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Technology Strategy Considerations in Reservoir Optimization*

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Abstract

The goal of this presentation is to review technology strategies used in optimizing reservoirs, including the identification of preferentially productive / exploitable zones and decision-making strategies for cost-effectively matching technology to overall goals. In reviewing definitions of "sweet spots" and the notion of optimizable reservoirs, a strategy for creating technologically definable and/or differentiable metrics can emerge. Appropriate technology strategy should be multi-disciplinary and incorporate geochemistry, geology, geophysics, and engineering, and different approaches should be developed for different stages in the lifecycle of the project. In addition to identifying processes and procedures, it is important to bring to the surface any and all underlying assumptions, beliefs, and/or habits of mind (or prejudices) that impact decision-making processes. The presentation will also examine how analytics, data mining, and "Big Data" can play a part in the process.

Introduction

The goal of this paper and presentation is to examine the critical issues involved in developing an effective technology strategy for optimizing reservoirs. As in all cases, the technology strategy is framed by real-world conditions and prevailing economic, technological, social, and financial contexts. In this case, the technology strategy under consideration is for unconventional oil and gas reservoirs, with an emphasis on fine-grained gas and liquids-rich low-permeability fine-grained reservoirs, which must rely on new technologies to achieve commercial levels of oil and gas production. Unconventional reservoirs tend to exhibit very low permeability and low porosity which, in the past, made them both unproducible and uneconomic. One can argue that the same is the case today, but viability is a function of an effective technology strategy.

The technology strategy must be cross-disciplinary and span the life cycle of the project, from identification of a prospective play, to developing the prospect and the reservoir. Effective horizontal drilling, multi-stage hydraulic fracturing, and other enhanced techniques and

technologies, comprise the heart of the technology strategy. Other factors that have made the formations producible have to do with dealing with water issues, reservoir pressures, and hazards. These must come together within the context of an effective capital / finance regime.

Early Adopters vs. Late Adopters

There have been successful and economic plays, including the Eagle Ford and the Bakken because of their liquids-rich production during a time of high oil prices. Companies are able to maintain profitability in predominantly gas plays such as the Barnett and the Marcellus when they implement the lessons learned from early exploration and production efforts.

Are the early adopters necessarily the winners, particularly when success usually translates to a glutted market and slipping market prices?

Let's examine the trajectory of the early adopter. They are visionaries, and they are also guinea pigs, at least to some degree, as new techniques and technologies are implemented. The early-adopters may benefit from the possibility of dominating the market or the technology-space. However, early adopters pay a high price, and they may not be able to maintain their market position if operating costs and capital requirements continue to be high.

Innovative technologies are disruptive. While innovators can benefit from the new challenges, it is important to formulate a strategy in order to do so. Early adopters must follow a strategy that acknowledges the fact that "late adopters" may benefit from the "learnings" of the early adopters. Similarly, those who purchase their entry into new technologies (and new plays), may find there are pitfalls if they do not have a good technology strategy in place. They may pay too much, acquire the wrong type of technology, or worse – they may obtain technology and a leasehold position that are not ideal, and ultimately cannot achieve goals.

A "Wall Street Play" vs. a "Sweet Spot Play"

When horizontal drilling and multi-stage hydraulic fracturing were used to "mine" massive blocks of acreage which contained oil or gas-rich fine-grained reservoirs, the prevailing notion was that the plays were of vast areal extent, with homogeneous, uniformly productive zones that could be "mined" in something that resembled an industrial operation.

The goal was to drill the formations in the play, establish "proof of concept" and then extrapolate reserves assuming homogeneity and also the existence of infrastructure and infinitely expanding markets.

Large capital investments were justified in this model because once "proof of concept" could be established, and vast acreage blocks could be demonstrated to be producible (and in short order), it would be possible to either produce the wells, or sell them to a company in need of bookable reserves and ongoing activity. It was the perfect "Flip That Lease" approach, and if the block happened to be the size of the state of Rhode Island, the value of the play could be significant. It was the perfect "Wall Street Play."

