RESERVOIR SOLUTIONS

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Oil & Gas: Tough times, *but we're ready*

Rietz likened today's environment to a "gut punch"

Ryder Scott CEO **Dean Rietz** expressed both concern and hope for the oil and gas industry at the 16th Annual Ryder Scott Reserves Conference on Sept. 16 and 17 via Zoom. He likened today's environment to a "gut punch," calling times tough.

Rietz cited the pandemic, dwindling demand, low oil and gas prices, bankruptcies, continued slander against fossil fuels, unrelenting pressure to reduce carbon footprints and election-year politics.

"We expect bankruptcies to progress throughout the remainder of the year and perhaps into next year as well," said Rietz.

Last year, in his opening remarks, Rietz discussed supply and demand, but said that was "out the window" in the current climate. He referred to annual surveys of conference attendees and their oil price forecasts 12 months out.

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The bar chart on this page shows 2018 and 2019 predictions for 2019 and 2020, respectively.

The plot's normal distribution revolved around a $59-a-barrel prediction last year.

"Only a few folks predicted a price lower than what it is today. It seems the concept, 'lower for longer,' was generally accepted by last year's participants, but no one could have predicted the events leading up to today's price hovering around $40," said Rietz.

In 2018, the plot's normal distribution revolved around a $75-a-barrel forecast by the audience.

"Until we start getting back to 'normal,' perhaps after a Covid-19 vaccine, we won't see an increase in demand anywhere close to recent years," said Rietz.

Changing with the times

Rietz affirmed Ryder Scott's commitment to its clients, given the pandemic, increased demands for green or sustainable energy and the resulting effects on the industry.

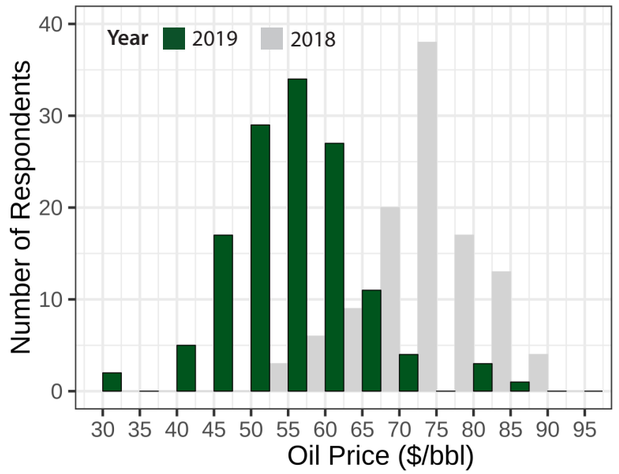
He mentioned several initiatives underway. Ryder Scott is working on a new venture with SLU Enterprise to develop a ratings system and to provide advice on a platform for tradable securities supported with future cash flows of undeveloped Permian Basin acreage.

SLU selected independent consulting firm Ryder Scott to develop the rating system and perform third-party evaluations.

"The Permian Basin has been the most important resource base in the world for nearly a decade, but its historical sources of capital have gone missing," the SLU website states.

Another venture, to be handled by Executive Vice President **Herman Acuña**, will expand services to include greenhouse gas management and sustainable energy consulting.

"We plan to have a major announcement about this in a separate webinar in the next few months," Rietz said.



Ryder Scott plans to assist the upstream and midstream operations of companies in environmental, social and corporate governance (ESG) activities. Deliverables will include independently certified sustainability reports and audits to verify and certify any one of several ESG programs and processes.

"More than 500 attendees to this year's webinar eclipsed previous attendance numbers at brick-and-mortar reserves conferences."

More than 500 attendees to this year's webinar eclipsed previous attendance numbers at brick-and-mortar reserves conferences. The webinar included audiences from Angola, Argentina, Bolivia, Brazil, Canada, China, Colombia, Ecuador, France, Great Britain, Italy, Kazakhstan, Kuwait, Indonesia, Japan, Malaysia, Mexico, Netherlands, Nigeria, Russia, Spain, and UAE.

"For those working some distance away from the greater Houston area, who have always desired to attend but couldn't for a variety of reasons, Ryder Scott extends a very special welcome to you," said Rietz in his opening remarks.

Ryder Scott considered posting videos of the conference to be available on demand, as the July newsletter indicated, but in the interim, the firm changed its plans.

Slide decks from webinar presentations are posted in PDFs at www.ryderscott.com/latest-presentations/.

Comment letters only public source for SEC interpretations of reserves disclosure rules

The U.S. SEC (Securities and Exchange Commission) has not adopted a regular program to disseminate general guidance on reserves reporting rules. In contrast, the Alberta Securities Commission publishes its Oil and Gas Review annually. The review summarizes filings of the previous year and specifies problem areas needing attention.

In lieu of that, the SEC provides feedback embodied in comment letters it publishes on the online public database EDGAR. Although these letters indicate how the SEC staff interprets or expects the rules to apply in a specific case, the interpretations are not intended to be general guidance.

"The letters allow us to understand the thinking of SEC staff," said **Miles Palke**, managing senior vice president, and speaker at the Ryder Scott reserves conference this year.

"Comment letters cannot change the regulations and are not considered definitive for many circumstances. However, they provide insight with an understanding that the SEC issues specific responses to specific filings by specific filers," he said. "Companies (reporting to the SEC) are expected to interpret the rules reasonably and consistently and provide the necessary information based on their interpretations."

