Driving innovation across the LNG value chain

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As has been reported by many already, the world needs more energy. By 2050 the global demand for energy is expected to have doubled (IEA's 2009 World Energy Outlook). At the same time environmental stresses are growing: the world must manage its greenhouse gas emissions as a matter of urgency. Over time, cleaner, renewable energy sources will meet an increasing share of demand, but experience tells us that it will take many years to gain overall acceptance of these new energy sources and to build the necessary infrastructure.

At Shell, we estimate that by the middle of this century around 30 per cent of the world's energy could come from bio-fuels, wind, solar and other renewable sources, and that nuclear could cover around 8 per cent of demand. This will, however, require a massive and coordinated effort by scientists, engineers and investors, and the remaining 62 per cent of primary energy supply will still have to come from fossil fuels. Natural gas, the fossil fuel with the lowest carbon intensity as well as the lowest nitrogen and sulphur dioxide emissions, will play an important role in the future energy mix and in meeting climate change targets. Thanks to innovation, the industry is now able to access the world's vast unconventional gas resources, providing cost-competitive supplies for many decades. Natural gas can reach consumers in a safe, reliable and efficient manner, both as pipeline gas or as LNG. Shell was involved from the beginning in the LNG industry, as technical advisor in the first commercial liquefaction plant in Algeria, in the design and shipping of the first purpose-built LNG carrier, the Methane Princess (see figure 2), and the buying of the actual LNG from the CAMEL plant for the UK.

Many innovations and technology improvements have lead to more cost effective and efficient plants. This article discusses how Shell is continuously innovating across the LNG value chain from LNG export to LNG import, focusing here on liquefaction and shipping.

Opening new frontiers in liquefaction

LNG train capacities have increased over time in order to capture the advantages of economies of scale. True mega trains of 7 million tonnes per annum (mtpa) and larger have been developed for those locations with very large gas reservoirs.

More recently the focus of technology developments has shifted towards increasing overall energy efficiency and as such, reducing emissions, and towards enabling access to gas resources in more challenging locations like (sub-) Arctic climates or off-shore regions.

New LNG designs, using for example more efficient turbines or waste heat recovery, can have a significant impact on the energy efficiency of LNG plants, thereby saving fuel and reducing CO_2 emissions. But for these designs to become successful in the future, it is important that they are cost competitive compared with less efficient designs. At the same time, it is essential that the new designs do not introduce large technical risks.

Shell developed a next generation LNG train design for the 3 to 6 mtpa range, based on the latest thinking regarding energy efficiency, costs, project and technology risks and operational flexibility. These energy efficient designs, based on aeroderivative gas turbines as compressor drives or heavy-duty gas turbines in combined cycle, are now available and can lead to considerably lower (~30 per cent) CO_2 emissions compared to conventional designs.

The power output of aeroderivative gas turbines is sensitive to ambient air temperature. This can negatively affect the LNG production of designs employing aeroderivative drivers in (hot) climates with large temperature swings. The issue can be solved by chilling the inlet air of the aeroderivative drivers. In this way, designs with aeroderivative refrigerant compressor drivers, like designs with heavy-duty gas turbines in combined cycle, can be applied in a wide range of climates. The new LNG train design offers a choice between simplicity, high efficiency and low CO_2 emissions whilst the concept remains fully scalable between 3 to 6 mtpa.

Floating LNG is complementary to conventional onshore LNG, as it enables tapping into difficult-to-reach off-shore reserves

The export-oriented integrated oil and gas project, Sakhalin II truly opened new areas for innovation. Situated in sub-Arctic conditions, the challenging environment necessitated the pioneering of many new technologies and business solutions.

At the heart of the Sakhalin II development is Russia's first LNG production plant (shown in figure 1), consisting of two LNG trains, together capable of processing gas to produce a total of 9.6 mtpa of LNG and the offshore export terminal. Shell developed the proprietary Dual Mixed Refrigerant (DMR) process, a two-stage liquefaction process, specifically to help cope with and even exploit the varying ambient temperature of Sakhalin. The LNG project started up in March 2009 producing significantly ahead of projections, and continues to perform well.

To monetise gas from offshore and close-to-shore fields floating liquefaction is being developed. Floating LNG is complementary to conventional onshore LNG, as it enables tapping into difficult-to-reach off-shore reserves. Floating LNG projects are technically feasible, but significant technical

Photograph courtesy of Sakhalin Energy Investment Company

Figure 1: Russia's Sakhalin II project is the country's first LNG production plant, consisting of two trains capable of producing 9.6mta of LNG

challenges for instance related to full integration of gas production, liquefaction, storage and off-loading need to be addressed. The reduced space and the dynamic motion environment, due to variable met-ocean conditions, requires innovative and breakthrough technologies.

