INNOVATION AND PARTNERSHIPS IN GAS

John Gallagher
Royal Dutch Shell plc

Keywords: Shell, innovation, partnership, gas, LNG, GTL, FLNG, Sakhalin, Pearl, Prelude

INTRODUCTION: A GLOBAL ROLE FOR GAS

Population growth and rapid industrialisation are driving global energy demand. By the middle of this century we may be using double the amount of energy we do today. This surge in demand is linked to economic development and greater access to electricity and personal transport. For example, between 2010 and 2050, worldwide car ownership is expected to triple to around 2 billion.

As energy demand rises, there will be growing environmental stress and an increased emphasis on adopting a more sustainable energy system. Nations and companies will have to find more energy at a much-reduced cost to the environment. The early signs of a shift are evident in our increased focus on new energy sources, including wind, solar and other renewable energy sources. Despite advances in renewable energy technology, fossil fuels are likely to account for more than 60% of the global energy supply in 2050, with nuclear power making up less than 10%. So, a more sustainable energy system will not be composed entirely of renewable energy sources.

No single government or industry sector can offer a complete solution. The energy challenge is truly global. Success will depend on international co-operation, harnessing new technologies and making the most efficient use of existing resources. If we accept that fossil fuels will play a key role up to and beyond 2050, how will we meet surging global energy needs while addressing environmental challenges? Natural gas, the cleanest burning fossil fuel, will be a vital tool in our efforts to reconcile these issues and move towards a more sustainable energy mix.

The shift to gas is most significant in power generation. In many countries, coal still dominates, but natural gas is proving the most popular option where cleaner burning energy solutions are being sought. Governments and power-generation companies are choosing gas because it is abundant, affordable and more environmentally acceptable than coal. Displacing coal-fired power with natural gas is the fastest and cheapest route to CO2 emissions reductions in the global power sector over the next 20-plus years. The environmental benefits of natural gas-fired power are tangible, substantial and immediate.

As technology advances, so does the ability of energy companies to unlock the world's gas resources. Reliable access to extensive reserves is a vital consideration for nations that are seeking to maintain their energy security. According to the IEA, the technically available gas resources equal 250 years of current production.

How will the co-operation to meet the energy challenge work? How will it develop? It has to start with a common vision. In business terms, this means that partners must share similar business drivers and have a broadly similar attitude to the risks that are inherent in innovation. This shared vision must be supported at the highest levels within the partner organisations at project level and with governments.

Innovative natural gas solutions, including the development of new products and the opening of new markets, require collaboration on technical and commercial issues. This paper will focus on what Shell has learned from recent project successes.

PARTNERSHIPS FOR INNOVATION AND COMMERCIAL SUCCESS

In any innovative business partnership there is a range of fundamental success factors for project success. Partners must share similar value drivers and have a similar appetite for risk, for example in their willingness to develop new technology. The partners should also have complementary skills and strengths (for example, field operations in combination with product development), complementary market knowledge and the capacity to extend the supply chain.

In addition to these fundamental factors for success, administrative alignment is also essential for innovative partnerships. Agreement from all the partners is needed on the long-term vision, the expenditure level and the technology focus, all supported by a well-designed and very clear contract. The roles of owners and project management, both jointly and individually must be transparent and clear. The management team must have the necessary freedom to 'get on with the job' having the trust of the owners. Finally, but no less importantly, there must be a good working relationship within the management team that is based on open communication and trust. In addition there must be confidence and trust with other partners like NGOs, governments, financers, insurers, product buyers, contractors and the component supply community.

The gas industry is, by necessity, built on long-term partnerships. The investments required for infrastructure development, the time needed to develop processing and transportation systems, and the extended periods over which large gas projects operate require partners to take a long-term view.

Wherever projects may be, value-driven partnerships between national oil companies and international oil companies are key to producing hydrocarbons effectively, efficiently and responsibly. The most effective industry partnerships are vehicles for delivering innovation, technical excellence and commercial success. Technical challenges can often be overcome more efficiently by combining expertise from all partners, but it is vital that the partnership extends beyond technical co-operation. Energy projects are complex and can be undermined by poor management of financial or political risks, or by a lack of agreement between partners about their main value drivers.

