RYDER SCOTT

2022 QUARTER 1

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RYDER SCOTT COMPANY LP
TEXAS

RESERVOIR SOLUTIONS

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We've had a good run and it's not over yet

-- Mike Wysatta, Public Relations Manager

In the almost 24 years I have written and edited *Reservoir Solutions* newsletter, I rarely spoke directly to you, our readers. With this, my last newsletter, I can now thank you directly for reading the quarterly, in some cases, for decades. I'm retiring from Ryder Scott, but the firm will continue to publish a newsletter, so stay tuned. Please see details on Page 13.

"...our hard-copy newsletters started to show up in boardrooms and on desks of top management"

Retro approach

When I started at Ryder Scott in the late 1990s, I noticed that companies were abandoning the mailing of printed publications in favor of digital. In addition, I spent more time to go through junk emails than "snail mail."

With a contrarian strategy in hand, Ryder Scott began to mail printed newsletters — a clutter cutter — with a focus on the reserves evaluation sector.

From early on, our hard-copy newsletters started to show up in boardrooms and on desks of top management because of the editorial approach and our leadership in events that shaped our industry.

After the fall of Enron Corp. and Arthur Andersen LLP, now 20 years ago, the U.S. SEC took dead aim at energy companies. Subsequent rulemaking in Sarbanes-Oxley Act stoked fear of big government enforcement and criminal penalties, even though SOX did not apply to unaudited reserves estimates per se.

In December 2002, the newsletter headlines were as follows:

- **SEC engineer cites red flags in reserves reporting**
- **Ryder Scott meets the press, discusses field technology**
- **Industry argues for booking reserves without flow tests**
- **Ryder Scott deepwater survey confirms booking practices**
- **O'Shea sees more audits of engineering work**

During that time, we not only followed and reported on SEC issues, but were participants in the dialogue. As an independent reserves auditor, Ryder Scott

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preferred not to have “a dog in the fight,” between industry and regulators.

However, industry’s technical arguments, including ours, were so strong that we became an advocate of sorts, while never losing sight that our main job was to assist clients to be SEC compliant.

We used editorial license to practice “gonzo journalism” where the reporter is part of the story.

“...our editorial approach and leadership in events shaped our industry.”

For instance, Ryder Scott published a newsletter article on a presentation we delivered at an industry forum, calling for the SEC to drop the Gulf of Mexico flow test rule in 2002. Industry supported its position based on advancing technology, cost-benefit analyses and safety concerns.

Internet were Canadian firms.

“Marketing” was still a dirty word for some dyed-in-the-wool professional services firms. They continued to rely on word of mouth and referrals to drive sales. (Those traditional methods worked and still work today.)

Then, “public relations” was personal selling, e.g., taking colleagues to lunch and “glad handing.”

For decades, Ryder Scott top execs belonged to the downtown Houston Petroleum Club, an oil-and-gas hot spot for power lunches and gala events. It was the place to see and be seen.

As one source published, “Some of the deals that shaped the modern oil and gas industry were hatched at the bar and at dinner tables in Houston’s Petroleum Club.”

in a global marketplace.

Firms realized that sales calls were much costlier than “hits” on a website. “Virtual” success became just as important to the bottom line as referrals and face-to-face selling.

The newsletter kept our website current over the first decade of the 2000s up to the present day. That includes in 2006, when the U.S. shale revolution began.

Some 15 years later, industry is still learning. See blurb, “Shale plays as challenging as ever,” on Page 7.

The latest editorial shift now focuses on ESG with an emphasis on environmental. See articles on pages 4 and 5.

To you, with care

Each newsletter was scrutinized by our newsletter committees made up of CEOs, presidents and others, including me, who reviewed the drafts closely.

This has been a team effort all the way up to the top of our consulting firm that stayed the course with its long-term commitment to fund newsletter costs.

The SEC reviewed comments and abolished the regulation. That marked the beginning of the “modernization” of SEC oil and gas regulations.

After that, Ryder Scott was thrust into headline-making news. In 2004, Royal Dutch Shell admitted it had overbooked proved oil reserves by 4.5-billion barrels, about 23 percent of its total, wiping billions of dollars off its market value.

The debacle led to the resignation of Shell’s chairperson, head of the core oil and gas division and chief financial officer. Shell called in Ryder Scott to “clean up” the reserves bookings that year. Our firm conducted an accelerated review of the Shell reserves classifications.

The *Wall Street Journal* called Ryder Scott for interviews, citing a B2B newsletter that had covered reserves issues six years before the Shell writedown. *Dow Jones, Reuters* and others followed, and Ryder Scott gained recognition with the news media.

This was quite a change from the 1990s, when Ryder Scott was not widely known outside its industry sector. (During the go-go ‘90s, Wall Street investment bankers knew Ryder Scott for its reliable technical due diligence on IPO launches.)

The only reserves consultants with a presence on the

New reckonings

During 2000 to 2010 — a decade of rising oil and gas prices — globalization accelerated.

Broadening the field were partial privatizations of state-owned companies including those in China, continued economic growth in Russia, rise of AIM and other alternative markets, and passage of free trade agreements.

(The economic impact of 9/11 was minimal. Markets bounced back to new highs in a few, short months.)

“...we became an advocate of sorts, while never losing sight that our main job was to assist clients to be SEC compliant.”

In 2003, Ecopetrol SA restructured to list on the NYSE. We did due diligence for the partial privatization after the CEO contacted us through information in the printed newsletter.

A strange evolution happened on the way to the future. The relatively tiny evaluations sector became enmeshed

Under a steady game plan to report news on the evaluations sector, our circulation reached almost 10,000 recipients before industry layoffs ensued post 2014.

Instead of downsizing, we went big.

In 2014, an outside professional graphics designer joined our internal team. I no longer had to do what was a rudimentary layout of *Reservoir Solutions*.

With more time for editorial, I increased the copy and page count, and the newsletter became a magaletter.

Industry chronicled

So many other conditions and events surfaced in the last 2 ½ decades that touched our industry, sector and Ryder Scott. If you want to see how much has changed, go to https://ryderscott.com/newsletters/ and read the earlier articles.

One headline of June 2002 reads, “Unconventional U.S. gas resources could stave off shortages, but technical hurdles persist.”

That sums it up.

Ryder Scott plans to launch a newsletter with a new name, look and focus in the April issue.

Please see We’ve had a good run on page 14

U.S. public issuers assess potential for material financial risks posed by climate rules

Oil and gas companies in U.S. markets are scrutinizing their climate-change policies and disclosures after receiving comment letters from the SEC last September.

***Utah Business* magazine reported in November that the government watchdog is primarily targeting "those in the oil and gas sector."**

The SEC received more than 550 responses, and could issue a climate change proposal as early as 2022.

The sample comment letter from the SEC refers to rules of more than a decade ago, the "2010 Guidance Regarding Disclosure Related to Climate Change, Release No. 33-9106 (Feb. 2, 2010)."

Through the letter, the SEC is pressuring public companies and serving notice that mandatory ESG rules are on the way, observers say. Companies are preparing in advance of the regulations.

The letter posed the following questions that resonated with publicly traded companies in the oil and gas industry:

1. What anticipated reputational risks may result from operations or products that produce material green house gas emissions?
2. Quantify any material increased compliance costs related to climate change.
3. If material, provide disclosure about your purchase or sale of carbon credits or offsets and any material effects on your business, financial condition, and results of operations.

If the climate proposal were final by 2022, then the SEC would likely schedule an effective date in 2023.

Last year, Chevron Corp. and others urged the SEC to support voluntary standards in the Task Force on Climate-Related Financial Disclosures. The standards take a markets-based approach to disclosing financial risks related to climate regulations.

The U.S. Financial Stability Board created the 2010 guidance for use by companies, banks, investors and government. FSB, an international body, makes recommendations on how to handle systemic risk in the financial sector worldwide. Gensler is a member.

Last year, majors and independents alike urged the SEC to continue to require disclosure of material changes and related financial risk, but to avoid climate change rulemaking.

The Western Energy Alliance and U.S. Oil & Gas Association commented that the SEC should "recognize its lack of statutory authority" to enact climate change regulation.

The American Petroleum Institute stated, "Any effort by the SEC that seeks to impose a major new climate disclosure regime but deviates from the well-established grounding in materiality could raise significant concern about whether the SEC has strayed far beyond its authority to regulate the securities markets."

Chronology of SEC Actions on Climate Change, Financial Risk

- **March 2021** — SEC announces enhanced focus on climate-related risks. The commission opened public comment on whether existing ESG disclosures are adequate in informing investors about known material risks, uncertainties, impacts and opportunities, and whether greater consistency is needed.
- **May** — The SEC Investor Advisory Committee approved recommendations urging the Commission to begin updating reporting requirements to include material, decision-useful environmental, social, and governance (ESG) factors.
- **July** — **Gary Gensler**, SEC chair, said he asked staff to develop a mandatory climate risk disclosure rule proposal for Commission consideration.
- **September** — The SEC sent **comment letters**. A Sept. 22 sample letter asked companies to disclose "the material effects of transition risks related to climate change."
- **December** — Gensler reaffirmed focus on climate disclosures.

SEC disclosure rules on GHG emissions require less reporting than other, related regulations

"Although some information related to greenhouse gas (GHG) emissions and climate change is reported in SEC filings, companies are reporting more in-depth data voluntarily or under other regulatory systems," said **Herman Acuña**, executive vice president and head of Ryder Scott ESG services.

As an example, he cited the Code of Federal Regulations 40 CFR 98, Mandatory Greenhouse Gas Reporting.

"The reporting landscape is rapidly changing. While reporting requirements may vary, the data and engineering principles behind the generation of the GHG statements by an entity remain materially the same," he said. "Establishment of the evaluation boundaries and inventories is key to the success of the evaluation."

Ryder Scott estimates GHG emissions through direct measurement, stoichiometric calculations and emission factors and follows guidelines of the International Petroleum Industry Environmental Conservation Association, International Association of Oil & Gas Producers and American Petroleum Institute.

Verification and validation (V&V) engagements will vary in scale and scope. Deliverables will include third-party ESG audits and independently certified sustainability reports.

Please see detailed article on V&V services in *Reservoir Solutions newsletter*, **July–September 2021, Page 8**.

Ryder Scott also analyzes renewable energy options and scenarios to determine optimum solutions.

For more information, contact Acuña at herman_acuna@ryderscott.com or **Sandeep Khurana**, head advisor–integrated services, at sandeep_khurana@ryderscott.com.

Environmental engineer joins Ryder Scott sustainable energy division

Manish Singh

Manish Singh joined Ryder Scott as a senior environmental engineer reporting to **Herman Acuña**, who heads the sustainable energy division. Manish has more than 25 years of experience in managing GHGs and Air Quality issues, including compliance with regulations and protocols. Before joining Ryder Scott, he was a contractor in corporate consulting at Hess Corp.

Before that, he was a senior environmental consultant and principal corporate auditor at Occidental Corp. for almost nine years.

His experience in climate change, sustainability and ESG in the upstream is as follows:

- Developed corporate-wide carbon footprint for three emissions scopes of the Greenhouse Gas Protocol (GGP). Developed metrics/targets for the GGP emission scopes per guidelines of API, World Resources Institute, IPIECA, etc.
- Developed carbon-footprint reduction strategies and evaluated green technologies.
- Refined processes for collecting, vetting, estimating and documenting GHG and air quality data.
- Assisted in preparing corporate sustainability reports and disclosures under various frameworks and standards.
- Tracked carbon policies.
- Familiar with certifications of ISO standards.

Singh began his engineering career in academics and government before joining El Paso Corp. in 2001. He was a principal environmental engineer for more than five years. Singh also held that title at TransCanada Corp. during 2007 to 2011.

He has worked on projects in or related to Canada, Colombia, Bolivia, Mexico, Oman, Qatar, UAE, Yemen, Libya, Guyana, Denmark, Malaysia, Thailand, India and the U.S.

Singh has a BS degree in mechanical engineering from the Birla Institute of Technology, India, and an MS degree in environmental engineering from Louisiana State University.

His initial work assignment was to complete the accreditation process of the American National Standards Institute for ISO 14065:2020 requirements for Ryder Scott.

The standards apply to bodies validating and verifying environmental information.

Recent SPE ATCE paper presents first "official" case study of learning curve

Ryder Scott documented learning curve in shale plays four years before 2018 PRMS guidelines

Eight years ago, Ryder Scott built a database of the Wolfcamp play in the Permian Basin to examine correlations between recoveries and drilling-and-completion and reservoir variables.

The firm noticed that despite thick, reasonably consistent upper, middle and lower sections in Wolfcamp, drilling results were not consistent from operator to operator.

Ryder Scott assigned reserves to some locations in Wolfcamp that were significantly lower than what the firm estimated for reserves in adjacent locations.

The answer was at hand. The Wolfcamp database showed the strongest correlations were between recovery levels and operator. That logically addressed the cumulative knowledge and operational practices of each operator.

Ryder Scott was onto something then — the effect of a learning curve. In simple terms, the more someone performs a task, the better he or she gets at it.

Now "machines" in iterative processes provide reliable analysis through machine learning.

The learning-curve phenomena, first formalized in 1885, was introduced by the PRMS in 2018, giving producers valid arguments for boosting future net cash flows and reserves based on the curve.

The PRMS stated, "In oil and gas developments with high well counts and a continuous program of activity (multi-year), the use of a learning curve within a resources evaluation may be justified to predict improvements in the time taken to carry out the activity, the cost to do so, or both."

Latest ATCE paper breaks ground

Ryder Scott staff wrote an SPE technical paper of a case study that factors in the learning curve concept in the PRMS, making it the first published study to do so.

Lead author **Jeremy Xia**, senior engineer, said, "The recommended workflow in our paper will enable evaluators to book PUD reserves more appropriately, but not necessarily more PUD locations. I mention this because there is a tendency to believe the learning curve usually leads to positive results."

The paper, "Integrated Workflow for Reserves Evaluation in Permian Basin based on Monograph 3," is available at onepetro.org.

Other contributing authors are **Eric Nelson, Larry Connor, Dan Olds** and **He Zhang** — all from Ryder Scott.

"Monograph 3 does not fully address most situations and challenges in the paper, and some of them are common," said Xia.

The recommended workflows that lead to reliable resources reporting are not enshrined in the PRMS or blessed and codified by regulators.

Background, premise

In 2011, the Society of Petroleum Evaluation Engineers (SPEE) published Monograph 3 as an industry guideline for reserves evaluation of unconventionals, especially for probabilistic approaches. However, stochastic methods are not applicable during the early stages of field development, state the authors.

"From the start of a project, evaluators can only book reserves based on adjacent locations using the traditional analogy method, which, along with volumetric analysis, are used in evaluating conventional reservoirs," the paper states.

The authors considered more than 300 shale well locations in the Permian Basin. They identified analogous wells based on location, geology, and drilling-and-completion (D&C) technology. The next step in the workflow was to estimate technically recoverable resources (TRRs) of analogous wells.

The authors developed five type wells, identified drilling opportunities and conducted a Monte Carlo simulation to develop a statistical distribution for undeveloped locations in each type-well area.

The paper illustrates the construction of type wells and statistical distributions in some of 22 figures (charts) in the paper. Zhang presented the paper at the 2021 ATCE in Dubai.

Workflow

The use of probit plots and binning strategies were key in developing the type wells. Categorizing wells in accordance with their characteristics is referred to as "binning" in Monograph 3.

"That step can be subjective when done by inexperienced reserves evaluators, which may cause inconsistent, highly variable reserves evaluation results," stated the paper.

A common mistake in binning strategy is to include too many type wells based on a single criterion, which usually results in a very small sample size for each type well and indistinguishable differences in type well bins.

The authors illustrated this problem in a binning strategy that just considered well locations.

To determine the number of drilling opportunities, the authors had to consider similar ownership and operations management to factor in the learning curve.

Monograph 3 recommends using anchor wells to determine proved areas of a resource play.

The paper stated that the anchor well method to define a geological proved area is time consuming and offers limited benefits to enhance the reliability of evaluation results.

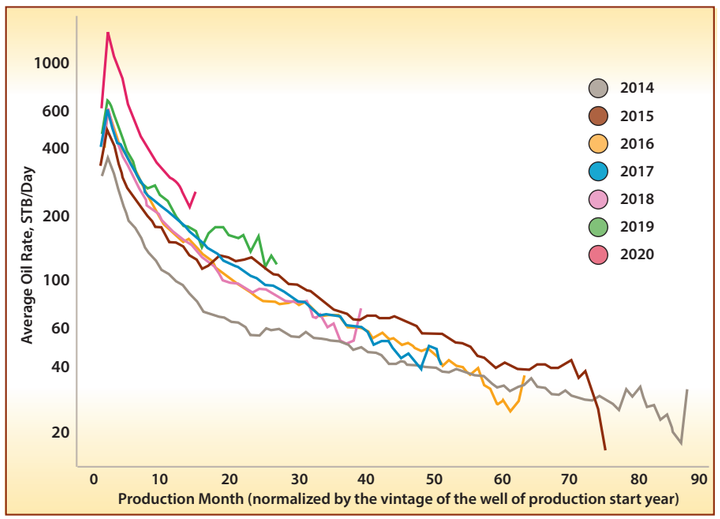
Consequently, the authors visually examined undeveloped well locations on a series of bubble maps and used their professional judgments based on knowledge and experience. Visualization was vital to the study.

Following the workflow steps in Monograph 3, the authors developed a lognormal distribution for the type wells.

When categorizing volumes, a common error is to multiply the number of undeveloped wells by the mean value from a log-normal distribution. This implies that the mean of the distribution is achieved regardless of the number of wells drilled. Fewer drilling locations create a greater risk of achieving the mean with fewer wells.

The Monte Carlo method yielded P10, P50 and P90 values and the per-ft P values were multiplied by the lateral lengths for each location to calculate 1P+1C, 2P+2C and 3P+3C TRRs.

Over a 10-year period, wells from 2011 to 2013 (not shown in chart) had much lower oil production rates than wells drilled and completed after 2014. Please see the following chart on this page with learning curve influence on production after 2014.



Those performance metrics established D&Cs as a primary benchmark for learning-curve applications. The statistics incontrovertibly show successful optimization of D&C strategies.

Monograph 3 does not address cases where sample sizes are smaller than recommended minimum numbers. However, evaluators might exclude noticeable outliers and proceed with caution.

The authors concluded that new concepts have evolved since the publication of Monograph 3, including the learning curve concept in the PRMS. It is especially relevant where well production performance is enhanced with optimized D&C technology.

The SEC has not commented on this concept to date.

Shale plays as challenging as ever

Over the past few years, news media, investors and others have singled out some overly optimistic production forecasts based on type well profiles (TWPs) in the Permian Basin and other unconventional plays.

In 2017, SPEE set out to provide guidelines on TWPs. Ten society volunteers working on the monograph set a "soft" deadline of a year to complete a draft while conceding the goal was optimistic.

Some five years later, mid-2022 is an "unofficial" target to finalize a draft of Monograph 5, "A Practical Guide to Type Well Profiles."

Keeping it simple

Perhaps the problem is not that convoluted. The SPEE monograph committee reported a year ago that a tweak to a common approach has led to more reliable TWPs, and that is to normalize production curves while keeping the well count constant.

The modified Arps hyperbolic model is still the most widely used method to develop decline curves for tight formations. If built properly, the model works well.

Discoveries must have "significant quantities"

Steve Phillips

Steve Phillips, head of Ryder Scott G&G, presented "The Significance of Significant or Just Give Me a Number" at the Ryder Scott annual webinar.

The title differentiates between "significant" accumulations (justified discoveries) and not so significant — those not on a pathway to reserves.

"It takes experienced judgement to discriminate between minor or background hydrocarbon occurrences and deposits with commercial potential that are 'significant,'" said Phillips.

Misused terminology in public statements can confuse. In one example, a company touted an exploration project with a hyped-up press release, pointing out an "astonishing thickness of reserves."

Later, the company disclosed it found no traces of oil and discontinued the operations.

Phillips expanded on the principles-based definition of "discovery" in the 2018 PRMS guidelines. Central to this definition is that a discovery has to have a "significant quantity of potentially recoverable hydrocarbons."

