FROM FLOWING TO LIFT: HOW BASIN DIFFERENCES SHAPE ARTIFICIAL LIFT DECISIONS IN THE PERMIAN

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ABSTRACT

Unconventional play drilling and completion are pushing for longer laterals and more aggressive fracturing to maximize reservoir contact. On the other hand, there is no one-size-fits-all solution for artificial lift. This study characterizes first production method trends in the Midland and Delaware Basins using a dataset of well completions, production performance, and production methods. Results show distinct variations in production method selection driven by geological differences, gas-oil ratio, and operators strategies. The Midland Basin is skewed toward ESPs and rod pumps, with lower GOR and shallower depths, while the Delaware Basin presents a higher preponderance of natural flow and gas lift due to higher GOR. Trends over time show evolving operator behavior, influenced by oil prices and estimated ultimate recovery (EUR).

INTRODUCTION

Unconventional wells often exhibit high initial production rates—frequently exceeding 5,000 barrels per day—but experience rapid declines within months. In this context, selecting an appropriate artificial lift (AL) method is critical for sustaining economic production over the well's lifecycle. Yet despite its importance, many operators continue to base lift decisions on peer practices rather than data-driven optimization. In the Midland Basin, for example, both smaller and larger operators tend to mirror the AL strategies of similarly sized peers (Pradhan et al., 2017).

Historically, artificial lift systems originally developed for conventional fields have been applied to unconventional environments with minimal modification. This approach often leads to inefficiencies and premature equipment failures. ESPs, in particular, can become cost-intensive due to the need for rig-based interventions when failures occur (Wilson, 2017). As such, basin-specific lift strategies that account for geological and operational variability are increasingly necessary (Martin & Economides, 2010).

Smaller operators frequently begin with ESPs to take advantage of high early-time flow rates, but typically transition to rod pumps once production drops below 350–400 BFPD. In contrast, larger operators may initially pilot gas lift systems and, based on field response, switch to rod pumps at a later stage (Pradhan et al., 2017). The use of gas-assisted plunger lift has emerged as a bridging method, enabling extended gas lift operation and deferring the need for rod pump installation for several years (Pradhan et al., 2017).

These practices illustrate how operator behavior—shaped by technical capability, economic considerations, and organizational preferences—can influence lift selection. However, such trends are not always aligned with the reservoir's production profile or long-term optimization goals (Awasthi et al., 2007).

This paper investigates first production method adoption patterns across the Permian Basin, focusing specifically on the Midland and Delaware sub-basins. It aims to identify the geological, operational, and economic factors driving lift choices and evaluate the outcomes of these strategies in terms of performance, reliability, and adaptability. By drawing on Enverus (Drilling info) dataset, literature insights, and comparative analysis, this study contributes to identifying the drivers behind operator choices and performance outcomes in unconventional reservoirs.

Literature Review

Selecting optimal production methods and enhancing their performance hinge on thorough analyses of production data, cost considerations, and reservoir modeling (Pradhan et al., 2017). Therefore, a comprehensive understanding of reservoir properties at the basin scale, along with geological formations, is crucial to validate analytical trends and rationalize results.

The Permian Basin, spanning approximately 86,000 square miles across western Texas and southeastern New Mexico, stands as one of the most prolific hydrocarbon-producing regions in the United States, accounting for about 17% of U.S. oil production in 2002 (Dutton et al., 2005). This expansive basin encompasses two primary sub-basins—the Delaware Basin and the Midland Basin—separated by the Central Basin Platform.

Delaware Basin Characterized by its greater depth and tectonic complexity, the Delaware Basin hosts formations like the Bone Spring, composed of interbedded sandstones, carbonates, and shales, offering high-quality reservoirs with porosities ranging from 8% to 15% (Carr, 2019). In contrast, the Midland Basin is more stable and carbonate-rich, featuring formations such as the Spraberry. The Spraberry Formation consists of tight sandstones, siltstones, and shales, with porosities between 5% and 12%, and generally exhibits lower permeability compared to the Bone Spring Formation. Advancements in hydraulic fracturing and horizontal drilling have significantly enhanced production from the Spraberry Formation, solidifying its role in the Permian Basin's growth. A notable formation spanning both sub-basins is the Wolfcamp Shale, an organic-rich shale with high total organic carbon (TOC) content, making it a prime target for oil and gas development (Jarvie, 2018). The Wolfcamp Shale's extensive reach and richness have positioned it as a focal point in unconventional resource extraction within the basin, Figure 1 shows Permian basin stratigraphy and Tectonic history.

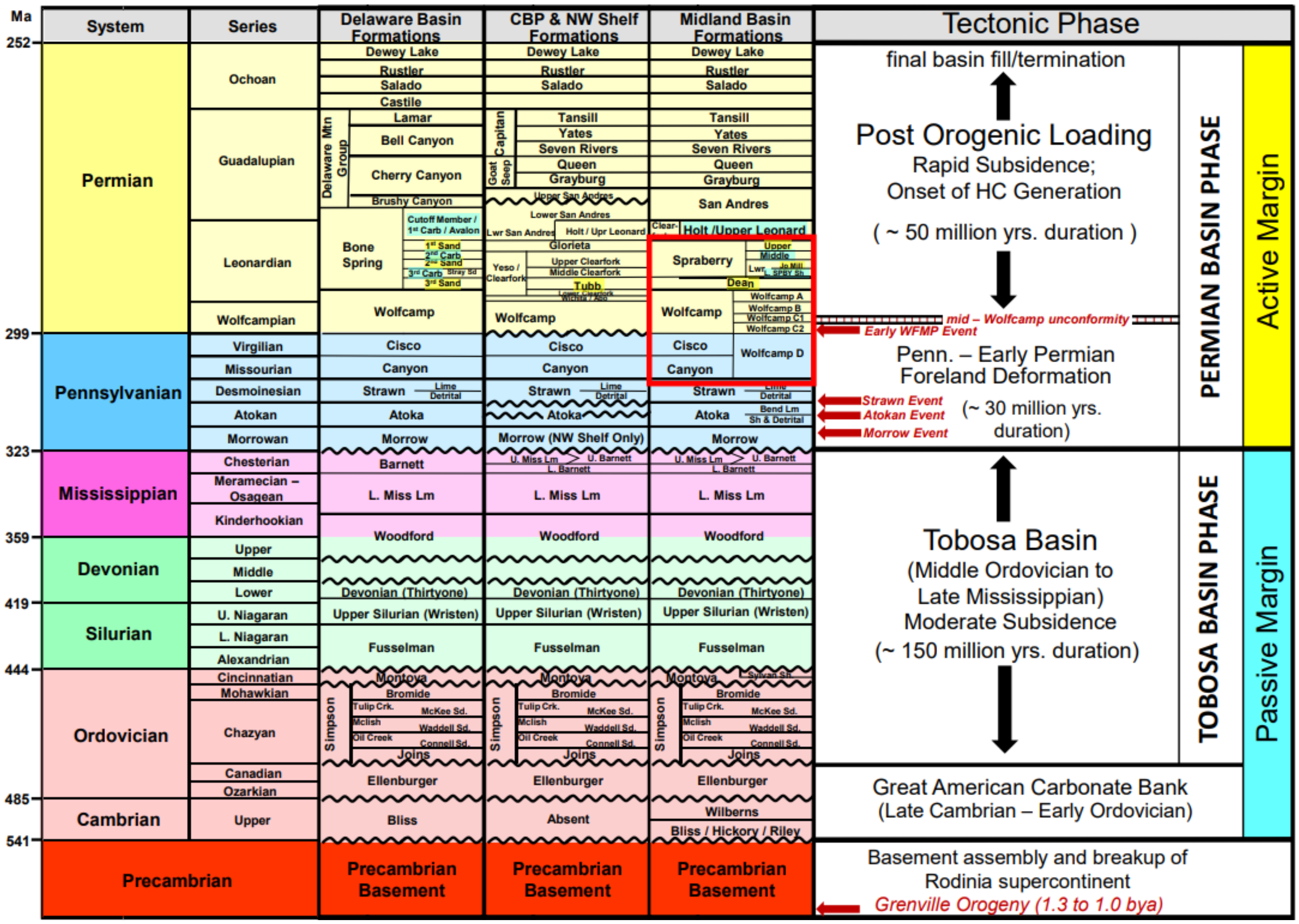

FIGURE 1. PERMIAN BASIN STRATIGRAPHY AND TECTONIC HISTORY.

