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Shell's Prelude development opens FLNG floodgate

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With an eye on moving liquefaction plants offshore to reduce costs, operators in Australia, Colombia, Indonesia, Malaysia, Equatorial Guinea, Israel, and the US Gulf Coast are studying FLNG projects.

When the final investment decision (FID) was signed for the Prelude floating LNG (FLNG) facility offshore Australia, FLNG technology quickly became the leading option for developing offshore gas fields or stranded gas fields onshore.

The Caribbean LNG project being developed by Exmar and Pacific Rubiales Energy is a barge-mounted FLNG plant that will be docked in Colombia to liquefy gas from onshore fields.

Then Petronas began construction on its PFLNG 1 project in June 2013 and made its FID on the PFLNG 2 project in February 2014. Both units are for offshore fields.

FLNG provides advantages for stranded gas reserves. For example, the Bonaparte LNG project offshore Australia will include the Petrel and Tern fields that were discovered more than 40 years ago and were considered too remote and relatively small to develop. Once those reserves are depleted, the FLNG vessel can be moved to another field to continue operations.

The Prelude development opened the floodgates for FLNG projects offshore Australia. Although Shell's facility is under construction and the Scarborough LNG and Bonaparte LNG projects have been approved, Western Australia's government wants to put the brakes on further FLNG projects, citing fewer jobs and less opportunity for domestic engineering and fabrication companies. However, the juggernaut of FLNG is picking up steam.

Rising costs drive FLNG development

During 2013, the Economics and Industry Standing Committee for the Parliament of Western Australia held hearings on the economic implications of FLNG.

At the committee hearings June 26, 2013, Nicole Roocke, director, Western Australia Chamber of Minerals and Energy, testified, "Unfortunately, research has identified that the cost of doing business in Western Australia has put us at the wrong end of the cost curve with us being at the more expensive end. Unfortunately, LNG projects in Western Australia are becoming less competitive in a significant manner with the costs of building and operating LNG facilities continuing to increase over and above that of our competitors."

She quoted a report by McKinsey & Co. on "Extending the LNG boom: Improving Australian LNG productivity and competitiveness" that said LNG projects in Australia were now 20% to 30% more expensive than competitors in emerging regions such as North America and East Africa.

For Shell, "FLNG allows a significant cost reduction. We expect something like 30%," explained Andrew Smith, Shell's country chair for Australia, to the committee Oct. 23. "The reality is that competition has increased for the markets that Australian LNG has traditionally supplied. Costs have increased, and we need to address those issues to remain competitive. FLNG is one of the ways that we can address those issues and remain competitive.

"FLNG will not be the best solution in all cases. But it is clear that FLNG has an important role in the development of Australia's gas resources right now. In many cases, the choice will be to develop with FLNG or not to develop at all," he added.

State government prefers onshore plants

Fran Logan, member of Parliament (MP) for Cockburn and deputy chair of the committee, was very blunt in his criticism. "What will Western Australia get out of FLNG technology? Nothing. We will get no engineering, fabrication, or construction jobs and no domestic gas. None of that will emerge from the implementation of FLNG technology.

"The only thing that comes out of FLNG technology for Australia is the wellhead taxes that are raised by the federal government because all the gas that is extracted by FLNG is in commonwealth waters. It is not surprising that the commonwealth will give approval to these FLNG operations," he continued.

In a speech before the state parliament, Logan said, "FLNG [facilities] are a job-killing technology for Australia and specifically for the Australian engineering, fabrication, and construction industries."

As many as 7,000 fabrication and construction jobs would be lost to FLNG facilities that are built in other countries, according to one trade union.

Browse LNG project strikes raw nerve

Woodside is the major equity holder and operator of the Browse Joint Venture (JV). The other partners are Shell Development (Australia) Pty. Ltd., BP Developments Australia Pty. Ltd., Japan Australia LNG (MIMI Browse) Pty. Ltd., and PetroChina International Investment (Australia) Pty. Ltd.

The development includes three gas and condensate fields – Brecknock, Calliance and Torosa, which are about 425 km (255 miles) north of Broome, Western Australia. Gross contingent resources (2C) are estimated at 450 Bcm (15.9 Tcf) of dry gas and 435.8 MMbbl of condensate.

