Liquefied Gas Floating Higher in the Water

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There has been a flurry of activity around the world in the past few months by a number of groups progressing technologies for offshore floating liquefaction facilities (FLNG). This culminated in June 2008 with Flex LNG Flex announcing a heads of agreement (HOA) with Mitsubishi and Peak Petroleum to jointly develop and market the world's first floating liquefaction project off Nigeria. Within a few days Flex announced another HOA, with Rift Oil to develop a FLNG project offshore Papua New Guinea. FLNG as a concept has been around since the 1980's, with technology research mainly promoted by the majors Shell and Mobil, for projects with large scale capacities, i.e. some 3 million tones per annum (mtpa). Despite a number of attempts the majors have been spectacularly unsuccessful over the past two decades at getting this technology off the drawing board. The momentum in the past two years has moved towards smaller technology companies partnering with marine engineering companies for vessel (hull) design and fabrication, and independent upstream companies holding stranded gas reserves.

Floating Leaner

In addition to the Flex LNG FPSO projects (each 1.7 mtpa capacity) other groups continue to announce progress with their own technologies. These include: Hoegh LNG / Aker/ ABB Lummus announcing (Sep 2007) their LNG FPSO (1.6 mtpa capacity); SBM / Linde also working pre-FEED (Sep 2007) on a LNG FPSO (2.5 mtpa); Teekay/Mustang/Samsung announced (May 2008) that its LNG FPSO was to be classed by ABS and Teekay announced an upstream alliance (April 2008) with Gasol / Africa LNG to market it vessel in West Africa. These groups all have their own proprietary technologies geared to a project scale generally too small to be of interest to the majors. They are targeting small stranded gas fields, rather than the large-scale projects still in the major's sights.

Undaunted by this small-scale competition Shell has recently issued (July 2008) an international tender for FEED and EPC contracts to construct its FLNG design - weighing 3.5 million tonnes, with a deck area of 450 m by 75 m – on which it would deploy its proprietary, new but tried and tested, liquefaction (Shell Automated Cool-Down) process. Shell continues to be focused on large-scale potential deployments with its FLNG technology and it is believed that the current target project is its Prelude gas discovery in the Browse Basin (NW Shelf, Australia – see Energy Tribune 16 June 2008).

Floating Lighter

An innovative solution that liquefies natural gas, but not LNG as we know it, is SeaOne's LNG Lite™ concept utilizing Compressed Gas Liquids™ (CGL™) technology. In the CGL process, a hydrocarbon solvent is added to the natural gas stream after it is cleaned of impurities. Its effect is to cause the gas to liquefy when subjected to a temperature of -40°C and a pressure of 1,400 psi. The first phase of the LNG Lite system, this step is accomplished on a loading barge moored at an offshore wellhead. The conditioned natural gas stream is then piped aboard the CGL carrier in liquid form and stored in a bundled pipeline (42-inch carbon steel) containment system with a gas cargo volume of some 1.5 billion cubic feet (bcf) contained in a 102 miles of coiled and bundled pipe. To deliver its cargo the CGL carrier offloads to a transmission barge, which simply expands and separates the gases.

In an article in the ABS Surveyor (Spring 2008) SeaOne compare economics for a 3tcf gas field delivering 3mtpa for 10 to 15 years using LNG Lite and conventional LNG. For a 2000-mile supply chain employing 1.5 bcf CGL carriers (about half the capacity of a standard size LNG carrier) supported by one loading and one offloading barge, SeaOne estimate a total capital cost of $1.5 to $2 billion ($0.75 to $1.00/mcf) compared to an LNG solution of $3.5 to $4 billion ($1.75/mcf to $2.00/mcf). Moreover, SeaOne claims that LNG Lite uses less than 60% of the energy in its supply chain than conventional LNG. ABS awarded (2007) Approval-In-Principle (AIP) to the LNG Lite concept vessel, but projects utilizing the concept are yet to be announced.

