Reservoir engineering expertise important in CCUS projects

Miles Palke

Miles Palke, managing senior vice president at Ryder Scott, presented "Greenhouse Gas — The Role of the Petroleum Engineering Consultant," at a July 15 company-sponsored webinar over Zoom.

He discussed the subsurface aspects of carbon capture, use and storage (CCUS); what a traditional reservoir engineering firm can provide; and how CCUS fits in with the Ryder Scott sustainable energy consulting practice.

Palke said that the Ryder Scott CCUS subsurface services include the expertise of drilling engineering for well design and cost estimates, engineering for completion design and stimulation and production engineering for vertical and inflow performance. Ryder Scott offers a nodal analysis package to clients that can be helpful for vertical flow.

Palke cited the firm's strength in evaluating and designing field development plans to enhance oil recovery through miscible CO_2 floods.

This includes estimating reserves, evaluating reservoir performance and infill drilling results, reviewing surface facility design for CO_2 re-injection compression projects, optimizing CO_2 flood management and calculating cash-flow economics.

Ryder Scott has evaluated most of the Permian Basin CO_2 floods.

"A lot of fields don't have prior histories of CO_2 flooding, so we have to bring in analogs," he said. "We have a big database of existing CO_2 floods we've studied and have dimensionless curves built for this. This can be done pattern-by-pattern or on a larger basis."

"We also have a strong background in natural gas storage. This is the process of using older reservoirs to hold natural gas produced in other places, and to withdraw the gas at required rates for peak shaving or seasonal needs," said Palke.

Ryder Scott underground gas storage services share technical features of potential GHG sequestration projects. Underground storage can include salt-mined caverns or porous media, such as retired oil and gas fields and aquifers. Ryder Scott assists clients in developing gas storage reservoirs through the use of reservoir simulation.

On subsurface gas storage projects, he stressed analysis of injection well construction, including metallurgical issues, and vertical well performance curves.

"We have to look at what it's going to take to make wells that can withstand the pressures required to inject gas at the required rates into the storage reservoirs," said Palke.

Understanding the inflow performance of injectors for a given bottomhole pressure and how much gas can be injected at what rate are key issues to tackle.

"There may be potential issues with containment of injected GHGs in subsurface media, which can be porous sandstone or carbonate, salt caverns or depleted oil reservoirs," said Palke.

Other subsurface factors include aquifer displacement and integrity and size of the trap. An effective trapping mechanism is necessary to prevent upward migration of oil and gas or GHGs through the reservoir rock.

Palke cited PVT properties of GHGs and miscibility pressure. "Gas injection has to reach a certain pressure to achieve a full EOR benefit. Mixing other gases with CO_2, such as separator gases from the field, will change miscibility and effectiveness. Not only will it change how the injectant reacts with in-situ fluids, it will change how much CO_2 is ultimately stored in the reservoir," he said.

Palke pointed out that tax credits and any EOR benefit can make or break project economics.

Ryder Scott has several geoscience tools and combines those with PVT analysis and material balance to estimate the size of the "tank," and more importantly, to assess the soundness and integrity of the reservoir.

The reservoir engineering approaches ensure that CO_2 stays in the ground and does not migrate out of the known accumulation.

Palke said the reservoir simulation group has full capabilities for each reservoir engineering tool cited in the chart below, including compositional reservoir simulation.

Ryder Scott CCUS Subsurface Services

Keeping CO_2 in the Subsurface

- Total Reservoir Engineering Approach inclusive of:
  - PVT Analysis
  - SCAL Analysis
  - PTA/RTA for Estimation of Reservoir Properties
  - Volumetric Analysis
  - Material Balance Analysis
  - Analytical Performance Modeling for Enhanced Oil Performance Estimation
  - Compositional Reservoir Simulation

A compositional reservoir simulator calculates the PVT properties of oil and gas phases once they are fitted to an equation of state (EOS). The simulator uses the fitted EOS equation to predict movement of the phases, and their compositions, in the reservoir.

"How many wells? What is the development planning process? You'll have to build it around a certain volume to be handled on an annual or other time basis," said Palke. "You're going to need to know how many wells it will take to get those volumes in the ground within the required time frame as well as some sort of contingency on top of that."

Ryder Scott uses pressure-transient analysis (PTA) and rate-time analysis (RTA) to estimate permeability and mobility, which in turn, provide answers on what injection rates to expect.