"Many exploration geologists have heard or said something to the effect that finding a 'teacup' of oil counts as a discovery," said Phillips. "This adage contradicts the PRMS guidance that the 'chance of geologic discovery' must anticipate the 'chance of development,' which is key to the overall goal of commerciality."

The definition leaves lots of room for misleading non-technical stakeholders and the public.

"The PRMS guides honest reporting of exploration project results," said Phillips. "This is one area where our ongoing commitment to ethics must lead the way for the technical work and public disclosures."

Why we fool ourselves

Some detectable levels of hydrocarbon concentration can be widespread in the subsurface, Phillips noted. In some wells, gas chromatography from mud logging may indicate thick intervals with trace levels of methane (denoted as C1) in a given sedimentary basin.

Surface geochemical prospecting may indicate the same.

"Thermal and biological generation and migration processes can be active over large areas," said Phillips. "However, concentration of hydrocarbons in conventional and unconventional reservoirs with commercial potential require favorable, relatively localized conditions."

He clarified what constitutes a discovery through four examples of non-discoveries. Pitfalls included no gas to surface, low recovery of oil, no traces of claimed oil, and misleading terminology that sidesteps commerciality.

All four cases are summarized in the **presentation slides**.

In looking at the mining sector as a parallel for the oil industry, Phillips noted that metal ore deposits are generally assumed to require a certain concentration above the average background levels in the earth's crust.

"However, this alone does not make a deposit significant," said Phillips.

He cited the textbook, "Physical Geology", by **Steven Earle**, who writes, "It's important to note that the economic viability of any deposit depends on a wide range of factors including its grade, size, shape, depth below the surface, and proximity to infrastructure, current price of the metal, the labor and environmental regulations in the area, and many other factors."

As in hard rock mining, no single petroleum reservoir factor can predict commerciality.

Phillips provided examples from a Ryder Scott internal database, stating, "The range of potentially commercial reservoir characteristics is very wide and careful technical analysis must be combined with thoughtful application of resource definitions."

For instance, the same quantity that might be significant in one case, say a shallow onshore reservoir near infrastructure, might be far from sufficient in a remote deep water play.

Exploration wells are typically drilled with hopes that the upside or, at least, the mean-case outcome will be realized.

Phillips asked, "How often are internal standards for minimum thresholds of key reservoir properties defined in advance of the project?"

He recommended consideration of exploratory well operations as an indicator of discovery status. In simple terms, data generated by a well must demonstrate that an in-place quantity of petroleum can be reliably estimated and has real potential for commercial recovery.

In looking at the mining sector as a parallel for the oil industry, Phillips noted that metal ore deposits are generally assumed to require a certain concentration above the average background levels in the earth's crust. The Morenci deposit, discovered in 1856, initially exploited high concentration metal ores by subsurface mining. Eventually, open pit mining was implemented to recover ore with copper concentration below 0.3 percent. For commercial exploitation, copper deposits typically need to exceed 0.5 percent and preferably, meet a 2-percent threshold. The lesson is that multiple factors contribute to commerciality.

Ryder Scott is certified in ISO 9001 and 14001 standards

When the auditor becomes the audited

Ryder Scott received independent certifications that it meets ISO 9001:2015 and ISO 14001 standards. The International Organization for Standardization (ISO) sets the requirements.

ISO 9001:2015 defines quality management systems (QMSs) based on documented procedures. ISO introduced 9001 in 1987. ISO 9001:2015 further defined the requirements for a QMS.

To earn and maintain ISO 9001:2015 active status, a company must show sustainable, continuous improvement of the quality of its products, processes and services.

ISO 14001 defines prerequisites for environmental management systems (EMSs). It does not address environmental performance. Instead, it maps out a framework that a company can follow to set up an effective EMS.

The requirements of ISO 14001, which meet European Union standards, set a higher bar for performance improvement, legal compliance and reporting duties.

Third-party inspectors conduct surveillance audits of certified companies in years one and two after the initial certification. The third year requires a recertification audit to maintain status. Years one and two after the recertification are subject to more surveillance audits.

Dekra was the independent auditor and certifier for Ryder Scott.

Dekra calls itself, "… the world's largest, unlisted, expert organization in the testing, inspection, certification industry." It is the largest inspection company in Germany.

Certifications demonstrate a company is compliant with other standards around the world.

"This took over a year of hard work and dedication to become certified," said **Dean Rietz**, CEO. "We had to create the necessary guidelines and policies to navigate through the certification process. I would like to highlight and thank **Herman Acuña**, executive vice president, for his efforts and oversight to make this happen."

Ryder Scott oilfield success was company maker

Early events in the oil industry led up to the emergence of Ryder Scott Co. and its work rejuvenating flagging production in the Bradford field in Pennsylvania in the mid-1930s.

The nation's oil boom began in the state. Production rates of the Bradford field peaked in 1881 when companies extracted 23-million barrels of oil that year or 83 percent of the country's entire output, stated the American Refining Group.

Thirty-five years later, the field was averaging only 40 barrels a day. Producers turned to waterflooding to squeeze more oil from the "played out" field.

Seeing an opportunity, Forest Oil Corp., a startup oilfield consulting company in 1916, promoted a process that involved the "injection of fluid into the oil reservoir to create energy to produce additional oil."

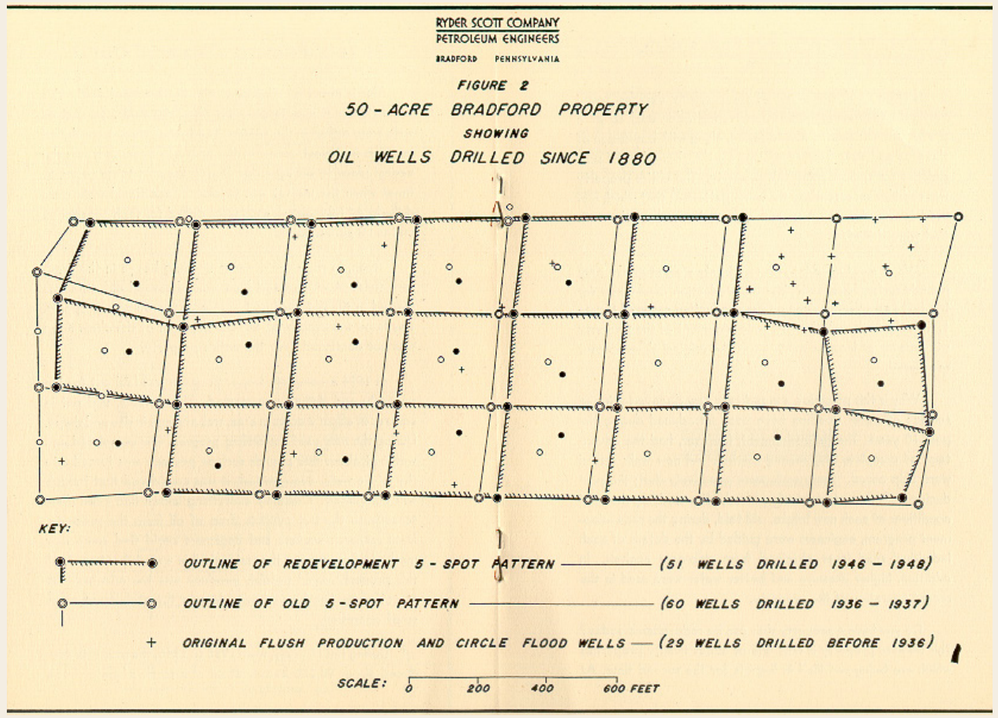
A history posted on the Forest website states that "within five years, Forest Oil was widely recognized throughout the oil and gas industry as not only the innovator of waterflooding, but the authority and leader in secondary oil recovery systems."

However, an upheaval in the oilfield services marketplace began to take shape in the mid-1930s. Producers in the Bradford field noticed that Ryder Scott Co., also an operator there, was out-producing everyone.

Soon after, in response to widespread demand, Ryder Scott exited the producing sector and launched its own full-time consulting firm.

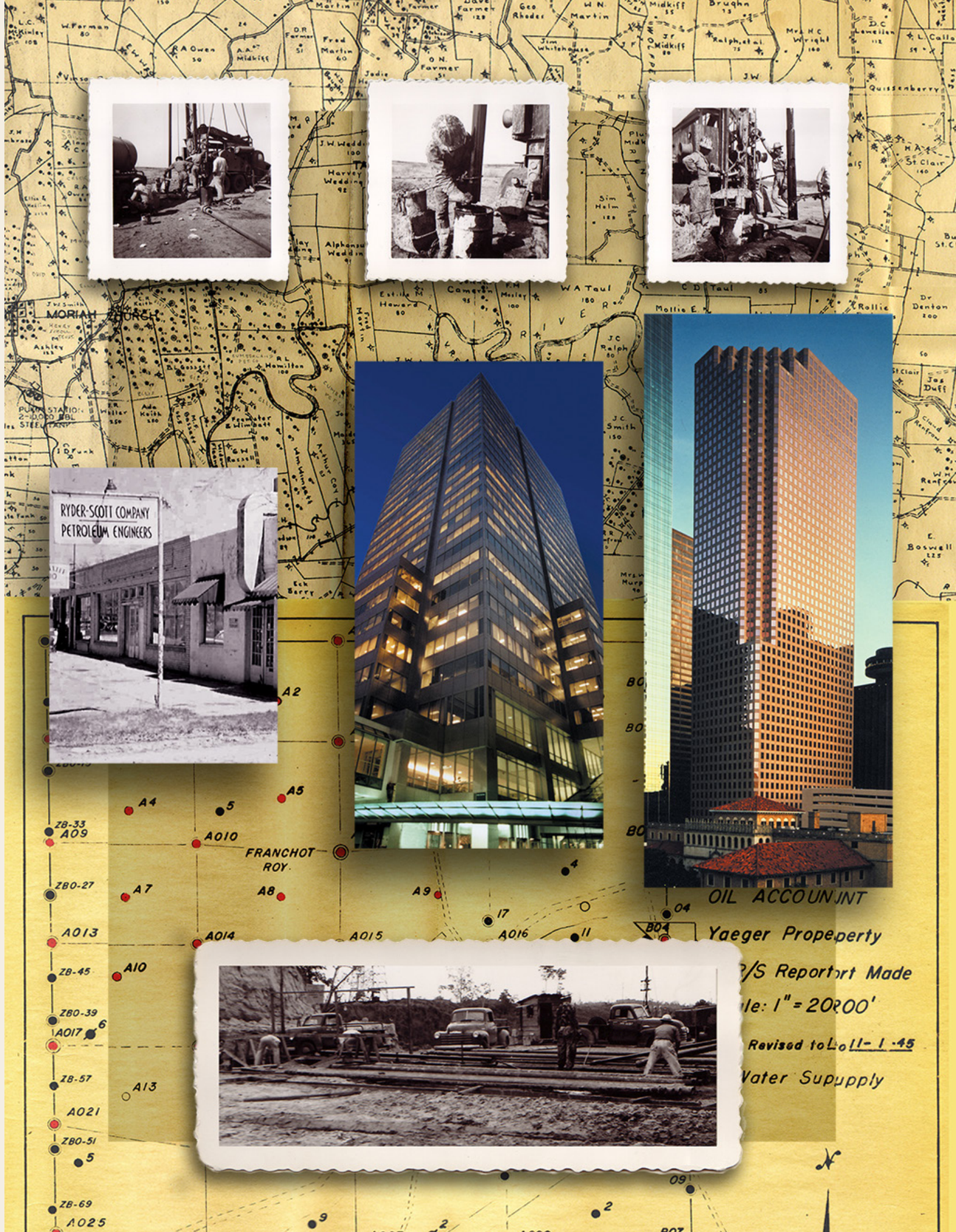
Ryder Scott quickly overtook Forest as the No. 1 consultant in secondary recovery. In fact, Forest became the first Ryder Scott client.

Please see Ryder Scott oilfield success on page 12



***Left** – This Ryder Scott map shows five-spot well patterns in a Bradford field property from 1880 to 1948. During that time, production peaked, hit bottom and climbed again after the firm re-engineered secondary recovery operations in the 1930s and 1940s.*

***Right** – Today, Ryder Scott bears little resemblance to the core laboratory of the 1930s. However, the firm still retains the principles of its founders — that oil and gas projects be evaluated and engineered to the highest professional and ethical standards.*



Ryder Scott oilfield success – Cont. from page 10

Donald T. May, head of the Ryder Scott core lab, recalled those days in an interview with *Reservoir Solutions* more than 20 years ago.

He said, "The operators were watching Ryder Scott. We were doing a Ryder Scott lease right next to Forest Oil. We way outdid them. They couldn't imagine what was happening. Forest Oil was recognized as a good waterflooder, but our deal was much better, and it was all due to chip coring. We could get the right answer and knew where the oil was to go after it."

That the firm was able to find sweet spots in producing trends is not surprising. Leading the way was the lab and its analysis of well logs and chip cores from cable tool drilling.

Contributing heavily to the engineering side was founder **Harry M. Ryder**, an engineer with previous oilfield experience at partnership Ryder & Richmond Corp.

Founder Ryder addressed concerns of producers in Q&A session in 1937

He advised producers to use reliable pressure data

In the mid-1930s, Ryder Scott Co. was a producing company in Pennsylvania. The firm was so successful that other operators in the Bradford field began asking for technical assistance. Oil was only a couple of dollars a barrel, so founders **Harry M. Ryder** and **David Scott Jr**. figured that they could be more profitable as partners in a consulting firm.

Donald T. May confirmed the business plans of the partners in an interview with *Reservoir Solutions* newsletter more than 20 years ago.

May was Ryder Scott's first hire in 1935, and it paid off. May headed up the first laboratory in the world devoted to solving waterflood problems.

Speech kicked off Ryder Scott consulting service

Ryder made a speech at a meeting at the request of the Kentucky Oil & Gas Association in 1937. That was the same year he incorporated consulting firm Ryder Scott Co. in Bradford, PA.

A letter from the association asked Ryder to review questions in writing from members ahead of the meeting.

Ryder said he was honored that the meeting organizers had asked him to lead the discussions on repressuring. He made the presentation in Lexington, KY, on June 4, hundreds of miles from Bradford.

Sharing his field-tested knowledge and introducing his new company were likely priorities for the trip.

Ryder and **C.C. Hogg** of the National Petroleum Co. debated the finer points of repressuring. Though not specific, Ryder said he respected the opinions of Hogg but did not always agree.

Hogg chaired the Production Advisory Committee, which aimed to map the oil sands of Kentucky and establish recovery factors to benefit producers there.

The most common repressuring medium at that time was air and air-gas mixtures. Air is not suitable for repressuring wells because it deteriorates oil and is combustible in some wells.

Ryder was aware of those shortcomings, saying that when air drags the oil, gas and gasoline are removed (lost). He added that air oxidizes the oil, increases the viscosity, makes oil more difficult to move and becomes problematic to refine.

Following are his closing remarks to the audience:

DISCUSSION ON REPRESSURING
In the Form of Questions by Producers
With Answers by **Harry M. Ryder**
Lexington, KY
June 4, 1937

Cores, laboratory logs and gauges are interesting, but utterly worthless unless they are put to work, and they are able and willing to do heavy duty, if given a chance. They are worse than useless, if incompetently handled.

A flow gauge reading taken at a key well will not be correct, if, at the moment, the line pressure is dropping, and may be worse than no reading at all. The reading of an open flow gauge will vary depending on the amount of oil over the sand, the time allowed for it to reach a steady state, when the well was last pumped and on other conditions, and all this must be taken into consideration.

If best results are to be obtained on any repressuring project, it seems worth repeating. Too much emphasis cannot be placed on care, thoroughness and competence in planning the project, the actual repressuring development of the lease and finally the continuous observation of the movements of the air, gas and oil and prompt applications of corrective measures as they appear.

If this idea is carried through consistently, the greatest possible returns will be the reward.

Ryder Scott to continue to inform industry through new newsletter

— **Dean Rietz**, *chairman and CEO*

Ryder Scott is changing editors of our flagship newsletter, *Reservoir Solutions*, as our outgoing editor, Mike Wysatta, retires. Please see the Page 1 article written by Mike.

We owe a big thank-you to him. Mike is a well-known staple in the reserves sector. His coverage has kept us abreast of the latest industry trends, news and important events over his many years at Ryder Scott.

Mike was very valuable to our Ryder Scott family. He had a knack for providing commentary on some highly technical topics while keeping the language concise and conversational to maintain reader engagement.

As one steps down, another steps up

Reflecting industry as a whole, a new, diverse generation is now guiding our newsletter. Our subject matter experts are our geophysicists, geologists and petroleum engineers.

They may not even be aware of their contributions to the newsletter. However, with every technical paper they write, or every presentation they make, they are helping to augment newsletter coverage and content. This has always been an important aspect of the Ryder Scott newsletter and will remain essential moving forward.

For instance, this issue features an article on a recent SPE paper written by Ryder Scott authors who introduced a case study of the learning-curve concept in the PRMS.

Like Mike, the new editorial staff knows that content is king, so, in some respects, expect continued coverage of technical presentations and papers in the newsletter.

Please let me introduce the new editor, **Pamela Sabo**. Many of you may already know the name since she has been at Ryder Scott for more than 20 years.


Pamela Sabo

Pamela has worn many hats during her tenure. She began her career at Ryder Scott in 2001, fresh out of college, with a bachelor's degree in mathematics and minor in computer science from the University of Texas at Austin.

She started in my group as a technician in the reservoir simulation department. Pamela moved through the ranks of technician, senior technician and analyst during the next 15 years.

She has always enjoyed working with others and when an opportunity arose in 2016, Pamela accepted the challenge to switch to business development as the coordinator.

In 2019, she became business development and sales manager after emerging as our No. 1 job candidate. Ryder Scott also had looked for an editor inside and outside our company, but in the end, Pamela's comprehensive understanding of our business, her natural writing abilities, and her

Please see Ryder Scott to continue to inform industry on page 14

We've had a good run – Cont. from page 3

For my part, I am leaving much wiser than when I started out in the industry in the 1990s, as a mid-career change.

I'm looking forward to simple pleasures punctuated with a few adventures. I won't stray too far away from a keyboard though. Ink runs through my veins.

You've been a good audience. Thanks for hanging in there with me. The future is yours.

*Editor's Note: Ryder Scott wants to hear from you, our readers, with comments and suggestions for future editorial content. Please send an email to **Dean Rietz**, CEO; **Pamela Sabo**, business development manager; and **Mike Wysatta** at info@ryderscott.com.*

Ryder Scott to continue to inform industry – Cont. from page 13

tremendous work ethic and attitude made her the right choice for the position.

Pamela recently received an MBA degree in marketing from the University of Houston.

You will notice some changes to the format and layout of our upcoming April newsletter, thanks to the hard work of in-house designer, **Deborah Corral**. **Emily Ammons**, business development coordinator, and **Sarah Sameei**, technical writer, are also on Pamela's staff.

She aims to increase content from staff contributions. Also, expect a new name for *Reservoir Solutions* newsletter.

Please reach out to Pamela with any suggestions, comments or observations via email at pamela_sabo@ryderscott.com.

Ryder Scott to commemorate 85th anniversary with a coffee table book this year

Ryder Scott plans to print and distribute coffee table books with photos and a history of the firm to celebrate its 85th year as a consultant. Oil historian **William R. Brice**, professor emeritus of geology and planetary sciences at the University of Pittsburgh at Johnstown, is doing research and writing an early history on a pro-bono basis.

Mike Wysatta, retired public relations manager, will edit and help write the book. **Ron Harrell**, chairman emeritus at Ryder Scott, is also doing research and writing.

Ryder Scott plans to print and distribute the books during Q3 to celebrate its 85th anniversary.

Dean Rietz, chairman and CEO, greenlighted the project and said he looks forward to producing a book rich in content and historical images to share with clients and colleagues.

TOP WORK PLACES 2021 HOUSTON CHRONICLE

Ryder Scott is a top workplace, say employees

Ryder Scott won a **Top Workplaces 2021** honor from the *Houston Chronicle* newspaper. The award is based on a third-party survey measuring employee feedback. More than 55,000 employees from 2,768 companies participated in the nomination process.