Partnerships also must be able to adapt to changing economics and economic uncertainty. This uncertainty is illustrated by the high and volatile oil prices seen in recent years. By working together in a partnership based on trust and mutual respect, partners can share the risks and rewards on a project and adjust their priorities. This added flexibility may put them in a better position to withstand the worst effects of market forces.

SHELL PARTNERSHIPS ON MAJOR GAS PROJECTS

SAKHALIN 2

Sakhalin Island is an oil and gas production centre of global significance. Its offshore hydrocarbon resources are estimated at 45 Bbbl of oil equivalent.

Sakhalin Energy was established in 1994 to implement the Sakhalin 2 project under a production-sharing agreement. The shareholders are Gazprom, Royal Dutch Shell, Mitsui

and Mitsubishi. The project involved the development of two offshore oil and gas fields, Piltun-Astokhskoye (mainly oil) and Lunskoye (mainly gas), to produce crude oil and liquefied natural gas (LNG) for export. Sakhalin 2 has created a dedicated oil and gas infrastructure, including three offshore platforms, offshore pipelines, the onshore Trans-Sakhalin pipeline system, an onshore processing facility, an oil export terminal and Russia's first LNG plant. Running at full capacity, it adds 5% to the world's current LNG capacity and can meet almost 8% of Japan's gas needs and 5% of South Korea's.

In a part of the world where winter can last for up to 240 days, the planning and project delivery for Sakhalin 2 presented a host of technical and logistical challenges. The temperature at Sakhalin can vary by more than 45°C between the hottest summer and the coldest winter day. In anticipation of the extremes that would be encountered at Sakhalin 2, Shell developed a process technology to take advantage of the very cold winters. The LNG trains at the facility use a Shell-licensed double-mixed-refrigerant (DMR) process. This advanced technology was designed to provide maximum production efficiency during Sakhalin's cold winters and underpins an LNG production capacity of 9.6 Mt/y.

In December 2008, Sakhalin Energy started the year-round production and export of oil via a new oil export terminal in the south of Sakhalin on the shore of Aniva Bay. In January 2009, Sakhalin Energy started Russia's first offshore gas production from the Lunskoye-A platform. The start-up of the facility, from pressurised pipeline gas to first LNG cargo, was accomplished in mid-winter within six weeks.

The successful start-up and continuing operations of the LNG plant lay the foundation for Russia to become a leading energy exporter to the highly competitive energy markets of Asia Pacific.

Image 1 – LNG carrier loading at Sakhalin 2's Prigorodnoye Production Complex

How the Sakhalin 2 partnership worked
The key challenges for the partners involved in the programme at Sakhalin were to deliver a successful and innovative engineering solution under extreme conditions and to ensure that all the operations met the relevant environmental protection targets. Meeting these challenges was a team effort. Success was impossible without the commitment and support of the shareholders; Shell Global Solutions, as technical adviser and process licensor; Chiyoda, as main EPC contractor; the many subcontractors and equipment vendors; and the Sakhalin Energy staff and their professionalism and commitment.

Gazprom joined the Sakhalin 2 consortium in 2007 and has made a positive contribution to project delivery. The project has also greatly benefited from Gazprom's world-class expertise in running gas development operations, and Sakhalin 2 is now a huge and growing commercial and technical success for all the partners.

Similar value drivers and view on innovation risks
Gazprom, Shell, Mitsui and Mitsubishi share some of the most important value drivers: stable and motivated management teams, effective operating systems, solid and diversified customer bases, realistic growth strategies and effective financial controls. Shell and its partners all place innovation at the centre of their values and business plans. Only companies that take a long view and are confident in their ability to innovate and deliver in very demanding conditions would have chosen to become involved in Sakhalin 2.

