Overcoming the challenges of scale and complexity

Innovation in LNG technology helps to unlock new resources

Demand for natural gas, the cleanest-burning hydrocarbon, continues to accelerate in key markets around the globe. However, the days of easy oil and gas are over and many large gas fields are located far from customers. Can the industry produce substantially more gas and deliver it to many more customers over much greater distances?

Liquefied natural gas (LNG), which has 600 times less volume than natural gas and can be transported from remote fields to key markets by ship, is expected to be a major part of the solution. Indeed, the International Energy Agency (IEA) estimates that the Organisation for Economic Co-operation and Development countries’ demand for LNG will double over the next five years.

The challenge, however, will be to keep up with this demand. Jeroen van der Veer, Chief Executive, Royal Dutch Shell plc, says that gas resources are relatively abundant, but he stresses that this does not mean they will be easy to develop: “We will increasingly have to find and develop supplies in harsher conditions such as Arctic seas and ultra-deep water; in deeper, more complex and tighter formations; and from gas contaminated with hydrogen sulphide and carbon dioxide.”

In other words, energy projects are already large and difficult, and they are becoming even more technologically challenging.

Take the multi-billion-dollar Sakhalin II project, for example. This centres on the development of some of the largest oil and gas reserves in the world and has involved the construction of Russia’s first LNG facility. But the project teams had to contend with sub-Arctic conditions, and the absence of infrastructure meant that everything had to be built from scratch.

The plant will have the capacity to produce 9.6 Mt/yr of LNG – 6% of the current global LNG capacity.

LNG was once a regional business with a strong Asia Pacific focus owing to that region’s distance from the world’s most important hydrocarbon resources. Now there are more inter-regional LNG sales. LNG accounted for about one-quarter of all the gas traded between regions in 2004; the IEA predicts that LNG will represent one-half of all inter-regional gas by 2030.

Long-term agreements have yielded the security of supply and demand that provide the foundation for future success and stability. Spot trading in LNG has grown in the fringes in recent years but is unlikely to constitute a major proportion of LNG sales. Both buyers and sellers much prefer “maximum security with a degree of flexibility” rather than “maximum flexibility with a degree of security.”

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Scale and innovation

The LNG business faces some distinct challenges: high capital and transport costs, complex technology and particular storage requirements. There is evidence that these are being overcome. For example, the Qalhat plant in Oman, which was completed in 2005, has one of the lowest unit costs of any liquefaction facility ever built. This facility has one process train, which has a capacity of 3.3 Mt/yr. It is a copy of the trains in the neighbouring Oman LNG plant and was the largest capacity LNG train in the world at the time of start-up.

Shell Global Solutions was responsible for the front-end design and engineering* activities for the Oman LNG facility and the later Qalhat plant. The optimised basic design reduced costs and helped to maximise the trains’ capacities.

Greg Lewin, President, Shell Global Solutions International BV, says that the organisation continues to improve its LNG technology. “We developed a new liquefaction process, called the double mixed-refrigerant process, to tackle the extreme weather conditions on Sakhalin Island. The process uses a mix of refrigerants in the first cooling stage, rather than just one, as was the convention. By varying the concentrations of the refrigerants, the system can compensate for the outside air temperature, which fluctuates from –25 to +25°C, over the seasons and maximise LNG production.”

Lewin adds that Shell Global Solutions is now developing the next generation of technology, the parallel mixed refrigerant process. Here, gas flows through two parallel liquefaction cycles preceded by a common pre-cooling cycle rather than the typical series of three successive cycles. “The parallel set-up boosts the maximum capacity of a single production unit to 8 Mt/yr, compared with the typical 5 Mt/yr for a conventional design,” he says. “It also improves reliability, since production can continue at 60% capacity if one of the parallel cycles shuts down.”

Nevertheless, prices for basic construction materials such as steel and concrete have soared. Equipment and contracting prices have also increased significantly and reflect the industry’s very high activity rates as well as inflation in regions of economic development.

Developers will continue to look for ways of reducing project costs. Gas now has to be delivered over much greater distances, and bigger ships should continue cutting the costs of this. Qatar has ordered six 265,000-m³ capacity LNG tankers – 75% bigger than the largest operating at the time of ordering.

The challenge for suppliers will be to continue bringing new capacity online when the market needs it in a world where the costs are rising relentlessly. LNG is a long-term business. It requires developers and operators to make long-term investments and commitments. The sector’s traditions of long-term partnerships of trust and sanctity of contract have led to its strength today. Maintaining this tradition is vital to LNG’s continuing success.
New infrastructure and production capacity are urgently needed to help address potential long-term supply/demand imbalances. Through further investment, LNG suppliers can contribute more to the energy security that will underpin global and regional economic growth.

Shell Global Solutions believes that high-capacity trains are the most economic when reserves are abundant and relatively easy to produce, assuming that the market can readily absorb large volumes in one go.

“The mandate of the LNG industry is to apply better technologies in larger, more-demanding, more-integrated projects, often in remote and sensitive locations,” says Lewin. “Shell has pioneered innovations in the LNG arena to extend the scope and scale of what an LNG plant can achieve, and it will continue to do so. Advances such as these will be vital if LNG is to continue to play a leading role in meeting the world’s developing energy needs.”

Improving LNG plant reliability and efficiency

“By using our operational expertise and fundamental understanding of the process, we have been able to develop new technologies to help our partners maximise production over the lifetime of their LNG plants. The automated cool-down technology is an example of this,” says Lewin.

The main cryogenic heat exchanger (MCHE) is the heart of an LNG plant and where liquefaction of the natural gas takes place. It consists of over 1,000 km of tubes contained in an aluminium shell. At start-up, the MCHE has to be cooled from ambient temperature to around –160°C.

The cooling procedure is complex and has always been a manual operation with operators controlling several processes simultaneously. During the execution of these tasks, other operational issues or a changeover between operator shifts can easily lead to an upset in the cooling process. In addition, the cooling-down process responds differently as it progresses.

“In some start-ups, we have seen the operational limits exceeded for 20 to 30% of the total cooling time,” says Lewin. “MCHE units typically have two to eight cool-downs a year. Exceeding the recommended limits will increase the risk of leaks from the tubes, which can cause unplanned shutdowns for repair work and, consequently, significant loss of revenue.”

The Shell automated cool-down tool enables more efficient cool-down and reduced flaring with fewer deviations outside the operational guidelines, and can be considered to be an autopilot that takes over certain manual actions.

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