The Delaware Basin generally exhibits higher reservoir pressures and greater natural fracturing, contributing to enhanced production rates (Dutton et al., 2005). Conversely, the Midland Basin, while containing similar formations, tends to have lower pressures and higher clay content, affecting permeability and fluid mobility (Fairhurst, 2022). These geological differences necessitate tailored production strategies. For instance, artificial lift methods such as gas lift are more commonly employed in the Delaware Basin to maintain productivity in its deeper, high-pressure environments (Gale et al., 2017)

The Permian Basin remains a cornerstone of hydrocarbon production in the United States, with both the Delaware and Midland Basins contributing substantially to its output. While they share similar stratigraphic units, variations in structural history, reservoir properties, and fluid characteristics lead to distinct production strategies. A nuanced understanding of these differences is essential for optimizing exploration and development efforts in the region.

METHODOLOGY AND DISCUSSION:

DATA COLLECTION AND PREPROCESSING

Data was collected from Enverus, focusing on wells across the Midland and Delaware Basins. Key preprocessing steps included: (1) Filtering by basin. (2) Unifying production method labels (e.g., "flowing" vs. "Flowing"). (3)

Deriving new columns such as operator type (public/private) based on Enverus' top 50 list (Enverus 2024). (4) Merging historical WTI oil prices (Crude Oil Prices (WTI), 2025)

Analysis Strategy

We followed a top-down approach: (1) Identify general trends over time. (2) Analyze basin-level differences. (3) Compare operator strategies. (4) Relate lift choice to GOR and EUR. Figure 2 provides the workflow starting from data collection to analysis steps

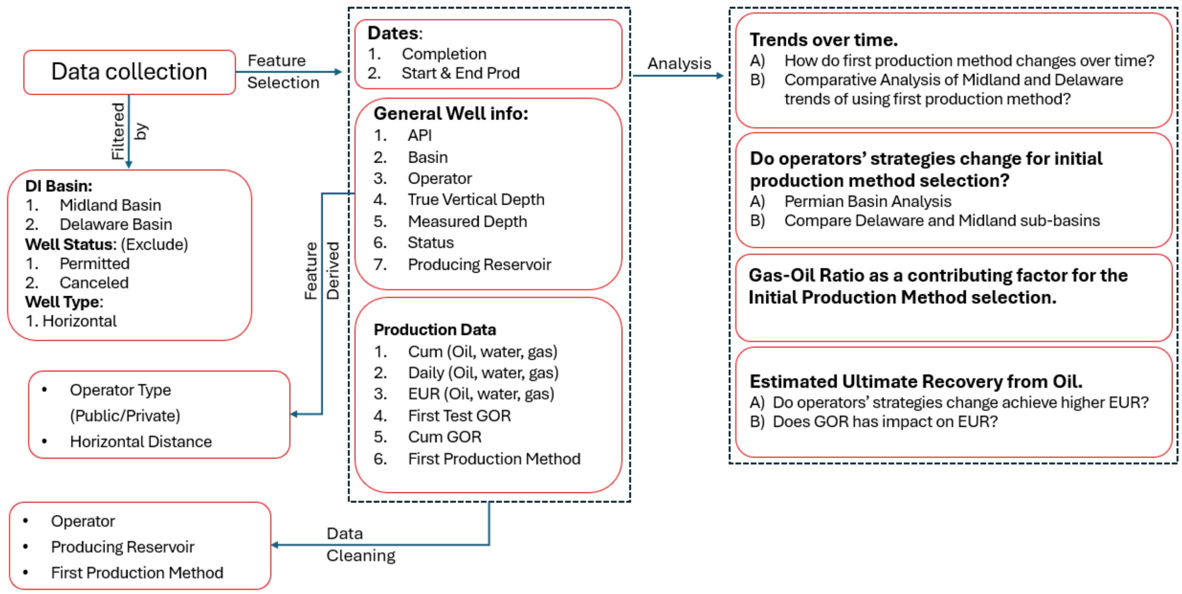

FIGURE 2. FLOW OF THE ANALYSIS

How does the Production Methods Change over time?

An analysis of artificial lift trends from 2014 to 2024 reveals a clear evolution in operator strategies across the Permian Basin. In the early years (2014–2019), natural flowing wells accounted for roughly 40–45% of lift methods, but this reliance steadily declined after 2020, falling below 20% by 2024, Figure 3. This trend highlights the decreasing contribution of natural reservoir energy, likely, due to the development of tighter formations or the adoption of new technologies aims at enhancing production optimization. Meanwhile, the use of pumping systems grew gradually starting in 2015 and surged after 2021, peaking at around 60% in 2022. This uptick closely mirrored the spike in oil prices, which peaked at approximately $95/bbl in 2022, suggesting that operators prioritized lift methods offering rapid production gains. In contrast, gas lift—once a minor player—began gaining traction after 2021 and reached around 30% usage by 2024. Its consistent growth indicates a strategic shift toward more adaptable and efficient lift systems, particularly in response to stabilized oil prices and improved gas infrastructure. Year-on-year data from 2022 to 2024 further reinforces these shifts: flowing methods declined significantly, pumping showed a moderate retreat, and gas lift steadily advanced. This trajectory suggests a maturing approach to production method selection, where operators are increasingly tailoring strategies to reservoir conditions, economics, and long-term production sustainability.

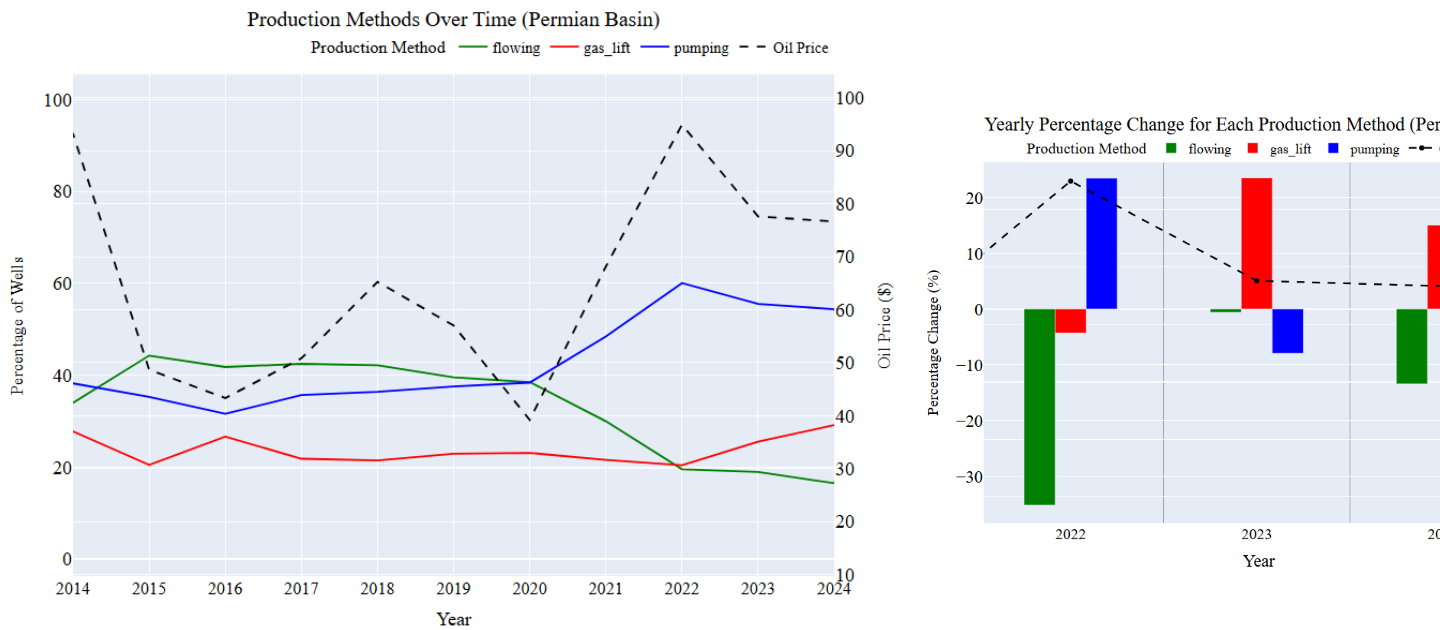

FIGURE 3. LEFT—PRODUCTION METHODS TRENDS OVER TIME ACROSS PERMIAN BASIN. RIGHT—PERCENTAGE CHANGE OF PRODUCTION METHODS OVER LAST 3 YEARS.