Latest comments

Palke said that occasionally, the SEC issues compliance-and-disclosure interpretations to provide guidance on reserves-related issues.

Filers are obligated to respond to comment letters. Generally, the SEC will release all correspondence related to the review, including comment letters, for posting on EDGAR, once the regulator has no further comments.

"Certain details of the correspondence may be redacted and, in some cases, filers may ask for confidential treatment for a period of time," said Palke.

He surveyed comments from May 2018 to May 2020, and put them in categories that show the most frequently cited issues in reserves disclosure oversight. Please see the chart below.

The most numerous SEC comments are related to disclosures and reconciliations.

"Under disclosures, the filer has not, in the SEC's opinion, disclosed enough information," said Palke. "To comply, the filer has to provide year-on-year reconciliation of the changes in reserves with an explanation of why they changed over time."

He has noticed that filers have a propensity to improperly categorize changes or lump them together. "For example, if reserves dropped due to both technical revisions and lower prices, the filer is expected to break them into separate items," said Palke.

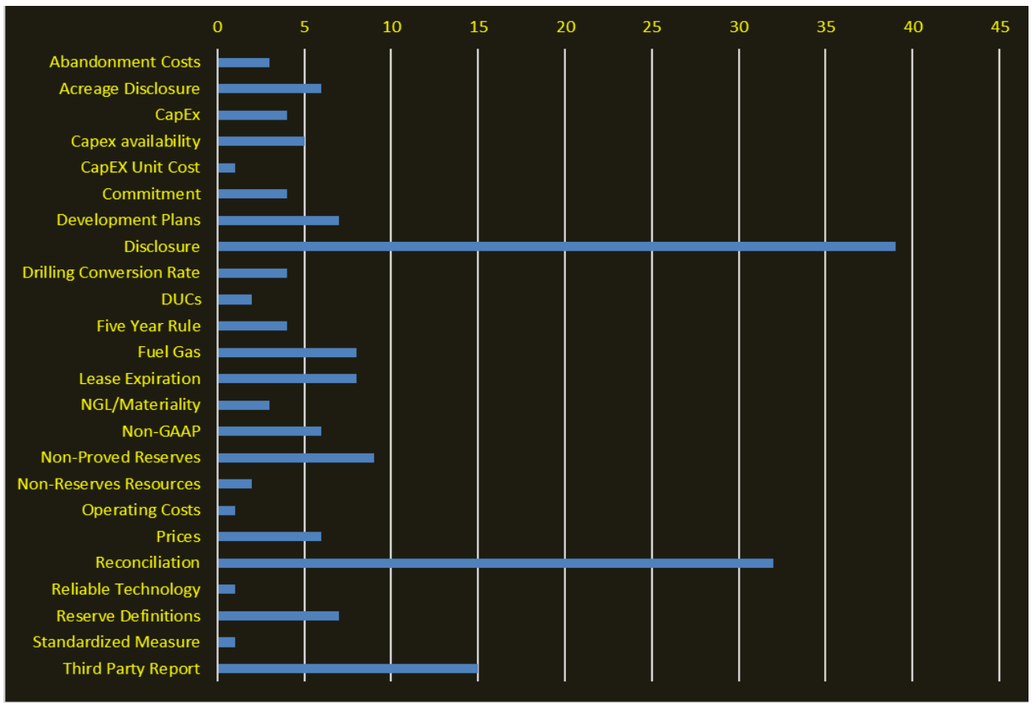
He added that reconciliation also includes instances where the SEC scours a filing and finds numbers that don't agree.

"The disagreement may be between the body of the 10-K filing and the reserves report," said Palke.

He also told the webinar audience that Ryder Scott is winding down support for its SEC Seeker search engine of EDGAR, which is linked via the Ryder Scott website.

"Ryder Scott developed and maintained the Seeker application to facilitate searches in EDGAR filings to find relevant content. Since then, the SEC has improved the searchability of the database," said Palke.

He encouraged Seeker users to shift their focus to EDGAR, and provided a brief demonstration for finding relevant comments on the SEC search engine. Palke outlined those steps in his slide presentation posted at www.ryderscott.com/latest-presentations/.



Before rules changes, SEC excelled at industry dissemination

Before the "modernization" of reserves reporting rules in 2008, the U.S. Securities and Exchange Commission staff was out front with general industry guidance. Twenty years ago, staff members participated in question-and-answer sessions at events sponsored by the Society of Petroleum Evaluation Engineers.

SPEE was the right crowd of evaluators. To be eligible for membership, candidates have to have specific college degrees, 10 years direct experience as an evaluator and, in some cases, state licensing. Members nominate and approve candidates.

In 2000, SPEE sponsored a two-day forum in Houston with SEC engineer **Ron Winfrey** and 160 in attendance. Winfrey took questions and clarified reserves reporting issues, including controversial ones.

Next year in 2001, Winfrey returned with another SEC engineer, **Jim Murphy**. They participated in a second SPEE forum of one day. They addressed issues involving seven actual cases disguised to protect confidentiality. Houston was the location again, and for the remaining forums.

