

Moving Australian Coalbed Methane Reserves Into Production Through Reservoir Simulation

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The Growth of CBM

Australia is a centre for Coalbed Methane (CBM) or Coal Seam Gas (CSG) with almost 40% of all global CBM reserves located in China, Australia, India and Indonesia.

Today, Australia has an estimated 198 billion cubic meters (Bcm) of CBM resources, according to a 2012 article by Hart's E&P, and Queensland has as much as A\$50 B worth of CBM projects in progress. These include the Surat Basin, which has been producing since 2006, and developments in the Bowen Basin that covers 160,000 km² of central Queensland and has produced the majority of CBM to date.

As the focus on CBM has increased, however, so has the quest for more effective technologies to help bring the reserves in such tight reservoirs into production. One such technology is reservoir simulation.

Reservoir Simulation and CBM Challenges

Reservoir simulation has undergone huge changes over the last few years.

The rise in computer power, such as 64-bit multi core chip clusters, parallel processing and computer-led automation, has ensured that reservoir simulation is contributing to faster decisions and a greater ability to determine the important 'what-if' scenarios relating to operators' reservoirs. Today, multi-million cell reservoir simulation models are the norm.

In addition, history matching technologies have also seen dramatic changes. Manual history matching has been replaced by robust and automated algorithms that allow the reservoir engineer to focus on developing a clearer understanding of reservoir mechanisms and their relative impact on production behaviour and creating simulation models that are fully consistent with their underlying geological interpretation.

It is against this backdrop that reservoir simulation has the potential to play a key role today in tight reservoirs and moving CBM reserves into production. CBM reservoirs today, however, come with a number of simulation and production challenges.

Firstly, there is the geological complexity of many CBM reserves represented by the often tighter and thinner coal seams that require more sophisticated drilling and completion techniques and irregular well trajectories. CBM is further characterised by a higher number of wells, shallower drilling and low-pressure extraction, requiring highly flexible, fast and accurate simulation programmes. A clear description of CBM well trajectories, for example, is often a vital input to simulation.

It is also important that any CBM reservoir simulation package is flexible and can incorporate individual variables into the simulation process. CBM simulation, for example, requires gas content data values at initial pressure, historical pressures, adsorption isotherms, and parameters to estimate the changes in absolute permeability. It is only through incorporating these variables that more accurate reservoir predictions can be generated.

Furthermore, horizontal and multilateral wells with different well trajectories must be incorporated into the model with the shrinking and swelling of the coal matrix (often through EOR techniques) also needing to be simulated.

As a result, modern full field, full physics simulator programmes that can be optimised for very large models have been developed, that offer black oil, compositional and thermal options.

Such programmes can simulate a wide range of physical processes such as black oil, compositional, dual porosity, steam, coal bed methane and polymer injection within the one programme and incorporate a wide variety of different variables into the simulation runs. The result when simulating CBM reservoirs is the ability to generate information on multi-well developments, identify the value of hydraulic fracture treatments, and optimise drilling and production programmes to name just a few benefits.

Case Study of Norwest in the Williston Basin

Norwest, a North American consulting firm to the energy, mining, and natural resources sectors, has extensive experience in CBM.

The company has experience in international CBM projects in Australia, Western Siberia, Kazakhstan, Italy, Southeast Asia, China, Chile and Colombia.

In this particular case, Norwest needed to optimise recovery on behalf of its client from the Williston Basin, a large sedimentary basin with significant CBM reserves that spans eastern Montana, western North and South Dakota and southern Saskatchewan.

In this case, Norwest's client did not have the expertise and manpower to embark on a full scale CBM modelling simulation. "Some of our clients don't have the expertise to do CBM modelling or large-scale simulation," said John Campanella, Senior Reservoir Engineer at Norwest at the time. "Others have the ability, but their people are spread too thin. They come to us to help get things moving."

The field in question was discovered in the early 1990s and was developed through open-hole completions in mile-long horizontal wells on 640-acre spacing. Production peaked in 1998 and has since declined.

Addressing Key Field Challenges

In the spring of 2002, Norwest began working on a full-field simulation project for the basin. Norwest's client needed a reliable full-field simulation model to optimise a high-pressure air injection and horizontal infill drilling programme for a tight reservoir within the basin.

One of the key challenges in the field, however, was that decline curve techniques could not accurately predict the oil rate response during transient periods in which new wells were drilled and producers converted to injectors. The relatively complex development and investment strategy also called for numerical modelling.

It was also felt that air would sweep the reservoir more efficiently than water and at a lower cost than CO₂. Norwest therefore needed to develop a cost effective, reliable full-field simulation model from which a high-pressure air injection and horizontal infill drilling programme could be optimised.

The Simulation Results

Nine years of production history and air injection information from a nearby field were used to calibrate the simulation model and achieve the history match. Working iteratively with the client to clarify the reservoir geology and tweaking the model to account for water lost into the formation during drilling (not otherwise factored into historical water and oil production), Norwest was able to achieve an excellent history match.

The model was tuned and validated to reflect drilling and conversion activity through the autumn of 2004, including 21 months of high-pressure air injection. Then, 12 months later, measured water and oil production rates were compared with the forecast. The model was then used to optimise the timing and sequence of infill drilling and the conversion of wells to air injection.