However, "Wall Street Plays" did not acknowledge high levels of heterogeneity. While shales and unconventionals may appear homogeneous

at first blush, they are in fact highly heterogeneous, and one must keep minimum cut-offs in mind: porosity, permeability, TOC, brittleness (frac-ability), and natural fractures / fracture networks.

"Wall Street Plays" emphasized large-scale operations as they developed a technology strategy to aggressively drill to define the extent of the play and to hold by production (HBP) as large a block as possible. The technology strategy used in a "Wall Street Play" is that of massive-scale aggressive "defining the block" with underlying assumptions that everything within that block would be more ore less uniformly productive. This is a great technology strategy for Wall Street. It's also a good one if one's goal is to intimidate the competition. For example, Russia's Gazprom or Saudi Arabia's Saudi Aramco are in an excellent position to exploit vast acreage blocks of unconventionals, and to book reserves that assume homogeneity (or at least homogeneous production thanks to the ability to implement "appropriate" technologies that equalize the production between sweet spots and relatively barren zones). Using a technology strategy that intends to achieve uniform production over heterogeneous reservoirs with potentially gargantuan production values is intriguing. It is aggressive, bold, and potentially irrefutable if certain strategic information is kept highly confidential.

In contrast, the "Sweet Spot Play" does not attempt to produce the entire block. Instead, it uses technology to identify areas of preferential enrichment, where conditions are ideal for production. "Sweet Spot Plays" are less capital-intensive. However, they are much more technology-intensive, and this approach simply does not work if the company cannot obtain the latest technology, the most experienced experts, along with a team of strategists who are generalists rather than specialists.

In the long run, the "Sweet Spot Play" approach is more sustainable because it is scalable. A small play can be economically viable, as can a larger one. What is problematized in the approach of a "Sweet Spot Play" is the notion of a vast, homogeneously exploitable play the size of Rhode Island (or half of Siberia).

Real-Life Scenarios

Stage 1 Operations: Acquiring Acreage / Selecting Locations / Managing Operations

Stage II Operations Beyond HBP: Strategic Development

Capital Issues: Investors, Partners, Mergers, Acquisitions

We are continuing to explore the best way to use technology to achieve strategic objectives in oil and gas operations, namely in optimizing exploration, drilling, completions, and production across a wide range of reservoirs.

A "technology strategy" is called for in this case because producibility of unconventionals as well as re-entered mature fields revolves around the successful application of new technologies.
Good selections of technology can result in increased production at economic costs.
Poor selections of technology can result in unsuccessful wells and high costs.

So, technology has become a “make or break” issue in today’s oil and gas operations.

So, we will take a look at a few real-life scenarios, and consider what technology strategy does in these cases.

Off the Blocks, Unto the Breach: Leasing, Seismic, Selecting Locations, Drilling, Completing: The Race for “Held By Production” (HBP)

Role Play: Let’s say your company has decided to open up a new shale play in a zone that was previously considered unproductive / uninteresting. Let’s say it’s the Ordovician Sylvan Shale, which seems could be productive in certain “sweet spots” where TOC and thermal maturity are better than in general.

Why Do We Need Technology and a Technology Strategy?

First, we need to use new technologies to determine where the ideal TOC / thermal maturity combinations lie in the Sylvan. We may need to take a look at cores in the area to get a general sense of locations and where to lease and drill.

We may want to shoot new seismic or acquire and reprocess existing seismic data. We need to understand what the new capabilities are.

Then, we need to use new data mining techniques and technologies for land work. We need to prepare mineral takeoffs, and to go in with a team and lease as quickly and quietly as possible. If the acreage is held by production and/or under lease, we may wish to farm in the zone, and/or buy the production / leases.

Needless to say, the Sylvan Shale will not produce without the use of new technologies. In order to determine how to drill, where the sweet spots might be, how to stay in the zone while drilling, and what kinds of completion methods to use (as well as stimulation), we need to understand all the choices we have with technology, and we need to put together a few scenarios so we can compare outcomes and anticipate decision points.

Stage II: After “Held By Production”: Strategic Development

People often think that once the acreage is held by production, live will become simple and all one has to do is hire a pumper, economically dispose of produced water, and simply watch one’s bank account fill up with money, like a reservoir after extended torrential rains. Unfortunately, life is not so simple. Unconventional reservoirs have unconventional requirements, which is to say that operating costs can be quite steep. There is usually a need to build infrastructure (midstream), and there are water disposal costs as well as processing. Finally, there can be production issues (steep decline curves) that require chemical costs for treatment.