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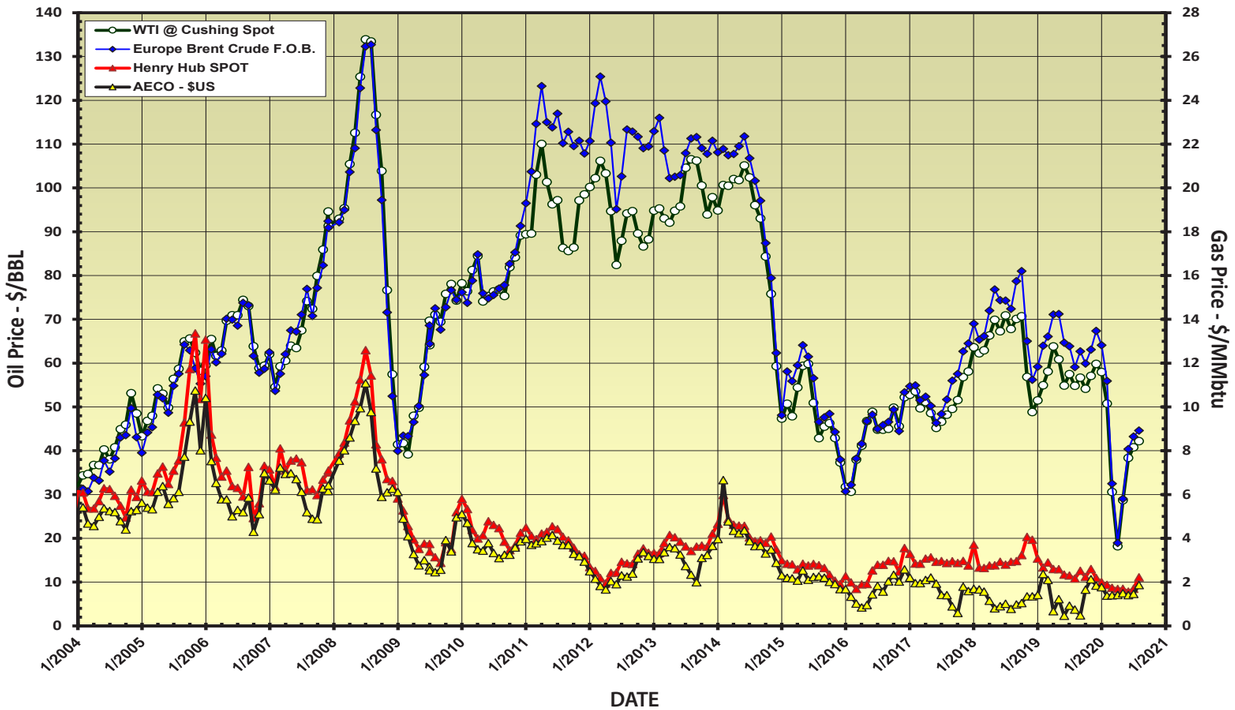
Price history of benchmark oil and gas in U.S. dollars



Published, monthly-average, cash market prices for WTI crude at Cushing (NYMEX), Brent crude and Henry Hub and AECO gas.

Why reserves evaluators should care about CO_2 capture and storage

The panel discussion at the 16th Ryder Scott Reserves Conference in mid-September focused on the operational, financial and research sides of carbon capture in the mid- and downstream sectors. The International Energy Agency estimates that carbon capture and storage (CCS) and other energy efficiencies will have a greater "impact" on reducing CO_2 than renewables by 2040. Carbon reduction is a major component of ESG (environmental, social, governance) programs.

"The core premise of the PRI is to incorporate ESG factors into investment decision-making."

Why should reserves evaluators care about CCS? For one, the financial health of the oil and gas industry may depend on it. Private equity funded producers are trying to assuage growing investor concerns about ESG and specifically, carbon-emission issues.

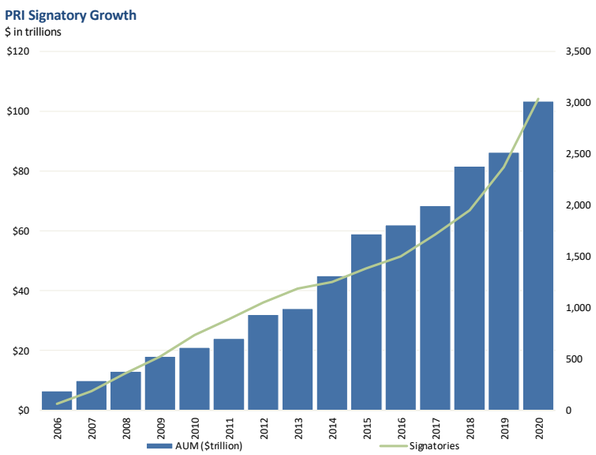
Investors that have traditionally bankrolled oil and gas projects, such as EnCap Investments and Yorktown Partners, are moving into the renewables space. Public companies — such as Total SA, Repsol SA, BP Plc and Royal Dutch Shell — are pledging to cut emissions to "net zero" as their stock prices tumbled during the Covid-19 pandemic.

Increasingly, public and private funding for E&P projects will come from "impact investors" looking to support oil and gas companies that reduce their environmental footprints and manage CO_2, a major greenhouse gas (GHG).

Morgan Stanley

Capital Markets Perspective

Increasing Focus on Responsible and Sustainable Investments



More than 3,000 organizations have signed up for the Principles for Responsible Investing (PRI). "Those asset owners and managers control more than $100 trillion of capital globally," said panelist **Logan Burt**, managing director at Morgan Stanley Energy Partners. See the chart below.

