Natural gas: a bridge to the future of global energy

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A glance at energy demand projections (Fig. 1) shows a near-doubling over the 40-year period from 1990 to 2030.[1] This goes hand-in-hand with projections for a 55 per cent rise in population[2], a 150 per cent increase in the number of passenger vehicles on the road[3], and a doubling of the number of commercial jets in service[4].

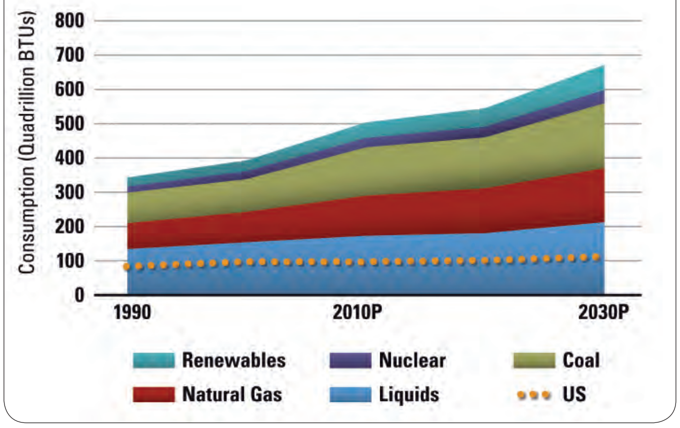
The unavoidable conclusion is that this increasing demand will drive up energy costs as resources become more scarce over time. And this means we have to continue to find alternatives to the energy sources that drove the phenomenal growth of the 20th century – coal and liquid hydrocarbons.

A bridge to future renewables?

The search for alternatives has focused mainly on renewable sources. But something has changed in the last decade that alters all the calculations for the future: the worldwide availability of natural gas, especially shale gas.

If we look at energy sources, liquids are expected to shrink as a percentage of total demand, and nuclear energy is expected to stay flat. Coal, renewables and natural gas will grow. In fact, renewable use could grow at the highest rate over this period. Today, renewables account for some 7.4 per cent of US energy consumption, most of which is hydroelectric power. If, as projected, that figure is 10 per cent in 2030, this suggests, in electricity generation alone, renewables will grow from 300 billion KwH to almost 800 billion KwH. That is the equivalent of more than 50 coal-fired power plants[5]. But how realistic is it to depend on renewable sources to meet this growing demand over the next 20 years? Despite the strong desire by some, the limitations of renewables will not allow this to happen that quickly.

Fig. 1 – Global energy demand by source



Note that, by 2030, global energy demand is forecast to be double what it was in 1990

Wind, solar and geothermal energy – which generate only electrical energy – have limitations that will prevent their rapid scaling up to fill the gap. Wind power requires a very large footprint to operate, and the wind does not always blow. Solar power is very costly – three to five times more costly than any other source. Geothermal energy is economically and technically attractive, but it is very location-specific and currently only practical where the tectonic plates meet. Hydroelectric power has similar geographic constraints. And, as they exist today, renewables generate only electrical energy with severe storage limitations and very limited application for powering transportation.

The virtues of natural gas

Natural gas, on the other hand, has properties that help it overcome the limitations of renewables. It has a mature infrastructure in many parts of the world – pipelines, delivery points and storage facilities. And because gas energy is stored in chemical form, it can be physically relocated to meet sudden shifts in demand. Plus, it is an exceptionally versatile fuel source, offering direct heat, power generation and even transportation. More than 11 million[6] natural-gas vehicles are in service worldwide; the technology is proven and commercialised. Also, natural gas produces 29 per cent less carbon dioxide than oil, and 44 per cent less than coal[7].

Best of all, natural gas is abundant. Even though gas production has climbed in the US in recent years, new technologies and our accumulated experience are allowing us to tap greater reserves. Reserve estimates are growing along with increased consumption.

Reserve estimates have increased by thousands of trillion cubic feet (TCF) and some experts are predicting that shale will provide up to 50 per cent of US natural gas by 2030[8]. The gas is there in the shale plays, and the world is anxious to have it. What more is there to say? It turns out that economic shale gas production is a daunting challenge.

Shale is the most common sediment on Earth, but it is not widely understood. Composition varies widely from one shale play to the next. Each one offers its own set of unique technical completion and production challenges, resulting in a special learning curve for each shale formation.

The keys to unlocking the shales, and, by extension, using natural gas as a bridge fuel to the future of renewable energy, lie in improved understanding of the formation, using more cost-effective technologies to maximise reservoir value, and integrating and optimising the shale gas asset development process. The following discussion touches on some the major inter-related elements.

Shale gas development: Wellbore placement, stimulation and completion

Advances in horizontal-well technology have been decisive in making shale development feasible. Drilling and completing horizontal wellbores exposes much more of the shale formation to stimulation and production.