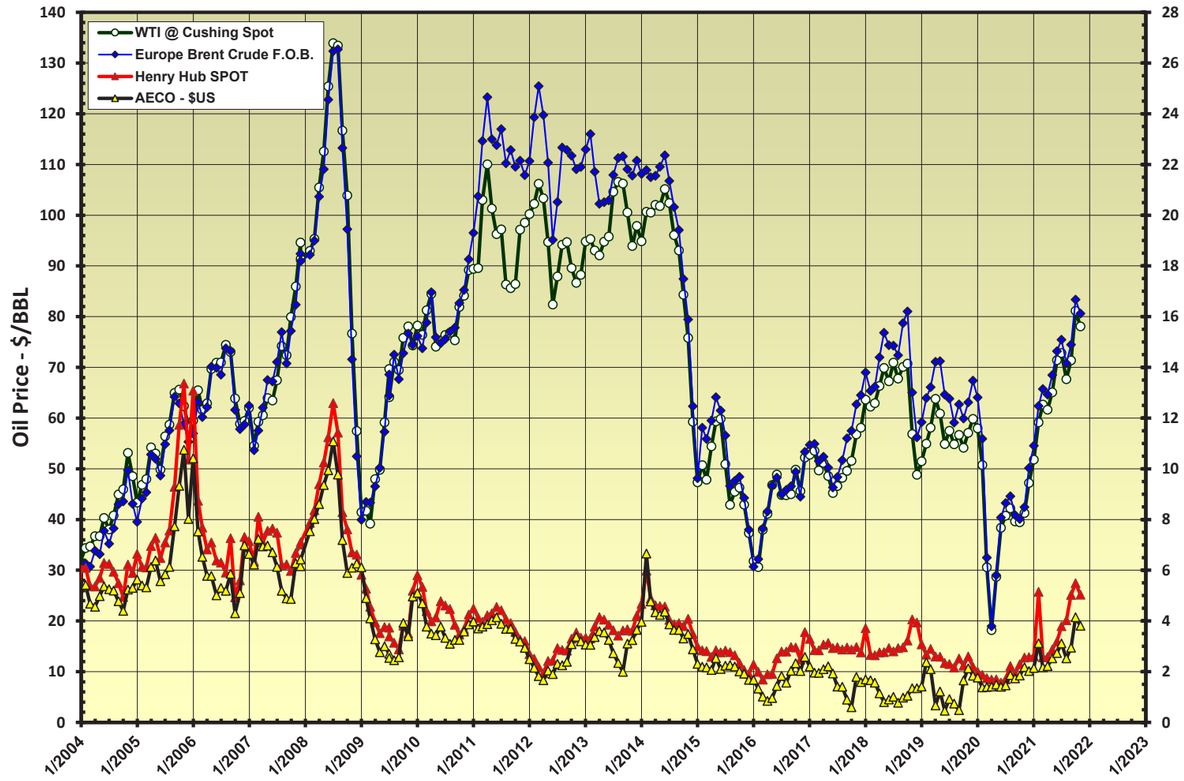
Only 175 companies climbed to the top, including Ryder Scott. The firm had a 66-percent response rate with 140 comments.

Ryder Scott's ranking was published in a special section of the *Houston Chronicle* on November 14.

The survey measures 15 drivers of engaged cultures, including alignment, execution and connection.

"You understand that it takes more than simply striving to be the best – it takes an attitude that we are all in this together," **Dean Rietz**, CEO, told employees. "Like a winning team. Like a tight-knit family. We care about each other."

Price History of Oil & Gas Benchmarks in U.S. Dollars



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

Publisher's Statement

Reservoir Solutions newsletter is published quarterly by Ryder Scott Co. LP. Established in 1937, the reservoir evaluation consulting firm performs hundreds of oil and gas reserves studies a year. Ryder Scott multi-disciplinary studies incorporate geophysics, petrophysics, geology, petroleum engineering, reservoir simulation and economics. With 119 employees, including 80 engineers and geoscientists, Ryder Scott has the capability to complete the largest, most complex reservoir evaluation projects in a timely manner.

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RYDER SCOTT

2022 QUARTER 2

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THE RYDER SCOTT QUARTERLY

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Welcome Note

By: Dean Rietz, CEO

As announced in the first quarter edition of our newsletter, previously named "Reservoir Solutions," we are embarking on a new era of this publication, now "The Ryder Scott Quarterly. " I hope you are as impressed as I am to see some subtle and some obvious changes, intended to update and refresh our newsletter as we continue to provide you with what's going on at Ryder Scott, along with new trends and developments within our industry. Congratulations to Pamela and her team on this inaugural edition of "The Ryder Scott Quarterly." I anticipate that Pamela will continue to look for ways to build on and improve both the look and content of our newsletter. On that note, please feel free to send comments to Pamela or me with feedback on the new look to our quarterly publication. We look forward to hearing from you. Thank you for your continued support; it means a lot to all of us within the Ryder Scott family.

Editor's Note

By: Pamela Sabo

Welcome to The Ryder Scott Quarterly. I am happy to take on the challenge of providing articles and information pertaining to the industry, to you, our readers. At the same time, I hope to highlight our staff's expertise through staff-written editorial contributions. As Dean mentioned in his note, adjustments will be made throughout the year to improve the newsletter. I look forward to hearing from you.

"The secret of change is to focus all of your energy, not on fighting the old, but on building the new." Dan Millman, Author

Missing Values and Sparse Data

By: Melanie Adelman
Associate Geologist at Ryder Scott

Article adapted from the presentation: "Missing Values and Sparse Data, International Geostatistics Congress 2021," Prepared By: Melanie Adelman & Jeffrey Yarus, Professor at Case Western Reserve University

Today, we are in the midst of a digital revolution in which people are integrating machine learning methods with earth modeling. Big data sets have made traditional techniques that rely on manual operations extremely difficult. Big data sets are too complex for simple well-by-well methods that may overlook subtle yet important relationships in the data. Many geoscientists are not familiar with these new techniques and may overlook business opportunities that these mountains of information could provide. So how do we move forward as project size continues to increase along with demands for cost and time efficiency?

Part of the answer is to better understand the nature of big data. A data set that is classified as big is not necessarily perfect. Geoscientists are often confronted with two fundamental problems in earth modeling: missing values in petrophysical well log data and sparsity of wells in a given area in which seismic coverage is not available. The objective of the research is to produce reliable models in the presence of missing values and sparse data with an eye towards automation of the modeling process.

Figure 1 is a cartoon showing a well with missing data occurring in the well log curves.

The Y-axis represents depth from the top of the logged interval to the total depth of the well. Each column on the X-axis represents a wireline log curve in the well. Examples of missing data existing in the logs are denoted by the yellow cells. These missing values can be in the form of a missing data value, a missing interval, or an entire missing well log. A common example of this problem is a field with numerous wells drilled by different entities over a lengthy time span. The density-neutron log may be the best porosity indicator for the field reservoirs, but only a portion of the wells have been logged with this tool. Some data have simply been lost over time. Can the missing data be reconstructed reliably?

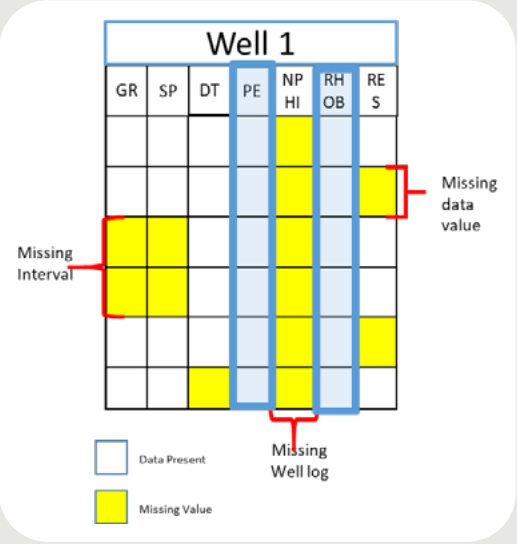


Figure 1—Different patterns of missing data

Depending on the software package being used, the default method executed on a data set with missing values may be listwise or pairwise deletions. In listwise deletions, an entire row is deleted from the analysis where an observation is missing a value in one of its variables. Thus, all variables could possibly be lost from the analysis. In pairwise deletions, an entire column is deleted from the analysis where a missing value is detected. The deleted data only pertains to the variable where the missing observation occurs. Thus, possibly the entire variable is lost from the data set. It has become common practice to insert null flag values (e.g., -999.25) to mitigate the listwise/pairwise loss of data by ignoring the missing values. However, this does not repair the data sparsity.

Furthermore, missing values can result in biased models if the missing values have a systematic relationship to any of the rock properties. Sparse data can be attributed to the overall difficulty in acquiring well data. Unconventionals are a good example of this scenario where many wells may be drilled but few are logged. When well control is sparse, the resulting model may have a higher-level uncertainty resulting in realizations being different from one another. Commonly, sparse data is supplemented with secondary data such as seismic. In order to create a reliable volume model, shown in **Figure 2**, secondary well data is necessary to supplement primary well data. What if seismic data is not available?

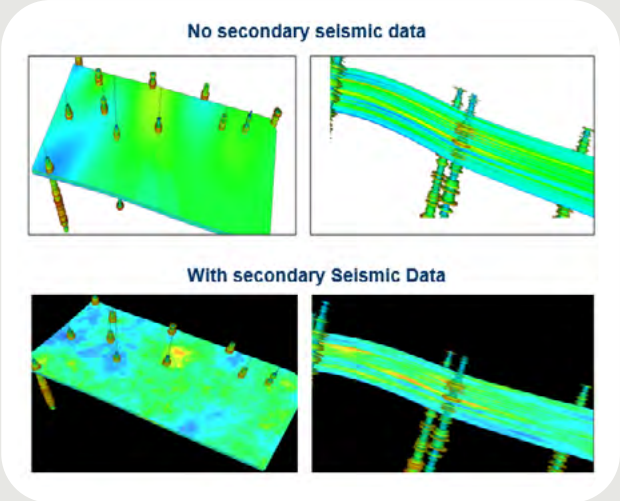


Figure 2—Top image shows surface with limited well data and no seismic and bottom image shows surface with limited well data supplemented with secondary seismic data. The top image is smoother with less detail than the bottom image.

Various tools are available to help address the problems associated with data missingness and sparsity. Using classical statistical and machine learning methods is proposed to predict missing values in well log data before simulation. Where these methods do not perform well, the remaining missing values are predicted during geostatistical kriging or conditional simulation. Under conditions of sparse data, shown in **Figure 3**, extracting properties from a burial history model or dynamic fluid flow model can be used as secondary data. Similar to seismic, basin model properties may have lower vertical resolution compared to well log data. Even so, this data can retain good horizontal resolution and can be used to improve model performance in the interwell space where log data are not available. Horizontal and vertical resolutions in basin models depend on the input resolution and number of well data included to build the model.

The classical or machine learning algorithms applied to the missing values are dependent on the missing value pattern existing in the data. Therefore, it is critical to identify the patterns of missingness and to treat each pattern separately to find a best performing model.

The results of the model prediction are also dependent on the strength of the relationship between the predictor and response variables. Using the other available well logs directly as predictors did not perform well where the predictor variables were also missing data. The resulting prediction drove model results toward a mean value rather than maintaining true geologic variance with depth. However, pretreating the variables with Principal Components – Factor Analysis (PCFA) preserves the variance in the data through eigendecomposition, creating a more robust predictor. Several models were run on each pattern including K-Nearest Neighbors, Bootstrap Forest, Boosted Trees, and Linear

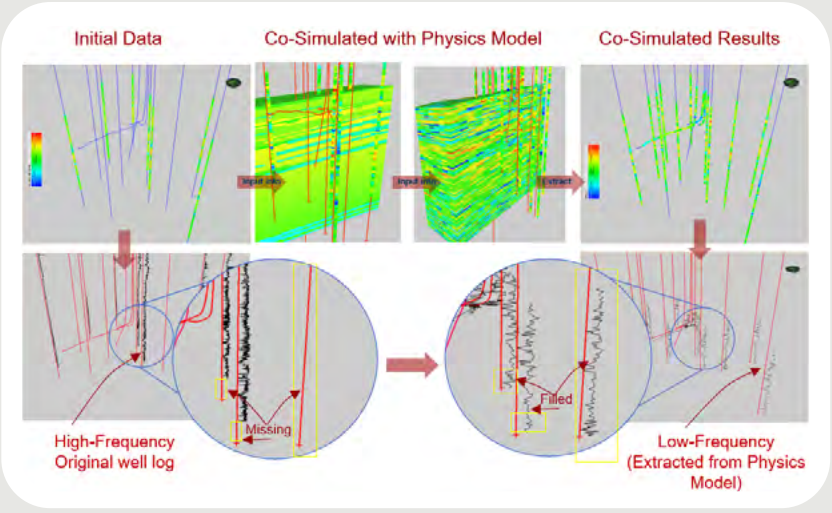


Figure 3—Sparse data set of 14 wells shown in the top left. A finite-volume physics model collocated with the primary well data creates a volume with missing data predicted where initial data is missing.

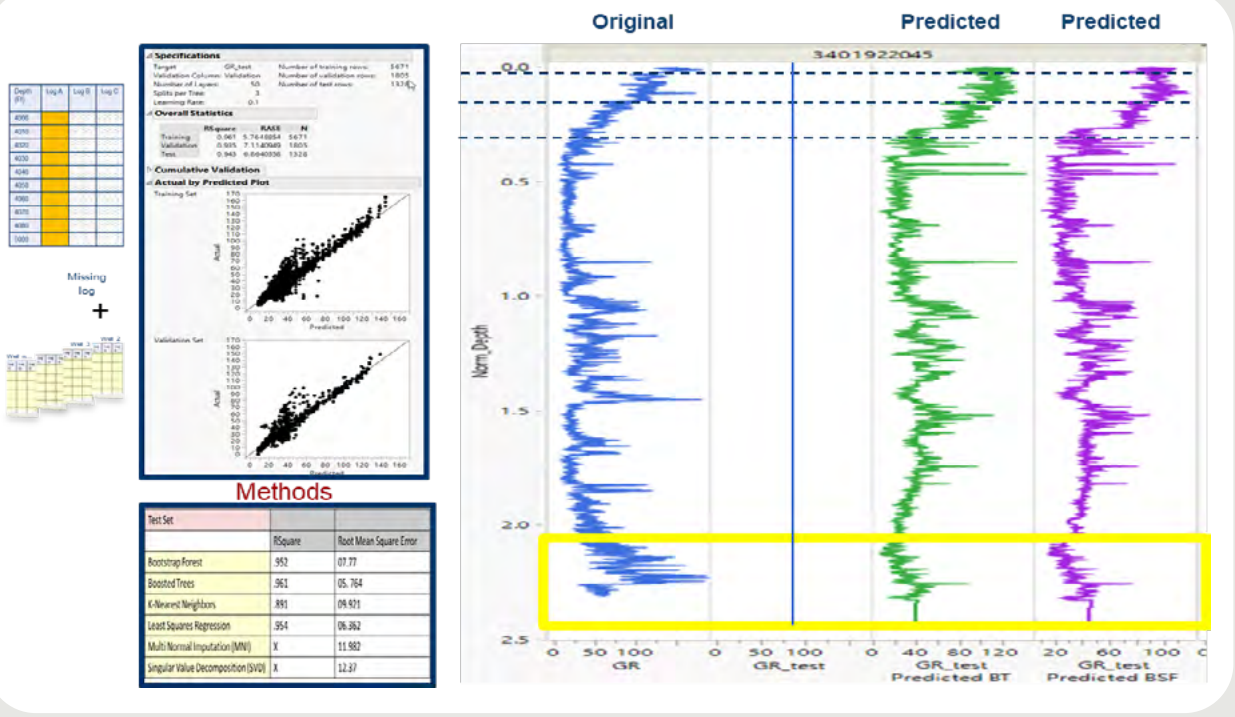


Figure 4—Example of a gamma ray log. Original log, shown in blue was manually deleted as a test set. All logs in all wells were used to generate the factors for factor analysis. Boosted Trees (green) and Bootstrap Forest (purple) were the best performing models. The models do not perform well at the bottom of the well since this is the deepest well log, and, at this level, there is not enough information from surrounding well control.

Regression and Imputation methods such as MNI and SVD. After several test cases of limiting the use of PCFA from neighboring wells, PCFA performed better with more well input. Model results were assessed quantitatively using cross-validation and a comparison of pre- and post-descriptive statistical measurements. As in **Figure 4**, viewing results in log format allowed for a qualitative measure of model performance.

The machine learning methods performed effectively on individual wells, particularly when using all of the data from the neighboring wells through factor analysis. However, when a well is missing all of the logs or missing data below the logged interval, machine learning algorithms perform poorly, as they are not designed to handle spatial correlations over large distances. Geostatistical simulation can be used to help mitigate the problem. If data are sparse and seismic is not available, properties from a finite volume basin model can be used. Basin models are not difficult to produce and are inexpensive compared to seismic.

Sequential Gaussian Simulation (SGS) is a stochastic geostatistical technique used here to simulate the well log properties (e.g., gamma ray, porosity, density). In order to calculate the level of uncertainty, 30 realizations were run on each model. Stochastic realizations are all equally probable models. The degree to which they differ from one another is a measure of the model uncertainty. When the data are sparse, simulating a property with missing values and no secondary data results in a low-resolution model with highs and lows distributed randomly across the volume. Each realization will be very different, an indication of high model uncertainty. By comparison, simulating a property that has imputed or predicted missing values and sparse data supplemented with secondary data from the basin model results in a more reliable earth model. **Figures 5 and 6** show the results of three different neutron porosity (NPHI) models generated using SGS. Model 1 was simulated using only NPHI, while Model 2 used NPHI collocated with density (RHOB), a more abundant property but still sparse. Model 3 was generated using NPHI with missing values predicted before simulation and collocated with a pervasive property extracted from a finite-volume basin model.

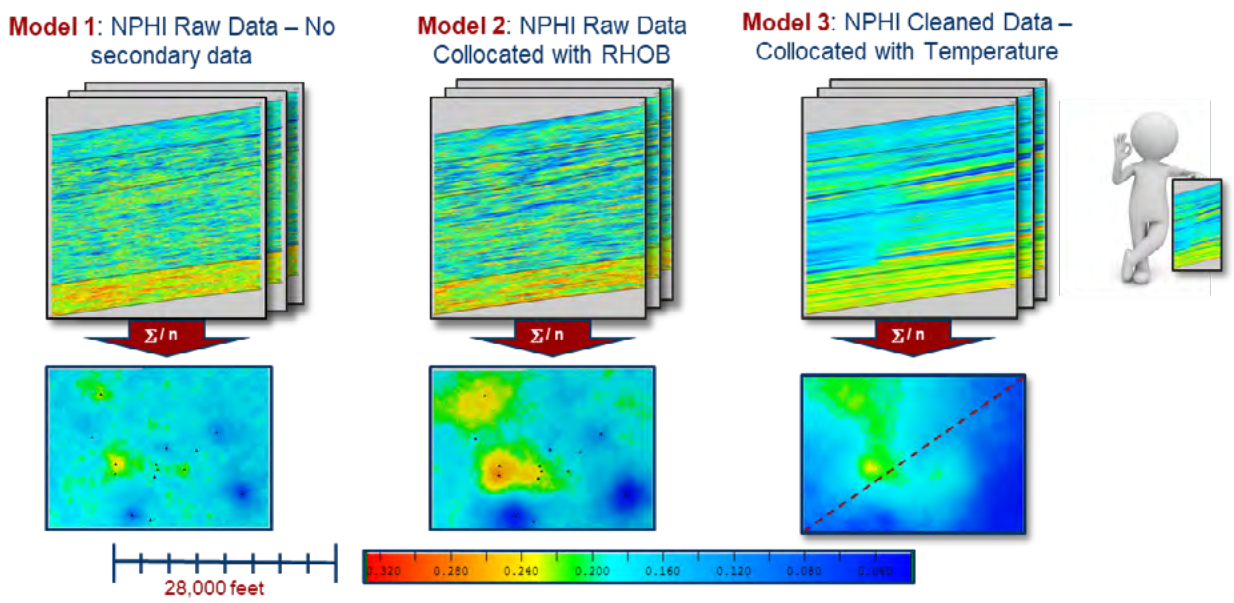


Figure 5—Results from each NPHI model. The top image in each model is showing a cross-section of 1 realization out of the 30 runs. The mean of each model was constructed and shown in the bottom image of each model. Models 1 and 2 appear highly pixelated, lacking continuity with highs and lows distributed everywhere. The mean layers of these models appear smooth due to averaging of highly different realizations. The Model 3 mean solution appears much more similar to each individual realization depicting more consistent continuity. Temperature explains 40% of the variance (r=0.6), but temperature is not highly variable thus why Model 3 appears smoother with less variance than Model 1 and Model 2.