The core premise of the PRI is to incorporate ESG factors into investment decision-making.

Burt also said asset managers have mandates to invest in companies with sustainable business practices. Over the past six years, those investments have more than doubled and now account for more than $30 trillion in assets under management.

The two most pressing GHG issues in the upstream sector are methane emissions and carbon capture projects, he said.*

Why it matters

Engineers and earth scientists have extensive opportunities to study hundreds, even thousands, of different oil and gas reservoirs.

"The two most pressing GHG issues in the upstream sector are methane emissions and carbon capture projects," Burt said.

"Some may have rock and fluid properties where CO_2 injections offer the likelihood of enhanced oil and gas recovery," said moderator **Ron Harrell**, chairman emeritus at Ryder Scott. "They may offer underground storage, sequestration or aquifer-disposal opportunities as well."

Applied technical expertise has fueled the development and deployment of carbon-handling technologies. "Energy professionals are naturally positioned to lead this effort through their technical knowledge of gas separation, CO_2 transportation as well as geologic storage," said Burt.

He also discussed the 45Q federal tax credit recently released by the U.S. Treasury Department. It allows companies to claim a tax break for investments in carbon capture and sequestration projects.

The credits are $50 per metric ton of CO_2 for projects that sequester carbon and $35 per ton for projects that capture carbon and use it in enhanced recovery projects. The credits, effective from the date of installation, are valid for 12 years and transferable.

"Transferable credits are very helpful in raising financing and encouraging JV partners for CCUS (carbon capture use and storage) projects," said Burt.

The panelists generally agreed that $35 per ton is an insufficient incentive for EOR projects.

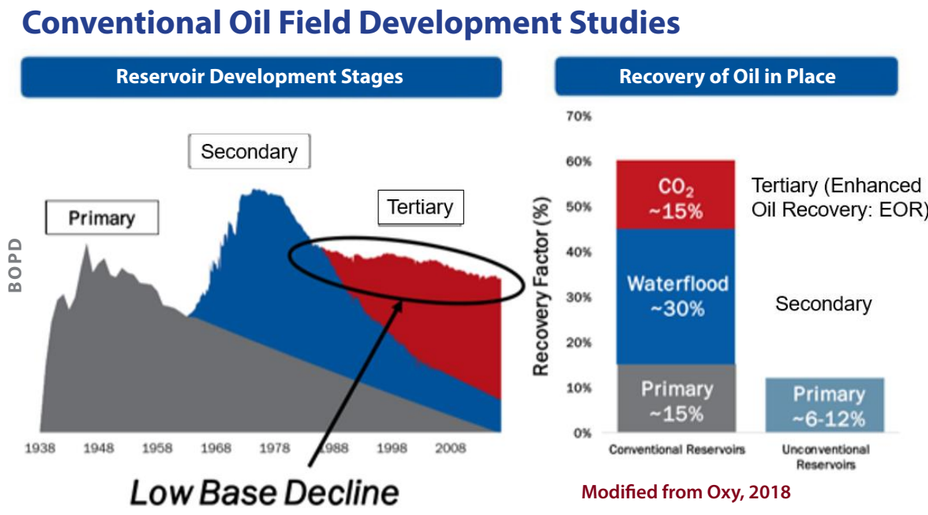
Currently, energy companies, across the globe, have planned 30 new CCUS projects that would more than double capacity over the next decade. More than 60 percent are slated for permanent geologic storage.

Development of carbon-handling technologies is robust in North America, not only because of the geology in the U.S. and Canada, but because the transportation infrastructure is in place.

Sequestration and EOR

John Hessenbruch, retired from Occidental Petroleum Corp., focused on carbon sequestration with EOR development. He showed a slide of conventional oilfield development strategies using primary/secondary/tertiary recovery as follows:

"Using tertiary recovery, as most of you know, involves



Modified from Oxy, 2018

CO_2 implementations," said Hessenbruch. "It has been demonstrated that up to 15 percent of the remaining oil in a reservoir can be produced using these techniques."

Producers in the U.S. have implemented more than 130 EOR programs using CO_2. As an example of a closed-loop system, 40 percent of the CO_2 is sequestered back into the reservoir while 60 percent is produced through the wellhead, recycled and reinjected into the reservoir to improve recovery.

Hessenbruch said 13 companies — IOCs and NOCs — have pledged $100 million each to support the Oil and Gas Climate Initiative investment fund launched in 2014. The goal is to reduce manmade GHG emissions worldwide, including upstream methane intensity to 0.25 percent by 2025.

Another chart showed leading companies in the U.S. with CO_2 EOR and sequestration projects, such as Occidental Petroleum Corp., Denbury Resources Inc. and Kinder Morgan Inc. The chart graphed the number of CO_2 injection wells vs. number of CO_2 projects.

Academia and Research

Christine Ehlig-Economides, professor of petroleum engineering at the University of Houston, reviewed the efforts of academics in CO_2 capture and management. She cited major funding sources for university research comprising the U.S. Department of Energy (DOE), National Energy Tech Lab (NETL), National Science Foundation (NSF) and industry consortia.