The Prelude hull was completed and floated from the drydock in November 2013. Nine tugboats were required to move the 488-m long hull. (Image courtesy of Shell)

The original development plan called for an onshore LNG plant at James Price Point, north of Broome, at a cost of US $36.1 billion. During the inquiry, Shell estimated the cost for FLNG would be 30% lower than for onshore plants given estimates that indicated that the Browse FLNG development would cost about $25.3 billion. With the size of the liquefaction plants on FLNG vessels, up to three FLNG facilities would be needed.

On Sept. 2, 2013, the Browse JV participants selected FLNG technology to commercialize the Browse resources, using Shell's FLNG technology and Woodside's offshore development expertise.

The members of the inquiry committee took the companies to task during the hearings, especially over the claimed return on investment. Jan Norberger, MP for Joondalup, quoted a report from an unnamed major organization during a hearing with BP representatives Oct. 21, 2013, that said the Browse FLNG project would have an internal rate of return (IRR) of 12.5% to 13%, while the onshore plant would have an IRR of 11.5%.

Norberger questioned the company's definition of rate of return. "It would seem to me that if you have two projects – both of which return a positive rate of return – they both make money. I would state that I believe what really happened was that you wanted to go for the more profitable option. By going to the more profitable option, the indigenous people of the Pilbara now miss out – a massive loss to Western Australia in regard to construction and potentially with royalties and domestic gas."

Peter Metcalfe, external affairs manager, BP, responded by saying the definition of commercial viability for BP is a combination of risks, costs, and revenues, which is inherently a judgment. "We can only speak for BP, and the view we arrived at is that [the onshore option] was not commercially viable."

In testimony Oct. 16, 2013, Robert Cole, executive director, Woodside, told the committee that the FLNG development cost was materially lower than the James Price Point reference case. "Woodside considers FLNG as the only viable option for commercialization of the Browse resource," he said.

The Browse JV participants agreed to begin basis of design (BOD) work in relation to the FLNG facility Aug. 20, 2013. The BOD phase will determine the major design parameters for FEED of the proposed subsea and FLNG facilities and associated infrastructure.

Woodside expects the completion of the BOD in 2014, followed by awarding the FEED in 2014 with the FID in 2015.

The state opposition to FLNG is aimed at forcing companies to build LNG plants onshore to provide jobs and royalties for Western Australia.

Prelude dwarfs other offshore production vessels

The most challenging aspect of the Prelude FLNG project is the scale. Shell has a world-class facility in a world-class shipyard on a bigger scale than has ever been done before, said Neil Gilmour, Shell vice president, development for integrated gas.

"You've always got that question: If you scale things up, what happens? We've been doing the preparation for Prelude going back 15 years actually. In the last two or three years there's an enormous amount of preparation put in by the Shell team, the Technip engineering team, and the shipyards at Samsung in Korea and also in Dubai. I feel that this is really about making sure we get the technology right and do this safely," he said.

"At Prelude we're using Shell's double-mixed refrigerant (DMR) technology. It's been used on Sakhalin. In fact, the mantra in Shell for FLNG is that it's a completely unorthodox combination of technologies we've already demonstrated. We have a huge LNG technology portfolio. We were really determined to take it offshore for FLNG. The technology that's gone onto Prelude has been proven," he explained.

"You always encounter things that you haven't anticipated, but we've adapted to that. Of course, for us on the FLNG program, we're really interested in getting No. 1 right because No. 1 is the starting point for No. 2 and so on," he added.

Prelude will become one of the first offshore fields in the world exploited using FLNG technology. The FLNG facility will produce at least 3.6 million tonnes per annum (MMtpa) of LNG, 1.3 MMtpa of condensate, and 0.4 MMtpa of LPG. The FLNG facility will stay permanently moored at the Prelude gas field for 20 to 25 years and in later development phases should produce from other fields where Shell has an interest.

Shell (67.5%) is the operator of Prelude FLNG in JV with INPEX (17.5%), KOGAS (10%), and OPIC (5%), working with long-term strategic partners Technip and Samsung Heavy Industries (the Technip Samsung Consortium).

The Prelude FLNG facility will be 488 m (1,600 ft) long and 74 m (243 ft) wide. When fully equipped with storage tanks full, it will weigh around 600,000 mt. The facility will be moored in about 250 m (820 ft) of water and remain on site during all weather events, having been designed to withstand a Category 5 cyclone. It will be about 475 km (285 miles) north-northeast of Broome.