COMPARATIVE ANALYSIS BETWEEN PRODUCTION METHODS IN MIDLAND AND DELAWARE BASINS.

A comparison of first production method trends between the Midland and Delaware Basins from 2014 to 2024 reveals key differences shaped by geology, reservoir conditions, and infrastructure maturity. Pumping remains the most dominant and consistent first production method in the Midland Basin. It grew steadily from around 40% in 2014 to a peak of over 65% in 2022, before tapering slightly to approximately 60% by 2024, Figure 5. This trend aligns closely with oil price fluctuations, as pumping activity peaked alongside the 2022 price surge. In contrast, pumping in the Delaware Basin has remained minimal, briefly rising in 2022 (nearly tripling in share) but still staying below 30%, Figure 4. It saw a sharp decline in 2023 and 2024, dropping by 35% in the latter year. This rapid drop-off suggests that pumping may be less suitable for Delaware's deeper, high-GOR wells and was quickly phased out after initial trials.

Gas lift adoption tells a different story. In the Midland Basin, gas lift has been gradually integrated, maintaining a relatively steady presence between 30–35% from 2016 through 2024, with modest growth (~10%) in recent years. However, in the Delaware Basin, gas lift has seen explosive growth since 2022—doubling in 2022, more than doubling again in 2023, and growing by another 60% in 2024. By the end of the period, gas lift became the second-most common first production method in the Delaware Basin, approaching 40% of usage. This reflects its adaptability to deeper wells and higher gas content, which characterize much of the Delaware play. Meanwhile, the slower uptake in Midland is likely due to the dominance of established pumping infrastructure and the basin's generally shallower well depths.

Naturally flowing wells have been on the decline in both basins, but with different trajectories. In the Midland Basin, flowing contributed roughly 45% of production methods in 2014 but declined steadily to about 15% in 2024. A small rebound was observed in 2024 (+10%), but the overall trend indicates diminishing reliance on natural reservoir pressure. In contrast, the Delaware Basin historically relied heavily on natural flow—making up 60–80% of first production methods in earlier years due to its higher reservoir pressure and natural fracturing. However, even here, a downward trend has been evident since 2021, with flowing now representing approximately 55% of production methods. Though still significant, year-over-year declines of 10–20% reflect the growing need for artificial lift as reservoir pressure depletes or new wells are drilled in tighter formations.

Overall, the Midland Basin demonstrates a more stable, infrastructure-driven reliance on pumping, while the Delaware Basin is undergoing a more dynamic transition—from natural flow to artificial lift, particularly gas lift. These differences underscore the importance of tailoring lift strategies to basin-specific geological and operational conditions.

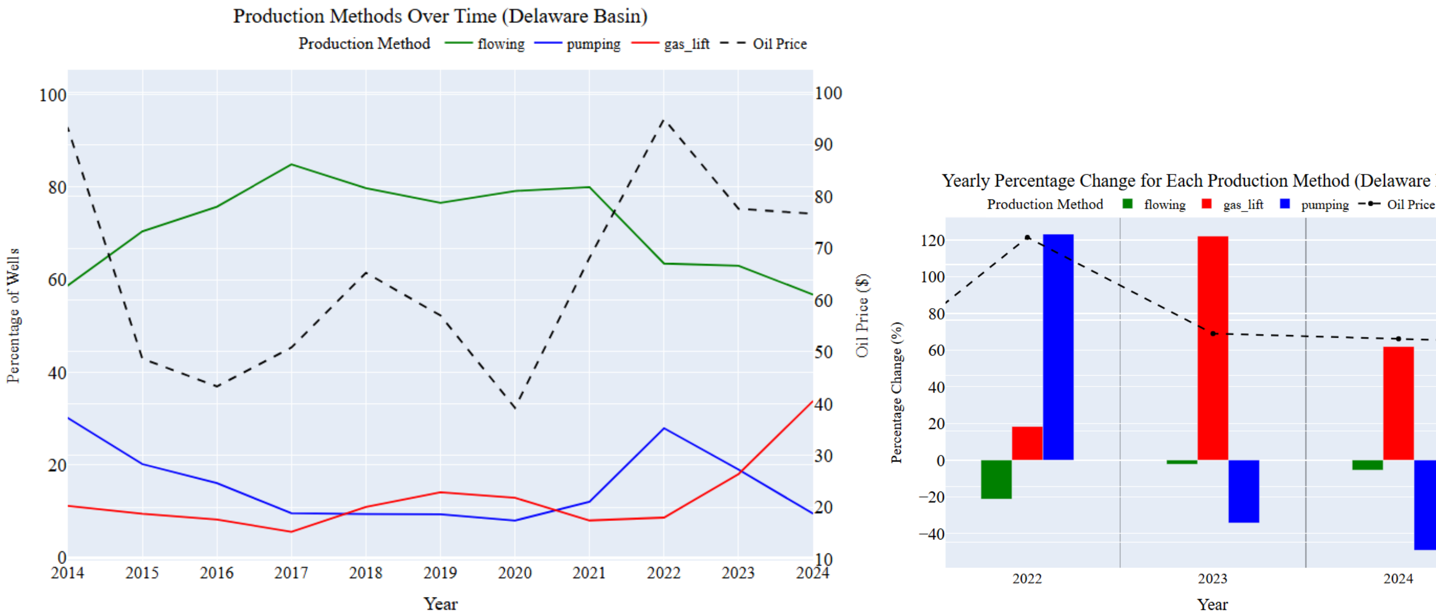

FIGURE 4. LEFT—PRODUCTION METHODS TRENDS OVER TIME ACROSS DELAWARE BASIN. RIGHT—PERCENTAGE CHANGE OF PRODUCTION METHODS OVER LAST 3 YEARS.