The high costs of producing unconventionals, particularly while continuing to drill acreage in order to hold it by production can mean very high capital costs.

A technology strategy can help you determine which technologies you really need, and also the level of investment and capital influx you'll need (and when you'll need it).

Strategic partnerings with companies that offer technological know-how as well as capital are often very desirable.

Realistic Concerns

- Fluctuating (and low) gas prices
- Rapid decline curves (and not sure why)
- Escalating drilling, completion, operating costs
- Extremely heterogeneous reservoir

If you're in the oil industry, you are well aware of the cyclical nature of the industry, and fluctuations in commodities prices.

The advances in horizontal drilling and hydraulic fracturing that made producing unconventionals (including shale gas) possible have also led to an oversupply, and a price drop.

As you consider your goal to develop the Sylvan Shale (in our hypothetical scenario), there are a few concerns:

1. Fluctuating and low gas prices: What will this mean to you? How will it impact decisions? If prices are low, what types of technology should you use in order to produce gas economically? Can you use some of the produced gas to thermally treat the water so it's pure enough to use for agricultural uses (and avoid paying for trucking and disposal)? What other options are available to increase efficiency?

2. Rapid decline curves: If your production is declining rapidly, it's in your best interests to find out why and to do what you can to optimize your production if at all possible. You will be facing a number of technology decisions, which range from refracing the well to using different treatments. All require expert understanding and experience.

3. Drilling, completion, and operating costs can rise dramatically, particularly when a play becomes hot, and there is a shortage of equipment and/or manpower. What can you do to keep your costs under control? What kinds of technology are appropriate?

4. Unlike the picture painted by Wall Street of shale plays as a "mineable" homogeneous mass, the reality of shale is that it's extremely heterogeneous. The Sylvan Shale would be no exception. You're going to have to find the sweet spots and do it as cost-effectively as possible.

Who are you talking to?

- Technical team (including specialists / managers)
- Executive level (since your strategy will shape the overall trajectory of the company)
- Land and legal team

As you develop a technology strategy, it is important to consider your team, your partners, your audience.

You can obtain valuable information from different parties in your team, and they can help you make decisions.

To continue with our Sylvan Shale scenario, let's imagine that we're moving ahead with our plan to develop the Sylvan Shale.

We need to talk to each team to obtain technological information that will help us achieve our goal.

Technical team:

Geologists: where is the play? The sweet spots? Where should we lease?
Land team: what is the acreage position? What are some of the legal issues?
Geophysicists: Where are productive limits? Any faults? Fracture networks?
Engineers (drilling, completions, reservoir): What are the main challenges? Costs? New technologies? Risks? Possible reserves?
Production team: What are the issues? What are challenges that need to be solved? Costs? Any "non-starter" possibilities?

Executive team:

Financial outlook: cash flow? Capital availability?
Strategic partnerships: mergers? Acquisitions?

Land and Legal team:

Land team: acreage? Filings / poolings?
Legal team: contracts, obligations, etc.

Match Technology to Overall Goal

- Common understanding of organizational mission / vision
- Predictable financial behavior (if you're a public company, Wall Street hates uncertainty; if you're looking to sell, so do potential
- buyers)
- Leadership:
- 10 years in the future
- 20 years in the future

Conclusion

A technology strategy for the "Wall Street Play" will be completely different than that of a "Sweet Spot Play." Nevertheless, they share a few things in common: they both endeavor to produce previously unproducible plays, and the goal of increasing bookable reserves remains the same.

Nevertheless, there is no easy way to arrive at a facile, "everything makes sense now" explanation of unconventionals. There are simply too

many competing interests, and their ultimate rationale for moving into the unconventionals space may not always be completely transparent.

What the Wall Street Play and the Sweet Spots Play have in common is the goal of identifying and then successfully exploiting previously unprospective, unproducible plays. In that respect, the approach is very useful.