Shell is well into the construction phase, with the majority of the attention focused on Samsung's Geoje shipyard. The hull was completed and floated from the drydock in November 2013. It was towed by nine tugs across the harbor and is secured quayside, where the topsides are installed and integrated. There are 14 topside modules. "The first module was completed in September, shipped back to Geoje, and installed in the hull," Gilmour said.

At the Dubai Drydocks, Shell has the world's largest turret assembled. SBM Offshore fabricated the turret for high mooring loads. It has a total weight of 11,000 tons with a height of 93 m (305 ft) for Prelude, according to SBM.

"One of these big records is the chain connectors that are going to link the FLNG to the mooring lines. These are enormous. You can almost stand inside edge to edge in the links," he said.

The subsea infrastructure is largely being built in Malaysia. The installation testing of the christmas trees was done before Christmas, Gilmour laughed.

FMC Technologies Inc. stated in a press release that it will supply seven large-bore subsea production trees, production manifolds, riser bases, subsea control systems, and other related equipment. An aftermarket agreement was signed that will result in FMC Technologies Australia Ltd. performing installation and commissioning services for the project.

FMC also will supply the Technip Samsung Consortium with seven offshore footless marine loading arms – four for LNG and three for LPG from FMC's plant in Sens, France. "In Singapore we've got the control systems for the processes for the FLNG. Some have been completed, and some of them are still under manufacture," Gilmour said. "Then we're drilling the seven production wells in Australia. That started in August 2013."

Shell awarded the infield support vessel to KT Maritime Services Australia Pty. Ltd. The JV partnership between Kotug International BV and Teekay Shipping Australia Pty. Ltd. will supply three 100-mt bollard pull vessels to assist in product offloading.

The concrete and structural work is underway in Darwin on the site of the mainland shore facilities.

"Basically we're making progress across a number of locations. As ever, safety and quality are the priority to make sure all this comes together right and also works the way that we planned," Gilmour emphasized.

"I think it's an extraordinary achievement, doing an extraordinary project in an extraordinary place. We talked about a program before we even had a project. I was personally amazed when I had a look at the plans for assembling the hull. I remember talking to the Samsung yard manager who showed me the schedule. It was like the world's largest Lego set," he said. "Then you look at the assembly of the hull. The construction of the hull went very fast, extraordinarily fast. We were very, very well prepared. It's like the choreography of a complex orchestra."

The keel was completed in May 2013, and Samsung began assembling the hull. A hull section is being lowered into place. (Image courtesy of Shell)

Bonaparte LNG remains on track

In January 2010, GDF Suez signed the final agreement for the purchase of a 60% share in three offshore gas fields in Australia from Santos. The transaction was part of the Bonaparte LNG project announced in August 2009.

Bonaparte LNG is an integrated FLNG project with a capacity of 2 MMtpa of LNG. The project includes the development of the Petrel, Tern, and Frigate gas fields in the Bonaparte basin in the Timor Sea.

The operator for this project, which has been approved, is GDF Suez Bonaparte. "We are now in the pre-FEED phase of the project, confident but still with a lot of work to do before reaching FID," said Jean-Francois Letellier, general manager, GDF Suez Bonaparte, to the committee Oct. 21, 2013.

"Today there is a design competition ongoing between two consortia – Technip and Daewoo Shipbuilding & Marine Engineering (DSME); and KBR and Hyundai Heavy Industries. There will be a winner in this competition, and this winner will be awarded the FEED and, subject to the FID, the execution," he explained.

ExxonMobil, BHP Billiton disagree on FLNG

The Scarborough gas field is about 220 km (132 miles) northwest of Exmouth in the Carnarvon basin. It is a mid-sized field with 226.5 Bcm to 283.2 Bcm (8 Tcf to 10 Tcf) of essentially dry gas resources in 950 m (3,116 ft) of water. The field is being developed by a 50/50 JV of ExxonMobil and BHP Billiton.

"ExxonMobil has selected FLNG as the lead development concept for Scarborough," said Luke Musgrave, vice president, LNG, ExxonMobil (Australia), during testimony to the inquiry committee Oct. 21. "We are doing concept studies, which we expect to continue through 2014. At the conclusion of those we need to make a decision whether to do FEED. At the conclusion of that we would have [to make an FID]."