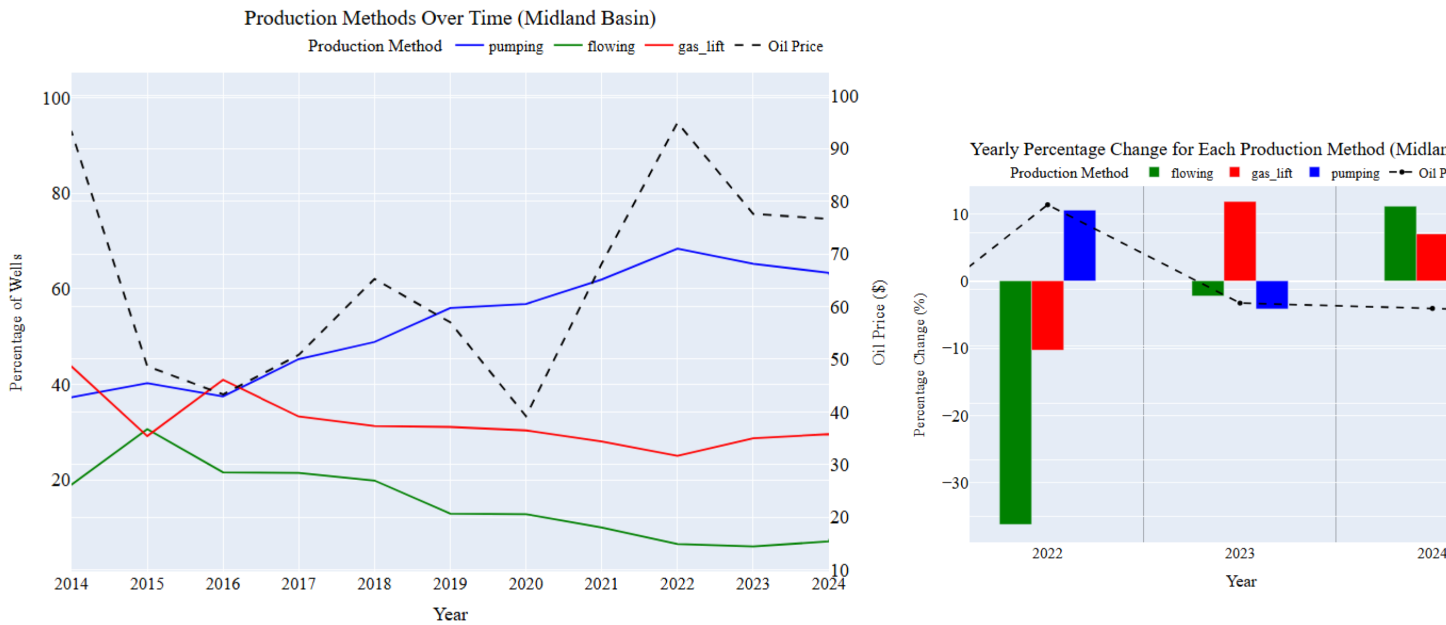

FIGURE 5. LEFT—PRODUCTION METHODS TRENDS OVER TIME ACROSS MIDLAND BASIN. RIGHT—PERCENTAGE CHANGE OF PRODUCTION METHODS OVER LAST 3 YEARS.

HOW DO INITIAL PRODUCTION METHOD CHOICES VARY BY OPERATOR TYPE AND BASIN?

Since 2014, production method choices among public and private operators in the Permian Basin reflect differences in strategy, capital access, and reservoir management. Public operators have shown a clear preference for infrastructure-intensive methods, with nearly 45% of their wells beginning production with pumping. In contrast, private operators lean toward more capital-efficient approaches, initiating around 40% of wells with natural flow. Overall, both groups have historically relied more on flowing and pumping than on gas lift, although gas lift adoption is gradually increasing, Figure 6.

In the Delaware Basin, where high reservoir pressure enables extended natural flow, over 70% of wells from both public and private operators began with flowing, Figure 7. The remaining distribution shows subtle distinctions: public operators are slightly more inclined to adopt gas lift earlier, while private operators make more frequent use of pumping, possibly to offset capital limitations by prolonging the natural flow phase.

In the Midland Basin, the lower-pressure environment prompts greater reliance on artificial lift. Pumping is the dominant initial method, accounting for over 50% of wells for both operator types, with public operators showing marginally higher usage. Gas lift ranks second in popularity, with similar adoption rates between public and private operators. Flowing is the least used method in Midland, though private operators continue to use it slightly more often than public companies, Figure 7.

These patterns suggest that while flowing remains a foundational method—particularly in Delaware—operator type plays a more significant role in the timing and selection of artificial lift methods. Public operators tend to adopt more controlled and infrastructure-heavy systems such as pumping and gas lift earlier in the well's life, reflecting larger budgets and long-term development plans. Private operators, by contrast, often prioritize early production simplicity and lower upfront costs, delaying transitions to more complex lift methods.

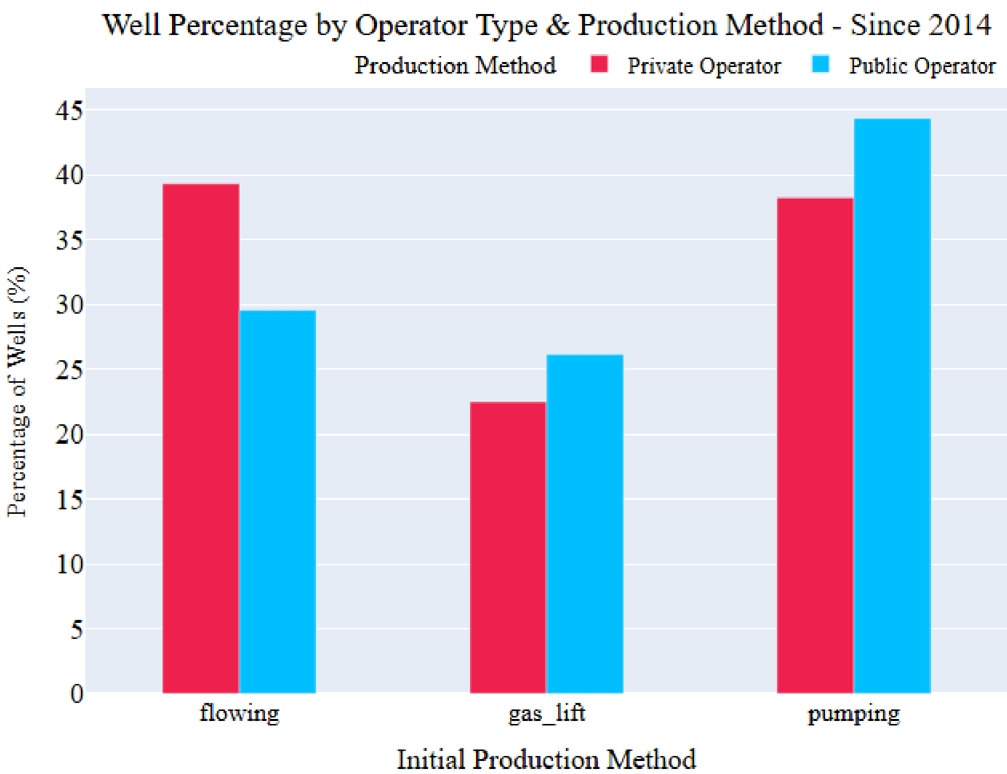

FIGURE 6. BAR CHART FOR THE INITIAL PRODUCTION METHOD BY OPERATOR TYPE.

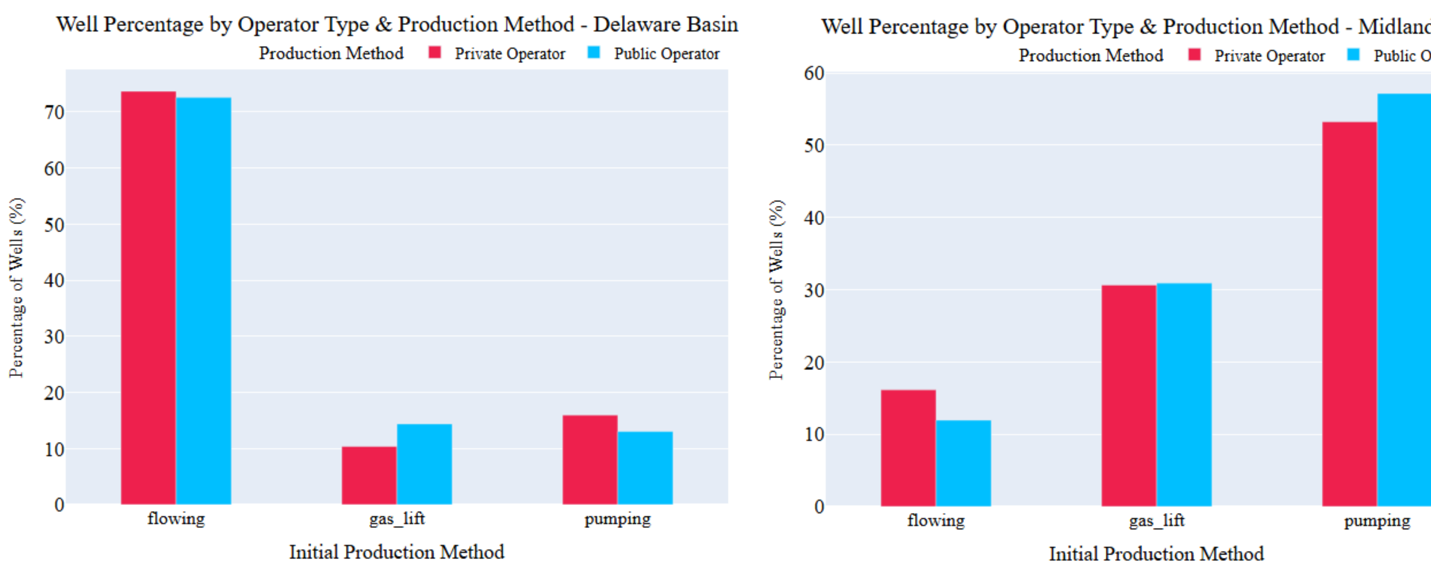

FIGURE 7. COMPARING OPERATORS' PRODUCTION METHOD SELECTION BY BASIN. LEFT IS DELAWARE AND RIGHT IS MIDLAND.

