govt., Shell, Total, Korea LNG Mitsubishi, Mitsui, Partex and Itochu	2000	2	7.1	2	240,000
		Oman Govt.,Oman LNG Union Fenosa, Osaka Gas, & Itochu	2006	1	3.7	2	240,000
PAPUA NEW GUINEA	PNG LNG	ExxonMobil, Oil Search, Santos, JX Nippon Oil	2014	2	6.9	2	320,000
PERU	Peru LNG	Hunt Oil, Shell, Marubeni, SK Group	2010	1	4.4	2	260,000
QATAR	Qatargas 1-T1&2	QP, ExxonMobil, Total, Marubeni, Mitsui	1997	2	6.4	4	340,000
	Qatargas 1-T3	QP, ExxonMobil, Total, Marubeni, Mitsui	1999	1	3.1		
	Qatargas II-T1	QP, ExxonMobil	2009	1	7.8		
	Qatargas II-T2	QP, ExxonMobil, Total	2009	1	7.8	8	1,160,000
	Qatargas III-T1	QP, ConocoPhillips, Mitsui	2010	1	7.8		
	Qatargas IV-TI	QP, Shell	2010	1	7.8		
	RasGas I- T1&2	QP, ExxonMobil, Kogas, Itochu, LNG Japan	1999	2	6.6		
	RasGas II- T3	QP, ExxonMobil	2004	1	4.7		
	RasGas II- T4	QP, ExxonMobil	2005	1	4.7	6	840,000
	RasGas II- T5	QP, ExxonMobil	2007	1	4.7		
	Rasgas III – T6	QP, ExxonMobil	2009	1	7.8		
	Rasgas III – T7	QP, ExxonMobil	2010	1	7.8		
RUSSIA	Sakhalin Island	(Sakhalin Energy) Gazprom, Shell, Mitsui, Mitsubishi	2009	2	9.6	2	200,000
TRINIDAD & TOBAGO	Point Fortin Train 1	BP, Shell, Suez, NGC	1999	1	3.0	2	204,000
	Train 2	BP, Shell	2002	1	3.3	1	160,000
	Train 3	BP, Shell	2003	1	3.3	1	160,000
	Train 4	BP, Shell, NGC	2005	1	5.2	1	160,000
USA	Cheniere Sabine Pass	Cheniere Energy	2016	1	4.5	5	800,000
	Kenai - Alaska	ConocoPhilips, Marathon Oil	1969	2	1.3	3	108,000
YEMEN	Bal-Haf	Yemen LNG, Total, Yemen Gas, Hunt Oil, SK Group, Hyundai	2009	2	6.7	2	320,000

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