The FLNG facility would have a capacity from 6 MMtpa to 7 MMtpa. He explained that the facility could increase the capacity because of the dry gas. No equipment or storage would be required for gas liquids, allowing more space for liquefaction.

In a Dec. 12, 2013, article in the *West Australian*, Tim Cutt, president, BHP Billiton Petroleum, was quoted as saying his company wanted to make sure all options were considered for Scarborough. BHP Billiton would like to look at existing infrastructure to see if it could be leveraged for the field.

Musgrave told the committee that the gas field has relatively low pressure. A pipeline to an onshore location would be at least 200 km (120 miles). Because of the low pressure, a floating compression platform would be required to move the gas that distance. The cost of building the compression platform, pipeline, and onshore liquefaction plant would be more than just building an FLNG facility for the field.

The LNG and natural gas liquids will be stored in tanks in the hull. (Image courtesy of Shell)

"It becomes very capitally efficient to eliminate the compression step and the transportation step by putting those facilities proximal to the reservoir itself," he added.

Barge-mounted FLNG for Colombia

The Caribbean FLNG Project is another facility under construction. In December Wison Offshore & Marine Ltd. began the installation of the topsides liquefaction equipment on what will be the world's first floating liquefaction and storage vessel in operation.

Exmar awarded an engineering, procurement, construction, installation, and commission (EPCIC) contract to Wison Offshore. The FLNG facility is being built for Pacific Rubiales Energy, Colombia. Fabrication began in late 2012 and is on schedule for first deliveries in 2Q 2015. The project consists of a nonpropelled barge that will be installed off the coast of Colombia. The FLNG barge will have a capacity of 500,000 mt/year. Black & Veatch will supply its single mixed-refrigerant PRICO liquefaction technology.

Exmar will build, operate, and maintain what it calls a floating liquefaction and storage unit. Storage capacity is 16,100 cm (568,600 cf). The barge is 144 m long, 32 m wide, and 20 m deep (472 ft long, 105 ft wide, and 66 ft deep) with a draft of 5.4 m (18 ft). The barge is designed with all power generation and utilities installed onboard and can perform offload side-by-side with an LNG carrier either with transfer hoses or loading arms.

On Nov. 5, 2013, Pacific Rubiales Energy and Gazprom Marketing & Trade Ltd. signed a heads of agreement with respect to a five-year sales and purchase agreement for about 500,000 cm/year (17.7 MMcf/year) free on board Colombia.

The FLNG barge is expected to be mechanically completed in April 2014 and be ready to be transported from the Chinese shipyard in fall 2014.

Malaysia orders two FLNG facilities

On Jan. 23, 2014, Malaysia's Petroliam Nasional Bhd. (Petronas) made the FID for its second FLNG project, which is named PFLNG 2. At the same time, the keel was being laid on the PFLNG 1 at the DSME shipyard in Okpo, South Korea. The PFLNG 1 is scheduled for completion by year-end 2015, while the PFLNG 2 is expected to begin LNG production early in 2018.

The PFLNG 1 vessel will be 300 m (984 ft) long and

60 m (197 ft) wide with a capacity of 1.2 MMmt/year and will be the first FLNG vessel to use a dual-row cargo containment system to limit sloshing within the tanks. For PFLNG 2, the vessel will be 365 m (1,197 ft) long with a capacity of 1.5 MMmt/year.

For the PFLNG 1 project Petronas is working with Technip and DSME. The vessel will be located on Malaysia's Kanowit gas field, which is 180 km (111 miles) offshore Sarawak. The EPCIC contract for PFLNG 2 was awarded to a consortium of JGC Corp. and Samsung Heavy Industries, including their Malaysian subsidiaries. The facility will be installed on the Rotan gas field in deepwater Block H offshore Sabah, Malaysia.

These FLNG facilities are part of Petronas' strategies to tap gas reserves in Malaysia's remote and stranded fields that are currently considered to be uneconomical to develop and evacuate.

Noble Energy targets Eastern Mediterranean

There is a smorgasbord of choices for Noble Energy for developing the Leviathan field offshore Israel, which contains about 538 Bcm (19 Tcf) of gas. Between all of its fields offshore Israel and Cyprus, the company has discovered about 991 Bcm (35 Tcf) of gas. It could deliver gas by pipeline to several countries, build an onshore LNG plant, construct an FLNG facility, or pipe gas to LNG plants in Egypt.