Complementary skills and market knowledge
Shell's key contributions to the success of Sakhalin 2 were its long and unrivalled expertise in LNG projects, planning and project delivery capabilities and expertise in process start-up. These skills were combined with Gazprom expertise in running gas development operations and onshore facilities and strong commitments from Mitsui and Mitsubishi as reputable LNG traders. Virtually all the gas from Sakhalin 2 has now been sold under long-term contracts to customers markets where the partners are very active and well-known. The integration of decision-making and business planning required by this project has only been possible because each of the partners is committed to open and effective communication and to sharing supply chain management responsibilities.

Capacity to extend the supply chain
The partnership formed for Sakhalin 2 has brought together four leading companies each with their own supply chains and preferred methods for dealing with suppliers and subcontractors. There is potential to expand the project through the Area of Mutual Interest signed with Gazprom in April 2007, which provides opportunities for growth, and enhances the prospects for Sakhalin-2 becoming a regional oil and LNG hub.

THE PEARL GTL PLANT

In addition to natural gas liquefaction, another innovative development in the global gas market is gas to liquids (GTL) technology. The GTL process produces synthesis gas, a mixture of hydrogen and carbon monoxide, from natural gas, which is then catalytically converted into liquid hydrocarbon products. Shell has a long-standing commitment to GTL technology, having developed the production process more than 30 years ago.

The Pearl GTL facility in Qatar, a joint development between Qatar Petroleum and Shell, is a fully integrated upstream–downstream project on a global scale. It has been designed to capture the full value chain, from offshore development through onshore gas processing to the refining of finished products and global distribution. When fully operational, the Pearl GTL plant will have the capacity to produce 140,000 bbl/d of high-quality GTL products, including gas oil, naphtha, kerosene, normal paraffin and lubricants base oils. This will help to meet

increasing demand for high-quality liquid hydrocarbons. The plant will also produce 120,000 bbl/d of natural gas liquids (liquefied petroleum gas and condensate) and ethane.

The plant will process gas from the world's largest single non-associated gas field, the North Field, which stretches from Qatar's coast out into the Gulf. The North Field contains more than 900 Tcf of gas, about 15% of worldwide gas resources. The Pearl GTL project illustrates how national and international oil companies can work together when they share common goals and business drivers and how these partnerships can reshape energy use.

Image 2 – Pearl GTL liquid processing unit

The scale of the Pearl GTL project and its desert location provided some stern challenges. It took one million hours, the equivalent of 500 years of full-time work for one person, to complete the conceptual design of the world's largest GTL plant, and 500 million man hours to build it. The construction phase lasted four years and tens of thousands of workers were trained to make sure all the sections of the plant were well built and would start up smoothly. In March 2011, the Pearl plant started receiving gas from the North field and production from the first GTL train started in June 2011. The plant was officially inaugurated by the HH the Emir of Qatar in November 2011.

The Pearl GTL project has combined Shell's technology and operational experience to deliver the facility on time and to achieve excellent performance from start-up. Bringing together teams and individuals with different skills and backgrounds is not always easy, but for the Pearl GTL project, the vision shared by the partner companies kept the project running smoothly.

How the Pearl GTL partnership worked

The Pearl GTL project is the result of a remarkable partnership between Qatar Petroleum and Shell. It marks the culmination of five years of project delivery, and nearly 40 years of GTL technology development. Shell's contribution to the success of Pearl GTL has focused

on innovation, technology and project delivery capabilities. The project was also made possible by the enormous support received from Qatar Petroleum and the people of Qatar during development and execution. Several factors come to mind. First, perhaps, is the quality of the resource - the North Field - being developed. Second, Ras Laffan Industrial City enables the efficient construction and operations of large petro(chemical) complexes and provides common facilities such as tankage, a harbour and emergency response facilities and services.

Similar value drivers and view on innovation risks

Both Qatar Petroleum and Shell are committed to developing hydrocarbon resources in effective partnerships while working to protect the natural environment. These ideas have been at the heart of the collaborative process for the Pearl GTL facility.

