Don’t Miss the Unconventional Resource Revolution’s Next Wave

Why Strategic Well Rejuvenation is the Key to Sustained Profitability in Today’s Oil and Gas Market

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ABSTRACT

In the North American shale plays, the most popular approach to developing assets is built on a cycle of repeatedly drilling, completing, and fracturing wells. As production from older wells declines, new wells are drilled and stimulated so operators can maintain constant production streams to meet their revenue targets. And because unconventional production rates decline so quickly that a well can become uneconomic in as little as 18 months, this cycle tends to repeat itself in rapid succession.

As a result, most E&P companies working in these plays are burdened with a business model that requires them to recoup all of a well’s CAPEX costs in a short period of time—leaving as much as 90% of a well’s potential production untapped. And in today’s climate of depressed oil prices, that model is both unprofitable and unsustainable.

Faced with this reality, many operators believe they have to choose one of three options just to stay in the game:

- Keep drilling and completing more wells, trying to manage until production declines to uneconomic levels
- Continuing to produce at low rates, hoping for oil prices to rebound
- Practicing the “pump and pray” approach, restimulating wells and getting inconsistent results.

But there is a fourth option. And in many cases, it is a better option.

By adopting data-driven processes, following best practices, and constructing better, refrac-ready wells versus drilling more wells, operators can reinvent their business models for unconventional assets.

This white paper details the process of strategic well rejuvenation—a data-driven, science-based method that helps operators understand the reservoir rock, uncover the reasons behind poor well performance, and identify and implement the most profitable well rejuvenation programs.

Traditionally, the short life of an unconventional well meant that all of its costs—including construction and infrastructure—had to be recouped quickly, thereby increasing lifting costs. In comparison, the lifting costs from the incremental production of a rejuvenated well benefit from the elimination of many start-up costs.
STRATEGIC WELL REJUVENATION: IMAGINATION IN A DEPRESSED MARKET

Well rejuvenation is the process of restoring production in existing wells through methods that can include wellbore cleanup, chemical treatments, artificial lift, or recompletion and restimulation. Already, the industry has seen positive results from rejuvenation projects that have generated production rates that equal or even exceed the well’s initial peak production, often with less rapid decline rates. And as oil prices plummet, rejuvenation is gaining more traction with operators in unconventional plays.

The simple truth, however, is that not every well is a good candidate for rejuvenation. With thousands of potential rejuvenation candidates, success depends on selecting only the right ones. The strategic well rejuvenation process helps operators do just that, giving them answers to some critical questions:

- Which wells have the greatest potential to be restored to, and to even exceed, initial production levels?
- Which wells offer the least risk?
- What are the optimal selection criteria in choosing a candidate well?
- What is the most effective means for rejuvenating the well?
- Is the desired rejuvenation treatment method economically feasible?

By restoring connections to previously stimulated intervals and tapping into zones that were missed by the initial completion and stimulation, a successful strategic well rejuvenation project can not only restore—and potentially increase—production, but also decrease the slope of the decline curve, thus improving ultimate recovery and extending the well life cycle.

The process follows four prescribed steps:

1. Screen and select candidate wells; wells with the greatest production potential
2. Diagnose the condition and specific rejuvenation needs of each of those wells
3. Prescribe the optimal rejuvenation treatment
4. Execute the rejuvenation treatment at the wellsite

“...re-fracking offered mixed results in the past, earning it the nickname ‘pump and pray.’”

– Bloomberg Business
STEP 1. SCREEN AND SELECT CANDIDATE WELLS

Selecting rejuvenation candidates with the best risk/reward ratio from an operator’s hundreds—or even thousands—of wells takes the right approach, the right tools, and the right expertise. The process includes:

- Mining historical reservoir and production data
- Applying advanced statistical methods
- Estimating the candidate well’s production potential

The amount of available information around a well has grown from a few key data points to hundreds of variables related to reservoir geology, well architecture, completion tools and techniques, pumping schedules, stimulation fluids, and production schemes. Taken together, those data can generate an almost infinite number of combinations that require an iterative process and advanced analytical tools, including predictive models, to help zero in on the best candidates.

**Mining Historical Reservoir and Production Data**

Often, the best rejuvenation candidates are located in the best producing areas—or “sweet spots”—within fields. However, because of the heterogeneity of unconventional reservoirs, pinpointing the best candidates is still challenging.