"The government lets you export 50% of your discovered big fields. Noble's strategy is to monetize the export reserves. We want to do that in a way that is mutually beneficial to the region, us, and our shareholders. Besides just taking care of the domestic market, we're also looking at regional markets that could be fed by pipeline," said Gerry Peereboom, director of LNG development, Noble Energy. "We have a modest contract with the Palestinian Authority, and we've already signed up with Jordan. Other possibilities are Egypt and Turkey. Besides LNG there are other options to seriously consider," he added.

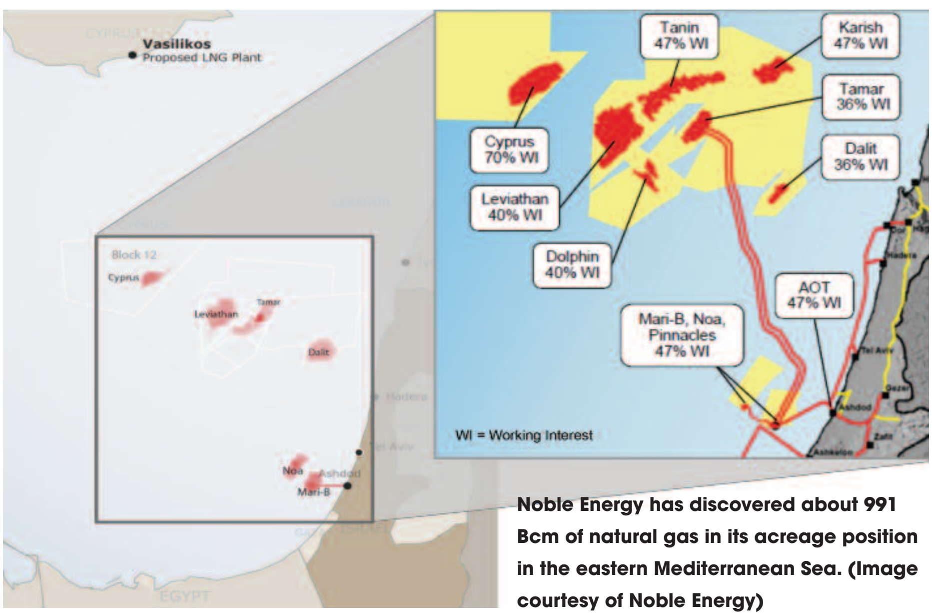
With that much gas, Noble could have a portfolio of different options that would give the company some risk mitigation. Reducing risk is one of the reasons Noble took on Woodside Petroleum as a partner in Leviathan. This will allow Noble to use its deepwater technology and gain Woodside's expertise in marketing LNG in places like Asia where that company has some excellent connections, he continued.

"Woodside is anxious to get into a producing region that is at an early stage of development. They seem pretty comfortable with Israel since they have taken a considerable period of time to do their due diligence. They are fully committed to this area, and I think Woodside is going to be a good partner," Peereboom said.

In February 2014 Woodside entered into a memorandum of understanding (MoU) with the Leviathan JV partners (Noble Energy Mediterranean Ltd., Delek Drilling LP, Avner Oil Exploration LP, and Ratio Oil Exploration 1992 LP) to acquire a 25% participating interest in the 349/Rachel and 350/Amit petroleum licenses for $1.03 billion. The parties were negotiating toward executing a fully termed agreement by March 27, 2014. After the agreement is signed, the interest shares will be Noble, 30%; Woodside, 25%; Delek, 16.94%; Avner, 16.94%; and Ratio Oil, 11.12%.

LNG is the preferred option for export since the markets are more geographically divergent. An onshore location in Israel faces the problem of limited coastline that the country would like to save for tourism. The areas with industrial activity are very crowded, and space is at a premium.

"It is not that onshore would be impossible, but it is enough of a challenge where we are seriously looking at FLNG," Peereboom explained.



Noble Energy has discovered about 991 Bcm of natural gas in its acreage position in the eastern Mediterranean Sea. (Image courtesy of Noble Energy)

The cargo storage tank is lowered into the hull of the Caribbean FLNG barge at Wison Heavy Industry's shipyard in Nantong, China. (Image courtesy of EXMAR Marine)

Part of the government's export policy mandate is that a project must supply the domestic market. Noble is already producing gas from the Tamar fields using a pipeline to shore. The government wants a second independent pipeline from Leviathan for supply security. Providing gas through another pipeline as well as exporting gas will be a win-win situation, he emphasized.