Outline / Key Ideas

Match Technology to Overall Goal

As you gain a notion of the technology that is available, and the potential, it's important to match technology to the goal.

First, it's good to know what the various technologies offer.

List the technologies.

List what they offer and how they relate to your project.

What is your organizational mission and vision? If it is to develop unconventional resources in a way that brings sustainable value to the company for at least 10 or 20 years, then that will help you decide how you want to develop the Sylvan Shale.
If your goal is to drill proof of concept wells and produce them, and the follow up with a program to hold the acreage (HBP) in order to sell (or "flip") the company, then your decisions will be quite different.

As you select technology, remember that you will need to do so prudently to avoid huge fluctuations in production, potential drilling crises, and production problems. If you're a public company, bear in mind that Wall Street hates uncertainty.

If your goal is to build shareholder value by your plan, and also through divestiture, then you will need to be prudent in your selection of technology. You need to take some risk, but always have various contingency plans in mind.

Also, keep your leadership philosophy in mind. Will your leadership be stable over the next few years? Next 10 years? What changes do you anticipate in 20 years?

Field/Reservoir Development

Think of the end before you plunge into the beginning. Nowhere does this hold more true than in the case of field and reservoir development where you must focus on optimizing sweet spots in order have an economically viable and sustainable play.

Here are a few things to keep in mind at the outside. Invest early, rather than retrofitting later.

- Capacity-building infrastructure, built for future financial flexibility
- Operate as though you will have continuous ownership (with significant exposure, which makes you operate more prudently than if you
- were intending it to be a short-term situation)

- Assume eventual merger or divestiture could be a possible outcome
- Assume "proof of concept" flipping could be a possible outcome
- Assume NOC partnering (and "selling" your ability to train and perform effective technology transfer to build technological know-how
- and capacity within their human capital)

There are a number of ways to approach the application of technology in the development of fields or a play in accordance with your company's vision and mission.

As you develop your strategic plan, you need to take a long-term strategic look at how you plan to develop your fields and the individual reservoirs in the field.

Let's return to our example of the Sylvan Shale:

Additional thoughts on capacity building: build with expansion in mind. Go for value-add, and do not box yourself in. At the same time, do not over-commit to today's technology. Tomorrow's technology may make your investment obsolete.

As you develop, you need to assume that you'll continue to own the field and a good position in the play so that you can have control of the decisions. If you sell a significant percentage, you run the risk of not being able to carry out your plan. Or, you may end up with an inconsistent application of technology, which could result in more harm than good.

At the same time, given the nature of capital costs, and your desire to maximize shareholder value, ultimately you'll consider the following options:

Eventually selling the holdings
Selling all or part of the holdings
Potentially "flipping" the entire play
Partnering with an NOC partner whose goal is to acquire technological savvy in order to apply it to their own fields

In any case, it is unlikely that the entire play will continue to be held and developed 100% by your company. So, it's important to consider the options, and the implications on the technology implementation decisions you'll be making.

Leadership

Let's take a look at leadership and technology strategy. Make sure that you develop two scenarios simultaneously.

- Long-term
- Near-term

It's important to develop two scenarios at the same time: first, a long-term scenario and the leadership decisions that will most likely come to pass.

Second, it's important to face near-term situations and develop a scenario that encompasses opportunities and challenges.

So, for example, in the case of developing a Sylvan Shale play, what kind of leadership should the company adapt?

Long-term:

Visionary? Solid appeal to investors and the financial community
Stable? Predictable; aggressive yet well-planned?
Clear rationale for all strategic partnerships, acquisitions, mergers, and divestitures

Near-term:

Pragmatic: clear argument with evidence to support decision-making, in a way that would satisfy detractors as well as supporters
Team-building: Inclusive and giving management teams the ability to have input
Collecting nay-sayers and having focus groups in order to avoid being encircled by sycophantic yes-men

Leadership: Current Volatility

Let's take a look at leadership challenges and implications in current situations
Political climate: what impact does the political climate have on your selection of technology? As you develop the Sylvan shale play, are you affected at all? Are there any drilling moratoriums? Any labor issues? Any disputes with respect to mineral rights ownership?
Environmental climate: what are some of the major issues? Water? Induced seismicity? Scarce water? Worry about contaminating the acquifer?

