Floating the next big thing

An artist's impression of Shell's Prelude FLNG facility.

The concept of floating LNG (FLNG) has been around since the first baseload LNG plants were built in Algeria and Alaska, however, despite significant development work through the '80s and '90s, the theory thus far hasn't been converted into practice.

With a number of FLNG projects proposed, both in Australia and overseas, this is set to change.

In Australia alone, Shell is planning to develop its Prelude and Concerto gas discoveries in the North West Shelf Browse Basin via FLNG technology; subject to FID, the Sunrise Joint Venture has selected FLNG as its preferred option for developing the Greater Sunrise gas fields in the Timor Sea; and Santos and GDF SUEZ are exploring the potential to develop Bonaparte LNG, in the Bonaparte Basin off the north coast of Australia, also via FLNG.

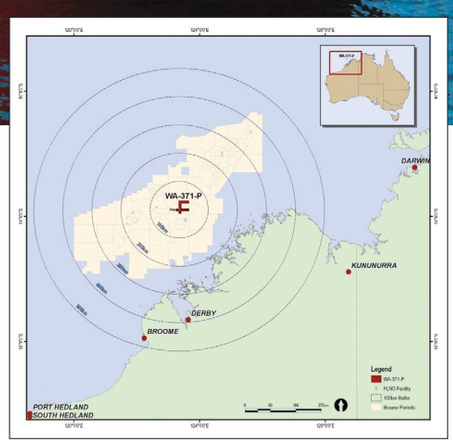
Shell is at the forefront of the development of FLNG technology, with Prelude set to flow first gas in 2016 and potentially become the world's first producing FLNG facility.

Shell Engineering Manager Steve Kauffman, who has been involved with Shell's FLNG drive since 1999, told *SPE News* he has seen FLNG grow from a single project-specific idea into an evolving business on the back of a 'design one, build many' approach.

He noted it's been 'a very long journey'.

In 1999, Shell explored the potential for the development of the Kudu field off Namibia via FLNG, and through 2000–2002 did the same with Sunrise. However, despite there being a reasonable amount of technical confidence, at the time neither project was progressed.

"The FLNG development went a little bit quiet after 2002. And then around 2005 we really started to push it again, and most of that push actually came from here in Australia. Then, as we did that, we had two extra principles that we worked into the design: repeatability—design one, build many—and redeployability", Kauffman said.



Prelude location map.

"By incorporating those, then we're able to, as a Shell group, sit back and say 'well, globally, we can see all of these potential applications, all the effort that we put in now to moving the design forward we will reap the benefit of many times over, and we will absorb the risk into a number of business applications and therefore the risk is

A view of the facility from above.

diluted and it's a much easier business decision to take'."

Kauffman said circumstances in Australia lend themselves to the FLNG concept, with many of the country's oil and gas resources situated a long way offshore.

"Particularly, I think, in the Australian environment, where there can be quite a varied number of resource holders, and they don't have to be all that big resources, here's a technology that enables them to be able to develop the field and not sit and wait for 20 or 30 years, or whatever it's going to be, to be on the back of a major as a major hub", Kauffman said.

"FLNG isn't in competition with a major hub, it's complementary to it. We still have our big hub developments—and Gorgon's an excellent example—but, by the same token, if there's a lot more gas, say further out to the west or up north, these resources don't have to sit and wait for that length of time until North West Shelf is starting to come off plateau, or until Gorgon is starting to come off plateau."

Shell is the 100% equity holder of the WA-371-P permit, encompassing the Prelude and Concerto fields, 475 km north-northeast of Broome. Shell believes, as the gas reserves are relatively small and remote (around 2–3 Tcf recoverable gas) the fields are well suited to development via FLNG.

The development, which Shell expects will have an operational life of 25 years, will produce an estimated maximum of 3.6 MMt/y LNG, 1.3 MMt/y condensate and 0.4 MMt/y LPG.

Kauffman said Shell was internally confident of the feasibility of the FLNG concept, however also engaged external sources to test its robustness.