Applying technology at this scale and investing so heavily in a single project does not happen everywhere in the world; it needs an enabling environment and that is what Qatar has to offer. The country is blessed by abundant gas resources, strong leadership, fast decision making and an absolute drive to deliver transparency in all business dealings. In addition, Qatar Petroleum acts as a partner with the fundamental belief that working together for success, where both sides win, is the right approach.

Qatar Petroleum, like Shell, has a strong track record of applying new technology in its field operations. This willingness to develop and apply the best technology is based on a shared attitude to technical innovation and a determination to achieve unparalleled standards of quality and service. The technology that lies at the heart of the Pearl GTL plant is the Shell Middle Distillate Synthesis (SMDS) process. The process was applied and proved on a commercial scale at the 14,700-bbl/d Bintulu GTL plant in Malaysia, and the experience gained there helped to improve the chemical catalysts that are integral to the SMDS process.

Complementary skills

Qatar Petroleum is responsible for all phases of the oil and gas industry in Qatar. The principal activities of the company, its subsidiaries and joint ventures include exploration, drilling and production operations, transport, storage, marketing and the sale of crude oil, natural gas liquids, LNG, GTL products, refined products, petrochemicals and fertilisers.

The country has also created excellent infrastructure and services at Ras Laffan Industrial City to support projects and operations. The project built a material offloading quay to import two million freight tonnes of equipment and material.

Shell's expertise in innovation, technology and project delivery provided a perfect balance of skills and capabilities on the Pearl GTL project. In terms of basic technology, Pearl GTL is based on proven, proprietary Shell GTL technology. Shell has spent nearly 40 years researching GTL technology, filing 3,500 patents in every step of the process, and has experience since 1993 operating the commercial-scale GTL plant at Bintulu and selling GTL products worldwide.

Complementary market knowledge

Qatar's profile as a leading national oil company with operations focused in Qatar and an excellent understanding of the Middle East region are complemented by the experience that Shell can draw on from its operations elsewhere in the world. This powerful combination of local expertise and worldwide experience will bring Pearl GTL products to a wide range of customers in a truly global market.

There are different offtake arrangements for the different products. As the global market share leader in finished lubricants, Shell will leverage its downstream trading and marketing

capabilities to access the 'highly liquid' global commodity markets and maximize the value of GTL products for Qatar and Shell.

FLOATING LNG

The industry faces a crucial infrastructure issue with meeting global energy demand. Around the world, new oil and gas discoveries are, on average, smaller and in increasingly remote and inaccessible locations. The cost of linking these new discoveries to existing infrastructure poses a problem for many potential developments. It was this challenge that led Shell to investigate a radical new approach to offshore gas development. The floating LNG (FLNG) concept will enable gas field operators to liquefy natural gas at sea on floating facilities instead of building pipelines to the coast and liquefaction plants ashore. This approach will open up offshore gas resources that were previously considered too small, remote or technically challenging for commercial development.

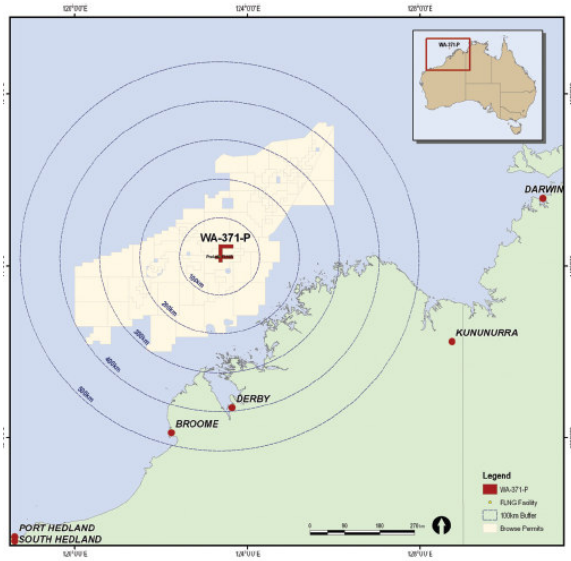

Image 3 – location of Prelude field

The FLNG technology will have a profound effect on the way gas fields are assessed and developed. It will be possible for LNG projects to go ahead more quickly and with less certainty about the volume of the gas resources to be tapped. It can also help to develop offshore resources earlier and/or faster, using FLNG as a monetization route for a single gas field or a cluster of smaller fields. Floating LNG technology is not just for remote resources far away from onshore infrastructure, it can truly extend our exploration reach. Part of the reason behind this flexibility is that an FLNG facility can be moved and reused elsewhere at the end of a field's life.