The first technical challenge is to optimise the wellbore placement, which means navigating through these complex reservoirs with greater precision. A breakthrough in the drilling process is the logging-while-drilling Azimuthal Focused Resistivity Sensor that acquires data in 32 discrete directions around the tool at 14 different depths of investigation – all up to 18 feet into the formation. This information gives early warning of changing lithology and geologic structure. The ability to detect contrasting formations deep into the reservoir provides the confidence necessary to drill faster without the risk of leaving the payzone.

> **There is no doubt that significant shale gas reserves exist in every part of the world and it is reasonable to predict that reserve estimates in these areas will increase over time as exploration begins**

Once the wellbore is drilled, the extremely low permeability of the surrounding shale formation means that economic production is impossible without stimulation, typically hydraulic fracturing. This operation can account for as much as 50 per cent of the cost of the well. Maximising the return on this investment, like the drilling process, depends on understanding what is happening in the formation and designing the treatment accordingly.

In hydraulic fracturing, one of the important technologies is microseismic fracture mapping. Installing geophones in an offset well enables monitoring the microseisms that occur around the wellbore when the hydraulic fracture process causes the reservoir to deform. This data can be displayed in real time, allowing the stimulation engineers to optimise the treatment design.

Using the seismic curtain as a background, the monitoring software displays the microseisms as coloured spheres (Fig. 2). The relative size of the spheres can even be graded to reflect the magnitude of the microseismic activity. The well trajectory and the top and bottom of the reservoir can be represented as coloured lines. Green spheres can show activity within the bed boundaries, and blue spheres illustrate the activity outside the payzone. When treatment outside the payzone is detected, the engineer can either shut down the treatment early, saving material for future stages, or lower the treatment flow rate.

The purpose of the treatment is to maximise the stimulated reservoir volume (SRV), which correlates very closely to improved production. Achieving maximum SRV is dependent on the ability to see, in real time, what is happening in the formation and to modify the treatment immediately rather than to simply assess the treatment after the operation.

For example, Fig. 3 shows a horizontal well with multiple fracture stages, each represented by different coloured spheres. The spheres are matched with rectangular blocks that are derived from the spatial distribution of the microseismic activity. These blocks represent the stimulated reservoir volume. The information acquired by this treatment can be used to adjust the treatment parameters, such as pumping rate, fluid properties, sand amounts, treatment volumes and spacing along the lateral to help optimise future treatments.

The need to drive down well costs and make shale gas basins economically viable has also led to the construction of horizontal wells with more than 20 frac stages. This is being done with completion technologies that are so efficient that they have helped reduce well completion time by 30-50 per cent.

There are a variety of completion solutions available for shale gas reservoirs; optimising the completion design depends on the specific conditions. For example: Is cement needed to support the formation while providing zonal isolation or can the formation accept an openhole design and compartmentalisation through the use of hydraulic set or swellable packer technology? Is the optimum stimulation a cluster of entry points calling

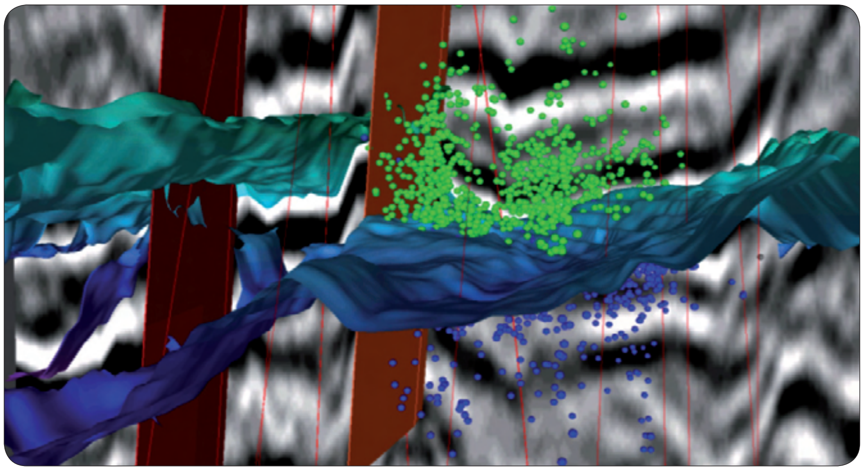


Fig. 2 – Microseismic fracture monitoring changes the game by enabling real-time monitoring of fracture creation and propagation

for a perforated design, or a single entry point with sleeve technology? A range of options is needed to find the one best suited to the reservoir and the surface conditions.