An optimized screening process leverages more than just field production data, encompassing such factors as:

- Overall recovery
- Decline rates
- Well architecture
- Stimulation design
- Production schemes

Advanced data mining techniques can provide a look into virtually any play in North America, enabling operators to study key production drivers. However, it is important to remember that data sets involving large well counts often contain many variables that are not ideally distributed, have missing values, bad values, or other problems. So it is crucial that the tools and techniques used in the data mining process can flag any potentially compromised data. Another best practice is building a single data set drawn from multiple sources—minimizing the risk of information gaps to ensure the most accurate and reliable screening possible.
Applying Advanced Statistical Methods

It is possible to pull raw data from multiple sources, both public and proprietary, cleanse it, and merge it into a single set. Using a geographic information system (GIS) application can improve data set interpretation by mapping the information in geographical perspective.

These methods can help operators better understand the impact of key well architecture, and completion and stimulation parameters. This allows one to create a baseline for reservoir performance and determine and explore the potential of various rejuvenation techniques within a specific play or field. With this information, wells located in good quality reservoirs with more to offer and/or wells possessing production issues that can be corrected effectively and economically can be identified.

Using proprietary data-gathering and filtering algorithms and GIS mapping, it is possible to merge public data with proprietary information, and then analyze it to determine well placement, original completion type, and original stimulation treatment details.

The best performers in a field often represent the best potential candidates, assuming that the remaining reserves are sufficient to be recovered profitably. For example, good producers with steep declines curves can be excellent rejuvenation candidates. In good-quality reservoir areas within the play, poor or intermediate producers that were under-completed or under-stimulated also can be good—or sometimes, the best—candidates. With under-performers, it is crucial to understand reasons for poor performance because, while a problem well can often be corrected, a poor-quality reservoir cannot.

Estimating the Candidate’s Production Potential

Once the best candidates are selected, the workflow must be able to provide an initial means of estimating post-rejuvenation incremental production. One reliable method is using a Monte Carlo simulation, incorporating key reservoir and well parameters to rank the rejuvenation candidates within the selected group of wells. This makes it possible to estimate each well’s rejuvenation potential and determine when rejuvenation programs may be needed over the life of the well.
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The two refrac wells shown above provide an excellent example of why a thorough screening process is essential prior to any CAPEX investment in a well rejuvenation treatment. The first well's rejuvenation treatment delivered results more than three times greater than the initial production of the well and quickly recouped the operator's reinvestment. In contrast, the rejuvenation treatment of the second well achieved less than half of the initial production of the well, and its projected incremental production is unlikely to earn back the additional monies spent on the refracturing program.

Step 2. Perform Individual Well Diagnostics

After the best candidates have been identified, an additional diagnostic analysis must be performed on each well in order to uncover its unique production challenges and to pinpoint issues that might preclude a specific type of rejuvenation treatment or render a treatment uneconomic.

Performing a detailed well diagnosis can include:

- Conducting a thorough cleanup. Almost every well will require a thorough cleanup prior to any rejuvenation efforts; in fact, some wellbore cleanouts have even been effective at temporarily boosting production to the desired recovery levels without any additional rejuvenation efforts.
- Verifying well integrity. It is crucial to evaluate the casing of the well and confirm its mechanical integrity. These data help determine the most effective isolation method—especially if restimulation is needed to improve production.
- Reviewing the original well logs. A comprehensive examination of all existing formation evaluation data helps in quantifying the remaining reserves and in understanding reservoir conditions. If formation evaluation data is scarce or unclear, it may be necessary to gather new logging data prior to investing additional CAPEX in rejuvenation treatments.
- Examining the original completion and stimulation program. A detailed review of the original completion and stimulation design can help create a diagnostic profile of the existing fractures and identify any areas that might have been untreated or under-stimulated.
Petrophysical analysis of legacy rock cuttings, mapped to specific well intervals or stages, makes it possible to refine production and stimulation profiles for wells that lack detailed formation evaluation logs.

**STEP 3. PRESCRIBE THE OPTIMAL REJUVENATION TREATMENT**

In some cases, production can be restored to desired levels with a cleanup program or with artificial lift technology.

But if refracturing is needed, the production profile data from existing stages can be combined with reservoir models to capture the full scope of subsurface data, providing the insight to design the most effective rejuvenation program.

The best way to build that program is with a process that weighs the technical feasibility and risk against the cost of intervention. It is also important to consider how the well will be put back on production after the treatment because proper flowback management plays an essential role in optimizing flow rates and in achieving desired production.

This process helps to ensure effective management of project costs by limiting reinvestments to viable refrac candidate wells that can be rejuvenated—at a fraction of the cost of new wells—not just once but multiple times.
Refractions older wells has become a popular topic of conversation among operators looking to boost recovery factors while reducing their CAPEX spend on new wells. However, refracturing is only one of many available rejuvenation treatments as detailed in the chart below. The proper rejuvenation technique should be based on the well’s specific production challenges and the potential return on rejuvenation investment.