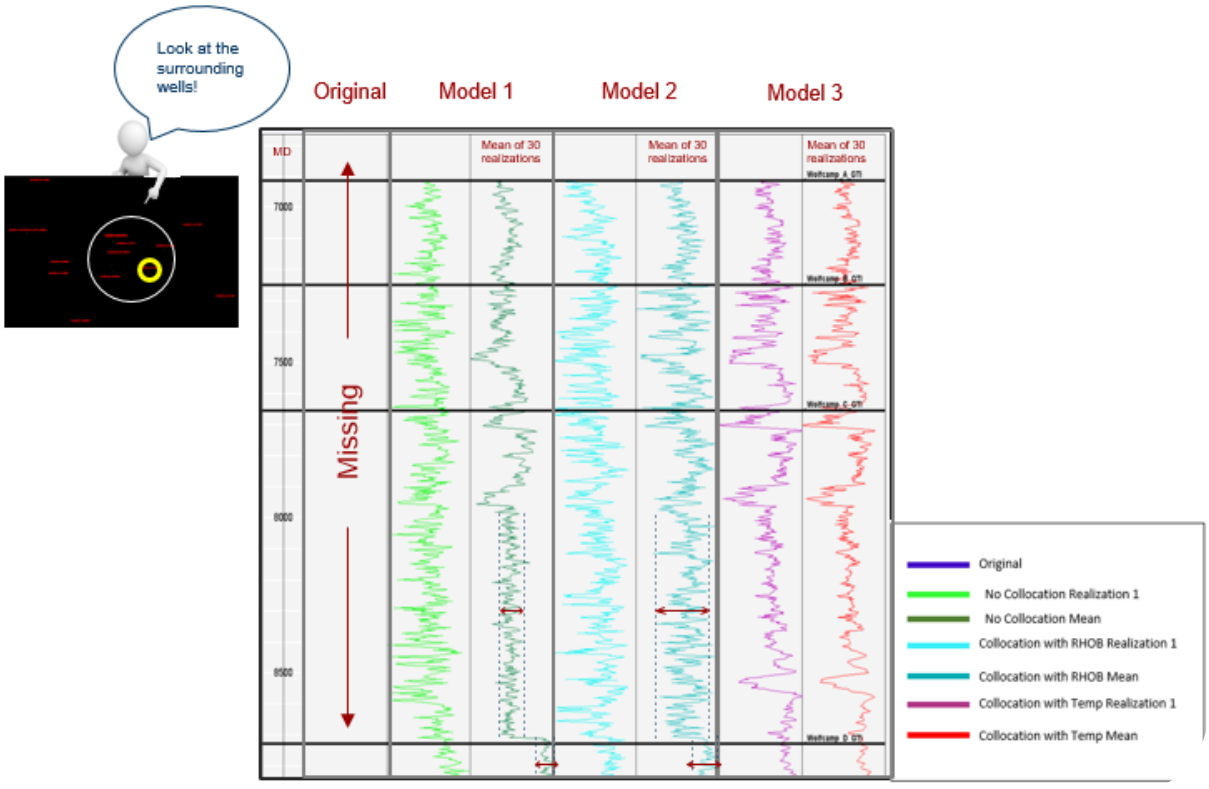


Figure 6—Extracted well logs from each model shown in Figure 6. The logs shown in each model include a log from 1 realization out of 30 and a log from the mean solution. Original NPHI log is completely missing and is surrounded by several wells with NPHI logs present.

Ryder Scott's annual conference has moved from September to May this year. The 18th Annual Reserves conference will be held virtually via the Zoom platform on the mornings of May 11th and May 12th CST.

The first 15 conferences were held in-person at the DoubleTree and Hyatt Regency hotels in downtown Houston. The annual conference grew to be the largest in-person gathering of reserves evaluators, with a full house of approximately 400 attendees. The pandemic in 2020 brought unexpected challenges; however we were able to find an alternate solution to the in-person event by streaming the conference virtually, allowing us to reach a much wider audience.

The first Ryder Scott Virtual Conference in 2020 was a great success with over 500 attendees around the globe. Our last conference reached more than 30 countries with 600 attendees. We expect to exceed these numbers this year, as we have decided to broadcast the conference twice in order to accommodate international industry professionals.

The conference will be broadcast at 8:00 AM CST on May 11th and May 12th. A second showing will be aired at 7:00 AM GST on May 12th and May 13th. The second airing has been added in an effort to reach our international clients and friends. Licensed petroleum engineers in attendance will receive a certificate to document earned CEUs (Continuing Education Units), which are required to maintain certain annual P.E. licensing requirements. The conference ends with an "Ethics Hour" that qualifies as a one-hour credit necessary to fulfill most state's annual ethics requirement for licensed engineers.

The 18th Annual Conference lineup includes well-known industry professionals. Speakers and agenda may change closer to the event. Updates will be posted at https://ryderscott.com/ryder-scott-reserves-conference/.

The conference will host the following speakers:

- Dr. John Lee, Professor at Texas A&M
- Miles Palke, Managing Senior Vice President at Ryder Scott
- Alexander MacKay, Project Engineer at Ryder Scott
- Effiong Okon, Executive Director, Operations at Seplat Energy Plc
- Herman Acuña, Executive Vice President at Ryder Scott
- John Allen, Senior Geologist at Ryder Scott
- Mukul Hariharan, Director and Manuel Amaro, Director of Engineering at Houlihan Lokey
- Panel Discussion, Moderated by Ron Harrell, Chairman Emeritus at Ryder Scott
    - Logan Burt, Managing Director at Morgan Stanley
    - Christine Ehlig-Economides, Professor at University of Houston
    - John Hessenbruch, Geological Consultant

If you are interested in attending the conference, please send an email to RSCConfHouston@ryderscott.com. Invites will be sent out in mid-April.

Zhang Presents SPE Paper at 2021 SPE-ATCE Conference

Vice President, **He Zhang**, presented the paper "An Integrated Workflow for Reserves Evaluation in the U.S. Permian Basin Based on SPEE Monograph 3" virtually at the SPE-ATCE Conference held in September 2021 in Dubai, which he coauthored with **Xiaoyang (Jeremy) Xia**, Senior Petroleum Engineer at Ryder Scott.

Other Ryder Scott coauthors include **Larry Connor**, Executive Vice President, **Dan Olds**, Managing Senior Vice President, and **Eric Nelson**, Managing Senior Vice President.

The paper was selected by an SPE program committee based on the submitted abstract, which is included below.

To read the full article, please visit: https://onepetro.org/.

Abstract

In 2011, the Society of Petroleum Evaluation Engineers (SPEE) published Monograph 3 as an industry guideline for reserves evaluation of unconventionals, especially for probabilistic approaches. This paper illustrates the workflow recommended by Monograph 3. The authors also point out some dilemmas one may encounter when applying the guidelines. Finally, the authors suggest remedies to mitigate limitations and improve the utility of the approach.

This case study includes about 300 producing shale wells in the Permian Basin. Referring to Monograph 3, analogous wells were identified based on location, geology, drilling-and-completion (D&C) technology; Technically Recoverable Resources (TRRs) of these analogous wells were then evaluated by Decline Curve Analysis (DCA). Next, five type-wells were developed with different statistical characteristics. Lastly, a number of drilling opportunities were identified and, consequently, a Monte Carlo simulation was conducted to develop a statistical distribution for undeveloped locations in each type-well area.

The authors demonstrated the use of probit plots and demonstrated the binning strategy, which could best represent the study area. The authors tuned the binning strategy based on multiple yardsticks, including median values of normalized TRRs per lateral length, slopes of the distribution lines in lognormal plots, ratios of P10 over P90, and well counts in each type-well category in addition to other variables. The binning trials were based on different geographic areas, producing reservoirs, and operators, and included the relatively new concept of a "learning curve" introduced by the Society of Petroleum Engineers (SPE) 2018 Petroleum Resources Management System (PRMS).

To the best of the authors' knowledge, this paper represents the first published case study to factor in the "learning curves" method. This paper automated the illustrated workflow through coded database queries or manipulation, which resulted in high efficiencies for multiple trials on binning strategy. The demonstrated case study illustrates valid decision-making processes based on data analytics. The case study further identifies methods to eliminate bias, and present independent objective reserves evaluations.

Most of the challenges and situations herein are not fully addressed in Monograph 3 and are not documented in the regulations of the U.S. Security and Exchange Commission (SEC) or in the PRMS guidelines. While there may be differing approaches, and some analysts may prefer alternate methods, the authors believe that the items presented herein will benefit many who are starting to incorporate Monograph 3 in their work process.

The authors hope that this paper will encourage additional discussion in our industry.

Ryder Scott Celebrates E-Week 2022

National Engineers Week, known as E-Week, took place February 20-26, 2022 to celebrate all engineers and the positive contributions that every engineering discipline and profession brings forth to improve overall quality of life. The week-long celebration was founded in 1951 by the National Society of Professional Engineers in order to recognize the importance of a technical education and a high level of math, science, and technological literacy. It motivates others to pursue engineering careers in order to provide a diverse and vigorous engineering workforce.

Currently, E-Week consists of more than 70 engineer, education, and cultural societies and more than 50 corporations and government agencies. E-Week in Houston, the Energy Capital of the World, reaches numerous schools, businesses, and community groups, and Ryder Scott is proud to be a business that gives back to those who recognize the benefits of pursuing engineering and technology careers. The Ryder Scott Company Friends of UHPE was created in 2012 in order to sponsor and support University of Houston (UH) petroleum engineering students as part of E-Week. Over the last 10 years, our donors have raised more than $90,000 for UH petroleum engineering students.

Ryder Scott Chairman Emeritus Ron Harrell with Trevor Eustaquio, recipient of the Ryder Scott Dr. John Lee Engineering Legacy Award and Juan Flores, recipient of the UH PEAB Dr. Thomas Holley Engineering Professionalism Award.

On Tuesday, February 22, Ryder Scott Company Friends of UHPE took part in the Engineers Week 2022 Program hosted by the UH Engineering Alumni Association (UHEAA). As one of the biggest sponsors of this event, Ryder Scott Friends of UHPE has a long-standing tradition of individuals at Ryder Scott coming together to support the petroleum engineering students at UH each year. This year, Ryder Scott raised more than $6,000 for the event. Thanks to our generous donors (some with no direct ties to UH), we were able to present eight petroleum engineering students with the Excellence in Petroleum Engineering Award and one student with the Dr. John Lee Engineering Legacy Award. Along with recognition of their outstanding academic achievements, each student received a cash award in the amount of $500.

Ryder Scott Company Friends of UHPE also supports other initiatives administered by the petroleum engineering department that benefit all of the petroleum engineering students. This includes the most recent initiative, the UH Petroleum Engineering Externship Program, which creates opportunities for students to get real-life working experience on projects led by industry partners.

Ryder Scott's Chairman and CEO, Dean Rietz, along with Ryder Scott's Chairman Emeritus, Ron Harrell, and Senior Petroleum Engineer and Data Science Coordinator, Adam Cagle, also serve on the UH Petroleum Engineering Advisory Board (PEAB) and help to raise funds for PEAB E-Week awards. Rietz, Harrell, and Cagle each presented a separate set of awards sponsored by PEAB to another group of deserving petroleum engineering students.

Reflecting on the success of this year's event, Cagle said, "Fundraising and coordinating with all of the donors and the school can be a lot of work, but going to the reception where I get to visit with these outstanding students and take part in recognizing them for their hard work makes it all worthwhile."

Adam Cagle with Ryder Scott Company Friends of UHPE student award winners

Ryder Scott remains dedicated to ensuring a diverse and well-educated future engineering workforce by increasing understanding of and interest in engineering and technology careers. We hope to encourage others to support their local educational institutions as well.

Ryder Scott New Hires

Andrew Thompson, **William Turner**, **John Allen**, and **Niels Snow** joined the Ryder Scott office recently, altogether bringing decades of diverse experience to the team.

Andrew Thompson rejoined Ryder Scott as a Senior Vice President and Manager of the Calgary office at the beginning of April 2022. He has over 30 years of diversified technical experience. His primary areas of expertise include reserves evaluations, reservoir modeling, drilling and completions, well testing and abandonment operations. Reservoir studies have included primary, secondary and tertiary recovery methods and analysis of unconventional low permeability and highly fractured reservoirs.

Most recently, Thompson worked as a Managing Director for Macquarie Group where he led the technical analysis for principle financings and investments in oil and gas companies. He conducted economic evaluations for oil and gas assets, led intensive due diligence processes, and monitored operations, production, and reserves updates.

Thompson was instrumental in developing and maintaining business operations in Calgary at Ryder Scott during his employment from 1995 to 2008. As the Manager of the Calgary office, he was a lead engineer and primary contact for several clients.

In the first five years of his career, Thompson worked as a Petroleum Engineer. He gained hands-on experience with various surface facility equipment at Magus Engineering Ltd where he performed on-site supervision of down-hole completions, well testing, work-overs, abandonments, and horizontal, directional, and under-balanced drilling operations.

Before that, Thompson prepared economic evaluations for oil and gas properties at Coles, Gilbert Associates Ltd. and then at Guard Resources Ltd. He began his professional career at the Alberta Energy and Utilities Board, preparing natural gas reserves estimates for long-term gas removal applications, pipeline applications, and reserves classifications.

Thompson is a member of the Association of Professional Engineers and Geoscientists of Alberta and Society of Petroleum Engineers. He has a BS degree in Petroleum Engineering from the New Mexico Institute of Mining and Technology. Before becoming an engineer, Thompson considered a career as a professional bareback rider in the 90s, traveling around Alberta, British Columbia, Saskatchewan and the northern United States, competing in rodeos as a novice bareback rider. He now enjoys mountain biking with his wife and getting in a few rounds of golf during his free time.

William Turner is a Senior Project Engineer in the Midstream and Upstream Integrated Services group at Ryder Scott. His diverse experience began with a decade of engineering, subsea and pipeline design, fabrication, and installation. His areas of expertise also include field development, production modeling, and cost and schedule estimation.

Before joining Ryder Scott in March 2022, Turner worked as a Lead Analyst for Rystad Energy. He monitored various elements of the energy supply chain including supply and demand, costs, and the financial strength of suppliers across all sectors from seismic to decommissioning. He also reviewed the energy transition to renewable sources such as offshore wind and solar.

Before that, he was the Vice President of Welligence Energy Analytics where he led the company's expansion into the US Gulf of Mexico and was instrumental in the launch of a product for use in evaluating assets for portfolio benchmarking, mergers and acquisitions, and new field developments.

From 2017 to 2019, Turner was a Senior Research Analyst for Wood Mackenzie. He started from bottom-up well-level analysis and field research, proceeded up to field level commercial analysis reports, ultimately developing a macro view of the region and the broader sector. With his extensive knowledge of deepwater technology, operations, cost estimation techniques, and project management, Turner brought a unique perspective to his team.

Turner began his professional career in 2007 at EMAS AMC, where he spent over 10 years and worked his way up to Deputy Project Manager. He managed major projects for subsea and pipelines for upstream and midstream operators.

He has a BS degree in Ocean Engineering from Texas A&M University and an MS degree in Technology Commercialization from the University of Texas at Austin. A true Texan, Turner owns and independently runs a small cattle farm. He enjoys spending his free time with his wife and two sons.

John Allen joined Ryder Scott in November 2021 as a Senior Geologist with more than 10 years of experience integrating seismic interpretation, geologic and geophysical data, and resource assessment to evaluate and develop profitable oil and gas prospects in conventional and unconventional plays. His specialties include integrated structural geology, tectonics, stratigraphy, geophysics, and play and prospect assessment.

Before joining Ryder Scott, Allen worked as a Geologist for the Department of the Interior in the U.S. Gulf of Mexico Regional Framework Unit. In this position, he collaborated with geologists and geophysicists to integrate regional salt body and tectonic datasets to create products for the evaluation of hydrocarbon systems in all known plays in the Gulf Basin.

From 2018 to 2020, Allen worked as a Senior Geologist for XTO Energy where he oversaw daily drilling operations and unit development planning. He also leveraged his expertise in risk and uncertainty analysis to create an innovative workflow for the characterization and valuation of subsurface volumetric resources in unconventional plays.

Allen began his career as a Geoscientist at ExxonMobil, where he worked for nine years, serving as team lead for risk and resource assessment. In this position, he managed multiple concurrent projects and provided geotechnical peer review for the exploration program, including prospect identification, maturation, operations, and acquisition and divestitures.

He has a BS degree in Geology from Furman University, an MS degree in Structural Geology from North Carolina State University, and a PhD in Tectonostratigraphicy from the University of Kentucky.

Niels Snow joined the Ryder Scott Houston office in December 2021 as an Associate Economist where he applies both qualitative and quantitative economic analysis to research pertaining to oil and gas. His specialties include economic analysis and cost and risk analysis.

Previously, Snow was a Market Research Analyst with Rare Petro. He researched, compiled, and analyzed information for assigned engineering projects. He also assisted with processes related to engineering, cost analyses, and podcast productions.

Snow has a BS degree in Petroleum Engineering and an MS degree in Mineral and Energy Economics from the Colorado School of Mines. He is a member of the Association of Petroleum Negotiators and the Society of Petroleum Engineers. Snow is a fourth-generation petroleum engineer. Before continuing in the family tradition, he enjoyed video editing and worked editing videos for YouTube.

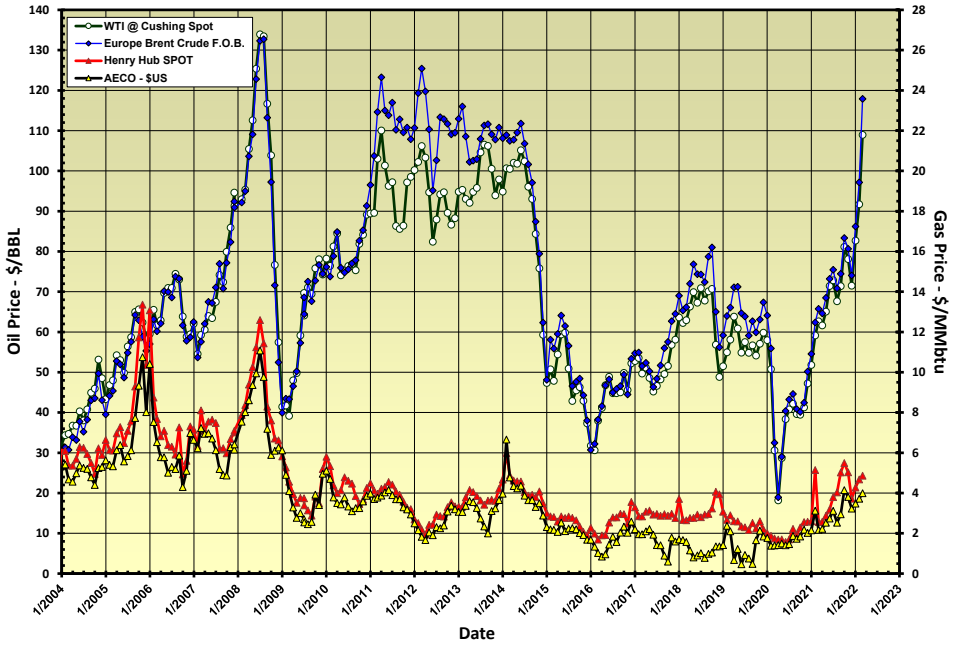
In Memoriam

Charles P. Milner, 91, passed away in March after a long life of devotion to the sciences and the arts. He joined Ryder Scott in 1967 as a petroleum engineer, working on major oil and gas projects throughout the world. Milner's expertise and work ethic served as an inspiration to colleagues and clients alike. He retired as President of Ryder Scott in 1990.

