

Delegate Report from LNG 18: International Conference and Exhibition on Liquefied Natural Gas 2016

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Background

The Delegates are extremely grateful for the learnings, experiences and networking opportunities provided from attending LNG 18. We have prepared this report to share our insights with the Australian Gas Industry Trust (AGIT) Board.

LNG 18: Re-drawing the global map of gas, was the second time that Perth had hosted the triennial event. This was particularly auspicious in the context of Australia becoming the world's largest LNG exporter by 2020. Several dominant themes emerged during the conference, which we will expand upon in the body of this report. In addition, we will provide our insights into the conference and our personal experiences.

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Themes Emerging from LNG 18

Evolving LNG Markets – the supply and demand dynamics

The location for LNG18 was highly topical for a discussion on LNG supply and demand balance, with around 60 mtpa of liquefaction capacity currently under construction or in start-up in Australia. This, combined with a further 60 mtpa under construction in the US Gulf of Mexico, has led to a massive increase in liquefaction capacity ready to supply the once-lucrative Asia-Pacific markets. Indeed it is estimated that for every one million tonnes of uncontracted LNG demand in the period 2023-2025, there is currently 2-3 million tonnes of competing uncontracted capacity from around 20 pre-FID projects. This, combined with the ramp-up of the Qatari megaprojects, has led to concerns of oversupply in the short term.

Demand growth, on the other hand, has been generally steady throughout this period. Growth has arisen both from new terminals and new markets. In particular the advent of Floating Storage & Regasification, a means to access LNG imports at lower capital cost with faster project delivery windows, is an important theme which will be discussed further in this paper. Within the last five years, several key new markets commenced LNG imports for the first time – including Singapore, Malaysia, Pakistan, Kuwait, Brazil and Chile. In the coming years this trend is expected to continue, with populous nations such as the Philippines, Columbia and Bangladesh planning for their first imports. In total over 30 countries now import LNG, compared with only 11 in the year 2000. By the early 2020s, this number is expected to top 50 as millions rise out of ‘energy poverty’ and join the global middle class, and millions more move from regional areas to cities where clean energy supply is a necessity.

That said, the short term remains a challenge for LNG producers and investors. Japan LNG averaged only \$10.70/mmBtu in 2015, compared with over \$16/mmBtu just one year earlier. Infrastructure financiers seek cash flow certainty from projects, which provides a challenge in such an uncertain market context. In this scenario, portfolio players with strong optionality of supply and demand positions stand advantaged to weather the price downturn.

New markets for LNG remain a fledgling but potentially material source of demand growth. Two potential LNG transport markets under development include road transport (trucking) and marine fuels (bunkering). The worldwide LNG-fuelled ship fleet has grown from 31 ships in 2012, to 75 today with a further 84 on order. Whilst these are small numbers in the global scale, the rapid growth exemplifies the advantages owners are realising, both in cost and environmental/emissions efficiencies from moving from traditional heavy oil bunker fuels to cleaner-burning LNG. To supply these vessels, 7 dedicated LNG bunker barges have now been deployed around the world.

LNG in trucking is another key substitution market which has attracted attention, particularly in the USA, due to low cost gas supplies. Some agencies have estimated that natural gas and LNG will

account for 160 billion cubic meters (bcm) of on-road fuel, nearly a fourfold increase on current demand.

The emergence of FLNG and FSRU – making LNG more accessible

It was clear throughout the conference that the evolution of 2 relatively new technologies, Floating LNG (FLNG) and Floating, Storage and Regasification Units (FSRU), are changing the direction of the LNG industry. FLNG is providing a means to monetise resources in remote or stranded gas fields that would otherwise prove uneconomical. Equally in the downstream gas market, FSRUs are making LNG more accessible to new and existing buyers.

The next couple of years will be paramount for FLNG to establish itself as a reliable technology in the industry. The outlook is promising however with Prelude FLNG under construction and Petronas FLNG 1 96% complete and planning for start-up in Q3 2016. If the technology proves successful and reliable it may also be the answer to breaking the boom and bust cycle currently being experienced in the market. With an overall lower CAPEX investment, it could facilitate suppliers to achieve Final Investment Decision (FID) on new projects in the coming years while the market demand remains low and there is increasing pressure to provide shorter term, more flexible export contracts.