The decision whether to have an onshore LNG plant or an FLNG facility has yet to be made; however, the company is interested in FLNG.

"We're going into FEED for FLNG. We've already shortlisted a few companies and consortia that are going to get an invitation to tender. We hope to be in FEED by mid-summer," Peereboom said.

"We're looking at an FLNG vessel with a capacity of about 3.25 MMmt/year. That could go up. Part of our overall planning is that we have to juggle how much we're going to supply domestically, how much might be piped to other regional countries, and how much LNG."

Noble will set the capacity going into the FEED work so that all the groups will have the same basis. The company will have two or three competing FEED contracts.

Leviathan is a very large field with a relatively flat structure, which is more challenging for development. The field is in water depths around 1,630 m (5,346 ft). Wells will be drilled to a depth of about 5,000 m (16,400 ft). The field is located 135 km (84 miles) west of Haifa, Israel. The field has very dry gas that is more than 99% methane. Wells are expected to be prolific. For example, wells in the Tamar field are producing 7.1 MMcm/d (250 MMcf/d), he said.

"Noble wants to be a real player in LNG. It is really a mix of staying involved in the upstream where we have a competitive advantage and becoming a serious player in the midstream – onshore LNG, offshore LNG, and pipelines," Peereboom said. "It is a pretty exciting time in FLNG, which will be an area of focus for Noble for several years."

Ophir taps FLNG for Equatorial Guinea

A number of companies have submitted proposals to Ophir Energy for FLNG facilities for offshore Equatorial Guinea, and several of these were shortlisted for further assessment with nonbinding letters of intent signed Feb. 20, 2014, in Singapore with the counterparties involved.

The Equatorial Guinea Ministry of Mines, Industry, and Energy and Ophir are reviewing the competing proposals and will execute an MoU with the selected FLNG vessel provider.

Ophir also signed a nonbinding letter of intent with Petrofac to provide services to the operator of the proposed gas development up to the FID. Duties likely will include preparing and issuing the field development plan for the project and coordinating the interface between the upstream and midstream elements. The project includes an FLNG vessel and a later onshore LNG train.

Currently, Ophir has an 80% interest in Block R, which covers 2,450 sq km (946 sq miles) in water depths from 600 m to 1,950 m (1,968 ft to 6,396 ft) in the southeastern Niger Delta. Three fields were discovered with total 2C of 74 Bcm (2.6 Tcf), which is enough to support a 2.5-MMmt/year FLNG development.

The FLNG project will be completed in phases, allowing slow ramp-up of volumes. The phased field development will be funded out of cash flow, Ophir said in a press release. Phase 1 will require seven wells. First LNG production is expected in 2018. The project has the full support of the government. A second onshore train is viable but needs more resources to underpin the higher cost and more capital required, according to the company.

During 2014 the key objectives are to establish the value chain for the FLNG development, confirm and increase the resource base with a three-well drilling program, and test a deeper liquids play. Ophir expects to add upstream partners to enhance the LNG development.

Abadi LNG project offshore Indonesia

The Indonesian government approved a plan of development for the Abadi gas field on the Masela Block in December 2010 for an FLNG vessel with a capacity of 2.5 MMmt/year and 8,400 b/d of condensate. Inpex (65%) and Shell (35%) are in the midst of two FEED contracts that are expected to be completed by mid-2014.

In January 2013 the FLNG FEED contract was awarded to two groups: JGC Corp., Technip, Samsung Heavy Industries, and Modec Inc.; and Saipem, Chiyoda International, PT Tripatra Engineers and Constructors, PT Rekayasa Industri, Hyundai Heavy Industries, and SBM.

The groups will conduct the FLNG FEED in parallel under a design competition. The FLNG EPC contract will be awarded to the group that provides technical and commercial superiority based on its overall design solution. The FID and the start of production will be determined based on the FEED results.

The Abadi gas field is estimated to hold enough reserves for the production of 2.5 MMmt/year of LNG for more than 30 years.

North American FLNG projects

As interest in LNG exports from Canada and the US continues to increase, several companies have begun work on FLNG facilities to move shale gas to overseas markets.