### TYPICAL REJUVENATION TECHNIQUES AND OBJECTIVES

<table>
<thead>
<tr>
<th>Technique</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deploy artificial lift to accelerate well flow</td>
<td>Repair or replace substandard original completion</td>
</tr>
<tr>
<td>Repair fracture degradation over time (closing or plugging)</td>
<td>Conduct a thorough wellbore cleanup to boost production</td>
</tr>
<tr>
<td>Enlarge fracture geometry/ enhance reservoir contact</td>
<td>Restimulate under-performing intervals with more suitable fluids and proppants</td>
</tr>
<tr>
<td>Extend well lift by introducing flow assurance additives</td>
<td>Increase conductivity in inadequately propped portions of the fractures</td>
</tr>
<tr>
<td>Restore and maintain fracture conductivity lost due to:</td>
<td>- Proppant embedment</td>
</tr>
<tr>
<td>- Cyclic stress</td>
<td>- Proppant degradation</td>
</tr>
<tr>
<td>- Gel damage</td>
<td>- Plugging from organic or inorganic deposition</td>
</tr>
<tr>
<td>Stilulate untreated (or under-treated) zones for greater reservoir exposure</td>
<td></td>
</tr>
</tbody>
</table>

### STEP 4. EXECUTE AT THE WELLSITE

Field execution is the final step in the refracturing process. The overall success of the project—both technical and economic—rides on the effectiveness and efficiency of the wellsite execution.

At this point, it is crucial that the proper products and services be applied to help prepare any well for the application of chemicals or the installation of artificial lift. When refracturing is prescribed, these technologies will play an important role in closing off existing stages that are not part of the refrac design and in isolating the desired frac stages to effectively restimulate the well.

During the refracturing process, monitoring fracture propagation is important to ensure the success of the job. These real-time data, combined with post-refrac analysis, is crucial to refine and enrich the reservoir models for the next refracturing operation. It takes a multi-well approach to identify the most effective rejuvenation treatments, and to help further **drive efficiency, reliability, and improved ultimate recovery**.

If the operator is working with a service company offering a full arsenal of completion, stimulation, and production technologies, they are often able to provide a **dedicated wellsite coordinator and project manager** for overseeing the project. This is recommended as it provides a single point of accountability for the project results and typically delivers improved communications and better execution efficiency.
A NEW BUSINESS MODEL FOR UNCONVENTIONAL ASSETS

To avoid repeating the mistakes of the past and artificially limiting the potential of the North American shale plays, it is crucial that operators in these basins jettison their outdated business models and begin treating each of these wells as a renewable asset. By emphasizing the placement of wells in the most productive portions of the reservoir, it is now possible to construct wells that can be rejuvenated multiple times to deliver more hydrocarbons than were previously possible—and deliver those hydrocarbons at a lower cost per barrel than with the current approach.

And this approach isn’t limited to new wells. Any operator today with an inventory of unconventional wells likely has multiple rejuvenation candidates that can be leveraged to improve his or her financial performance with minimal CAPEX reinvestment. The key is to pinpoint those wells quickly and efficiently, determine the most effective (and most cost-effective) rejuvenation treatment, and reinvest only in those wells with the best potential and least risk.

And that is now easier than ever before. By adopting a more strategic approach that leverages the process outlined in this paper and partnering with the right service provider or providers, operators can transform their current business model into one that can deliver consistent value to their organization… in both good times and bad.

This process has been applied successfully in numerous North American shale applications by Baker Hughes as part of its NextWave™ production rejuvenation solution.

To learn more about this solution and how it has been applied to help operators efficiently target and rejuvenate unconventional wells, please visit BakerHughes.com/NextWave.

ABOUT THE AUTHOR

Hans-Christian Freitag is Vice President of Integrated Technology for the Global Products and Services group at Baker Hughes. He joined Atlas Wireline Services in 1989 and has worked in operations, geoscience, and management positions around the world. In 2002, he moved to Baker Hughes INTEQ and oversaw the development and market introduction of advanced logging while drilling technology. From 2005 to 2008 he was responsible for formation evaluation in North America. From 2008 to the end of 2013 he held a number of senior and executive management positions with Baker Hughes in the Middle East and Asia Pacific. Before assuming his current role, he was Vice President for the Unconventional Resources group in the Eastern Hemisphere. He has authored publications on open-hole and cased-hole formation evaluation for the Society of Petrophysicists and Well Log Analysts and the Society of Petroleum Engineers. Freitag holds an MSc in Geophysics and a BSc in Physics from TU Berlin and TU Clausthal in Germany.