Here are a few additional factors:

"Shock of the New" – "new" or at least "new to you" is always headline grabbing. It is important to know when and how to announce your use of technology

"Freshness factor"

The Allure of the Fantastic – technology has a "magic" factor, and the potential constitutes the magic; however one can oversell and arouse unrealistic expectations, so be careful

Technology Strategy

Transformative technology – as you review technology, the key is to understand which technologies are truly transformative and which ones are simply distractors, or worse, empty promises.
"What do you think is the single technology that will make the most significant difference in optimizing oil and gas shale production in North America?" (*World Oil / Shale Technology Review*, July 2013)

World Oil's article in July 2013 discusses what experts view are the technologies that can transform the oil industry.
But how? What are they transforming? It's a fundamental question, but worth asking.

Technology (ostensibly) can effect the following transformations:

· Make a previously unproducible formation producible (and at a reasonable cost)

- Make a formerly environmentally horrible situation a good one: deal with the inputs and byproducts of new production (and new techniques) – specifically disposing of frac fluid and produced water
- Turn a formerly expensive operation into one that is more reasonable

Strategy & Definitions ("Sweet Spots")

Recognizing the definitions are functions of current technological limitations (or perceptions of such)

- Unconventionals / Shale Plays
- Brittleness (and ways of determining it)
- Fracture networks
- Faults and other structural determiners
- Porosity (granular / secondary / dolomitization, etc.)
- Permeability
- TOC and maturation factors

Strategy & Definitions ("Sweet Spots")

Recognizing the definitions are functions of current technological limitations (or perceptions of such)

- Deepwater
- Turbidite architectures
- Compartmentalization due to permeability barriers
- Salt deformation, etc.

Technology applied to developing a play –
Must define or understand what constitutes a "sweet spot" – and understand that "sweet" is opposed to "unsweet" and "unsweet" is essentially a barren or unproducible / economically untenable (at least today) zone
It is useful to take a step back and acknowledge that "sweet" really refers to "recoverable" and that "recoverable" is a moving target – depends on technology and technological advances.

Business Drivers: Technology Strategy

Business drives the development of technology. However, the economic climate and current financial contexts can have unintended consequences.

- Can impede sweet spot-driven approach (need to hold the acreage or continuous drilling clause, as in some unconventionals and also in
- offshore blocks)
- Can restrict the type and amount of technology used (need partner "buy-in" for expensive seismic acquisition and/or processing / re-

- processing)
- Cost-benefit analysis / ROI for each important set of data and/or test
- List and include in AFE and/or Joint Operating Agreement
- Can cause one to miss the window for the tests / data gathering (example: seismic, cores, logs, etc.)

Service companies often strategically partner in order to provide "breakthrough" services. One example is CGG Veritas and BakerHughes. Others include service companies who team with university consortia to support research and the development of new techniques.

Partners, Teams, & Technology Strategy

- Partner issues (disagreements, non-payment, election not to participate) can lead to the wrong focus in belt-tightening – need to re-think
- the "difficult choices"
- Engineers and geologists must be able to see through some tactics used in well-timed production manipulations (just before earnings
- reports, etc.)
- Lack of midstream facilities can skew numbers, and weaken case for new locations and/or tests: Service companies recommending a
- path of action need to be well aware of any and all midstream issues, and also the big picture

Monitoring Progress As You Go

- Measurements and Analytics
- What metrics do you gather as you go?
- How do you know they're appropriate?
- Meshing metrics / cluster analyses
- Decisions that must be made as you go
- Cluttered, undifferentiated, potentially obfuscating data
- The danger of oversimplification

Reality Check for Technology Strategy Development

No one can have perfect knowledge of the future, and not every case study or "lookback" will necessarily yield insights that will protect one from mistakes or assure ongoing success.

It's clear, though, that all technology strategy must be shaped with an eye to the road ahead. It is important to think ahead to potential business-driver impediments and be sure to anticipate potential changes or disruptions.

So, a good technology strategy is forward thinking and responsive. Develop a preemptive strategy to be able to obtain the data needed to make good decisions based on best practices and utilization of best technologies.