"We went through that process in 2008. There were over 40 different specialists that were involved; it took seven months of elapsed time, it was really quite a lot of time to run through and to follow up and to go through everything … It was a very worthwhile process to go through—and I think always important too, that it isn't just you're looking through your own glasses all the time at your own product."

He said, while Shell doesn't underestimate the engineering challenges associated with the first generation of FLNG technology, FLNG is essentially the bringing together of a number of established technologies.

"The novelty—and I don't like using the word novelty—is what we bring together. It's not new technology. The types of pumps that we pump with the cooling water systems are already in service in crude refineries up in Northern Europe; all of the LNG loading pumps that we use within them, and the membrane systems and whatnot, they're already in use in the industry; the actual hull and the naval architecture that goes into the substructure, again, is coming directly out of the LNG carrier industry. You almost just build two LNG carriers—they just happen to be side-by-side."

The structure will measure 468 m by 74 m and, when fully ballasted, will weigh around 600,000 t. It is officially classified as a 'facility' rather than vessel, and will be the largest floating structure ever built.

"It has thrusters, but the thrusters help it weathervane, that's all they do. So, they're pointing in the wrong direction, they're east-west, they're not north-south … It is towed to the location with tugs; then it is hooked up to the subsurface, all the pipes coming up to the turret, and then it sits there", Kauffman said.

"It's interesting when we talk to the naval architects about all of this, because they say this is just normal naval architecture. Yes, it's big, but why is it that we've never built something this big? Well, there's never been a purpose for something this big … It's more the fact that the need is different. than that it's a major technological challenge."

Kauffman said a lot of storage volume is needed because all of the product carriers will have to come directly to the processing facilities.

"We have about 220,000 m^3 of LNG and we have 90,000 m^3 of LPG, which can be used for LNG. So, that 90,000 is sort of multiservice, and then we have 120,000 m^3 of condensate.

"If you add all of that up, you've got a fairly big substructure. Then you put in the membrane tanks—so, really, what we do here, is we leverage on the experience of the LNG carrier industry", he said.

"The hull structure is actually built very much like a carrier, an LNG carrier. The bow does have some what we call, or what the naval architects call, formwork. In other words, it has some shape—and it has shape to be able to deflect waves, particularly the very, very large waves that might be generated during a cyclone. You're still creating that bow, such that those waves are broken and move away and don't come over and splash onto the deck."

Kauffman said LNG will be loaded via conventional loading arms, the same as used on LNG jetties.

"It's what we call enhanced side-by-side loading—so, once the LNG carrier is moored … Essentially there's a guidewire, and with some positioning system logic, that helps the loading arm, coupled with the manifold, on the LNG

carrier. It increases the motion window to which that coupling can occur …

"There's definitely relative motion. The loading arm, of course, sees one differential of motion. It doesn't matter that it happens to be moving; the point is, it's just how much is it moving relative to what it's wanting to couple to. All we needed to do was to enable a mechanism that had greater tolerance to motion."

Explaining that, as required under life-at-sea regulations, diesel will be available for emergency power generation, Kauffman said the facility will be powered the same as any other LNG plant.

"The same as an onshore LNG plant, it's the methane from a certain part of the process you'll bring up into the fuel system … in our case we run our refrigerant compressors with steam turbines", he said.

"We've actually gone, if you like, a little bit old fashioned in some parts. But, again, that was for reliability. Steam-driven LNG plants are still the most reliable plants in the world. The problem with building steam-driven plants is the huge utilities that you're having to build onshore, and to get all of the water in and out for the condensing. But when you're sitting out there in the ocean, one thing that's pretty free is the cost of that water. That enables the reliability of good old fashioned steam turbines to be used.

"Robustness has been very much a key driver. You want a good, solid, robust operation, because you want to be able to ensure the security of supply to your customers."

Kauffman said Shell has designed the facility to withstand a one in 10,000 year event, the equivalent of worse than a category five cyclone. He noted its size is a natural barrier to extreme weather conditions.

"Indeed, as you work through all of the different studies, the size is very helpful to reducing a lot of the risks. Then, when we look at what extra do we have to add to designing one in 10,000—not much. A lot of it we were getting just from the concept that we had.