The Canadian project is ahead of the US developments. In August 2013 Exmar entered into a letter of intent with LNG Partners LLC and LNG BargeCo BBVA to provide a floating liquefaction and storage unit (FLSU) that will be docked on the west bank of the Douglas Channel near Kitimat, British Columbia.

Exmar will design, construct, and deliver a barge-mounted liquefaction plant, which uses the PRICO liquefaction process for a facility with a capacity of 700,000 mt/year in 1Q 2016. The FLSU will be chartered by Exmar to the BC LNG Project for a firm term period of 20 years.

The project has already received its export permit from the Canadian government and was expected to obtain all required approvals and permits by the end of 2013, according to Exmar.

The artist's rendition of the Caribbean FLNG facility shows an LNG carrier docked next to the liquefaction barge. Caribbean FLNG will begin commercial production in 2Q 2015. (Image courtesy of EXMAR Marine)

Three FLNG projects were proposed for the US Gulf of Mexico near Port Lavaca and Brownsville, Texas, and Venice, La.

Excelerate Energy completed its FEED work for its 4.4 MMmt/year dockside FLNG, which will be near Port Lavaca, Texas. The study determined the Lavaca Bay LNG facility will cost $2.4 billion dollars, according to a May 2013 press release from the company. The facility is expected to be in service by 4Q 2018 pending Federal Energy Regulatory Commission (FERC) approval.

The company was granted permission to export to free-trade agreement (FTA) nations by the US Department of Energy (DOE). It filed for non-FTA approval in October 2012.

On Feb. 24, 2014, Excelerate said it filed its formal application with the FERC requesting authorization to construct, own, and operate the first US FLNG export facility. Rob Bryngelson, president and CEO of Excelerate, noted in a press release, “We continue to make strong progress on all fronts and hope to make an FID within the next 12 months.”

Excelerate is fourth in order on the list of applicants the DOE is currently processing, the company continued.

The floating liquefaction, storage, and offloading (FLSO) vessel will have a storage capacity of 250,000 cm (8.8 MMcf). There will be a fully integrated onshore gas processing plant. The facility will interconnect to the region’s existing pipeline system. The project will be designed and permitted to add a second FLSO facility for a total production capacity of up to 10 MMmt/year.

The Evolution-class FLSO vessel has a maximum production capacity of 3 MMmt/year using three individual 1 MMmt/year processing modules. The LNG storage consists of 10 side-by-side GTT Mark III membrane cargo tanks.

The Port of Brownsville project is being developed by Eos LNG LLC. The project will use a barge-mounted liquefaction plant. Wison will provide project management, engineering, procurement, construction, and commissioning of the facility, according to a presentation by Andrew Kunian, CEO, Eos, at the North American LNG Export conference sponsored by Zeus Intelligence Dec. 12, 2013.

An FID is expected by July 2014 with a date of delivery of Jan. 1, 2018. The facility will have a capacity of 2 MMmt/year. The site can be expanded to 4 MMmt/year. The FLNG barge is estimated to cost $750 million with another $250 million for onshore infrastructure.

The Edinburgh, Texas, pipeline connection is 96 km (60 miles) away from the terminal site.

Cambridge Energy Group Ltd. is proposing the 8.2 MMmt/year FLNG export project near Venice, La., Sherman Bryant, CEO, told the North American LNG Export conference. The project would consist of two self-propelled 4.1 MMmt/year FLNG vessels, one pipeline to six interconnections with intrastate pipelines, 12 LNG carriers, six tugs, and six LNG shuttle carriers.

The project received DOE approval for FTA countries Nov. 21, 2012. Cambridge Energy Group filed for non-FTA export approval in the same month. The company received FERC approval to begin prefiling its project April 16, 2013. FERC approval for the project and the FID are expected in 3Q 2015.

FLNG projects delayed

Since February 1999, when an environmental impact statement was completed for evaluating onshore liquefaction and FLNG for the Greater Sunrise development in the Timor Sea, Shell has been pursuing FLNG. However, in 2001, Shell and its partners, Woodside Petroleum, ConocoPhillips, and Osaka Gas, tabled the FLNG concept. Political differences between the governments of Australia and Timor-Leste continued to delay the development of the Greater Sunrise fields, which were discovered in 1974.

Then in April 2010, following the announcement of the Prelude FLNG project, the Greater Sunrise JV partners selected Shell’s FLNG technology for field development – subject to, of course, government approvals and FID. The facility would produce around 4 MMmt/year of LNG.