"It's rather attractive to work with NETL, because funding is usually in collaboration with industry," she said. NETL funding focuses on carbon capture, advanced storage, storage infrastructure and carbon use and reuse.

For private funding, Stanford University and Columbia University have major CCUS programs. In some cases, they are leveraged with the DOE and NSF. Columbia offers an MS degree in carbon management and Heriot-Watt University in the U.K. offers an MSc degree in CCS.

Ehlig-Economides concluded, among other observations, that natural gas with CCUS offers carbon neutral electricity. Furthermore, CCS and CCUS depend on core petroleum engineering skills.

Slide decks for this discussion and for all webinar presentations are posted in PDFs at www.ryderscott.com/latest-presentations/.

** Last year, Permian Basin methane emissions from oil and gas production were estimated to be 2.7 million tons per year, representing the largest methane flux ever reported from a U.S. oil/gas-producing region. Methane is at least 25 times more potent at trapping the earth's heat than CO_2.*

Heat-induced microfractures have potential to boost shale gas recoveries economically

Will thermally induced microfractures stimulate incremental tight gas production enough to justify enhanced recovery costs? Without deployment and rigorous field testing, the oil and gas industry has more questions than answers.

With budgets too lean for trial-and-error in the field, the North America industry is turning to modeling to uncover clues on the feasibility of thermal microfracturing.

A recent study examined "Thermally Induced Microfractures and Improved Recovery from Shale" in SPE Paper No. 200457-MS, 2020. By applying heat to shale and creating thermally induced microfractures, the authors mimicked processes that are naturally occurring.

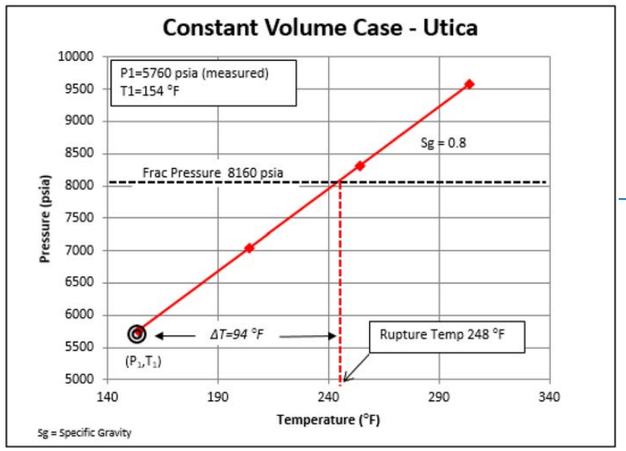
Numerical modeling clues

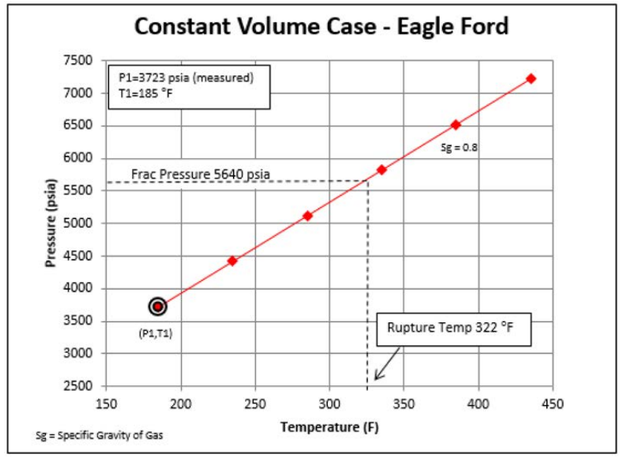
Former and current Ryder Scott petroleum engineers **Don P. Griffin**, retired from Ryder Scott, and **Dean C. Rietz** and **Miles R. Palke** at Ryder Scott — collected geological and well data from the Utica and Eagle Ford shale plays and used a modified ideal gas law and linear heat-transfer equation to investigate thermal recovery of gas from microfractures.

Specifically, the authors of the paper sought to answer the following questions: What incremental temperatures are needed for the pressure within the confined pore to rupture that pore? What time frames are needed to heat a significant area of the matrix to rupture temperatures? What are the distances that microfractures can be induced to form within a timeframe?

Griffin et al. assumed linear heat transfer in hydraulically fractured wells and radial transfer for unstimulated wells.

They plotted pore pressure vs. temperature for a range of specific gas gravities for the Utica and Eagle Ford shale plays in an equation-of-state approach.





The chart shows reservoir parameters at the gas-oil contact and assumes a specific gas gravity (Sg) of 0.8. In contrast to the Utica, the Eagle Ford shale has relatively high temperatures and low pressures near its 6,000-ft deep gas-oil contact. The required temperature to rupture a confined pore was found to be 322°F — an incremental temperature increase of 137°F above the reservoir temperature (T1) of 185°F.

Griffin et al. considered heat sources, operational issues and various applications.

"If it can be demonstrated that the creation of thermally induced microfractures in shale leads to improved hydrocarbon recovery and economics, then many currently uneconomic properties may become worthwhile," stated Griffin et al.

They examined hydraulically fractured and drilled-but-uncompleted properties as well as areas where fracing was banned.

They stated that thermally induced microfracturing has the potential to improve the economics in properties with the following characteristics:

- Lower gravity, higher viscosity oils
- Structural limits or lease restrictions requiring shorter lateral lengths
- Productive shales deeper than currently developed

Griffin et al. investigated the following heat sources: air injection, steam injection and electrical heating. They did not evaluate microwaves.