Sleeve technology, in particular, deserves a closer look here. Conventional plug-and-perforate completion methods require intervention for each stage, typically allowing only one or two zones to be stimulated in a 12-hour period. New methods allow as many as nine zones to be completed in 12 hours. Halliburton's current record is six zones in three hours and 45 minutes. This jump in efficiency comes from using a system of sliding sleeves that enable fracture placement control by consecutively opening the sleeves for sequential treatment of each zone. This technology also enables economical access to the areas of the reservoir that might otherwise be considered marginal and, therefore, left uncompleted.

Using these technologies has allowed an operator in one of the major US shale gas basins to reduce drilling and completion time per well to 32 days. At that rate, an operator rig can drill and complete 10 wells per year instead of the three wells per year with conventional methods.

Natural gas development is environmentally sound

Our industry understands our obligation to develop shale gas assets in an environmentally sound manner and to continually improve our environmental efficiency in the same way we are improving our economic efficiency. We are focusing our efforts on three important areas.

First is the responsible use and reuse of water. Across the industry, considerable effort is being made to develop solutions for the treatment of both produced water and fracture-treatment flowback water. Many of us in the industry believe that innovations such as electrocoagulation will help deliver solutions. Electrocoagulation technology offers an environmentally friendly water treatment option that is not based on chemicals. The technology involves applying an electric charge to a fluid to help remove heavy metals, suspended solids, organic material and many other contaminants.

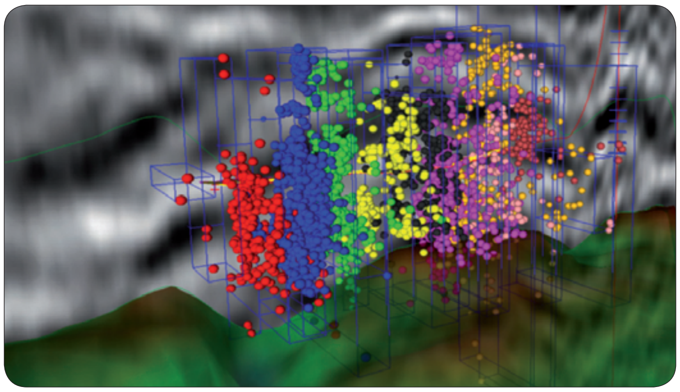


Fig. 3 – Microseismic monitoring can help optimised fracturing results by enabling the calculation of stimulated reservoir volume (SRV)

Second is reducing the overall environmental impact of our operations. This extends from using pad drilling and extended-reach wells, to reducing vehicle miles and the amount of equipment on location, to the possibility of using natural gas to fuel the hydraulic fracturing equipment.

Third is a migration to green chemistry for reservoir stimulation through fracturing treatments. We have succeeded in eliminating the requirement for biocides in fracturing fluids by adopting ultraviolet-light technology, which is familiar from domestic uses such as sterilising tooth brushes.

We have also developed a chemistry scoring index to assign a numeric score to the environmental, physical and health impact of chemistry used in well stimulation. This approach can provide a solid basis for choosing more environmentally focused chemistry while balancing the choices with chemistry performance and overall well-completion costs. This will enable operators to make an informed decision and will assist in ongoing efforts to develop products with improved health, safety and environmental performance.

Bridge to the future

Shale gas development is rapidly advancing in North America, as operators and service companies apply new technologies and assimilate the lessons of experience. So, should we consider shale gas the bridge to an alternative energy future? To answer this question, perhaps we should consider the views of an expert. Theodore Levitt, Professor Emeritus of Marketing at Harvard, in an article entitled *Marketing Myopia*, suggested that the oil and gas industry may find itself in much the same position of retrospective glory as that of today's US railroad industry[9].

This article was published 50 years ago. What Professor Levitt failed to consider was the impact that technical innovation would have in making oil and gas the most cost-competitive energy source. Even today, after half a century of waiting for that prediction to come true, we may discover that this bridge could take another 50 years to cross. ❏

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1 EIA International Energy Outlook, 2009
2 US Census Bureau Database
3 Vehicle Ownership and Income Growth, Worldwide: 1960-2030 (p 20)
4 Boeing Long Term Outlook
5 Annual Energy Outlook - http://www.eia.doe.gov/oiaf/aeo/index.html
6 http://www.iangv.org/tools-resources/statistics.html
7 http://www.eia.doe.gov/cneaf/electricity/epa/epata3.html
8 http://www.halliburton.com/ps/default.aspx?navid=1613&pageid=3892
Information courtesy of Society of Petroleum Engineers (SPE) 68755 "Some Predictions of Possible Unconventional Hydrocarbons Availability Until 2100," Yuko Kawata, Kazuo Fujita, The University of Tokyo
9 Theodore Levitt, "Marketing Myopia", Harvard Business Review, Vol 48, no 5, (Sep-Oct 1970). Reprint of article published in 1960.