Petrobras and BG Group also put an FLNG project on hold. In 2009 the companies signed a JV to work on

The Vantage drillship *Titanium Explorer* will drill the wells offshore Equatorial Guinea for the FLNG project. (Image courtesy of Vantage and Ophir Energy)

FLNG projects. According to a press release, in July 2011 Petrobras postponed the use of FLNG to develop fields in the Santos basin beyond 2016. A FEED that compared FLNG to a pipeline option was completed, and the company selected the pipeline.

Another promising FLNG project offshore Papua New Guinea (PNG) also hit rough sailing. Flex LNG executed agreements with InterOil, Pacific LNG, LNG Ltd., and Samsung Heavy Industries in April 2011 for EPCIC of an LNG project to liquefy gas from the Elk and Antelope fields in Gulf Province, PNG. The target date for commercial production to begin was 2015.

The FEED was completed in December 2011 for the Gulf LNG project, and Flex LNG was ready for the FID. However, the PNG government and other stakeholders were unable to finalize terms, according to a January 2012 press release. The company already had deployed capital for the project with Samsung. The initial order for the FLNG vessel was changed to LNG carriers instead. No decision has been made on the Gulf LNG project.

Speculative FLNG projects

SBM designed a mid-scale FLNG solution for stranded gas fields. The concept consists of converting two Moss-type LNG carriers into a catamaran-type FLNG facility. The FLNG facility would have a capacity of 1.5 MMmt/year to 2 MMmt/year and be suitable for stranded gas fields between 14.2 Bcm and 56.6 Bcm (0.5 Tcf and 2 Tcf). Converting older LNG tankers into FLNG facilities would reduce costs and require less time since the storage tanks would already be installed. SBM has performed generic pre-FEED work together with Linde Engineering on an FLNG vessel using a pre-cooled dual nitrogen-expansion process. Press reports speculate such an FLNG vessel could be installed first in either Indonesia or Australia.

Another FLNG project has been touted by ENI for its Area 4 license offshore Mozambique. This would be in addition to the onshore LNG plant, which is currently in FEED. Australia also has a speculative FLNG project based on the Crux field in the Browse basin. The field could be tied into Browse FLNG. E&P

Class keeps pace with FLNG development

By **Tor-Ivar Guttulsrod**, ABS

According to Clarkson Research Services Ltd.'s "Offshore Intelligence Monthly," there is a cumulative FLNG requirement of 36 FLNG projects with targeted delivery dates by 2020. While all of these projects will not materialize, it is probable that as many as 16 FLNG vessels could be in operation by that time. FLNG technology could make a significant contribution to the 4 Bcm/d (140 Bcf/d) of natural gas production expected in six years' time.

Although the FLNG process is relatively new, the basic technologies – such as gas processing and liquefaction – are proven technologies that can be modified for offshore application. The same goes for gas storage and offloading. But it is unwise to assume that these similarities make the transfer of technology from onshore to offshore simple. It is important to recognize that land-based plants and floating units are different in a number of significant ways. An FLNG unit introduces vessel motions to the process and to offloading and presents challenges for carrier operations. The separation distance between the FLNG and the carrier can introduce considerations for topsides arrangement.

Design and operational issues combine to create the biggest technical challenges in FLNG terminal design. Among these are the large size of terminal hulls and LNG containment systems, load effects in shallow water, sloshing that can occur when a hull is only partially filled, offloading operations, and critical interfaces between the hull and topsides and between the hull and the mooring system.

Mechanical stresses are another concern because they can cause fatigue that impacts the operational life of topsides processing equipment. Offshore equipment can be subject to cracking caused by vessel motions and by corrosion resulting from saltwater spray. Meanwhile, space and weight limitations make equipment installation and piping more challenging than for land applications. Modular equipment on FLNG installations changes the layout and necessitates additional safety and operational studies.

Recognizing these challenges, the industry has undertaken R&D targeting such issues as integrating subsea architecture with FLNG, process marinization, side-by-side and tandem offloading systems, and testing and qualifying the components that will be used in LNG transfer systems.

For the FLNG sector to grow safely, there have to be international standards and regulatory requirements, best industry practices, and environmental guidelines. ABS is helping to create this framework through the recently formed global gas solutions team, which is working with industry to address FLNG challenges. ■