"600,000 t fully laden. So, you could imagine if that's sitting out there in the ocean it's hardly going to move, or its motion is so slow that it doesn't really have that much effect on all of the processing equipment."

Kauffman said Shell has paid particular care to risk management and covering all contingencies.

"The safety management system that we run is something that's called 'Hazards and Effects Management Process', and really it just has four very simple stages that we go through: you must identify the risk, and then it's the assessment of the risk, all of the mitigation and controls that you need to control the risk, and then you still have a recovery aspect to the assessment of the risk", he said.

"We did very specialist work with organisations in the UK on explosion modelling and overpressure modelling. And, a lot of the time, you are testing at the worst case, you are taking an event that you might think is one in a million, but you're still taking the circumstances of that to understand what the consequence is and whether or not you can do something about reducing that consequence.

"Risk is always having a look at how often something's going to happen, the frequency, and the consequence if something happens, and you can affect both of them in your engineering—you can reduce the frequency and you can reduce the consequence by certain engineering modifications or changes or practices."

The facility is designed to sit in place for 25 years; in the 25th year there will be a scheduled dry dock.

"Essentially you have to dry dock it, mainly for the painting systems in the ballasting tanks and the hull. But, you also then do what we call a rejuvenation—which is the same that you do in an onshore LNG plant", Kauffman said.

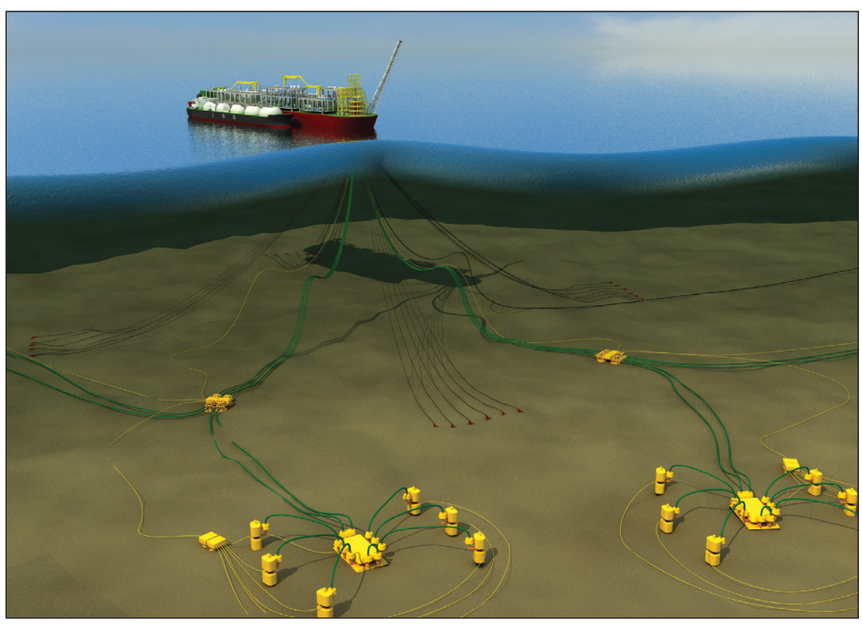
"It's not a big undertaking, but it does have to be disconnected. You disconnect your mooring system and lay back on the seabed, you then isolate all of your risers, again, lay those on the seabed, you tow it, you do whatever necessary work there is within the dock, you tow it back again, and then you reconnect everything up in the same way that you did when it first went out to site."

Kauffman told *SPE News* Shell is ideally positioned to drive the development of FLNG technology.

"Shell found itself in a fairly, I don't think I'm wrong in saying, privileged position, in that we have five very big technical pillars within Shell from where we needed to bring all of that knowledge.

"We have a very large presence in liquefaction technology—so, that was absolutely essential. We have a Shell shipping technology arm, and that's all of the LNG carrier experience; we have FPSO experience, offshore production … in fact, I think Shell is the largest offshore operator; and then you've got the product management for major, mega projects."

FID for the Prelude project is expected in 2011. ◆



A view of the FLNG subsea infrastructure.