Shell Prelude was the first project to reach FID in 2012 and is currently under construction in South Korea. The prelude project is mammoth and with a total length of 488m, it has one of the biggest hulls ever built. When in operation Prelude will have the capacity to produce 5.3 million tons per annum of liquids including LNG, LPGs and Condensate. Once construction is complete the facility will be shipped to the Prelude and Concerto fields northeast of Broome, Western Australia, where it will remain on location and in operation for 20 – 25 years.

Petronas FLNG1 was not the first project to achieve FID however it is on track to be the first FLNG facility in operation with a planned start-up of Q3 2016. Petronas FLNG1 is a purpose built mid-scale facility with the capacity to produce 1.2 million tons per annum of LNG. The facility will be located in the Kanowit gas field 180km offshore of Bintulu, Sarawak. As a comparison to Prelude the facility is significantly smaller with a total length of 365m. With Petronas FLNG2 also under construction, Petronas is expanding market opportunities with the production of LNG from many small gas fields in Malaysia.

The FSRU technology has been established in the industry for over 10 years and currently has around 30 units in operation worldwide. This is expected to grow to 70 FSRU's in coming years. FSRUs are a large ship with LNG storage, regasification and export facilities. They can either be new builds or retrofitted from a traditional LNG carrier. FSRUs are becoming increasingly attractive to the downstream gas market as they have shorter project development and lower CAPEX investments to traditional onshore facilities. The flexibility of FSRUs also provides opportunities to countries like Brazil and Argentina where the demand is seasonal or erratic. The mobility of the units and ability to also be utilised as a traditional LNG carrier is another benefit to buyers.

The Toscana FSRU has continued the evolution of the technology with successfully starting up the first unit to be operated in open water. The unit is located 22km off the coast of Livorno, Italy, in a water depth of 120m. Toscana is a traditional LNG carrier that has been retrofitted with LNG loading

arms, regasification and nitrogen units and an external mooring turret for gas export. The FSRU receives LNG from conventional LNG carriers and following regasification, exports natural gas via a 36.5km pipeline to the Italian distribution network. The unit has the capacity to load 135,000m³ of LNG in around 12 hours and has similar operational features and capacities as nearby onshore facilities.

The Toscana project CAPEX was estimated at over US \$ 700 MM which is actually more than the equivalent onshore LNG regas terminal of similar capacity. The key driver to provision of an offshore facility versus the standard onshore facility was to preserve the aesthetic of the pristine coastline which underpins the tourist market in the region. Hence, FSRU technology has provided a solution which satisfies all stakeholders which is becoming key within the energy security debate.

Recently FSRU's have also been cost effectively deployed in Jordan, Egypt and Pakistan which have opened new markets and reduced the capital 'barrier to entry' through both the lower CAPEX required and the opportunity to lease these facilities.

New LNG markets may be realised through FSRU technology and these comprise; South Africa, Morocco, Indonesia, Bangladesh, India & Pakistan.

With the progression of these traditionally onshore facilities to an offshore environment, both technologies have had to overcome similar challenges in design. One of the biggest challenges both FSRU and FLNG facilities are faced with is being able to load LNG in open water conditions. Both Toscana FSRU and shell Prelude FLNG have adopted a conventional style side-by-side mooring arrangement with LNG loading arms that are designed to move between the 2 vessels. During commissioning of the Toscana FSRU, LNG loading in varying open water conditions was successfully tested 4 times using the new loading arm design.

Another common challenge was the design of static equipment for motion experienced in a marine environment. Piping systems, especially those in cryogenic service, had to be designed to cater for all degrees of motion and traditional tray contacting columns were redesigned using packed or random packing to ensure hydraulic resistance to lateral liquid flow. During design, projects completed extensive fluid dynamic analysis to evaluate the behaviours of liquid LNG and LPGs in motion. The Petronas FLNG1 project completed fluid dynamic analysis on all motion sensitive equipment to validate level instrument settings and help prioritise which units needed to be located closest to the ships centre of gravity.

The biggest challenge to new FLNG projects however has been the design of facilities in the absence of industry guidelines and lessons learnt. As a result, Technip who has been involved in both Shell's Prelude and the Petronas FLNG1 projects, worked with clients to develop a fit for purpose set of standards and implemented initiatives to ensure inherently safe FLNG designs. Key focus areas include the optimisation of deck layout and cryogenic spill protection. Shell's Prelude project for example has located the highest risk process and storage areas at the opposite end of the vessel to the living quarters. The living quarters is also separated from the rest of the facility by a 20m safety gap to minimise the risk to personnel in the event of an incident.