Former Ryder Scott employee and friend of Milner, Joe Magoto said "Will Rogers said, 'I never met a man I didn't like,' bottom line, I never met anyone who didn't like Charlie Milner."

Before joining Ryder Scott, Milner worked at Phillips Petroleum Company, followed by El Paso Natural Gas, and Tenneco. He received a BS degree and an MS degree in Petroleum Engineering from the University of Texas at Austin.

Price History of Benchmark Oil and Gas in U.S. Dollars



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The Ryder Scott Quarterly
is published quarterly by Ryder Scott Co., LP. Established in 1937, the consulting firm performs hundreds of independent studies a year and offers a wide range of services – including reserves evaluations, geological studies, reservoir simulation modeling, integrated studies, facility evaluations, data analytics, economic analyses, expert witness testimony, and sustainable energy consultancy to name a few. With 113 employees, including 77 engineers and geoscientists, Ryder Scott has the expertise and capability to complete the largest, most complex reservoir evaluation projects in a timely manner.

RYDER SCOTT | 85th Anniversary 1937 - 2022

Cover picture is of the Digboi Field, one of the oldest oil fields in the world. Picture taken by Dean Rietz, CEO.

RYDER SCOTT

2022 QUARTER 3

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THE RYDER SCOTT QUARTERLY

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Welcome Note

By: Dean Rietz, CEO

As announced in the January edition of the newsletter, Ryder Scott is celebrating our 85th Anniversary. We are reflecting on these past 85 years and amazed at the growth of the industry and the many changes we have experienced along the way. We feel fortunate to be here after so many years, embracing times of great success and directly facing times that challenge us. There is nothing more important to Ryder Scott than our industry's ability to continue to provide low cost energy with minimal environmental impact. We will continue to be your trusted, independent, and highly experienced energy consultant. In order to maintain top talent as costs rise and inflation continues to impact us all, we have implemented an adjustment to our rates. Please see my article discussing this at the end of this newsletter.

As always, feel free to send comments to me directly at Dean_Rietz@RyderScott.com.
I welcome your feedback.

Editor's Note

By: Pamela Sabo

Thank you to our readers who sent a note to me following the inaugural edition of The Ryder Scott Quarterly. I hope to continue to receive notes from you. At Ryder Scott, we are dedicated to you, our industry friends, and believe the best way to bring you what you want is to build lasting relationships with each one of you. I recently attended URTeC in Houston where Ryder Scott hosted a booth. Thank you to all who stopped by and to my work colleagues who assisted with the event. I hope to see more of our industry friends soon. Please check our website and social media platforms to keep up-to-date on where we may be next.

"Continuous improvement is better than delayed perfection." Mark Twain

Khurana Presents at 2022 OTC Offshore Technology Conference

Vice President, **Sandeep Khurana**, presented the paper "Carbon Capture, Utilization, and Sequestration Value Chain" at the OTC Offshore Technology Conference held in May 2022 in Houston, which he coauthored with Steven Beck.

Abstract

The objective of this paper is to demystify the components of the value chain for carbon capture, utilization, and sequestration (CUS). The focus is on the technological challenges and advancements in capture, compression, transportation, and storage as well as the incentives available to deliver economic CCUS projects.

The paper identifies main components in the value chain, related costs and ways to reduce the overall breakeven carbon price, and shares economic case studies from recent projects and developments underway in the industry. The paper specifically compares and contrasts between two distinct case studies to assess the CUS value chain as follows:

- A standalone project case study from carbon capture to injection with a breakdown of the cost along with an economic analysis to establish the breakeven carbon price and ways to reduce it.
- A regional development case study in which the paper evaluates various development concepts of carbon capture sources and distribution of carbon for enhanced oil recovery (EOR) and storage to contemplate ways to reduce further the breakeven carbon price.

The paper elaborates on challenges of carbon sequestration in the reservoirs and carbon resource storage-resource-management-system. It covers carbon tax credits available in the market place. Finally, the paper highlights a way forward for the industry to optimize the value chain segments with use of new technology and elaborate on configuration of regional concepts.

Introduction

To prevent the effects of global warming, the Intergovernmental Panel on Climate Change (IPCC) has determined a global temperature increase limit of 1.5°C by 2050. This limit will require an additional 5,635 million metric tonnes per annum (MTPA) of carbon capture capacity. As of 2021, 39 MTPA of deployed carbon capture capacity exists worldwide, with 43 MTPA of full-scale projects currently in various stages of development. With the total estimated carbon capture capacity expected to reach only 82 MTPA in the next few years, compared to the required carbon capture capacity of 5,635 MTPA to meet climate targets, it appears to be an opportune time in the market for new carbon capture, utilization, and sequestration or storage (CUS) projects.

Continue reading the the full article here: https://onepetro.org/.

Ryder Scott Vice President Sandeep Khurana presented at the 2022 OTC Offshore Technology Conference on May 3, 2022.

Annual Reserves Conference Reaches Record Number of Attendees

The 18th Annual Ryder Scott Reserves Conference was moved to May 11 and 12, different from previous years when the conference was held in September. The conference committee consisted of Pamela Sabo, Chair, Ronald Watt, IT Manager, Emily Ammons, Coordinator, and Deborah Corral, Designer.

The third year held virtually via Zoom, the conference was offered at two different times in order to reach more of our clients and industry friends around the globe. We reached a record number of 745 unique industry professionals from 45 different countries. The conference cultivates a better understanding of the latest industry trends and findings and also provides a platform that encourages individuals to exchange new ideas and concepts.

Ryder Scott's Chairman and CEO, Dean Rietz, opened the conference and welcomed all attendees to the program. The Chair of the Reserves Conference and Ryder Scott's Business Development and Sales Manager, Pamela Sabo, made introductions throughout the event.

Left Ryder Scott's Chairman and CEO, Dean Rietz, middle Business Development and Sales Manager, Pamela Sabo, right Seplat Energy's Executive Director, Effiong Okon.

Speakers and their respective topics included:

- Dr. John Lee, Professor at Texas A&M University – Uncertainty in Type Well Construction? What Uncertainty?
- Effiong Okon, Executive Director of Operations at Seplat Energy Plc – Global Gas Market
- Alexander MacKay, Upstream and Midstream Integrated Services Project Engineer at Ryder Scott – The Natural Gas Value Chain
- Miles Palke, Managing Senior Vice President (Reservoir Simulation) at Ryder Scott – SEC Comment Letters
- Herman Acuña, Executive Vice President at Ryder Scott – SEC Proposed Enhancement and Standardization of Climate-Related Disclosures
- John Allen, Senior Geologist at Ryder Scott – Geology of Unconventionals
- Panel Discussion on Energy Transition
    - Moderator: Ron Harrell, Chairman Emeritus at Ryder Scott
    - Panelists
        - John Hessenbruch, Associate at David Hoffman & Associates
          Industry: Global Supply Chain Challenges for the Energy Industry
        - Logan Burt, Managing Director at Morgan Stanley Energy Partners
          Money: Recent Energy Industry Trends
        - Christine Ehlig-Economides, Professor at University of Houston
          Research: Workforce Development for an Energy Transition
- Lance Kinney, Executive Director at Texas Board of Professional Engineers and Land Surveyors – Ethics Hour

All available presentations are posted on our website at www.ryderscott.com.

The committee is beginning preparations for the 19th Annual Reserves Conference. It is being planned for May 2023, and due to the success of this year's conference, it will be held virtually. We hope to reach even more industry professionals around the globe. Please reach out to Pamela Sabo if you would like to receive an invitation to the event.

The next article is based on Alexander MacKay's conference presentation.

The Natural Gas Value Chain

By: Alexander MacKay, Project Engineer at Ryder Scott

Introduction

With the increasing focus on environment, social, and governance (ESG) considerations in the energy industry, the importance of natural gas as a low carbon intensity energy source continues to grow. In the United States, one of the largest and most diverse global energy markets, consumption of coal is declining and consumption of oil has remained relatively constant since the mid-2000s. In contrast, consumption of natural gas along with growth in renewable energy sources are increasing to meet energy demand. **Figure 1** shows natural gas demand growth is the largest of any energy source since the mid-2000s.

Understanding the production, transportation, marketing, and sales of natural gas can provide valuable insight. We have developed a rigorous value chain analysis in-house where we start from gas production to product delivery to the market. We identify areas to optimize cost and improve sale margins. Value chain analysis can be performed in a global market or targeted to a specific region.

In our analysis, we calculate the equivalent unitized cost ($/Mcf) of each component of the value chain. This facilitates comparison of the commerciality of natural gas products based on demand and identifies dynamics within the value chain. We base our analysis on a deep understanding of subsurface resources to generate gas supply scenarios, analysis of production and midstream infrastructure and plants, and, finally, fiscal and regulatory considerations. This allows for us to apply value chain analysis for a wide array of applications For upstream operators, we can provide

	Fossil Fuels[a]					Renewable Energy[b]						
	Coal	Natural Gas[c]	Petro-leum[d]	Total[e]	Nuclear Electric Power	Hydro-electric Power[f]	Geo-thermal	Solar	Wind	Bio-mass	Total	Total[g]
1950 Total	12.347	5.968	13.298	31.615	0.000	1.415	NA	NA	NA	1.562	2.978	34.599
1955 Total	11.167	8.998	17.225	37.380	.000	1.360	NA	NA	NA	1.424	2.784	40.178
1960 Total	9.838	12.385	19.874	42.091	.006	1.608	(s)	NA	NA	1.320	2.928	45.041
1965 Total	11.581	15.769	23.184	50.515	.043	2.059	.002	NA	NA	1.335	3.396	53.953
1970 Total	12.265	21.795	29.499	63.501	.239	2.634	.006	NA	NA	1.431	4.070	67.817
1975 Total	12.663	19.948	32.699	65.323	1.900	3.155	.034	NA	NA	1.499	4.687	71.931
1980 Total	15.423	20.235	34.159	69.782	2.739	2.900	.053	NA	NA	2.475	5.428	78.021
1985 Total	17.478	17.703	30.866	66.035	4.076	2.970	.097	(s)	(s)	3.016	6.084	76.334
1990 Total	19.173	19.603	33.500	72.281	6.104	3.046	.171	.059	.029	2.735	6.040	84.433
1995 Total	20.089	22.671	34.341	77.162	7.075	3.205	.152	.068	.033	3.101	6.559	90.931
2000 Total	22.580	23.824	38.152	84.620	7.862	2.811	.164	.064	.057	3.008	6.104	98.702
2005 Total	22.797	22.565	40.217	85.623	8.161	2.703	.181	.058	.178	3.114	6.234	100.102
2006 Total	22.447	22.239	39.731	84.477	8.215	2.869	.181	.061	.264	3.262	6.637	99.392
2007 Total	22.749	23.663	39.368	85.805	8.459	2.446	.186	.066	.341	3.485	6.523	100.894
2008 Total	22.387	23.843	36.769	83.041	8.426	2.511	.192	.075	.546	3.851	7.175	98.754
2009 Total	19.691	23.416	34.779	77.862	8.355	2.669	.200	.079	.721	3.940	7.609	93.943
2010 Total	20.834	24.575	35.321	80.723	8.434	2.539	.208	.093	.923	4.506	8.268	97.514
2011 Total	19.658	24.955	34.639	79.263	8.269	3.103	.212	.114	1.168	4.616	9.214	96.872
2012 Total	17.378	26.089	33.833	77.304	8.062	2.629	.212	.162	1.340	4.517	8.860	94.387
2013 Total	18.039	26.805	34.398	79.224	8.244	2.562	.214	.225	1.601	4.861	9.464	97.130
2014 Total	17.998	27.383	34.658	80.017	8.338	2.467	.214	.337	1.728	5.016	9.762	98.297
2015 Total	15.549	28.191	35.368	79.090	8.337	2.321	.212	.427	1.777	5.015	9.752	97.407
2016 Total	14.226	28.400	35.712	78.319	8.427	2.472	.210	.570	2.096	5.063	10.411	97.384
2017 Total	13.837	28.055	36.043	77.907	8.419	2.767	.210	.777	2.343	5.045	11.142	97.660
2018 Total	13.252	31.153	36.892	81.271	8.438	2.663	.209	.915	2.482	5.105	11.374	101.235
2019 Total	11.316	32.252	36.866	80.413	8.452	2.564	.201	1.017	2.635	5.056	11.473	100.471

Figure 1 — Primary energy consumption by source, quadrillion BTU (EIA).

Natural gas has diverse applications that include electricity generation, industrial usage as a feedstock for fuels, chemicals and fertilizers, and commercial, residential, and transportation fuel as compressed natural gas. It also has a growing role in the production of hydrogen. Natural gas products of interest in the market are liquefied natural gas (LNG), methanol, and ammonia.

insight into relative profitability of downstream products to inform the sell side of future natural gas contracts. For midstream asset owners, we can provide confidence in future gas supply through midstream systems and insight on cost of gas from fields to modify future-tariff contract structures. For downstream industrial consumers, we can provide confidence in future gas supply, offer insight into their competitive position in the market, and frame

their negotiating position for securing future gas contracts. For national oil companies and regulatory bodies, we can clarify incentives for future developments based on fiscal terms.

For clients in the petrochemical industry, we will outline and execute a case study that focuses on a specific region to elaborate on value chain definitions, data, and conclusions.

Value Chain Analysis

The natural gas value chain comprises five (5) primary components as shown in **Figure 2.**

In our case study, the regional value chain includes gas supply from both offshore and onshore sources, with primary demand composed of industrial users.

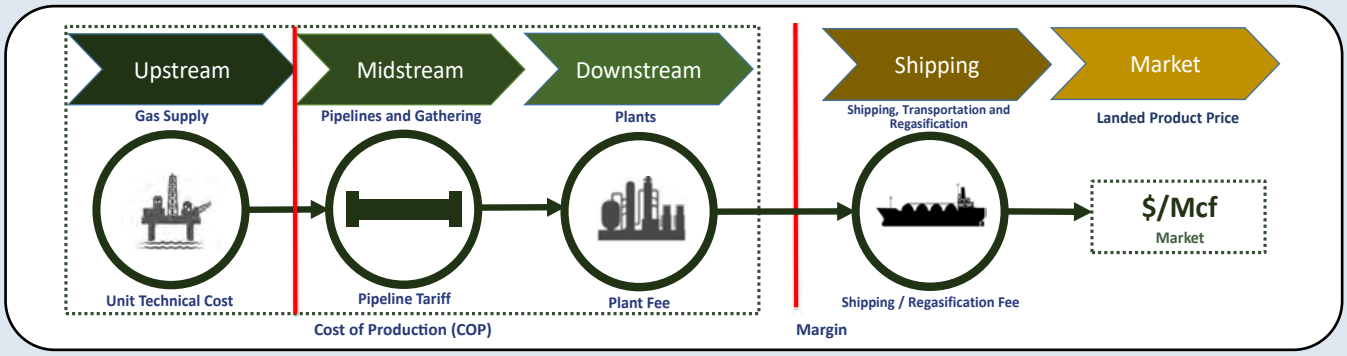


Figure 2 — Natural gas value chain.

The upstream component consists of natural gas reservoirs and the production facilities that lead to gas supply forecast. We account for the upstream component of the value chain cost by calculating Unit Technical Cost (UTC). UTC is an indicator used in the energy industry to determine the profitability of upstream developments on a volumetric basis. The general formula for UTC is in **Equation 1**.

$$UTC\left(\frac{\$}{Mcf}\right) = \frac{Technical\ Cost\ (CAPEX + OPEX)}{Recoverable\ Resources\ -\ Royalty}$$

(Equation 1)

UTC is calculated on a "field life" basis, where all future CAPEX and OPEX are accounted for in technical cost. Recoverable resources are net of upstream shrinkage (i.e., fuel usage). Net present UTC can be accounted for by applying an appropriate discount rate.

The midstream component consists of the transportation infrastructure, herein gas transmission lines, to deliver gas to demand centers. We account for the midstream component of the value chain by calculating a midstream tariff. The formula for the midstream tariff is in **Equation 2.**

$$Pipeline\ Tariff\left(\frac{\$}{Mcf}\right) = \frac{Regulated\ Return\ +\ OPEX}{Total\ Throughput\ Volume}$$

(Equation 2)

The regulated (annual) return may be analogous to the cost of capital determined by assessing the original CAPEX for the pipeline system and applying a flat yearly rate of return.

The downstream component consists of the plants utilized to generate industrial natural gas products. In our case study, these products include LNG, ammonia, and methanol. We account for the downstream component of the value chain by calculating a plant fee. The formula for the plant fee is in **Equation 3**.

$$Plant\ Fee\left(\frac{\$}{Mcf}\right) = \frac{Technical\ Cost\ (CAPEX + OPEX)}{Supply\ Gas\ -\ Fuel\ Gas}$$

(Equation 3)

Similar to UTC, the technical cost is calculated on a plant life basis. Plant shrinkage is accounted for by subtracting fuel gas from supply gas.

The summation of the UTC, midstream tariff, and plant fee is defined as the Cost of Production (COP), and it is a potentially important metric for comparing the relative cost of producing products. This comparison can be applied to different products within the same value chain or for the same product across different regional value chains.

The shipping component of the value chain accounts for the cost of transportation to global markets. We account for the shipping component by calculating a shipping fee. The formula for the shipping fee is in **Equation 4**.

$$Shipping\ Fee\left(\frac{\$}{Mcf}\right) = \frac{Total\ Cost}{Transported\ Volume}$$

(Equation 4)

In order to capture the "total cost", a model is required to consider the variables that will affect total shipping cost. These include but are not limited to the duration of voyage, tanker volume, charter fees, port calls, and product type. Product type is particularly important for LNG. Regasification is required for the back-end of shipping and LNG has a high boil off rate relative to other products.

The last component of the value chain is market price. Price varies based on market conditions and can vary significantly between global benchmarks for certain products. Conducting a market study during value chain analysis is important to frame expected variation of product prices within study parameters. With the components and their ranges established, margins can be calculated for natural gas products for different scenarios. A visualization of margin analysis is in **Figure 3**.

In this example, margins are calculated by subtracting the Freight on Board (FOB) product price from the COP. The FOB price is the landed global product price with the shipping fee subtracted. These margins can provide a robust starting point for commercial negotiations and can be calculated at other points of the value change depending on the requirements of the project.

Case Study Results

Our case study focuses on industrial natural gas products for a regional value chain. The purpose of this case study was to assist with negotiations to secure future gas contracts for users in the region. In parallel to the development of value chain component ranges for margin analysis, we performed a gas supply study to project future regional gas volumes, reviewed regional demand and domestic capacity forecasts, and performed a regulatory study to ensure that these dynamics were adequately captured in our component ranges. Value chain cost ranges ($/mcf) for the case study are shown in **Figure 4** on page 7.

The upstream UTC represents the most significant cost component range, driven by development status, reservoir properties, location, infrastructure maturity, and resource size. This result is typical, although it may not apply for value chains where gas infrastructure is fully developed.