The up-front investment of time and resources needed to develop the FLNG concept and to turn it into a viable field development option has required long-term vision, a high and sustained level of expenditure and a firm focus on technology and engineering innovations from each of the partner companies involved.

The first of these facilities will be the *Prelude* FLNG facility, which will enter service offshore Australia. At 488-m long and 74-m wide and with a water displacement of around 600,000 tonnes, it will be the largest floating offshore facility in the world. This vast and complex structure required more than 1.6 million hours for the front-end engineering and design phase of development.

Prelude FLNG will be built at Samsung Heavy Industries at the Geoje Island shipyards in South Korea. After construction, the facility will be towed to its operating location approximately 475 km north-northeast of Broome, Western Australia. There, the facility will be moored and hooked up to the undersea infrastructure; then the integrated production system will be commissioned.

Image 4 – Artist's impression of the Shell FLNG facility

The LNG, liquefied petroleum gas and condensate that the *Prelude* FLNG facility produces will be stored in tanks in the hull of the facility before transfer to carriers. These products will help to meet the growing demand for natural gas.

For Shell, FLNG technology will complement onshore LNG production and will provide governments, partners and customers with a wider range of options to meet energy demands and environmental targets. In tackling this project, Shell drew on experience from one end of the gas value chain to the other. Combining expertise in deepwater projects, floating production facilities, gas treatment and liquefaction, LNG carriers, marine operations and LNG marketing and trading has been crucial to the FLNG concept.

Engineering and commercial expertise coupled with a willingness to innovate have been vital to making FLNG technology a reality. Building an FLNG facility is much more than placing a liquefaction plant on a barge, and it has only been possible because of the close working relationship and aligned business objectives of the companies working on the project, and a collaborative relationship with stakeholders in Australia.

How the FLNG partnership is working

Shell is committed to having a positive impact in the countries in which it operates, and partnership goes beyond an agreement with formal shareholder partners. It also encapsulates an attitude and way of working with governments, contractor partners and other key stakeholders.

To translate the FLNG concept into reality, Shell found contractor partners that could provide key engineering skills. In 2009, Shell signed an agreement with a consortium comprising Technip and Samsung Heavy Industries for the design, construction and installation of multiple FLNG facilities. In May 2011, the final investment decision was taken and the Technip Samsung Consortium was given the notice to proceed with the construction of the

Prelude FLNG facility. For an innovative project on this scale, choosing the right partners was vital. As three recognised leaders in their respective fields Shell, Technip and Samsung bring together a wealth of complementary skills, reputations for innovative thinking in technology development and a shared commitment to business excellence.

The Prelude FLNG project will also contribute to the Australian economy through tax revenues, creating hundreds of jobs and providing opportunities for Australian businesses. Working with the Australian government to ensure that the project meets the country's aspirations has been essential.

Shell's capability to deliver FLNG opens new roads to monetize gas fields that otherwise could remain stranded for a long time. For example Shell has been chosen as the strategic partner to develop the massive Abadi field in Indonesia.

Similar value drivers and view on innovation risks

Shell believes that Prelude, the world's first FLNG project, will define the future for offshore LNG development. Although it is not a large LNG development, the Australian benefits of the Prelude FLNG project are substantial. Because of its lower development costs, FLNG allows the development of gas resources that otherwise would stay in the ground. The project will create about 350 direct jobs and 650 indirect jobs, and will provide billions of dollars in tax revenues in addition to the capital and operating expenditure expected to be invested in Australia. Shell, Technip and Samsung are all innovative companies with engineering staff who are accustomed to pushing the limits of current systems and to developing new techniques and technical solutions.