The chart shows reservoir parameters at the gas-oil contact and assumes a specific gas gravity (Sg) of 0.8. The estimated required temperature to rupture a confined pore is 248°F — an incremental temperature increase of only 94°F above the 154°F initial reservoir temperature (T1).

Findings for Linear Heat Transfer

In one to seven days, thermal operations may be able to create microfractures extending one to five feet from a heating source.

- The required incremental temperatures, relative to the reservoir temperature, are low and may be less than 100°F in some cases, e.g., the Utica shale.
- The extension of this work to light oils appears to be promising based on the results of high specific gravity gases as proxies.
- The authors investigated sustained heating sources of 500°F and 800°F and identified two mechanisms to deliver heat — air and steam injection. They did not consider electrical heating.
- Hydraulic fractures should provide the permeable conduits needed to transport heat significant distances from the wellbore.
- Creating structurally weak, microfractured zones a few feet deeper than the existing fractures appears feasible. Such zones can provide entry points (soft spots) for hydraulic fracture treatments to contact new reservoir matrices to increase ultimate recoveries of wells.

Unstimulated well – Radial Heat Transfer

- Thermally induced microfractures in the shale matrix before hydraulic fracturing may be beneficial.
- Microfractures may be an optional stimulation in areas where hydraulic fracturing is banned or not feasible.

The 20-page paper has 17 charts/illustrations, 14 references and numerous equations and formulas used in the model. It is available at www.onepetro.org.

After 22 years, print edition of *Reservoir Solutions* discontinued

Ryder Scott discontinued the print edition of *Reservoir Solutions* newsletter beginning with the July issue. The Covid-19 pandemic and proliferation of virtual home-based offices have rendered printed business-to-business (B2B) materials semi-obsolete.

"We may bring back the printed version as business operations globally go back to normal," said **Mike Wysatta**, public relations manager.

The hard-copy publication made its way to thousands of offices around the world via domestic and international mail for 22 years.

Ryder Scott continues to email the publication. To receive the e-newsletter, please send business card information to Wysatta at mike_wysatta@ryderscott.com. Canadians are required to opt-in to receive B2B emails.

In addition, the newsletter is posted at the Ryder Scott website at www.ryderscott.com/latest-newsletter/. Over its run, the hard-copy *Reservoir Solutions* was referenced by the *Wall St. Journal, Oil & Gas Journal* and other business and trade publications.

Recent studies measure bias in production forecasts

Proved reserves filed with the SEC were within 1 percent of actual reserves, one study reported

Historical oil and gas production has not measured up to production forecasts, say industry "scorekeepers." They say that on average, companies filing with regulators have let bias creep into reserves estimates and production profiles. Compounding the situation is few companies look back at production records to compare them to forecasted numbers to recalibrate, according to these researchers.

For estimated future production to be reliable, operators have to follow a development plan and drilling schedule. An operator may veer from its plans for various "unforeseen" reasons, including poor drilling results, new well and other technical information, mid-year budget revisions, increased costs, decreased commodity prices, transportation bottlenecks, new regulations, mechanical failure, divestitures, acquisitions, change in ownership and direction, change in drilling priorities, delays by service companies, delays for government approvals and even pandemics.

All that makes recalibration more difficult. In addition, bias does not necessarily play a role in 100 percent of extraneous factors that change company plans, execution and therefore, forecasts.

This article will summarize recent findings of two surveys on the effect of bias in reserves and production forecasts.

One surprising conclusion was that proved reserves estimates filed with the SEC were within 1 percent of actual reserves, although this says nothing about outliers and ranges of reserves values. By definition, estimates of proved reserves have at least a 90-percent probability that the actual amount produced will equal or exceed the estimate.

Authors of the paper, "Technical Revisions Reveal Overconfidence in U.S. and Canadian Reserves Estimates," SPE Paper No. 201116-PA, stated the following:

"Because U.S. companies are not required to distinguish between (1P and 2P) categories, their single estimates end up somewhere in between, and apparently, closer to the P50 value. The U.S. 1P estimates disclosed seemed to satisfy only the certainty criterion for 2P reserves," the authors stated, while recognizing other possible causes.

The U.S. data set covered more than 10 years of information during 2007 to 2017 on 32 companies, raising questions as to what constitutes a representative sample size of public issuers in the U.S. market. The data set was limited because only companies, with revisions of previous estimates and revisions caused by price variations, fit the survey design.

"The U.S. analysis could be biased toward companies that provided this information," stated the authors.

SEC-case reserves reports

Several press reports this year have focused on questionable disclosures of reserves and production forecasts, especially in the Permian Basin, where infill or extension wells are robbing parent wells of pressure and production.

Weighing in on the topic, CEO **Dean Rietz**, said, "We strive to keep our clients compliant with SEC reporting rules while documenting full value of their assets as permitted. SEC-case proved reserves are considered conservative by many."

Producers plan their business cases, including field development projects, on 2P (sum of proved and probable) reserves, not proved.

"We look for consecutive, upward, year-to-year reserves revisions in proved reserves since we know the SEC frowns on the opposite. We know we are doing a good job, if the forecasts are not far off from actual production and upward revisions are not significant," said Rietz.