Do public and private operators adopt different artificial lift strategies between the Midland and Delaware Basins?

Private operators demonstrate significant variability in their artificial lift deployment, often responding rapidly to changes in market conditions, well performance, and available capital. This flexibility is evident in the Delaware Basin, where both public and private operators initially rely heavily on natural flow due to high reservoir pressure.

However, in 2023, public operators accelerated the transition to gas lift, increasing its use by approximately 160% compared to 2022, while private operators followed a similar trend but at a more conservative pace, registering an 80% increase over the same period. This divergence reflects the greater capital flexibility and long-term planning typical of public entities, Figure 8.

In the Midland Basin, where lower reservoir pressure necessitates early artificial lift, pumping remains the dominant method for both operator types. Public operators have maintained a steady reliance on pumping, with usage increasing gradually and gas lift adoption remaining stable at 32–35% over the past eight years. In contrast, private operators have shown a sharper rise in gas lift usage, with a 50% increase observed in 2024 alone, indicating a more experimental or adaptive approach as their wells mature, Figure 9.

Overall, these trends highlight that public operators tend to adopt structured, long-term lift strategies, while private operators remain more agile and responsive, adjusting methods based on near-term economics and field performance. These behavioral differences shape not only lift selection but also the timing and trajectory of production optimization across both the Midland and Delaware Basins.

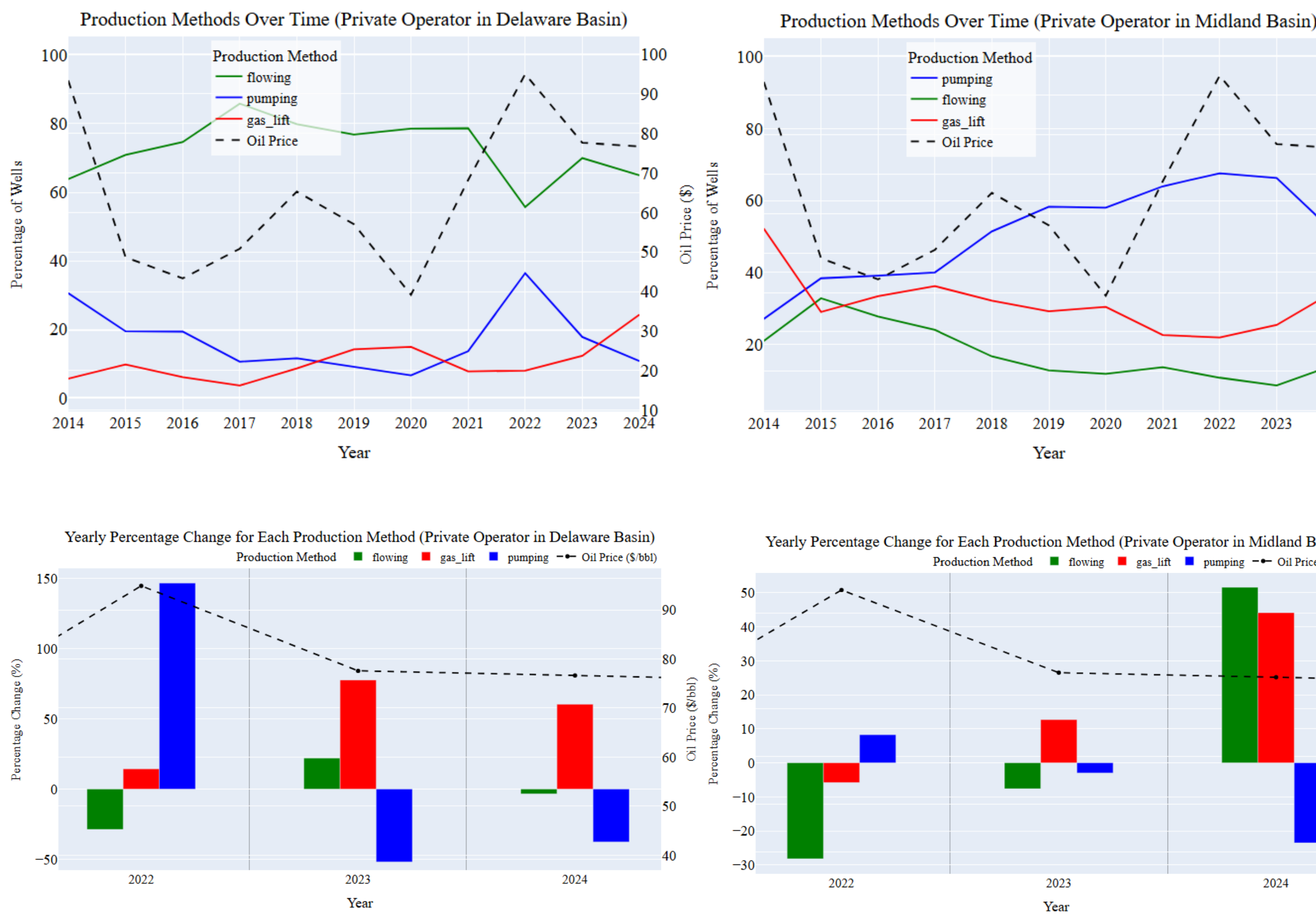

FIGURE 8. PRIVATE OPEARTORS' PRODUCTION METHODS' STRATEGIES IN MIDLAND VS DELAWARE BASINS.