The downstream plant fee also represents a significant component range, driven by product plant type, capacity and design life, and/or age. The midstream

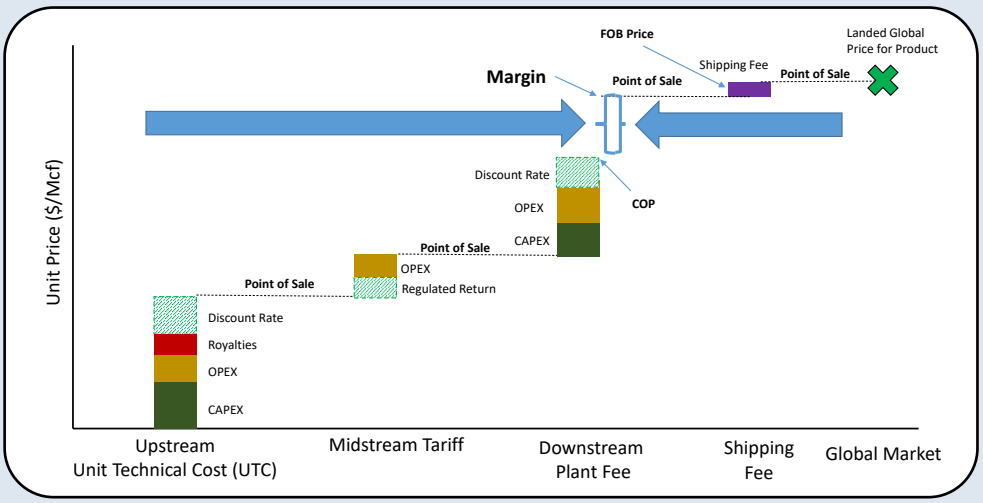


Figure 3 — Margin analysis.

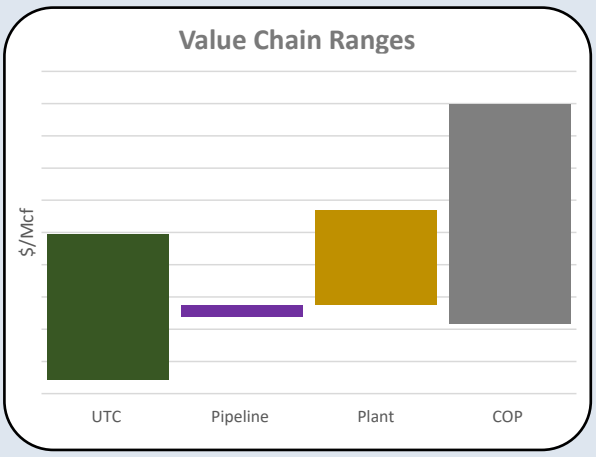


Figure 4 — Value chain cost ranges.

pipeline tariff does not represent a significant component range.

This result is typical, although it may not apply to value chains where gas supply is remote, which would require building dedicated infrastructure for a development.

In order to perform value chain analysis, we developed a model with the capability of considering various scenarios, storing component cost ranges, and calculating / illustrating product margins.

Using the results of the gas supply, demand studies, and projected future market conditions, we developed margin scenarios based on projected gas supply, regional demand, capacity, and projected market conditions. Based on selected regional conditions, we chose a scenario that held the UTC, pipeline tariff, and aggregate shipping fee constant and varied plant fees and market prices. **Figure 5** illustrates the margins for this scenario.

The variation of margins between products outlines the position and value proposition of each product. The results of this margin analysis provide negotiation support for gas contracts and demonstrate the competitive standing of natural gas products in the value chain.

In addition, the resource study provides a confidence range of gas supply going forward and the demand study outlined likely allocation of the gas supply.

Together, these exercises allowed for us to increase confidence with making business operations decisions in the future for the region.

As stated earlier, value chain analysis has a wide array of applications for all energy industry participants, and this case study highlights one. The value proposition of these studies will grow as the position of natural gas in the energy industry continues to strengthen.

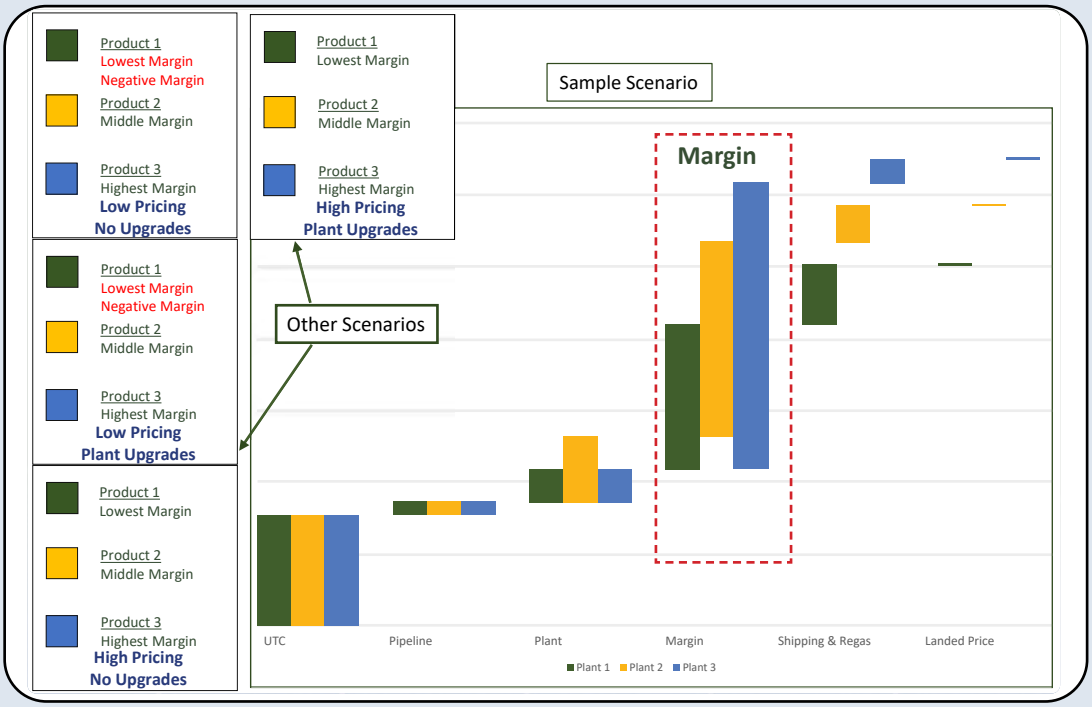


Figure 5 — Case study margin analysis.

Inflation and Increasing Costs Drives Rate Adjustment After Four Years

By: Dean Rietz, Chairman and CEO

Starting in August, Ryder Scott is implementing a modest increase to our billing rates. This is the first change to our standard rate sheet in four years. While we are reluctant to do so, external factors require us to make such a change.

Since the oil and gas commodity price collapse at the end of 2014, the industry has been struggling to meet the demand for oil and gas while staying profitable in a low-price environment. During this time, Ryder Scott has done our best to respond to our clients' requests and needs while keeping our billing rates competitive. In 2018 when prices rose, we implemented a slight increase to our standard rate sheet, which has remained in-place.

With commodity prices continuing to increase since 2015, producers have been able to stay competitive – from a staffing standpoint – with modest increases in compensation (based on published SPE and other salary surveys). Since our commodity price (our billing rate or rate we charge our clients) has been essentially flat since 2018, we have lost ground, comparatively speaking. Fortunately, the loyalty and connectedness of our staff have kept our work-family intact, but this can only be sustained for so long.

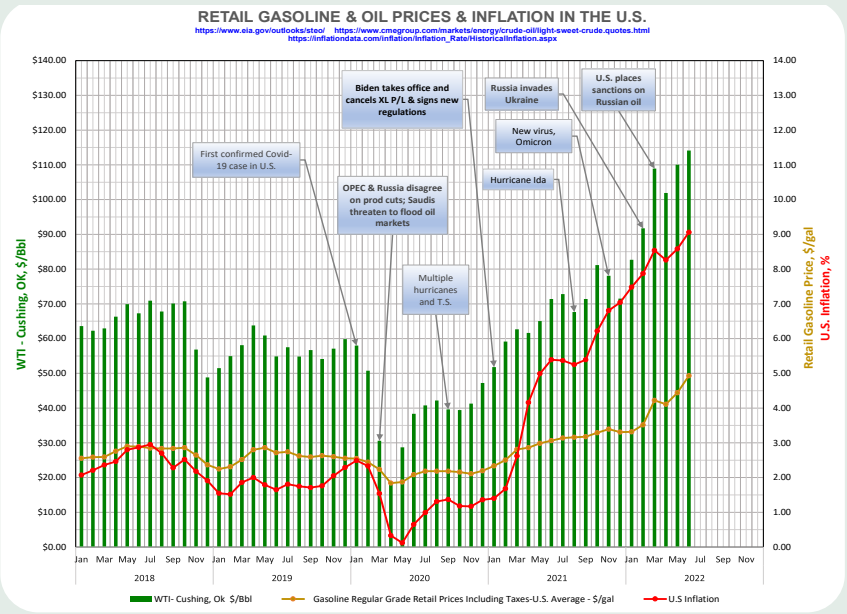
We recognize the impact on demand for oil and gas following the initial and continued effect of the COVID-19 pandemic. We further recognize the tightening of belts by nearly all participants in our industry, including staff reductions implemented by many of our clients. However, the pendulum has swung, and there is now an increase in demand for petroleum engineers and geoscientists, providing an uptick in compensation rates. This, along with the recent and significant inflation impact, necessitates us to implement a rate adjustment at this time in order to stay competitive and attract and maintain a staff of the best evaluators in the industry.

We note that many of our clients are seeing significant improvements in their revenues, yet we also acknowledge that, just like us, their expenses are increasing. We are also aware that many in the E&P community are profitable, including both our clients and non-clients, and this profitability is continuing to rise. There is nothing more important than our industry's sustained ability to continue to provide low cost energy with minimal environmental impact.

I would like to emphasize that we have decided to raise our standard rates in order to stay competitive and keep the high-end talent that our clients expect and demand. I hope that you – our industry friends, supporters, and clients – understand our position, and you are able to accept and incorporate this modest increase within your standard operations, with minimal impact due to the currently high commodity prices. Ryder Scott appreciates your understanding in this matter and recognition of the times we are in.

We are proud to be associated with you, our industry friends and clients. Our client list is unmatched, and we pledge to continue to exceed your expectations and be your trusted partner.

I welcome any questions, comments, or concerns. Please feel free to contact me directly at Dean_Rietz@RyderScott.com.



Important Dates

Ralph Fellows Celebrates 100th Birthday

Ryder Scott's first geologist, Ralph Fellows, turned 100 on June 8th. Fellows is an integral part of Ryder Scott's history. Hired on in 1968, Fellows worked as a geologist and became a Senior Vice President and a member of the Board of Directors; he retired in 2000. Fellows served in the US Army and was a recipient of many awards, including the Purple Heart. He graduated with a B.S. in Geology from The University of Texas at El Paso and an M.S. in Geology from Southern Methodist University.

From left to right are Ryder Scott's Vice President, Gillian Rosen, Business Development and Sales Manager, Pamela Sabo, Managing Senior Vice President Philip Jankowski, Business Development and Sales Coordinator, Emily Ammons, and Senior Geologist, John Allen.

Ryder Scott Exhibits at URTeC

Ryder Scott participated in the 10th Annual Unconventional Resources Technology Conference (URTeC) at the George R. Brown Convention Center in Houston on June 20, 21, and 22. The conference is run by the SPE, AAPG, and SEG and is considered one of the best conferences for the most up-to-date information on the latest in unconventionals.

Gillian (Gilly) Rosen, Vice President and Geoscientist at Ryder Scott, was an invited panelist at a session on "Carbon Capture and Energy Storage Today: A Burgeoning Industry or Still a Future Promise" on the second day of the conference. The increased interest in carbon capture was apparent in the high attendance and the conversations sparked from the panel discussion. Her presentation, "A Certifiable Path to Negative Emissions," highlighted the critical need for mass deployment of Carbon Capture Utilization & Sequestration (CCUS), the utilization of the SPE-SRMS guidelines for booking carbon capacity, and demonstrated how petroleum industry professionals already have the skills and expertise to make global carbon capture goals a reality. "The number of inquiries we've been receiving for CCUS projects has been snowballing over the past few years. It's exciting to see overall awareness around carbon capture increase, even more so when we can help turn that into viable and impactful projects for our clients," said Rosen.

Ryder Scott also had a booth on the exhibit floor, discussing various topics with clients, prospective clients, and mingling with industry friends.

85 Years Delivering for our Clients

RYDER SCOTT | 85th Anniversary 1937 - 2022

Ryder Scott's official 85th anniversary was on July 1, 2022. Over these 85 years, Ryder Scott has responded to and provided services to our clients according to their changing and growing needs. Known in the early years for our chip coring related services and water flooding expertise, our range of services have expanded as the industry has transformed since 1937. We pride ourselves in staying abreast of the latest technologies yet emphasize the continued delivery of the traditional services that our clients depend on. We look forward to continue to grow and work with our clients as our industry adapts to new challenges. A big thank you to all of our clients, past and present, who have placed trust in the Ryder Scott name; it is greatly appreciated and we are humbled.

Ryder Scott New Hire

Jeff Craggy joined the Ryder Scott Data Science Group, led by Adam Cagle, on April 1, 2022, as a Data Analyst, where he applies his knowledge of data processing and collaborates with engineers and other data professionals to extract data figures, create reports based on findings, and monitor key performance indicators to determine business initiatives' success. His specialties include statistical modeling, data analytics, machine learning, and software engineering.

Previously, Craggy was a Software Development Engineer for Analog Devices. He designed, developed, and built ETL technologies to be used in semiconductor big data analytics systems. He also identified run-time parsing bottlenecks and effectively optimized and doubled throughput.

He began his professional career as a MySQL Database Administrator for Analog Devices. In this position, he designed, developed, built, and maintained full stack web applications. He converted data into actionable insights by visually modeling historical trends while also supporting engineers with instruction documentation used to set up accounts and install database drivers.

Craggy holds a BS degree in Computer Information Systems from DeVry University. He is a certified data science professional. New residents of the Houston area, Craggy and his wife have enjoyed exploring Houston's diverse culture.

Ryder Scott Promotions

The board of directors promoted the following personnel:

- **Philip Jankowski** to Managing Senior Vice President
- **Amara Okafor** to Senior Vice President
- **Marsha Wellmann** to Senior Vice President
- **He Zhang** to Senior Vice President
- **Olga Logvinova** to Vice President
- **Andres Suarez** to Vice President
- **Sara Tirado** to Vice President
- **Melanie Adelman** to Geologist
- **Gabe Gallegos** to Geologist
- **Joey Hunter** to Assistant Controller
- **Steve Phillips** to Advising Senior Vice President

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The Ryder Scott Quarterly
is published quarterly by Ryder Scott Co., LP. Established in 1937, the consulting firm performs hundreds of independent studies a year and offers a wide range of services – including reserves evaluations, geological studies, reservoir simulation modeling, integrated studies, facility evaluations, data analytics, economic analyses, expert witness testimony, and sustainable energy consultancy to name a few. With 113 employees, including 77 engineers and geoscientists, Ryder Scott has the expertise and capability to complete the largest, most complex reservoir evaluation projects in a timely manner.

RYDER SCOTT 85th Anniversary 1937 - 2022

Cover picture is of the Oil Field Flyover Ector County, Texas. Picture taken by Adam Cagle, Senior Petroleum Engineer, Data Science Coordinator.

RYDER SCOTT

2022 QUARTER 4

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Vist ryderscott.com for more information about the services we provide, updated price forecasts, price charts, the latest Ryder Scott news and more.

Welcome Note

By: Dean Rietz, CEO

With winter and colder weather approaching and projected shortages, price spikes of heating oil, natural gas, and diesel fuel, we are reminded of the importance of a reliable and affordable domestic supply of crude oil and natural gas. As professionals in the industry, passionate about our work, it is our responsibility to inform others that, as an industry, we are committed to supply inexpensive energy to the world in an environmentally conscious manner. Along those lines, Ryder Scott has prepared a paper to explain such things as the significant difference between an estimate of original oil in place (OOIP) and proved reserves volumes to individuals such as investors new to oil and gas or media personnel (such as reporters and journalists) A condensed version of the paper is included on Page 10 of this newsletter, and the full paper will be available on our website soon.

Contact me directly at Dean_Rietz@RyderScott.com with any comments. I appreciate your feedback and enjoy conversating with you, our clients and industry friends.

Editor's Note

By: Pamela Sabo

This past quarter, Ryder Scott staff participated in events, panel discussions, and speaking engagements on topics currently relevant in the oil and gas industry. It was good to visit with clients and friends who stopped by our booth at the 2022 SPE-ATCE in Houston to talk about new trends in the industry. There was an increased interest in our new Sustainable Energy Division, as it encompasses CCUS. Page 9 of the newsletter has a short summary on this new endeavor.

"Don't settle for average. Bring your best to the moment. Then, whether it fails or succeeds, at least you know you gave all you had."
Angela Bassett

Subsurface Geologic Resource Evaluation for Unconventional Reservoirs

By: John Allen, Senior Geologist

Introduction

As oil and gas production from unconventional plays continues to drive total North American hydrocarbon production, it has become incumbent for geoscientists and engineers to develop suitable methodologies to estimate subsurface resources and reserves in these increasingly important reservoirs. For decades, geologists and engineers working in conventional reservoirs have integrated their work products into the volumetric equation to estimate both in-place and recoverable resources. While this method has been successful for conventional resources, the question remains as to its applicability to unconventional resources. The need for accurate geologic estimation of subsurface resources can become particularly apparent when considering reserves estimation for undeveloped locations that lack sufficient offset production **(Figure 1).** For this discussion, I will outline a case study that tests the applicability of the volumetric equation to unconventional resource assessment, and then discuss a petrophysical workflow that aids both geoscientists and engineers in understanding the in-place resource potential for a given asset within an unconventional play.

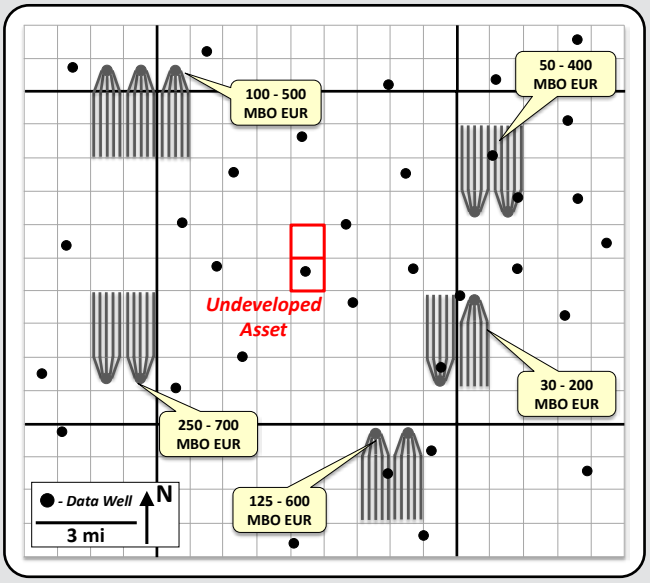

Figure 1 — Hypothetical acreage map for an undeveloped location (red sections) in an unconventional play. Note the distance to offset production and that horizontal producers in the reservoir display a variable range of EURs complicating resource estimates.

What are Unconventional Resources?

The term *unconventional resources* broadly describes those reservoirs that do not conform to the more traditional hydrocarbon plays exploited in the many decades leading up to the early 2000s. The term “unconventional” is used in place of more descriptive terms such as “tight” or “ultra-low permeability,” and it can be a catch-all for an expansive set of non-traditional hydrocarbon resource types (e.g., Shale Oil/Gas, Coalbed Methane, Natural Bitumen, Gas Hydrates). It is commonly understood that reservoirs containing unconventional resources possess some, if not all, of the following characteristics:

1. Occur in predominately fine-grained rocks,
2. Low average porosities ($\phi < 10\%$),
3. Low average permeabilities ($K < 1mD$),
4. Self-sourced,
5. Vertically continuous and laterally expansive pay.

A notable feature of unconventional reservoirs is that pay is continuous and tends not to conform to more traditional trapping configurations. However, unconventional reservoirs, particularly shale oil/gas, possess storage capacity in the form of mineralogical and/or organic porosity. This

observation suggests that traditional methods for resource estimation, such as the volumetric equation, should be applicable to some unconventional reservoirs (i.e., shale oil/gas).

$$EUR = \frac{GRV * \frac{N}{G} * \emptyset * S_{hc} * RF * CF}{FVF}$$

Equation 1 — The volumetric equation. EUR – Estimated Ultimate Recovery GRV – Gross Rock Volume; N/G – Net to Gross Ratio; ϕ – Porosity; S_{hc} – Hydrocarbon Saturation; RF – Recovery Factor; CF – Conversion Factor; FVF – Formation Volume Factor.