Bias: Overconfidence and optimism

Quantifying bias in decision-making is not a recent trend. Researchers have measured bias in reserves disclosures for 44 years, beginning with **E.C. Capen**, who recognized tendencies for overconfidence and optimism and published his findings in the *Journal of Petroleum Technology*.

Before that, psychologists **Amos Tversky** and **Daniel Kahneman** introduced the notion of cognitive biases in 1972.

Biased thinking and decision-making are rooted in human nature. They arise in budget-justification processes. Incentives and bonuses for meeting reserves targets encourage bias. The causes for bias include motivators toward high-side forecasts, excessive pride of ownership, emotional carryovers, delusion and deception.

The upstream sector has distilled the reasons for bias to two measurable human tendencies — overconfidence and optimism.

Overconfidence

Humans, including reserves evaluators, have a natural tendency for overconfidence, which is an underestimation of uncertainty. Evaluators gauge uncertainty levels in their production forecasts to reflect a range of possible outcomes from the P10 high to the P90 low.

The ability to do this objectively and generate reliable estimates is directly related to the overconfidence/underconfidence continuum.

An overconfident evaluator has a narrower range of possible outcomes, leaving little room for a missed call at early field development stages when data is insufficient.

Optimism

Optimistic forecasts give greater weight to the upside. Evaluators can develop optimistic forecasts by reacting to motivators or by overlooking human error. Underestimating downside causes unpleasant surprises — more downtime than anticipated, longer-than-expected durations for drilling and completions and lower-than-expected actual oil production.

Pessimism, on the other hand, is responsible for undervaluing oil and gas assets. That bias handicaps a company in trying to take advantage of opportunities in acquisitions and divestitures and in portfolio management.

In the A&D world, sellers seldom undervalue assets. It is widely known that "seller's reports" boost reserves volumes to the high side to entice buyers. Taken to an extreme, biased reports underpin "pump and dump" schemes.

Bias in Charted Territory

Reserves engineers don't have to take a Psychology 101 course to realize underlying human tendencies get in the way of objectivity. Certainly, the evaluation sector has attempted to reduce bias by increasing reliance on automated routines, machine learning, blind fitting and artificial intelligence, which has been an option in decline-curve analysis programs for 40 years. The problem with black boxes is bias-influenced, erroneous assumptions and notoriously

Please see Recent studies measure bias on page 12

Recent studies measure bias – Cont. from page 11

bad data — garbage in, garbage out — can skew model results.

The chart, opposite, shows an estimated reserves distribution represented by the red curve. It is overconfident with a narrower estimated probability range than the true distribution (blue curve). Ideally, actual reserves fall within the P10/P90 range approximately 80 percent of the time.

The curve also has shifted to the right of the mean P50 value of the true distribution, indicating an optimistic forecast of reserves.

Quantitative analysis

Through quantitative analyses, two Society of Petroleum Engineers technical papers, finalized this year, studied the effect of bias in production forecasts and reserves.

One of the papers, peer approved in February, outlines due diligence procedures for evaluators, investors and regulatory agencies.

The SPE paper, previously cited in this article, was written

"...proved reserves estimates filed with the U.S. Securities and Exchange Commission were within 1 percent of actual reserves." — Gomez et al.

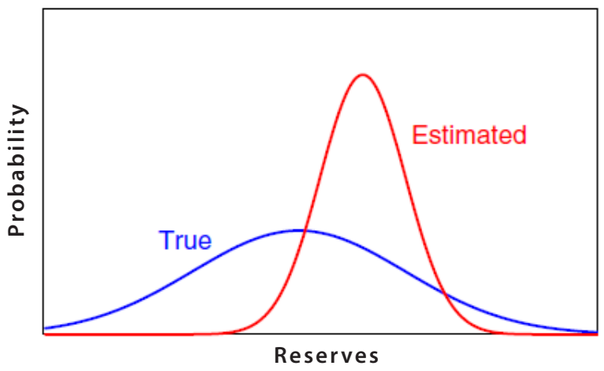
by first author **Diana Gomez** at Texas A&M University. Professor **John Lee** is also an author as well as **Duane McVay**, both at Texas A&M.

They analyzed bias in 1P or P90 reserves reported to the SEC and Canadian Securities Administrators (CSA) as well as 2P or P50 reserves also filed with the CSA. Public issuers in Canada report proved and probable reserves under National Instrument 51-101.

As previously stated, Gomez et al. tracked technical revisions (TRs) from reserves reconciliation reports during 2007 to 2017. They analyzed the reliability of a group of probabilistic assessments on calibration plots to compare the number of actual outcomes to the probabilities of outcomes.

Their tracking of TRs allowed for the review of changes attributable to "the skills and practices of the assessors" with no effect from economics, including price, a major change agent. The authors use the term ROTP (reserves other than price). A common industry term is "technical reserves." However, that expression ignores that evaluators estimate reserves under economic limits.

The method presented by Gomez et al. may also prove to be valuable to the business and trade press and to financial analysts who follow public oil and gas companies in U.S. markets. While filers in Canada report TRs separately, filers in the U.S. market combine technical and economic revisions,



Estimated reserves distribution that is overconfident and optimistic.

making it difficult to isolate TRs.

To overcome this, Gomez et al. calculated ROTPs by subtracting price-related revisions from revisions of previous estimates. The difference is desired TRs are subject to some assumptions.