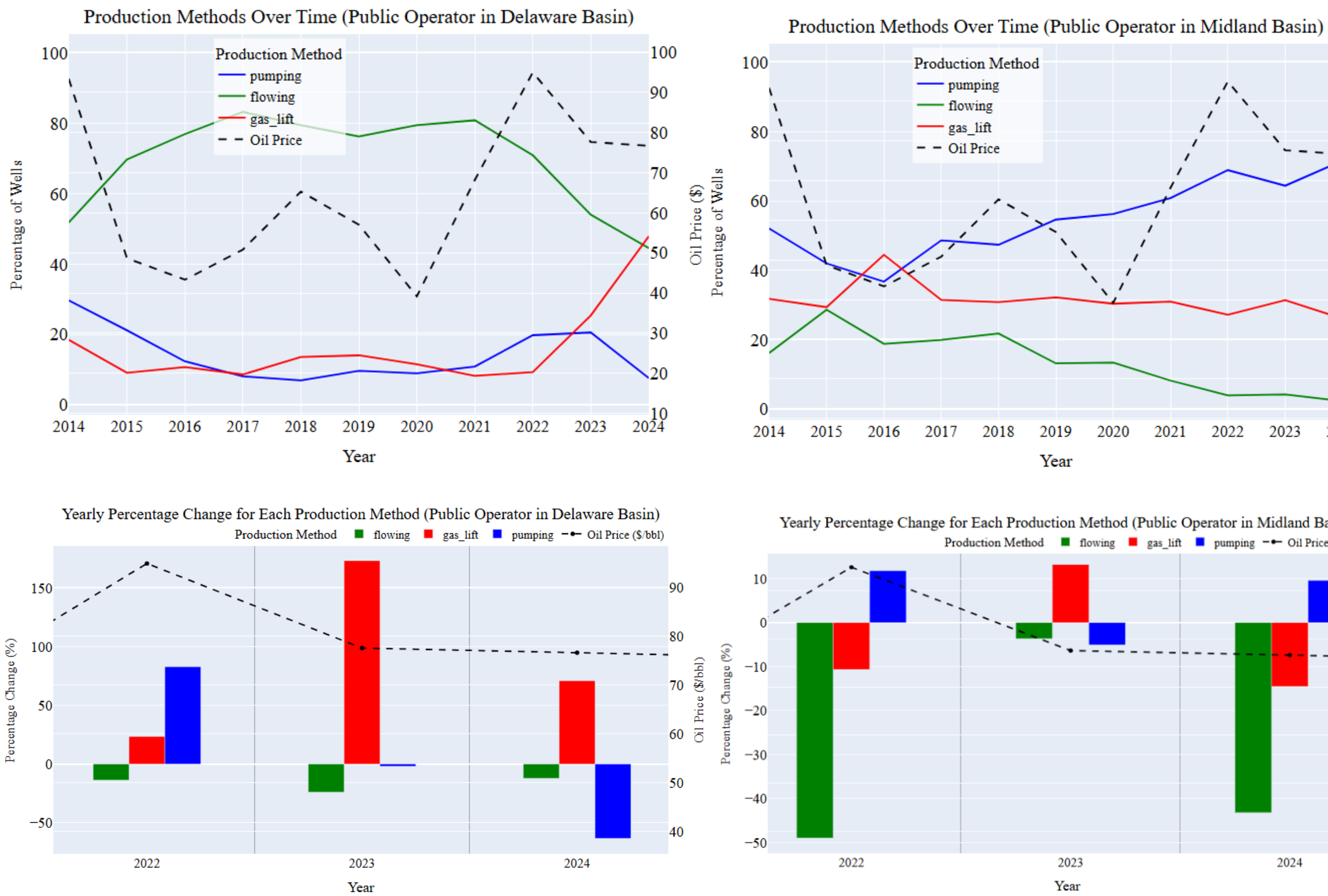

FIGURE 9. PUBLIC OPEARTORS' PRODUCTION METHODS' STRATEGIES IN MIDLAND VS DELAWARE BASINS

GOR ANALYSIS

Gas-oil ratio (GOR) trends offer valuable insights into reservoir fluid behavior and drive mechanisms, with a comparison of first test and cumulative GOR revealing key differences in production dynamics between the Midland and Delaware Basins. While both regions show an increase in GOR over time, the Midland Basin experiences a far more pronounced rise—from a median of ~1,000 scf/bbl initially to ~2,500–3,000 scf/bbl cumulatively, with some wells exceeding 10,000 scf/bbl, Figure 10. This steep increase suggests stronger solution gas drive and potentially more volatile oil, where gas is liberated rapidly as reservoir pressure drops below the bubble point. The sharp GOR growth also implies more aggressive pressure depletion, possibly due to higher production rates and the widespread use of pumping as the initial lift method—known to exacerbate bottomhole pressure decline and accelerate gas evolution.

In contrast, the Delaware Basin begins with a higher first-test GOR (median ~1,800–2,000 scf/bbl), reflecting deeper, overpressured reservoirs and more gas-prone fluids, Figure 10. However, the cumulative GOR increase is relatively modest, suggesting more stable pressure conditions or more effective pressure maintenance. This behavior is consistent with the basin's heavier reliance on natural flow and gas lift, lift methods that typically preserve reservoir pressure for longer durations. The narrower GOR growth trajectory in Delaware may also indicate less volatile oil or more controlled drawdown strategies enabled by gas lift infrastructure.

Taken together, these observations highlight a two-way relationship between fluid behavior and production method selection. While GOR evolution can influence the choice of artificial lift, the chosen lift strategy can, in turn, accelerate or moderate changes in GOR over time. Understanding this interaction is critical—not only for optimizing current performance but also for anticipating when a shift in lift strategy may be necessary as reservoir conditions evolve.

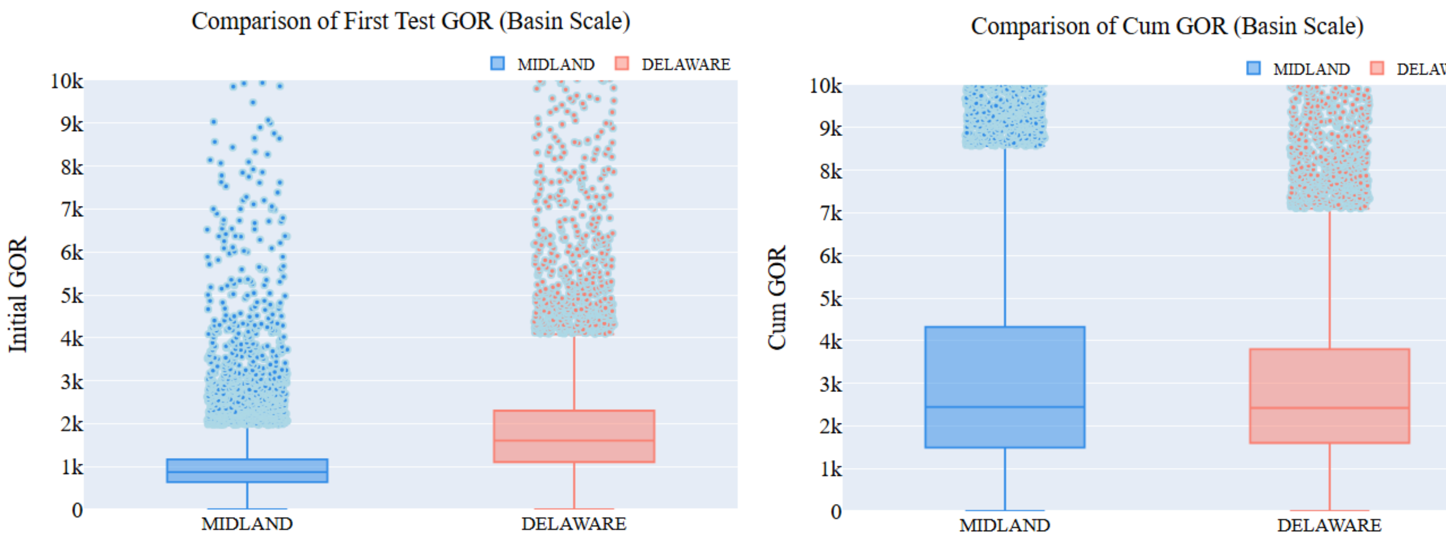

FIGURE 10. GAS-OIL-RATIO FROM INITIAL TEST ADN CUMMULATIVE CALCULATION FOR DIFFERENT BASINS.

EUR Analysis

The distribution of estimated ultimate recovery (EUR), Figure 11, highlights a distinct advantage for the Delaware Basin over the Midland Basin. Delaware wells not only exhibit higher median EUR values (~550,000-600,000 bbl)—less than Midland (~400,000-450,000 bbl)— but also display a broader range of high-performing wells. This outcome aligns with the literature that associates Delaware's elevated reservoir pressure, higher GOR, and greater natural fracturing with enhanced recovery potential (Carr, 2019; Dutton et al., 2005). When segmented by production method, gas lift and natural flow deliver the highest EUR in Delaware, while pumping lags behind. This reflects the strong natural drive in high-GOR systems and gas lift's ability to sustain production as pressure declines. In contrast, gas interference limits pumping efficiency in these conditions Figure 11. In the Midland Basin, gas lift and pumping achieve similar results, while natural flow underperforms—likely due to insufficient reservoir energy in low-GOR environments. Here, artificial lift is essential, and pumping performs well in handling heavier fluids with minimal gas interference. These trends underscore the importance of aligning lift strategies with reservoir conditions to optimize recovery across both basins.