The main objective of cryogenic spill protection is to minimise the likelihood of escalation. Brittle fracture of carbon steel is a critical hazard arising from a cryogenic spill and both projects have taken

measures in design to minimise this risk. The Petronas FLNG1 project has provided thermal protection to critical systems as well as passive cryogenic protection and fire protection systems to minimise escalation and consequence of a cryogenic spill.

In conclusion, the future for LNG production offshore is looking increasingly bright and these relatively new technologies are one of the main drivers in the ability to make natural gas more accessible to new and existing markets. They also have the potential to be a key contributor in facilitating countries move towards natural gas as a cleaner primary energy source.

Simplifying Complex Projects

LNG 18 was an incredible advertisement for the world's big, complex, cutting edge LNG projects; Shell's Prelude FLNG project; the Yamal Arctic LNG project; and the three Queensland Curtis Island LNG facilities delivered by Bechtel. It was clear that the development of LNG facilities, both onshore and offshore, are incredibly complex, and require disciplined Project Management in order to deliver these projects on time and on budget. However, as Neeraj Nandurdika, director of oil and gas practice at Independent Project Analysis put it, "Project Management is the science of planning combined with the art of reacting to surprises", and pointed out that "by that definition, we are not very good artists". He noted that "for any project, when a project slips its first hydrocarbon date or first cargo, almost every time there is only one reason for the origination of that slip – that slip originates in engineering". In today's modern projects, complexity is introduced via the overlap of technical complexity, organisational complexity and the complexity driven by local forces and overarching politics. In order to solve this "fog" of complexity, modern project management would need to adapt and move away from the linear systems that have defined project management of the past.

The increasing prominence of short/spot market

One of the key topics of discussion was the increasing proportion of LNG being sold on a spot or short term basis. ~29% of the current LNG sales volumes (according to Oxford Institute of Energy Studies) are made up of spot and short-term sales. This is a 3-fold increase since 2006 and almost a 10-fold increase since 2000. The key drivers behind the emergence of increased spot and short-term sales include:

- Structural over-supply of LNG, meaning more flexibility is required from suppliers (and more on-selling from buyers)
- Emergence of LNG portfolio players (aggregators)
- Recent period of project ramp-up, resulting in uncommitted volumes
- Market uncertainty requiring more flexibility from buyers and sellers
- Increased liberalisation of markets, as well as the emergence of smaller players, smaller markets and increasing access to regasification facilities
- Increased inter-regional activity

In terms of the future outlook for spot and short term sales, varying views were discussed at LNG18. The most common view was a still-increasing proportion of sales will be sold on a spot and short-term basis in the near-term (~45% by 2020 according to OIES and ~50% by 2020 according to Berkeley Research Group). This is likely to be driven by the continuation of the factors mentioned above, in particular the increasing oversupply (once US LNG ramps up), the increasing emergence of traders/portfolio players and smaller players, as well as ongoing market liberalisation. One of the uncertainties presented was how the roll-off of long-term contracts and the subsequent renegotiation of those contracts might affect the view of spot/short term sales in the longer term. It was proposed that the increase in the spot market is aiding market liquidity and is ultimately assisting in an accelerated path to a LNG price index, which is discussed further below. Whilst most panellists agreed this still had a way to play out, there was a discussion around how the short term sales piece is already impacting contracts, with 'shorter-term' (e.g. 3-5 years) contracts increasing, increasing gas price indexing within contracts and also the possibility of increased price reviews.

One of the key questions regarding spot and short-term sales was whether or not an increasing level of short term sales is sustainable, as ultimately longer term contracts will be needed to underpin FID's once the market rebalances (or enters undersupply).

Commoditisation of LNG

Many of the presentations during the conference discussed the changing LNG market and the potential for a liquid and transparent LNG market price. Further to that, a question alluded to but rarely addressed head on was around the potential for the commoditisation of the global gas/LNG market.

To influence the creation of commoditisation a number of changes to the LNG market that currently exists are required. Such changes include

- improving the connectivity between the existing localised markets through increasing the volume of spot trading
- increasing the supply of tradable LNG to provide depth to the market
- The development of an LNG hub with transparent price indexing out of which a futures market may develop.

So, has LNG commoditisation begun? The industry continues to predict a growing role for natural gas into the future, however the current oversupply of the LNG market is leading to a number of changes in contracting strategy as the market swings in favour of the buyer, these changes indirectly increase the amount of spot LNG trade. Recent changes to contracting behaviour include:

- Contracts of shorter term and smaller size,
- Increased volume flexibility through reduced take-or-pay quantities,
- Increased destination flexibility allowing the buyer the ability to re-sell and arbitrage
- Price diversification away from historic oil linked price markers towards indices influenced by gas-on-gas competition such as NBP and Henry Hub.