Floating Existing Technology

It is interesting to review how FLEX LNG, only formed in 2006, has managed to steal a march on the competition in having placed orders for some of its vessels more than a year ago and now announcing partnerships along two supply chains. Its LNG Producer (LNGP) is a self-propelled FPSO combining existing technologies:

- sloshing resistant SPB containment systems retaining maximum deck space
- dual nitrogen turbo-expander liquefaction technology
- proven LNG transfer technology – marine loading arms
- proven ship-to-ship mooring system

Four “LNG Producer” hulls (each of 170,000 m^3 capacity) on order at Samsung Heavy Industries (SHI) in Korea (orders placed from March 2007 to April 2008 for deliveries from Dec 2010 to Mar 2012), each with nameplate liquefaction capacity of 1.7 mtpa. Each LNG Producer hull including storage tanks, power generation, offloading equipment, accommodation, ship-board turret systems and all utilities necessary to support the installation of the 1.7 mtpa topside is reported by FlexLNG to cost some US$460 million The topside orders for the hulls have yet to be placed, but the design cost is expected to fall within the US$ 550 to US$700/tonne liquefaction capacity. The topsides will consist of a generic liquefaction module and a field specific feed gas processing module

The vessels are designed to process some 230 mmscf/day of feed-gas with 12-15 % feed-gas shrinkage and equipped for side-by-side offloading. They will be equipped with a disconnectable turret mooring system. Dual nitrogen expansion cycle selected for Liquefaction is proven technology onshore and has the following additional offshore advantages:

- modularized
- easy start-up & shut-down
- single phase / single component refrigerant
- low equipment count with a small footprint
- no hydrocarbon refrigerants improve safety

These benefits are well established but come at the price of lower efficiency than mixed refrigerant processes (e.g. Wood et al. 2007). The SPB containment system, out of favour for many years in conventional LNG carriers avoids the sloshing issues posed by membrane storage tanks and, shortage of available deck space for processing equipment posed by spherical Moss-type tanks.

The involvement of Mitsubishi as an integrated equity partner in its upstream projects (announced June 2008), the LNG Producer vessels and providing, reportedly, robust long-term LNG off-take terms for 1.5 mtpa with prices indexed to oil and gas benchmarks should facilitate the equity and debt financing required for the Nigeria project to deliver its first cargo in 2011. Gas reserves from the Peak Oil operated offshore Nigeria licence OML 122, are expected to provide the required feed gas for some 15 years.

In its PNG project Rift Oil will be providing feed gas from onshore PPL235 and PPL261 licences in remote western PNG. That gas is to be piped to the FLNG vessel with annual production of 1.5 mtpa targeted to start in 2012. More good news for this venture is the announcement (July 2008) of the Puk Puk -1 gas discovery drilled in the PPL235. Some of the LNG may be sold to the Gove alumina refinery in Australia's Northern Territory. It will be interesting to follow the progress of the Flex-Rift FLNG project versus the two larger conventional gas liquefaction schemes that have moved into FEED studies in 2008: ExxonMobil-led PNG LNG 6.3 mtpa US$11 billion plant; 9+ mtpa Liquid Niugini plant (Interoil, Merrill Lynch and Pacific LNG). These land-based plants are not expected to enter production until 2013 at the earliest, illustrating the potential fast-track benefits of offshore smaller schemes.

Plenty of Willing Floaters

The other LNG FPSO consortiums are pursuing quite distinctive designs and, in particular, different liquefaction technologies:

- ***Hoegh LNG***-led group will use Lummus's NicheLNGSM dual turbo expander liquefaction process and Aker's SPB containment system providing a storage capacity of 180,000 m^3 and a 312-m deck length.
- ***SBM / Linde*** plan to use a multi-stage mixed refrigerant liquefaction process, as deployed by Linde at Snohvit LNG plant in Norway, with larger storage capacity of 230,000 m^3 also involving SPB-type tanks. Japanese ship builder IHI is commissioned to design the hull.
- ***Teekay/Mustang/Samsung*** design involves Mustang's LNG Smart® liquefaction process in which all refrigeration is provided by the process fluid using turbo expanders and no refrigerant storage is required. The simplicity of the process suggests that it should be able to accommodate variable gas production rates, typical of oil and gas producing fields, particularly associated gas volumes, and

frequent shutdown start-up cycles more easily than mixed refrigerant processes. Initial design involves a combined storage capacity for LNG and LPG in excess of 200,000m^3.

More Seeking to Floating

With no flaring rules no starting to bite major producers in some countries (e.g. Nigeria) small scale floating LNG solutions are becoming commercially viable for handling large volumes of associated gas. For large gas fields remote from infrastructure floating LNG also offers some advantages. Inpex apparently has the support of Indonesia's BP Migas to pursue its plan for a US$4 billion FLNG solution for its Masela Block in Timor Sea rather than an alternative plan to build a pipeline to Australia. Environmental concerns about damaging the Kimberley coastline in Northwest Australia have led environmental groups to support schemes being evaluated by Woodside and Shell to build a communal FLNG processing hub for Browse Basin gas field developments.

For a technology that has had such a long gestation period, FLNG is now very much on the development agenda.

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