The Volumetric Equation

The volumetric equation is a static measurement of the hydrocarbon volume in the subsurface calculated via the integration of geologic and engineering parameters **(Equation 1)**. The intent of the equation is to estimate the potential volume of reserves in a reservoir based on available data (i.e., core, well logs, seismic). It was originally developed for volumetric estimation of in-place and recoverable resources in discreet, conventional traps and plays. However, the underlying principle of the volumetric equation also applies to continuous, unconventional reservoirs that a) occupy a volume of rock, b) have storage capacity (i.e., porosity), and c) part of that capacity is occupied by hydrocarbons (i.e., saturation). We developed the following case study to test the applicability of the volumetric equation to the unconventional resource estimation in shale oil/gas plays.

Case Study

To determine the applicability of the volumetric equation to unconventional resource estimation in shale oil/gas plays, a study area was selected from a producing field in an active, unconventional play **(Figure 2a)**. The goal of this case study is to compare forecasted EURs from actual horizontal producers to predicted EURs calculated from geologic and petrophysical inputs to the volumetric equation. The field covers a 35 square mile area, consists of a single reservoir interval, and contains over 40 active horizontal producers that have been online for more than two years (10+ years in some cases). EURs for these horizontal producers were forecasted in-house using decline curve analysis (DCA) software in Spotfire or tabulated from available online sources.

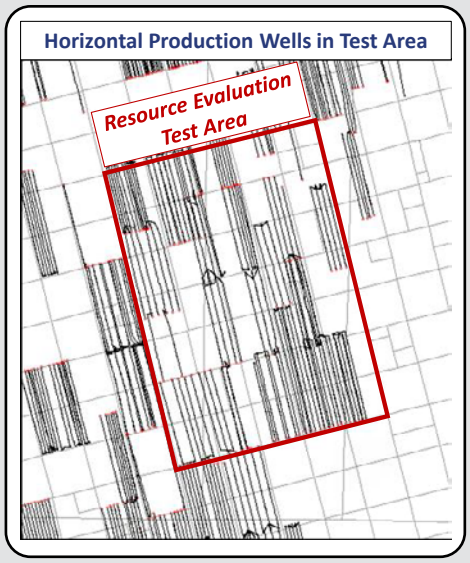

Figure 2a — Map of case study field area (Red Box; sections are one square mile) displaying the location of horizontal producers in the target reservoir.

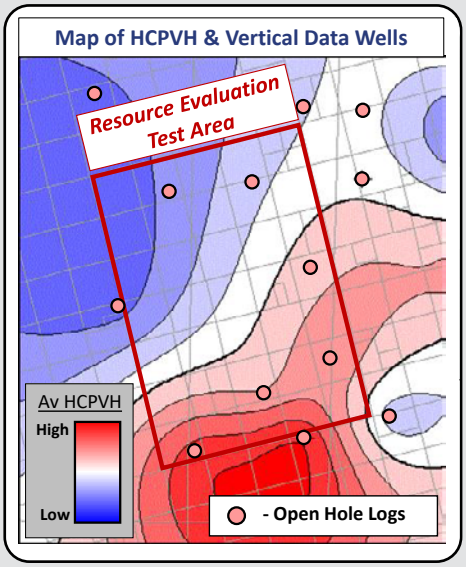

Figure 2b — Same region from Figure 2a displaying a contour map of (HCPVH) and locations of vertical wells with open-hole digital logs.

To solve the volumetric equation, 42 vertical wells with a full suite of open-hole digital logs (i.e., GR, ResD, RhoB, PhiN, PEF) were identified within or in the region surrounding the case study field **(Figure 2b)**. Thicknesses, porosities, and hydrocarbon saturations were calculated from these open-hole digital log suites for the producing reservoir using petrophysical inputs discussed in the subsequent section. The in-place resource was determined for each well using minimum net-pay cutoffs of 4% porosity and 80% water saturation. The resultant hydrocarbon pore-volume height (HCPVH) contour map for the target reservoir of this analysis is displayed in Figure 2b.

Geologic and petrophysical parameters calculated from the digital well logs were also input into Ryder Scott's

proprietary stochastic simulator (STOVOL), along with appropriate ranges for drainage area and recovery factor, to probabilistically estimate EUR per well using the volumetric equation. The probabilistic EURs were then compared to the forecasted EURs from the producing horizontals **(Figure 2c)**. The graph in Figure 2d illustrates that predicted EURs from the volumetric equation are a statistical match to actual DCA forecasted EURs from the producing wells in the field, suggesting that geologic and petrophysical solutions to the volumetric equation in unconventional reservoirs can provide reasonably certain estimates for in-place volumes in shale oil/gas plays.

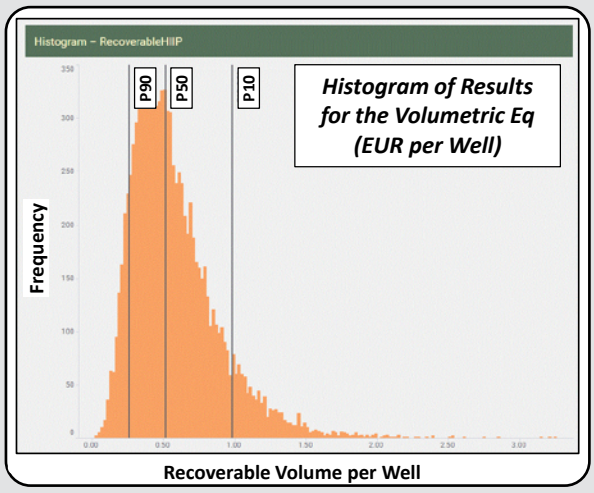

Figure 2c — Histogram of stochastic results for EUR per Well derived from STOVOL analysis of the volumetric equation for the case study area.

Application of Volumetric Equation to Reserves Estimation

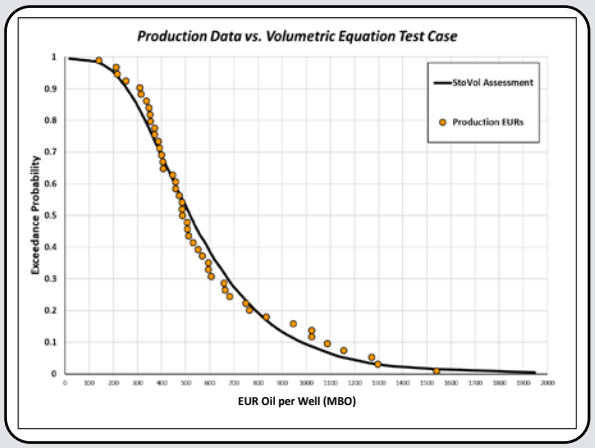

Figure 2d — Exceedance probability plot comparing the probabilistic EUR per well results (solid black line) from STOVOL to the DCA forecasted EURs for actual production horizontals in the case study field area (orange circles). The two datasets are statistically indistinguishable (Z-Score = 0.357) indicating the volumetric equation can be used to estimate resource in unconventional reservoirs.

How can geoscience contribute to resource and reserve estimation in unconventional plays, particularly for undeveloped assets where analog production is sparse? The case study above demonstrates that petrophysical inputs to the volumetric equation derived from common digital logs can reasonably assess in-place hydrocarbon volumes for some unconventional play types. The role of the geoscientist is to delineate which terms of the volumetric equation have the greater impact on in-place resource estimations in the unconventional reservoir of interest, and which petrophysical workflows provide sufficiently accurate information given the business objective(s).

The geological terms of interest in resource estimation are typically gross-rock-volume (GRV), porosity, saturation, and hydrocarbon pore-volume (a product of the first three terms).

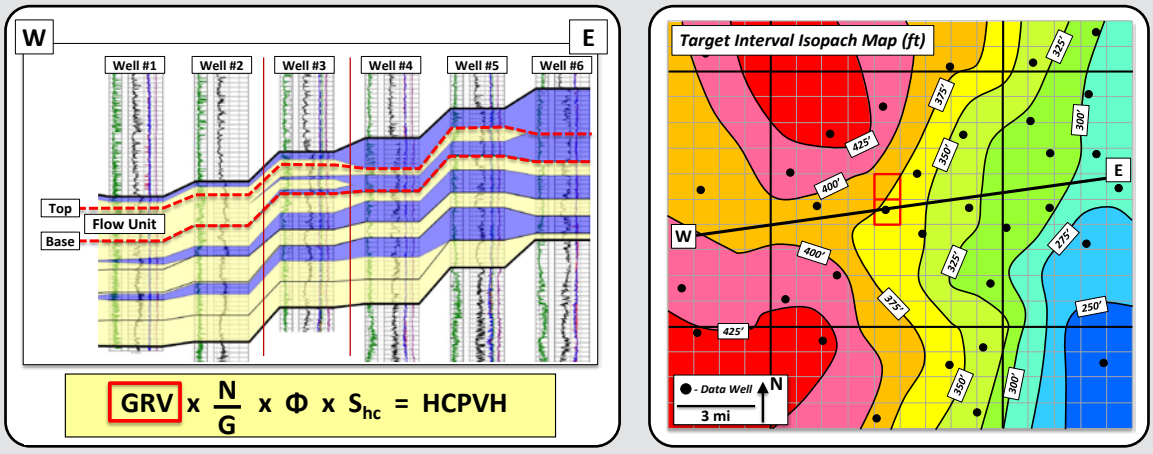

Figure 3 — Isopach map for the hypothetical unconventional reservoir. Inset well cross-section runs west to east through the map area and delineates the top and base of the reservoir. Blue regions on the cross-section indicate interpreted shelf deposits and yellow regions indicate deepwater deposits.

GRV is deceptively complex when considering continuous and laterally extensive resources (e.g., unconventional reservoirs). The geologist might be tempted to estimate the in-place potential of entire mappable formations right down to the last hydrocarbon molecule. However, a full hydrocarbon audit of the Permian Wolfcamp Formation provides little in the way of useful information when it comes to calculating reserves on a flow-unit basis. Thus, when selecting the volume of rock for analysis, it is always important to consider the scope and purpose of the analysis, as well as suitable analogs for productive reservoir intervals and flow units **(Figure 3)**.

Porosity is an important petrophysical property as it represents the potential hydrocarbon storage capacity for the reservoir and other petrophysical parameters depend upon its accurate calculation. There are many logging tools that measure porosity **(Figure 4)**, and the final reported measurement usually comes in two flavors: total porosity and effective porosity. Both calculations require a correction for the amount of organic content in the reservoir (e.g., Kerogen), which is typically established using highly sophisticated logging tools or conventional core analysis. Porosity also serves the dual role of providing cutoffs for a net-pay calculation. In particular, net-pay cutoffs of 2-3% porosity are quite common and applied in most optimistic cases, with 5-6% porosity cutoffs applied in more pessimistic scenarios. Once porosity has been established, water saturation can then be determined for the

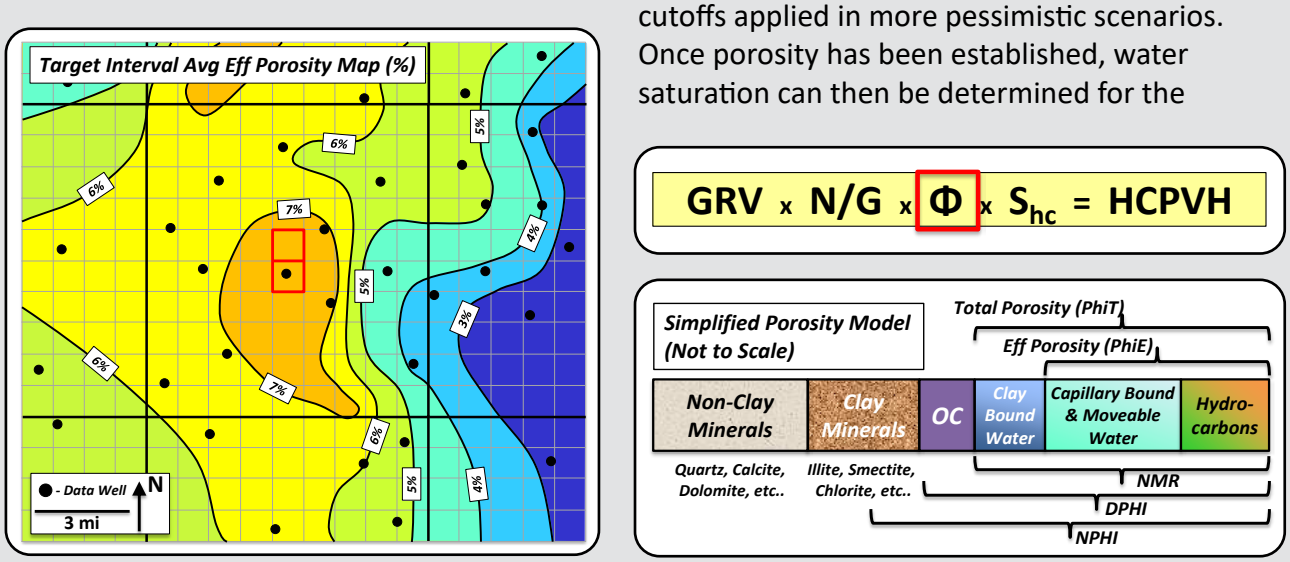

Figure 4 — Average effective porosity map for the hypothetical reservoir. Simplified porosity model illustrates some of the logging tools available for measuring porosity, as well as, the petrophysical distinction between total and effective porosity. OC – Organic Content.

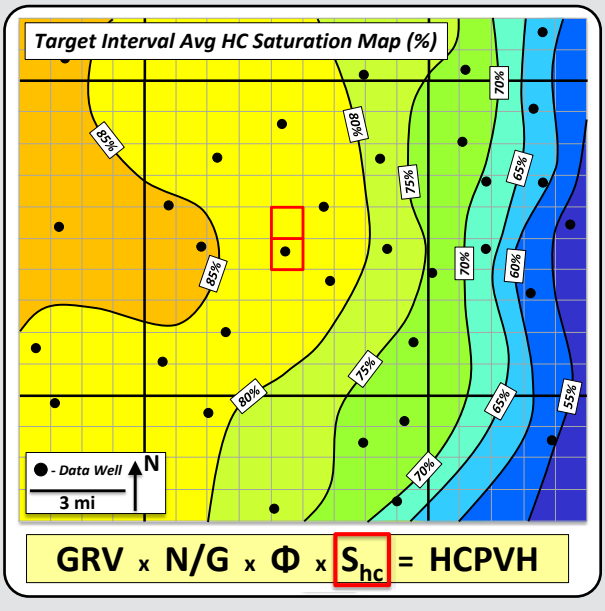

Figure 5 — Average hydrocarbon saturation map.

reservoir interval and mapped accordingly **(Figure 5)**. There are several options available to the geoscientist to accomplish this (e.g., Modified Simandoux, Dual Water Model, Archie's Equation), each with their own inherent strengths and weaknesses. Hydrocarbon saturation is then calculated as 1 (one) minus the water saturation ($1 - S_w$). It is important to note that deriving hydrocarbon saturation from the water saturation only accounts for the liquid hydrocarbon phase and free gas. If the geoscientist or engineer is interested in calculating the potential absorbed gas fraction in the reservoir, then additional conventional core analysis or TOC correlation will be required.

HCPVH, often referred to as SoPhiH, can be calculated after GRV, porosity, and hydrocarbon saturation have been established. HCPVH can be thought of as a proxy for in-place resource density and can be converted directly to OOIP and/or OGIP if a formation volume factor is known. Maps of HCPVH **(Figure 6)** can be used by geoscientists in various ways: 1) they can aid in establishing reasonable certainty of a subsurface reservoir's lateral resource continuity; 2) as demonstrated in our case study, they provide geologic confidence in the projection of discovered developed resources to undeveloped targets some distance away; 3) they can aid in the selection of analog production areas when generating type-curves for reserves calculation. Going back to our initial example **(Figures 1 & 6)**, resource estimation using the volumetric equation, along with petrophysical maps derived from inputs to the equation, are a helpful tool in assessing subsurface reserves for developed and undeveloped assets.

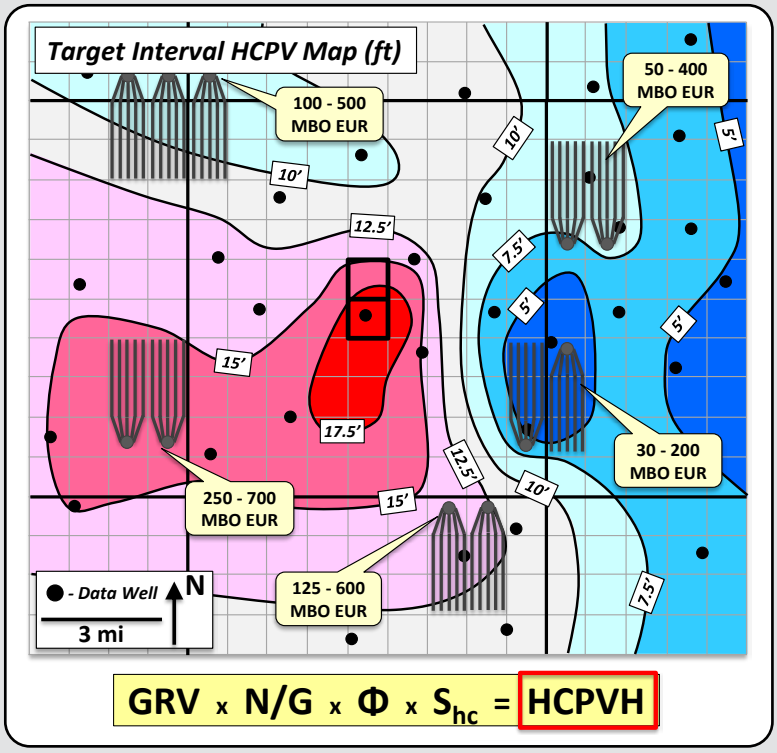

Figure 6 — Hydrocarbon pore volume height (HCPVH) map. Bold black boxes illustrate the same undeveloped acreage from the previous maps. Overlain are the offset production horizontals from Figure 1. HCPVH maps such as this can be useful for understanding resource extent and density. They are also useful for selecting geologically appropriate regions for production forecasting and type-curve development.

Concluding Remarks

Geoscientific analysis is an important tool for the delineation and appraisal of subsurface hydrocarbons in unconventional reservoirs. The case study presented herein demonstrates that traditional geologic methods for volumetric estimation (i.e., volumetric equation) can be utilized to reasonably estimate subsurface resources in some unconventional play types. It is important to stress that resource evaluation is no single individual's purview. Geologists and engineers should work together when estimating subsurface resources to ensure accuracy and reciprocity of results between geological resource density maps and forecasted production type-curves.

Explore Ryder Scott's Geological Consulting Services

Ryder Scott maintains a comprehensive suite of commercial geoscientific software, providing versatility when assessing geological and geophysical data. We apply risk-assessment expertise to undrilled prospects and trends. In some cases, Ryder Scott performs original geophysical mapping and basin modeling work. In any assessment of an exploration prospect, we adopt a method of risk analysis, bring objectivity and consistency to portfolio valuation, and apply discriminating economic criteria to prospect selection.

For more information regarding Ryder Scott's geoscience services, please contact Head of Geosciences and Managing Senior Vice President, Philip Jankowski at Philip_Jankowski@ryderscott.com.

Gilly Rosen (second from the right) at 2022 AAPG Conference

Dan Olds at SPE ATCE 2022

Ryder Scott Current Events

During the fourth quarter of 2022, Ryder Scott employees made appearances at AAPG, ATCE, and the University of Houston. Our representatives spoke on several relevant topics which are currently shaping the oil and gas industry. Topics included sustainable energy, PRMS Applications Guidelines, engineering professionalism, and more. Our employees are valuable contributors to the constantly evolving industry, and their abilities, knowledge, involvement, and experience are a major part of why our company continues to lead and grow with the latest technology and trends.

AAPG Conference

Gilly Rosen, Vice President and Petroleum Geoscientist at Ryder Scott, served as a panelist at the 2022 AAPG Conference where she discussed how Ryder Scott has advanced its workflows and best practices to match the ever-evolving technology and trends in the industry while also adhering to the highest standards regarding reserves reporting. Throughout her presentation, emerging technologies and subsequent new directions that Ryder Scott would be taking were discussed.