As mentioned above a steady increase in spot/short term sales has already been seen and is expected to continue into the future.

Additionally, the development of a gas hub in Singapore has begun. Singapore's status as one of the busiest ports in the world coupled with its established oil trading hub and access to financial resources makes it Asia's best option for a trading hub. Singapore has open access arrangements in place for its facilities and has already taken steps to increase LNG import and storage capability. The development of a trading hub in Singapore facilitates more competitive pricing and decreases buyers reliance on long term contracts, however in order to meet the needs of the rest of Asia, Singapore will need to ensure it can handle sufficient volume to supply the expected quantity of spot trades.

Despite the changes to contracting strategy increasing supply for spot trading and the development of an LNG trading hub providing an accessible market, commoditisation remains somewhat off. Poten and Partners suggested some key challenges to commoditisation:

- High costs associated with LNG and the low energy density hinder commoditisation (for example, high capex means long term take-or-pay contracts are still required, ultimately limiting amount of spot and therefore liquidity and commoditisation potential)
- High transport and storage costs limiting physical connectivity between markets and therefore propagating market segregation and ultimately restricting true gas-on-gas competition

So, despite creating more LNG trade, ultimately the high costs of LNG project development, transportation and storage will limit LNG commoditisation. Industry needs to work collaboratively to improve technology to create a more efficient way of producing and transporting LNG for a truly commoditised market to emerge which is still many years away.

Continued Collaboration needed amongst all Industry Stakeholders

A theme that was common throughout the conference was the need for continued collaboration amongst all industry stakeholders to ensure the promise of natural gas as the long-term partner to renewables as a source of clean and affordable fuel is realised.

The industry has done an extraordinary job of solving complex technical and commercial challenges through all stakeholders working together in a spirit of long-term partnership.

Producers, consumers, suppliers and governments have unique sets of incentives, but for projects to move forward collaboration must continue to prevail. This is more important than ever in the current challenging backdrop of low prices and changing market dynamics. Each stakeholder will have to collaborate and play a role in sharing the risk to ensure necessary investments are made to meet future expected long-term demand.

In the current landscape buyers have greater bargaining power and are demanding greater flexibility and shorter term contracts from producers. However buyers will still need to take-up long-term contracts to ensure necessary project financing is received to fund future investment. To this end working together with producers to negotiate flexible contract terms such as more frequent price reviews and destination flexibility in exchange for long-term firm commitment will be necessary.

Producers will also need to work closely with suppliers to design projects that manage and mitigate risks to intelligent levels rather than eliminating risks totally to keep costs down and improve project

competitiveness. Producers will also need to work closely with all parties along the supply chain through labour, procurement and contractor management for instance to deliver the most economical construction projects on time.

Technological advancements will also be critical to staying competitive in capital developments. Industry collaboration on Research & Development with strong local and federal government support at the WA: ERA facility for instance has resulted in significant technological applications that have improved the productivity of the industry.

Governments also play a critical role working with industry to get projects off the ground and promote investment. This is achieved through streamlining environmental approvals and working closely to engage community groups early to address potential concerns that might impact LNG projects.

COP21 – Partnering natural gas with renewable

For countries to meet their COP21 commitments, there is a need to remove coal from the energy mix and partner natural gas with renewables. Developed and developing countries agreed at the COP21 climate change convention to keep global temperatures "well below" 2.0C. As countries transition to renewables, to ensure a stable and predictable supply, natural gas should act as a companion fuel. However, fuel switching for environmental purposes has not yet gained momentum; over the last decade there has been a marked increase back to coal in non gas-producing countries as gas is not cost competitive relative to coal.

Carbon pricing was a topic of debate as some believe it is required to create a level playing field for natural gas and coal. Natural gas emits half as much carbon dioxide than coal, making it a cleaner source of fuel. However, globally there has been no firm policies promoting the role of natural gas in decarbonisation. Countries and companies alike are torn on the issue. Chevron CEO John Watson argued that the free market can be trusted to reduce emissions and a carbon price is detrimental to energy affordability. Conversely, Shell CEO Ben van Beurden believes the externalities of coal need to be properly priced which will position gas a natural ally with renewables. While the Prime Minister acknowledged the pivotal role gas plays in delivering energy with lower carbon emissions and supporting renewables which produce power only intermittently, there was no mention of any policies to price carbon.