"Typically, when we're looking at the enhanced recovery benefit from a CO_2 flood, we're looking at dimensionless recovery curves that plot a tertiary recovery factor of oil vs. CO_2 or other gas injectants," said Palke. "We like to look at the prior performance of the reservoir, analyze how it's performing under CO_2 flooding to get a sense of performance and then build a dimensionless curve that will project it going forward."

Ryder Scott generated the model below that shows a reservoir used for gas storage. It was originally a gas discovery produced down until it was depleted and then the reservoir was converted to gas storage by injecting a working storage volume of gas into it.

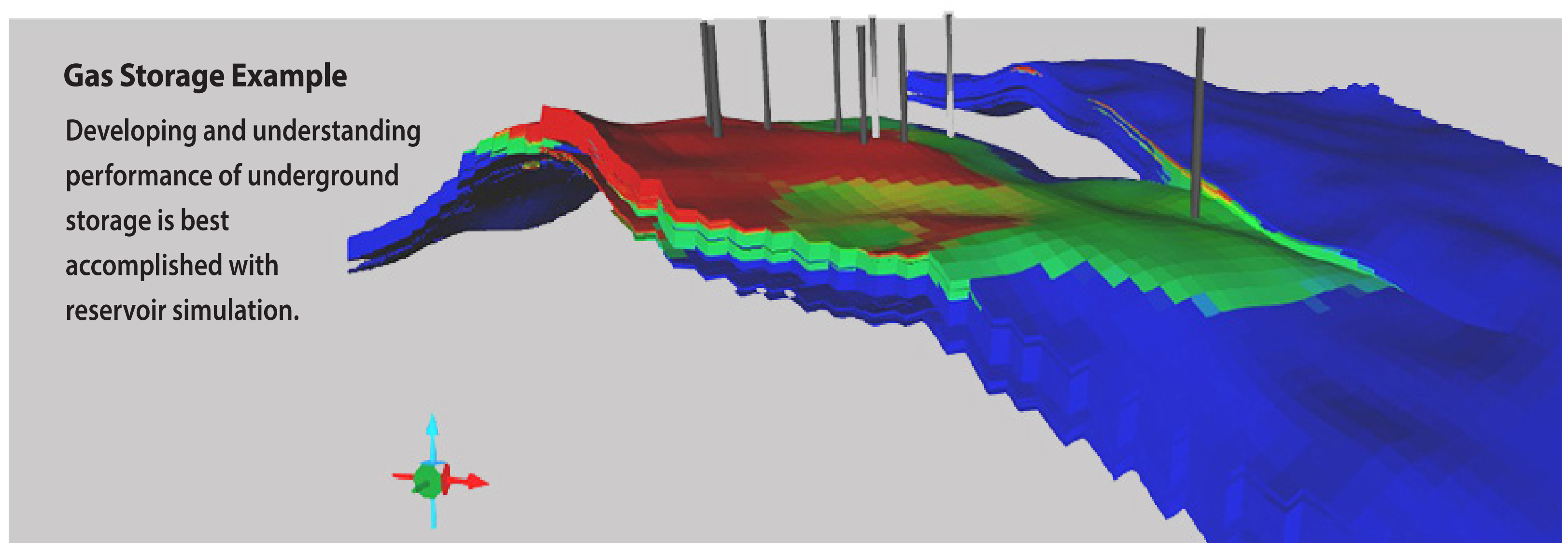
"This is an interesting problem because the reservoir simulation showed the original gas accumulation in this high area in red. However, the reservoir actually has a fault separating it from an upthrown fault block in blue and that fault dies out to the south," he said.

Over injection cycles, gas had been pushed down to a spill point (where the green meets the blue.)

"Everywhere you see color is gas that has migrated out of the original location of the gas accumulation. The simulation model was helpful to demonstrate what migration had happened in the past. The example shows a typical kind of problem when storing gas in the subsurface in a gas-saturated phase," said Palke.

If the trap has any faults/flaws, the simulation can calculate how much gas has been lost and how much would probably be lost in future storage cycles for optional development scenarios.

For more information, please contact Palke at miles_palke@ryderscott.com.



Gas Storage Example

Developing and understanding performance of underground storage is best accomplished with reservoir simulation.