Advancements in machine learning and predictive analytics are necessary as vast quantities of data must be managed and understood. Since quality assurance and quality control are imperative, Ryder Scott is now ISO 9001 and ISO 14001 certified as part of its commitment to quality standards and processes. Regarding reserves reports and certifications, Ryder Scott continues to be a leader in field evaluations and reserves reports and certifications.

Rosen spoke at length regarding Ryder Scott's growing Sustainable Energy Division. For over eight decades, Ryder Scott has been conducting reservoir and field studies and reserves evaluations. It is precisely for this reason, Rosen states, that sustainability was a natural fit for Ryder Scott. Ryder Scott's extensive experience in enhanced oil recovery projects has provided a smooth transition into sequestration specific projects. "Our experience with auditing and certifying our client's assets in accordance with the SEC and SPE-PRMS Booking Guidelines for reserves is now directly applicable to assessing carbon capture, utilization, and sequestration projects in accordance with

Ryder Ssott 2022 SPE ATCE Booth

SPE-SRS guidelines for CO2 storage capacity," said Rosen.

SPE-ATCE

Ryder Scott hosted a booth at the 2022 SPE Annual Technical Conference and Exhibition held in Houston's George R. Brown Convention Center on October 3-5, 2022.

The theme of this year's event was The New Oil and Gas Journey: Agility, Innovation, and Value Creation. At this event, international speakers discussed necessary strategies that would help maintain business continuity for companies along with their overall competitiveness. Industry leaders, including Ryder Scott employees Dan Olds and Gilly Rosen, participated in discussions on trending topics such as the net-zero transition, accelerating the uptake of new technology applications, financing future projects, energy mix collaboration, and more.

Dan Olds, Managing Senior Vice President at Ryder Scott and current SPE OGRC Chair, presented an update of the committee's current activities at the SPE Pavilion theater.

Before the 2018 PRMS update was released, the OGRC had been working on the related "Guidelines for Application of the Petroleum Resources Management System" that would accompany it. The Application Guidelines (AG) was completely overhauled. There were volunteers from around the world, not only from SPE, but also from the "sister" societies that approve and sponsor PRMS such as WPC, AAPG, SPEE, SEG, SPWLA, and EAGE. Charles Vanorsdale, an OGRC committee member, did a tremendous job as editor. The lengthier, updated version has integrated examples throughout and includes chapters in Petrophysics and Reservoir Simulation. In the 2011 version, each chapter was essentially a stand-alone discussion, but the OGRC fully integrated the chapters throughout the document. The glossary has expanded with additional terms not found in the PRMS as the glossary was limited to only terms actually used in PRMS.

Parallel with the AG, the OGRC was creating stand-alone examples along with a frequently asked questions (FAQs) section that currently covers 42 questions on a variety of topics. The examples

and FAQs will be posted on the SPE website with the intent to revise, clarify, or add to both as needed rather than wait for a new version of PRMS.

The AG, examples, and FAQs are set to be posted on the SPE website soon. The release will likely take place before the end of October 2022. In addition, a new release of the PRMS Version 1.02 will be posted to address several minor editing and grammar problems and to clarify consistent treatment of synthetic gas.

The OGRC also presented a position statement to SPE on the use of PRMS principles being applied to non-hydrocarbons. The OGRC was aware of several instances where individuals wanted to use PRMS as the framework to classify and categorize helium and hydrogen (gaseous extraction from reservoirs), lithium and bromine (solution extraction from reservoir brines), geothermal and heat extraction, and synthetic gas extraction from coal seams. In all cases, the exploration and exploitation techniques used would be considered standard oilfield practices, or "oil and gas demonstrated engineering." It is commonly believed that PRMS provides a better framework than mining guidelines for such situations. The SPE board approved the position statement, which should also appear on the SPE website soon.

UH Petroleum Seminar Series

On October 14, 2022, **Dean Rietz**, Ryder Scott's Chairman and CEO, spoke about Engineering Professionalism and Ethical Conduct at the University of Houston Petroleum Seminar Series. This seminar series features industry-recognized experts who present on trending industry topics.

Rietz discussed the canon of ethics and guidelines for professional conduct as stated by the Society of Petroleum Engineers. It is expected for petroleum engineers to remain dedicated to ethical practices while making judgments with a fundamental concern for the safety and wellbeing of the public and the environment.

Resume and interview etiquette suggestions were presented to the audience, which was mostly comprised of students.

Rietz encouraged the attendees to actively pursue lifelong education, adhere to the engineering code of ethics, participate in engineering organizations, persevere in their careers, and maintain a healthy work-life balance.

Ryder Scott Sustainable Energy Consulting Services

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- Storage Resource Certification
- Subsurface and Surface Facilities Integration
- Economic Benefit Analysis

For more information, please contact Head of Sustainable Energy Herman Acuña, Executive Vice President at Herman_Acuna@ryderscott.com.

Estimates of Oil and Gas Volumes: Unraveling and Understanding the Terminology from Oil-in-Place to Proved Reserves

Below is an excerpt from a white paper written by Ryder Scott staff members including Dean Rietz, Chairman & CEO and Guale Ramirez, President. The paper is intended for an audience not familiar with the terms commonly used in oil and gas reserves evaluation. The full paper will be posted on our website at a later date. Please utilize this paper to cultivate a deeper knowledge among colleagues and friends outside of the industry.

Introduction

Oil and gas industry professionals, such as petroleum engineers and geoscientists, commonly use certain words and terminology specific to the industry. It is important to understand the meaning of and difference between these terms, as press releases or disclosures from exploration and production companies (E&P companies) are distributed in the public domain and therefore, read by an audience outside of the oil and gas industry. Certain industry-specific terminology may be (inadvertently) inappropriately interchanged or simply misused, causing unintended harm related to the use of the disclosed information. The purpose of this paper is to provide the reader a better understanding of certain frequently used terms.

How much oil and gas exists beneath the surface?

There is a fixed amount of oil and gas remaining to be discovered, and recovered, beneath the earth's surface; hence, oil is considered a non-renewable resource. While the amount of oil on our planet is fixed and, therefore, limited, the amount of oil that we can recover (or produce) in the future varies. The three biggest reasons why this recoverable amount changes with time are 1) new information acquired may provide more refined (better) estimates, 2) the development of new exploitation technologies and 3) the economics related to the production of the oil.

Estimating the amount of oil-in-place

Oil and gas volume estimation employs sophisticated approaches, utilizing all available data. Engineers and geoscientists can estimate the number of barrels of oil in the reservoir using equations such as the volumetric equation. The parameters that play a role in such an estimation typically have a degree of uncertainty, usually because a limited amount of naturally varying data is available to perform that calculation.

The estimation of OOIP is important to evaluation engineers, geoscientists and E&P companies as it defines the potential size of a reservoir that has been or is yet to be discovered. Furthermore, it is the starting point for estimating the recoverable portion of oil from a reservoir. The next sections discuss the industry terms ***resources*** and ***reserves***. These terms describe the volume of oil – or the portion of OOIP – in a reservoir that is anticipated to be recovered.

Estimating how much of the OOIP can be produced

Assessing the subsurface resource volumes requires an estimate of OOIP. Of the OOIP, the amount that might eventually be produced is the recoverable portion The factors that influence the recoverable amount include the characteristics of the actual oil (e.g., viscous or heavy with poor flow qualities or light with better flow capability), the characteristics of the rock (e.g., porous with interconnected pore space, permitting the oil to flow), the geological characteristics of the reservoir, the available reservoir energy to transport the oil to the wellbore and lift it to the surface, and the type of operations managed by the operator (e.g. installation of pumping units or other type of artificial lift to assist in lifting the oil). These all affect the percentage of the OOIP that can be extracted from the subsurface. Therefore, even if a reservoir contains a large amount

of oil, only a fraction of it, generally in the range of 10% to 40% for oil reservoirs, will be produced. The fraction of the OOIP that is recovered (or to be recovered) is called the recovery factor (RF). Regardless of the estimate of OOIP, the amount of oil estimated to be recovered from the reservoir is the volume that is most important from a commercial perspective.

There can be considerable uncertainty in estimating the amount of oil in the subsurface that can be economically produced as well as the likelihood that those volumes will actually be commercially recovered. In order to explain this aspect of oil and gas exploration and exploitation, the next section focuses on certain applicable terms that shed light on how estimates of recoverable oil are technically classified and categorized.

Petroleum Resources

Resources are separated into discovered and undiscovered in the Society of Petroleum Engineers Petroleum Resources Management System (SPE-PRMS), one of the most common oil and gas classification systems used worldwide. The recoverable resources are divided into production (quantities already produced), reserves, contingent resources and prospective resources. It is the recoverable portion of petroleum resources that can potentially result in commercial income-producing projects for an E&P company. The unrecoverable portion is generally recognized as volume that will remain in the ground (within subsurface reservoirs) until new technology or commercial conditions change such that some additional portion can be considered recoverable.

The distinction between prospective and contingent **resources** depends on whether or not there exists one or more wells and/or other data indicating that a discovery has been made by the drilling of an exploratory well. The distinction between contingent resources and reserves depends on whether a project to develop the discovered petroleum resources is commercial or not. In this sense, commercial defines if a company considers a project worthy of continued investment in order to eventually bring recoverable volumes to market.

There are three classes of resources from the most uncertain and highest risk, to the most likely to be recovered, and finally the least amount of risk and uncertainty. These are summarized below:

- **Prospective Resources:** Estimations of prospective resources volumes are the most uncertain and carry the highest risk. Identifying the risk and uncertainty related to reported volumes of prospective resources is critical to understanding the potential viability and worth of such reported quantities.

- **Contingent Resources:** SPE-PRMS defines contingent resources as “those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations, by the application of development project(s) not currently considered to be commercial owing to one or more contingencies.” Two of the most prominent contingencies are related to economic conditions (product prices and costs to produce) and technology. Both of these contingencies result in risk and uncertainty related to recovery of such volumes.

- **Reserves:** The third and highest classification of resources in terms of commercial maturity is reserves. These future recoverable volumes have the greatest impact on the value or worth of a company as it relates to exploration and production operations. Oil and gas companies periodically publish a reserves report that reflects the volumes they expect to recover under specific economic conditions. Estimates of reserves are also categorized according to the uncertainty related to the amount of oil that can potentially be produced.

- Proved reserves provide the lowest uncertainty or highest probability of being recovered. Barrel for barrel, proved reserves possess the highest value.
- Probable reserves are less likely to be recovered than proved reserves but more certain to be recovered than possible reserves
- Possible reserves possess a high degree of uncertainty; much higher than proved and probable reserves. As expected, possible reserves should be ascribed a lower economic value per barrel than proved reserves and probable reserves, due to the greater uncertainty pertaining to their recovery.

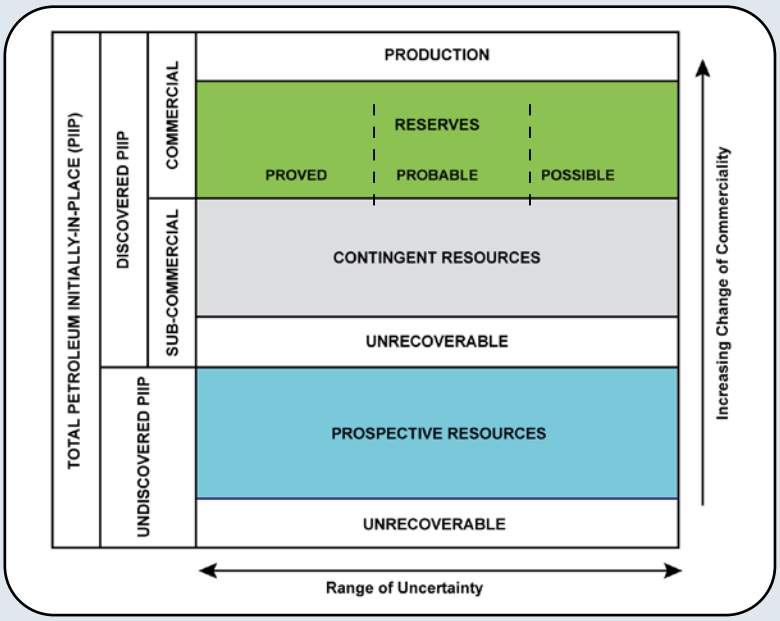
Public Disclosure

Different regulatory bodies throughout the world have specific rules for company disclosures pertaining to the reporting of reserves and/or resources. For example, in the U.S., the Securities and Exchange Commission (SEC) only allows the reporting of reserves (proved, probable, and possible), and most companies will only report proved reserves, even though they can report all three categories. Many companies prefer to inform the investing public what is highly likely to be recovered (i.e. proved reserves), thereby providing a high level of confidence in the estimates along with greater certainty in their ability to deliver the volumes.

Regulatory bodies outside of the U.S. may allow or even require the reporting of additional classifications and categories of resources in disclosures to the investing public. For example, National Instrument 51-101 (NI 51-101), which governs the disclosure of oil and gas activities for securities regulatory purposes in Canada, requires reporting proved and probable reserves and allows for contingent and prospective resources to be reported.

In Summary

While it may be useful to know how much oil is estimated to be in the ground, determining the amount that can be recovered is of greater significance and essential for investment purposes. Recoverable volumes of resources depend on many factors, including among others, the geological nature of the reservoirs, the composition of the hydrocarbon fluids, the operating methods and type of equipment utilized, and the commercial or economic environment (oil prices and costs to drill, produce and transport products). Many of these are complex factors requiring the knowledge and experience of many trained professionals in the geological and engineering professions.



Adapted from SPE-PRMS

Ryder Scott New Hires

Natalie-Nguyen La joined the Ryder Scott Houston office in August 2022 as a Senior Petroleum Engineer with diverse experience in reservoir engineering and petroleum reserves evaluations. Her areas of expertise include production forecasting, waterflood management, field development planning, and integrated reservoir modeling.

Before joining Ryder Scott, La worked for Shell Oil Company, starting as a Reservoir Engineer and working her way up to Senior Reservoir Engineer. In her position, La oversaw forecasting and reporting components of reserves booking. She managed production analog studies and benchmarked dynamic model forecasts against offset wells using decline curve analysis and simple material balance models.

La has coauthored several technical publications discussing such topics as modeling production decline in unconventional formations, characterizing nanoparticle transport in porous media, and production analysis using bottom hole pressure of oil production from an unconventional reservoir.

La has a BS degree in Mathematics and Chemistry from the University of Houston and an MS degree in Petroleum Engineering from The University of Texas at Austin. She is a Licensed Professional Engineer in the State of Texas. In her free time, La enjoys playing tennis, bike riding, and walking her two dogs.

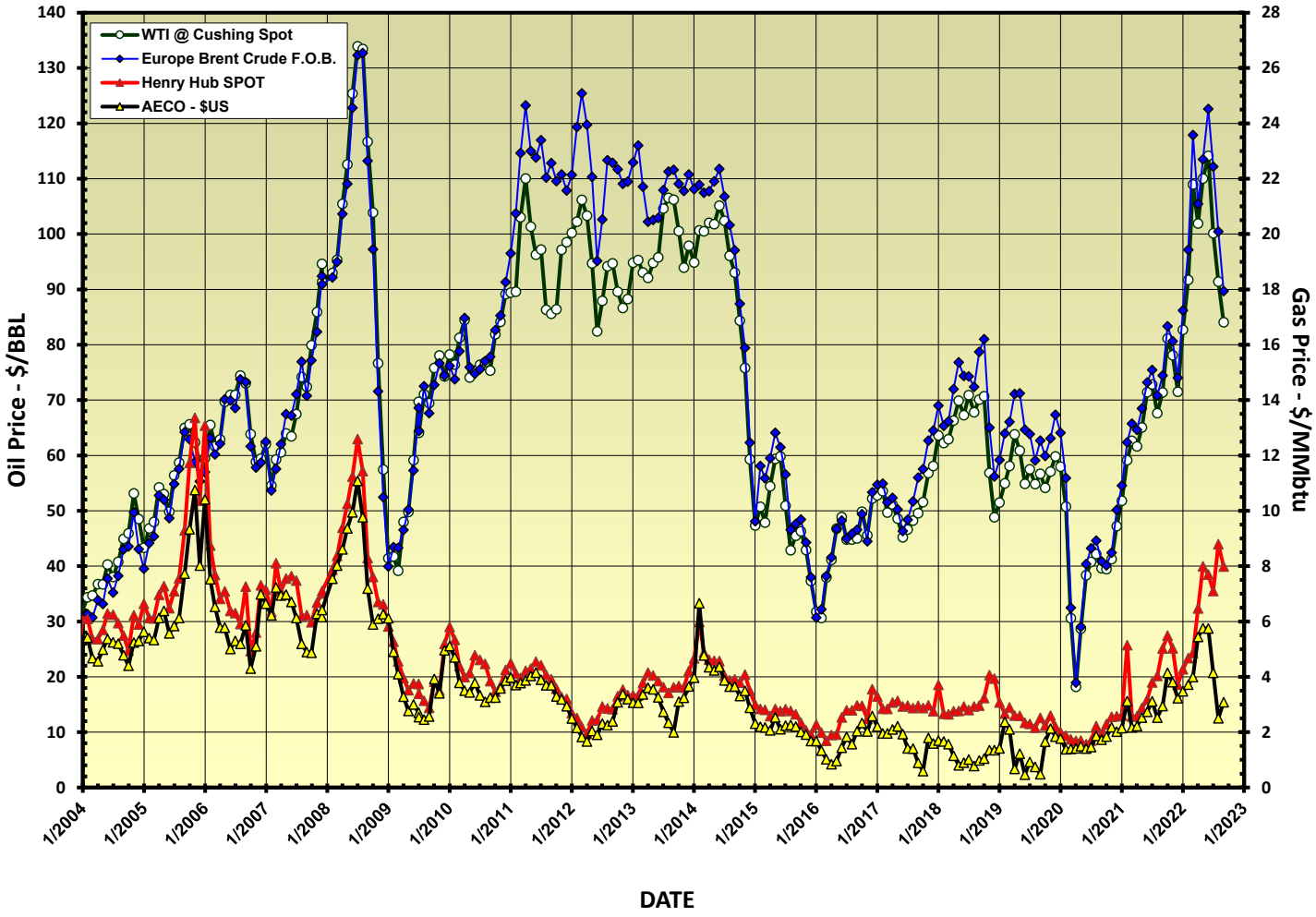
Ekene Ohaegbu joined the Ryder Scott Houston office in September 2022 as a Senior Petroleum Engineer. She has 14 years of experience in reservoir engineering, including reservoir management, economic and reserves evaluation, and A&D evaluations for various oil and gas unconventional resource plays in the U.S.

Ohaegbu worked as a Petroleum Engineering Consultant at EP Valuation where she worked on borrowing base redeterminations for companies seeking reserve-based loans. Before that, she was a Senior Planning Analyst at Marathon Oil Company where she worked closely with multidisciplinary teams, delivered production and financial forecasts for the annual budget/ plan and quarterly plan updates, and analyzed planning scenarios.

Ohaegbu was previously a Senior Reservoir Engineer and Field Development Team Lead at Murphy Oil Corporation. She managed south Louisiana fields and Eagle Ford shale assets focusing on field development planning, evaluating and estimating reserves, evaluating the economic viability of oil and gas projects, and supporting the business development teams by providing technical due diligence for acquisitions and divestments of assets. Ohaegbu also worked as a Reservoir Engineer at Quicksilver Resources Inc. and Schlumberger Data and Consulting Services as a Reservoir Engineer.

Ohaegbu holds a Bachelor of Engineering in Petroleum Engineering from the Federal University of Technology, an MS degree in Petroleum Engineering from Texas A&M University, and an MBA from the University of Houston. Ohaegbu enjoys volunteering in her community, traveling, and painting.

Price History of Benchmark Oil and Gas in U.S. Dollars



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

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RYDER SCOTT 85th Anniversary 1937 - 2022

Cover picture is of Larch Valley Banff National Park, Alberta Canada taken by Michael Lam, Vice President, Technical Specialist.