"The predictions and actuals matched almost exactly," said Campanella. "We're pretty proud of that, especially because it was during a huge transient phase when things were changing rapidly. I think it shows what an engineer can accomplish by properly using an effective simulation tool."

The predicted production and injection forecasts (see figures 1 and 2) matched the actuals and, based on the new production programme, field recovery is expected to more than double.

Since 2005, three drilling rigs have been active in the field, and new infill wells drilled on 160-acre spacing. Whereas estimated primary recovery was originally only between eight and 10% of original oil in place, now the client's company is predicting recovery of 24%. All field development plans that included more

than 125 horizontal wells and extensions by 2009, were driven by the results of reservoir simulation.

Furthermore, in addition to high-pressure air injection, the client is also investigating the possibility of a hybrid air and water injection programme to further improve recovery and reduce operating expenses. The company is also using what it learned in this project to set up simulation models for two older fields nearby, in order to evaluate proper well spacing and plan infill drilling in the next year or so.

Lessons for Australian producers

So what lessons can we take from this North American case study and apply to Australian producers?

Firstly, there is the importance of reservoir simulation when it comes to CBM reservoirs.

Campanella commented: "A lot of companies involved in CBM don't use reservoir simulation which often is a big mistake. We see tremendous losses in productivity, especially when companies drill horizontal CBM wells without simulation. Some just poke a lot of holes in the ground and hope and either they drill more wells than they need to, wasting money unnecessarily, or they sit on unproductive areas pumping water for way too long because they don't understand what's going on."

CBM today is a very complex play where operators need to lower the water pressure so gas will desorb from the coal. By plugging the gas content and absorption isotherm into a reservoir simulator along with historical information on pressures, operators can find out exactly how to get

gas out of the ground, how fast they can produce it and what their peaks will look like. Only reservoir simulation provides this information to the operator.

Secondly, there is the importance of accessibility.

"Personally," said Campanella, "I think reservoir simulation should be brought down to every engineer's desktop. We need to push simulation out of the back room and into the mainstream where people can use it on a daily basis. In addition to the big 3D projects, there are a lot of existing fields where simulation could be applied, but too often it gets skipped."

Finally, although not directly relating to the Norwest case study, there is the need for multi-component simulation in CBM reservoirs.

Enhanced CBM simulation today, for example, involves the tracking of a number of gases, such as carbon dioxide and nitrogen, with a compositional model required to track the individual components as well as accounting for the adsorption/desorption of these components. Simulation programmes that have the ability to track multiple components in the gas stream are required.

A Major Future Impact

There's no doubt that CBM reservoirs are likely to have a major future impact on oil and gas production in Australia for many years to come – ushering in perhaps as big a revolution as with shale gas in North America.

As operators look to introduce ever greater efficiencies and move reserves into production, it's clear that reservoir simulation will have a vital role to play. ■

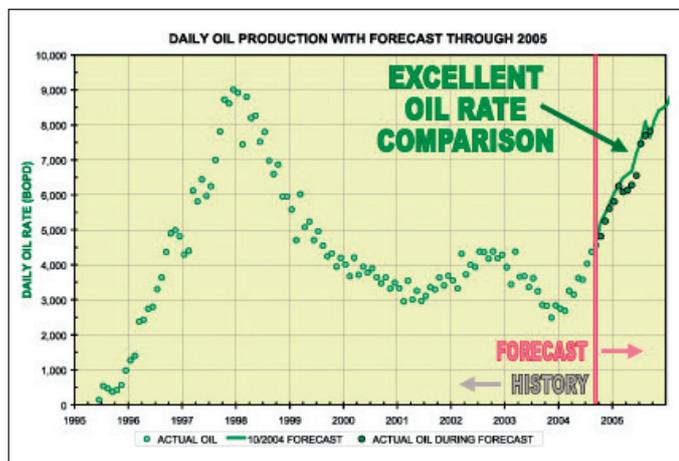


Fig. 1.

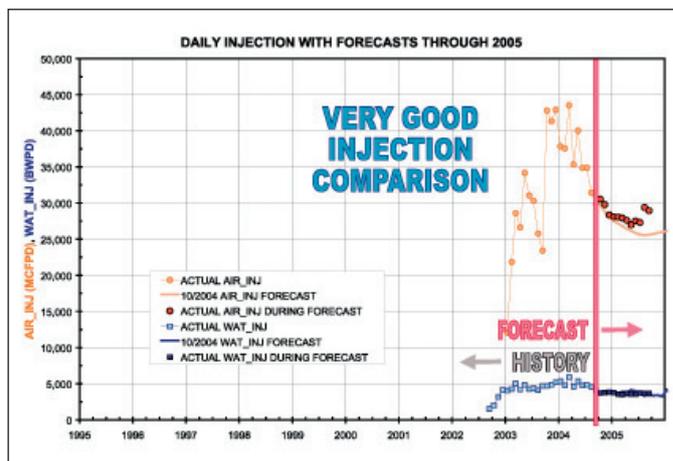


Fig. 2.