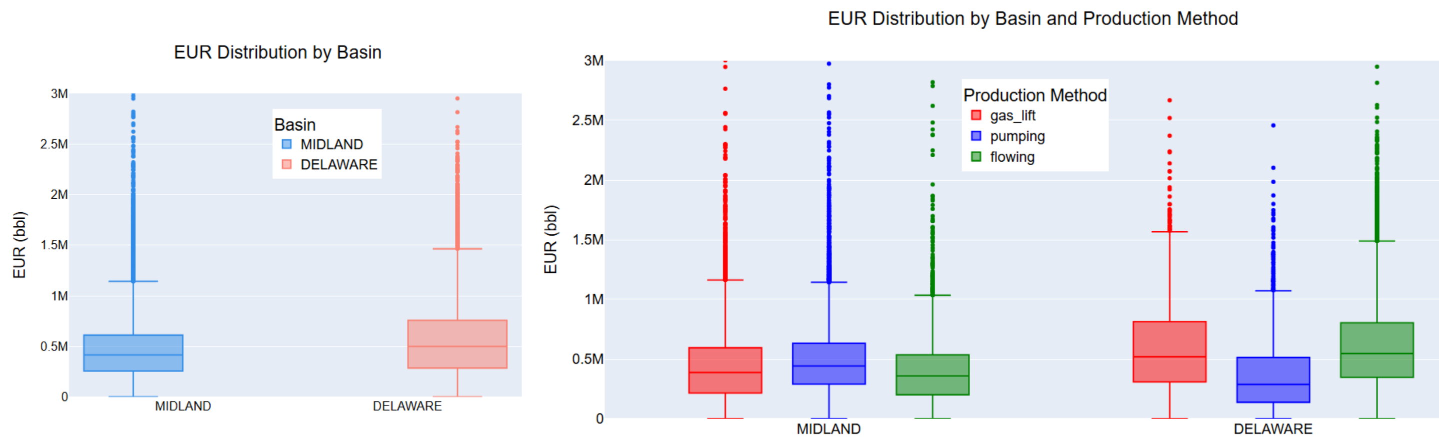

FIGURE 11. ESTIMATED ULTIMATE RECOVERY PER BASIN AND PRODUCTION METHOD.

EUR performance varies significantly depending on both the GOR range and the initial artificial lift method applied. In low-GOR reservoirs (<500 scf/bbl), pumping consistently outperforms gas lift, displaying higher median EUR values and a tighter distribution, indicating more predictable performance. In contrast, gas lift exhibits both lower and more variable EUR in this range.

In moderate-GOR environments (500–2,000 scf/bbl), the performance of gas lift and pumping is more balanced. Both methods achieve comparable median EURs and show similar variance, although pumping retains a slight edge in terms of tighter EUR distribution. These results suggest that in this intermediate GOR range, either lift method can be effective, with outcomes increasingly influenced by well-specific parameters such as completion design, reservoir heterogeneity, and operational optimization.

In high-GOR reservoirs (>2,000 scf/bbl), the performance gap becomes more pronounced in favor of gas lift. Wells using gas lift demonstrate not only a higher median EUR but also a longer upper tail, indicating a greater number of high-producing wells. Conversely, pumping systems show reduced efficiency and lower overall EUR in this range. This trend can be attributed to gas interference in pump operations—manifesting as gas locking or diminished volumetric efficiency—which impairs liquid handling capability under high gas content. Gas lift, by contrast, thrives under these conditions, leveraging the available gas to maintain effective lift performance. These findings are consistent with prior research by (Wilson, 2017) who emphasized gas lift's operational advantage in high-GOR, low-pressure environments where traditional pumping methods struggle to maintain flow stability. These results, Figure

12, confirm that GOR-specific artificial lift selection is critical to maximizing recovery and should be integrated into early well planning and production strategy.

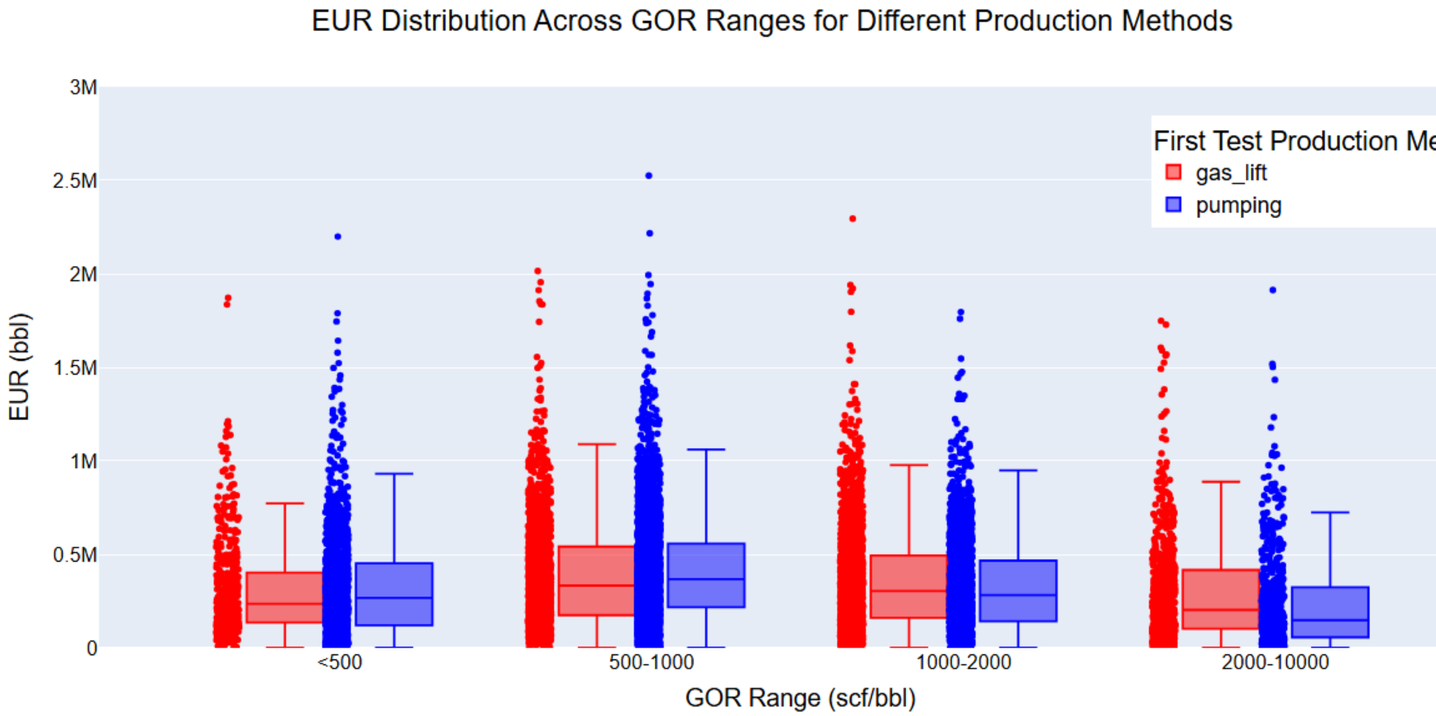

FIGURE 12. ESTIMATED OIL RECOVERY ACROSS DIFFERENT GOR RANGES.

An evaluation of Estimated Ultimate Recovery (EUR) for oil from 2022 to 2024, segmented by initial production method, reveals evolving performance trends for gas lift, pumping, and natural flow. Among the three, flowing wells consistently achieved the highest median EUR, ranging from approximately 600,000 to 650,000 barrels across all three years. These wells also exhibited a broad distribution, with frequent high-producing outliers reaching up to 1.6 million barrels. Pumping, on the other hand, maintained the tightest distribution, with EUR medians consistently between 500,000 and 550,000 barrels. While this suggests reliable and predictable performance, it also reflects the method's limitations in delivering high-end production, particularly in gas-prone or deeper formations. Notably, gas lift has shown steady improvement across the three-year period, with median EUR rising modestly from around 550,000 barrels in 2022 to slightly higher values in 2024. Despite its wide distribution—indicating some variability in performance—gas lift consistently includes a large number of high-EUR outliers, many surpassing 1.5 million barrels. This trend points to a broader industry learning curve, where operators are becoming more proficient in designing and optimizing gas lift systems, especially in response to rising gas-oil ratios (GOR) and increasing reservoir depletion. The method's improved outcomes over time also reflect expanded gas infrastructure, better well selection, and enhanced operational control—factors that have contributed to gas lift's growing role in unconventional production strategies.