Complementary skills

Floating LNG technology combines Shell's commercial capabilities, LNG, offshore, deepwater and marine technology and a proven ability to deliver mega projects. Shell's expertise is complemented by Technip's in depth knowledge of project management, engineering and construction for the oil and gas industry, and core activities subsea, offshore and onshore. In addition, Samsung has extensive experience of constructing LNG carriers and offshore projects. The Samsung Heavy Industries' shipyard in Geoje, Korea is one of the largest shipyards in the world, with one of only a handful of dry docks in the world able to accommodate the construction of a facility of the Shell FLNG facility's size.

Within Australia, Perth will also be established as a centre for operational excellence in FLNG technology and onshore support for the FLNG facility will be primarily provided out of Darwin with some specialist support provided out of Broome and Perth. In preparing to operate the facility, employees will receive extensive training in Australia and at other Shell LNG locations around the world, ensuring that Australians will be some of the first Floating LNG technology experts in the world.

Capacity to extend the supply chain

The development of the Prelude FLNG facility involves contributions from a huge range of subcontracting companies. The experience and track record that Technip, Samsung Heavy Industries and Shell have in contracting, procurement and managing supply chains are helping to keep this complex project on track and cost competitive.

Shell is also proactively seeking to provide full, fair and reasonable opportunity for Australian industries to participate in the Prelude FLNG project. Shell is working with the Industry Capability Network and the Project Connect website to maximise opportunities for Australian businesses.

STRONGER PARTNERSHIPS FOR AN UNCERTAIN WORLD

Economic uncertainty and changes in regulatory frameworks can cause a rapidly changing and often unpredictable business landscape. Major gas projects of the kind described in this paper require large capital investments and substantial technical resources to be applied over an extended time period.

For projects that take years from concept to start-up, the economic conditions that apply at the start of operations may be very different from those at the outset. Consequently, projects must be robust and well planned so that they can adapt to changes in the commercial climate. Effective, mutually beneficial partnerships help all of the companies involved to respond to changing conditions and shifting project priorities and to minimise the financial risks that are a part of any major project.

Successful partnerships may be more difficult to establish and maintain in tough times when project economics are tight. Entering into a partnership means sharing risk and responsibility, so companies must choose their partners with care. But, if a project is well defined and has drivers and objectives agreed by all parties, there are many reasons to embrace a partnership that extends shared expertise and capability.

In the future, partnerships are likely to be even stronger than they are now. For example, Shell anticipates closer partnerships with national oil companies. The key skills that national oil companies can draw on, along with their investment in research and development and resource stewardship, will be complemented by the scientific, technical and management expertise available within Shell.

Meeting the macro-economic and global energy demand challenges will require all the combined technical expertise and financial muscle of the national and international oil companies. These are the lasting, value-driven and mutually beneficial partnerships that enable nations and companies to generate and share growth throughout the economic cycle. These are the partnerships that have delivered the most success in the past. And there is every reason to believe that they will continue to do so in the future.

Applying what it has learned in successful projects leads Shell to believe that there is scope for more and stronger partnerships in future gas developments. The collaborative successes highlighted in this paper show that there is no project so large or complex that it cannot be achieved effectively and efficiently by working with others.

REFERENCES

1. “The Golden Age of Gas”, International Energy Agency
2. “World Energy Outlook 2011”, International Energy Agency
3. “Sakhalin Energy’s initial operating experience from simulation to reality: Making the DMR process work”, Verburg R et al., LNG16, Oran, 2010.
4. "Pearl GTL: People delivering a world-scale project”, Brown, A., Gastech, Amsterdam, the Netherlands, March 2011.
5. “Innovation and Technology creating Optionality towards Optimisation of Value: from FLNG to GTL”, Kretzers, R., World Petroleum Conference, Doha, December 2011.
6. “FLNG: designed for high availability”, Pek, B., World Petroleum Conference, Doha, December 2011.
7. “Partnering in the Abadi Project, the Masela Block, Arafura Sea, Indonesia”, INPEX Corporation Press Release, 22 July 2011.