The key dimensions of Shell's generic Floating LNG concept are 480 x 75 metres, with about 3.5 mtpa LNG capacity plus associated LPG and condensate production, taking total liquid production potential to around 5 mtpa. The Floating LNG design is suitable for a wide range of feed compositions and metocean conditions.

LNG shipping

In developing Floating LNG, we not only made use of our experience in liquefaction and in off-shore operations, but also of our track record in shipping. Our expertise in shipping includes feasibility studies, benchmarking, port and terminal advice, technical consultancy, fleet operations and vessel procurement.

At the end of 2009 the world LNG tanker fleet consisted of around 336 vessels. Through our Joint Ventures and direct ownership, we have equity, management or chartering positions in around a quarter of the global LNG fleet. Shell Shipping has been at the forefront of the development of LNG carriers and helped to develop the codes and standards the industry abides by. Our experience extends from the very first LNG vessels through to modern day technologically advanced designs.

The majority of ships can carry around 135,000 to 145,000 m3 of liquefied natural gas at atmospheric conditions, in huge, insulated tanks which keep the liquefied gas at -160ºC.

As LNG train capacities have increased over time in order to capture the advantages of economies of scale, ship capacities have increased as well. The Methane Princess mentioned earlier had a capacity of some 27,000 m3 of LNG divided over nine cargo tanks insulated with balsa-wood and glass-fibre, in the seventies LNG carrier size increased to around 125,000 m3 and then for many years stayed around 135,000 m3. The Q-Flex and Q-Max LNG vessels introduced by Qatargas in 2008 were a true step-change, these vessels are capable of transporting respectively 215,000 m3 and 265,000 m3 of LNG.

Shell provides ship management and maritime services to a fleet of 14 Q-Max vessels and 11 Q-Flex vessels owned by Qatargas' shipping company, Nakilat. The agreement covers a full range of services, including staff recruitment, training and operational management of all the vessels.

The developments in shipping follow a similar pattern to the developments in liquefaction, a continuous focus on economics and meeting ever more stringent environmental

Figure 2: The SS Methane Princess, the world's first purpose-built LNG carrier, approaching Canvey Island, UK

targets is absolutely key. Reducing fuel consumption is a main development area, driven both by cost saving goals and environmental concerns (less fuel consumed means less emissions). Shell actively participates in many industry-wide programmes to improve the environmental performance of its shipping operations. The Shell managed LNG carriers have been awarded Green Passports, which certify the environmental credentials of a vessel and are independently supplied by Lloyd's Register and Det Norske Veritas, but continuous improvement and development is needed.

The successful changeover from Heavy Fuel Oil (HFO) to Low Sulphur Marine Gas Oil (LSMGO) is such a development. To comply to the European Union Directive 2005/33/EC, which requires all ships at berth in EU ports to reduce sulphur emissions to 0.1 per cent, Shell undertook a detailed study, not only to find the best and safest way to comply with this legislation, but also to meet potential future emission requirements by the International Maritime Organisation (IMO). The evaluation concluded that from the main options evaluated, the switch-over to LSMGO would ensure full compliance while ensuring process safety and personal safety. The primary technical challenge was the application of LSMGO in marine boilers, including high pressure boilers on LNG carriers. In the end many adjustments to the system design and key areas were made to ensure a safe and automated switch-over to LSMGO, to enable the fleet of Shell managed ships to comply as required to the EU directive by 1st January 2010.

Safety has already been mentioned, the LNG shipping industry has a very good safety record with the safety performance of the Shell managed fleet consistently among the best in the industry. The shipping industry works closely together and shares many of their learnings, as for instance was done at the LNG16 conference in Algeria where the results of a joint investigation into the effects of fire on LNG carrier cargo containment systems was presented.

Conclusion

The world is changing rapidly, it is not sufficient to do what you have been doing, there is a continuous need to improve. Shell is active through the full LNG value chain, from gas well to burner tip. Our experience has taught us to be passionate about continuous innovation.

It will take technical excellence and continued innovation to push the boundaries of the gas and LNG supply envelope ever further, whilst keeping cost in check. Shell remains committed to work together with its partners and continue with its proud track record of innovation. ❑