Reducing costs to increase competitiveness

Reducing the cost of delivered LNG had particular resonance in the current energy environment, where LNG demand is under threat from other energy sources e.g., coal in the power mix, and where pre-FID projects are facing challenging economics to secure investment decisions e.g., due to prevailing low price environment.

The technical elements driving cost were extensively reviewed throughout the conference. Dan Kinsey of the CB&I focussed on key elements to minimise costs at the pre and post FID stages. Critical success factors to be considered prior to FID were noted as owner and contractor

partnership e.g., risk allocation, site selection e.g., topography and EPC model e.g., modularisation. Post FID Mr Kinsey advocated that minimal technical changes would drive cost improvements.

Cost innovation in shipping was widely discussed. The BG/Shell's Blue Amazon project focussed on increasing LNG carrier efficiency by reducing daily fuel and emissions through the application of hull optimisation. Another opportunity widely spoken about and already being progressed in the industry was LNG as a shipping fuel. Dr Gerd-Michael Wuersig and Dr. Ing from DNV view LNG as the shipping fuel of choice partly driven by cost.

Ensuring capital productivity through innovation, standardisation and understanding optionality and uncertainty was raised by Brian Murphy of Bain and Company. Focus in these areas could support reducing costs with Mr Murphy citing examples of 60-70% cost reduction through design simplification and 35% cost reduction through supplier collaboration.

Building on similar concepts, the Chiyoda Corporation put forward the concept of "Chiyoda LNG-X" conceived to drive fastest delivery and lowest capex through design standardisation. Key elements to the concept included ready designed blocks, standard specifications and all executed by one contractor.

Finally, the emergence of the US as a LNG exporter has recognised the impact of the cost of gas into the LNG plant. With the US market at historic price lows driven by the shale revolution's rig productivity (6 times improvement 2008-2016), dry gas projects outside of the US must compete with this low cost gas supply source in order to secure LNG contracts required to drive final investment decisions.

Conference Insights

Technical Tour

The Technical Tours were an incredible opportunity to witness firsthand the amazing academic advances that are being made by Western Australian institutions as part of the Western Australian Energy Research Alliance. The whirlwind tour included stops at the University of Western Australia (UWA), and the Australian Resources Research Centre (ARRC), which is a collaboration between the CSIRO, Curtin University, UWA and the federal government's National Measurement Institute. Key research projects that resonated with the AGIT scholars were:

- Understanding how currents, tides and cyclones affect the stability of pipelines on the seafloor;
- Investigations into how effective dynamic anchors are in different soils at UWA's small geo-technical centrifuge, the world's busiest; and
- How to tackle hydrates without the use of expensive monoethylene glycol (MEG).

Thought Leadership Luncheons

The Thought Leadership Luncheons enabled a small section of the AGIT scholars to enjoy a three-course lunch whilst hearing directly from some incredibly influential leaders not only in the LNG

industry, but in the broader energy and political spheres as well. A particular highlight was the Thought Leadership Luncheon featuring US Ambassador to Australia, John Berry and Australian Foreign Affairs Minister Julie Bishop. The key message from Minister Bishop was that LNG is fundamental to Australia's ability to meet the COP21 targets, whilst Ambassador Berry's takeaway was that energy is in every equation when it comes to improving the quality of life for all of our global citizens.

Opening Ceremony

The Opening Ceremony was uniquely Australian experience, showcasing the best of our cultural diversity. The Welcome to Country lead by Dr. Richard Walley was particularly moving as was the Aboriginal contemporary dance piece performed by the Ochre Dance Company. This was followed by a reading of the iconic Australian poem, My Country, by Dorothea Mackellar, and a beautiful rendition of I am Australian by Billie Court. The Australian Girls' Choir then brought the house down with three classic Australian pop songs, including the goose-bump inducing, I Still Call Australia Home.

Personal Experiences

Networking Opportunities

The networking opportunities afforded the AGIT scholars was second to none. It was an amazing opportunity to rub shoulders with the leaders in the LNG industry, and to pick their brains on topical issues such as the ones discussed in this report.

AGIT Scholars

Meeting and spending time with the other AGIT scholars was one of the highlights of the trip. A fantastic bond was formed between all the scholars, and we are all excited to see how these relationships grow as we all progress our careers in the gas industry.

Perth

Whilst Perth is a focal point for the gas industry in Australia, only two of the AGIT scholars were based locally. So it was a fantastic opportunity for the East-coast based scholars to spend some quality time enjoying Perth and the surrounds.