They stated, "TRs occur primarily because of new subsurface information acquired over the year." As examples, they cited production data, new wells and test data.

Gomez et al. examined TRs by year, company and company size. For companies reporting to Canada authorities, the authors evaluated TRs by fluid type (light/medium oil, heavy oil and gas) and resource type (conventional vs. unconventional). They found several relationships between reliability and categories.

The other paper, "Production Forecasting: Optimistic and Overconfident – Over and Over Again," (SPE Paper No. 195914-MS) was also peer approved in February. **Reidar B. Bratvold** at the University of Stavanger (UiS) is the first author. Also contributing were **Erlend Mohus** at the UiS and **David Petutschnig** and **Eric Bickel**, both at the University of Texas.

They analyzed private filings received by the Norwegian Petroleum Directorate (NPD). Bratvold et al. reviewed initial annual oil production forecasts at the time of the financial investment decision through the fourth year. Several international oil companies have a sizable presence in Norway.

The authors started with company filings on 85 oil and gas fields. They eliminated 30 fields that did not produce oil, had poor or missing associated data, experienced startup delays and had associated data past 2017. Oil production was the only focus.

In their paper, the authors did not comment on any effects from reducing the sample size. In some cases, a select group of qualified fields may not represent the larger, unculled population.

Bratvold et al. tracked technical revisions on the fields to

compare probabilistic estimated (P90/mean/P10) volumes to actual production. In total, they analyzed 549 forecast years from 55 oil fields in the Norwegian continental shelf.

The paper offers a method to reduce bias by encouraging and rewarding evaluators for providing unbiased forecasts. Bratvold et al. cited one method, reference-class forecasting, that provides an outside view of a given project by referencing past comparable projects. They plan to elaborate on that method in a subsequent paper.

Referring to his paper recently, Bratvold said, "We argued that there are two categories of biases: cognitive and motivational. We did not argue that one is more important than the other. However, we did suggest that motivational biases stemming from organizational structures and incentive systems may be significant."

Several disciplines depend on forecasting and refining their models over time.

"Weather forecasting …has experienced significant improvements over the last two decades: 7-day forecasts made today are as accurate as 5-day forecasts 22 years ago," stated Bratvold et al. "Unfortunately, in the oil and gas industry, the development of probabilistic forecasting systems has not been accompanied by commensurate effort in developing procedures to assess the performance of …forecasts."

Differentiation between deterministic and stochastic methods is a distinction without a difference to Gomez et al.

"Reserves estimates are probabilistic assessments regardless of whether the reserves are estimated deterministically or probabilistically," they stated.

Bratvold et al. reviewed fields operated by companies under the NPD resource classification system. It requires companies to file petroleum volumes in low, base and high uncertainty categories.

Although base-case estimates are calculated using deterministic or stochastic methods, all forecasts they used were probabilistic.

Gomez scorecard

- Gomez et al. found that filers in Canada overestimated 1P reserves and underestimated 2P reserves. U.S. filers over estimated reserves more often than Canadian public issuers.
- Filers in U.S. markets reported positive revisions of 51 percent for 1P reserves, a significant departure from the 90-percent reasonable certainty level in definitions of proved reserves. The irony: Proved reserves estimates were within 1 percent of actual reserves.
- U.S. filers were neutral to completely overconfident and moderately to completely optimistic.
- Overall, filers in Canada were moderately overconfident and slightly pessimistic.
- Canadian filers showed no improvements in overconfidence or pessimism in reserves reconciliations over 11 years. U.S. filers do not disclose the data necessary to track the two components of bias.

Bratvold scorecard

- Bratvold et al. found an 84-percent chance that the actual production in the first four years will be less than the P50 (mean) forecast, and a 59-percent chance it will be less than the P10 forecast.
- Empirical data shows there is only a 31-percent chance that the actual production will fall within the P10-to-P90 range.
- The production shortfall relative to production forecasts is as poor now as it was 22 years ago.
- There were no signs of performance improvements, despite advances in uncertainty modeling, which suggests biased input is at work.

Both of these papers outlined assumptions and hypothesized likely reasons for bias. The authors defined the scope and design of the surveys, detailed their procedures, and presented instructive charts and graphs. Gomez et al. analyzed the relationship between bias and company size, product type, etc. The papers are available for purchase at www.onepetro.org.

Before rules changes – Cont. from page 5

In 2002, SPEE hosted its third forum with the addition of division supervisor **Roger Schwall**. Industry experts urged the SEC to allow companies to book proved reserves from Gulf of Mexico deepwater discoveries without having to conduct costly, unsafe production flow tests.

In 2003, Schwall, Murphy and Winfrey took questions from an audience of 200 at the fourth SPEE forum. Schwall said that industry's reliance on so-called "can't-miss" technology had resulted in reserves writedowns over two preceding years.

That was the last SPEE reserves forum with the SEC. At an event organized by the Energy Forum in 2004, Schwall made a major announcement — in lieu of a flow test, the SEC decided not to object to the use of seismic and well data to justify booking proved undeveloped reserves from GOM deepwater discoveries.

Over the past 16 years, the SEC has been largely missing in events designed to clarify regulatory reporting for the industry. **John Hodgin**, a petroleum engineer at the SEC, spoke at a 2015 technical session and 2016 annual meeting, both hosted by SPEE.

Publisher's Statement

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