Overall, the performance of gas lift between 2022 and 2024 illustrates not only its technical adaptability but also its increasing alignment with reservoir realities in maturing shale plays. As operators continue to face more complex fluid systems and higher GOR environments, gas lift appears to be emerging as the most scalable and responsive artificial lift option, bridging the gap between early flow potential and long-term production sustainability.

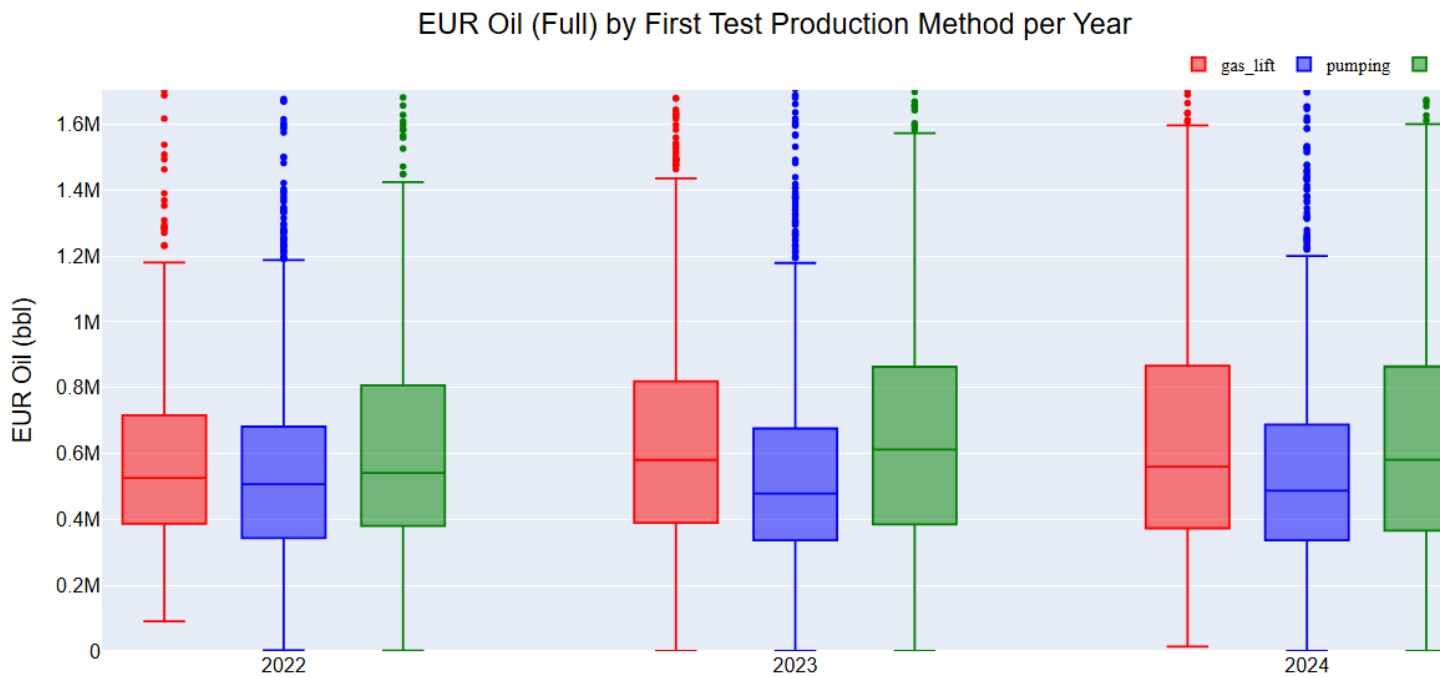

FIGURE 13. EUR OIL FOR DIFFERENT FIRST PRODUCTION METHODS OVER YEARS.

CONCLUSION:

This study analyzed first production method trends across the Midland and Delaware Basins, highlighting the interplay between reservoir characteristics, operator strategies, and artificial lift selection. The results show that artificial lift decisions are not uniform across the Permian Basin but are instead shaped by geological differences, particularly reservoir depth, gas-oil ratio (GOR), and pressure regimes.

In the Midland Basin, operators predominantly favor pumping systems due to lower GOR and shallower depths. This infrastructure-heavy approach yields predictable EURs but may limit upside potential in more volatile reservoir conditions. In contrast, the Delaware Basin exhibits a more dynamic evolution of lift strategies. Historically reliant on natural flow, Delaware operators have increasingly transitioned to gas lift in response to declining reservoir pressure and maturing infrastructure. This method has proven particularly effective in high-GOR environments, consistently delivering superior EURs compared to pumping.

Operator type further influences lift strategy. Public companies, with greater access to capital and long-term development plans, tend to adopt more structured lift strategies, including earlier gas lift implementation. Private operators, on the other hand, often favor natural flow and delay lift transitions to optimize capital efficiency, though they have shown increasing gas lift adoption in recent years.

The analysis of GOR and EUR reinforces the importance of aligning artificial lift selection with reservoir fluid properties. Gas lift emerges as a scalable and resilient solution in high-GOR and pressure-depleted systems, while pumping performs best in lower-GOR scenarios. Furthermore, the upward trend in gas lift performance over time reflects industry learning curves, improved infrastructure, and better optimization practices.

Overall, production optimization in unconventional plays demands a basin-specific, data-driven approach. Operators must move beyond standardized lift strategies and tailor artificial lift deployment to evolving reservoir conditions. This shift is essential to unlocking long-term recovery potential and ensuring economic viability in increasingly complex shale environments.

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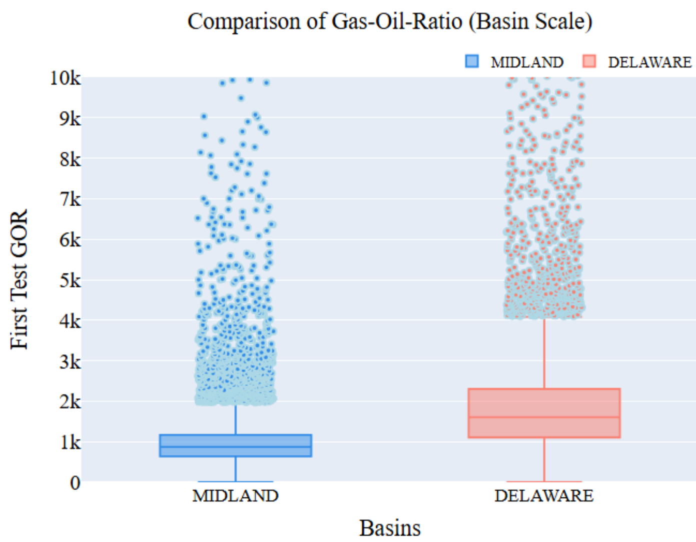
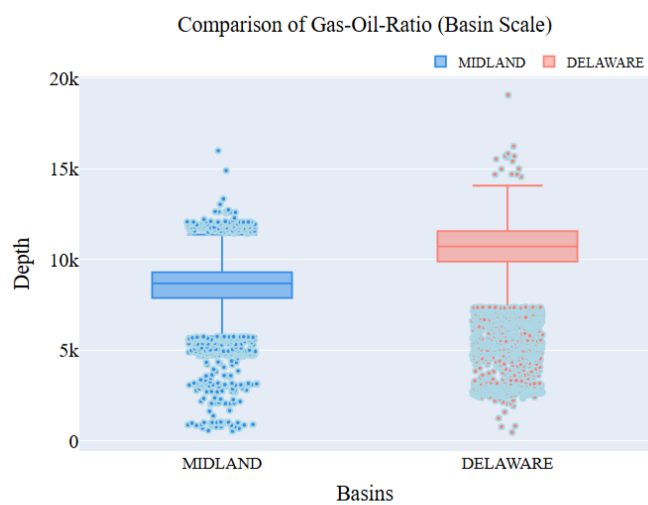
Appendix

Changes on Basin Scale…

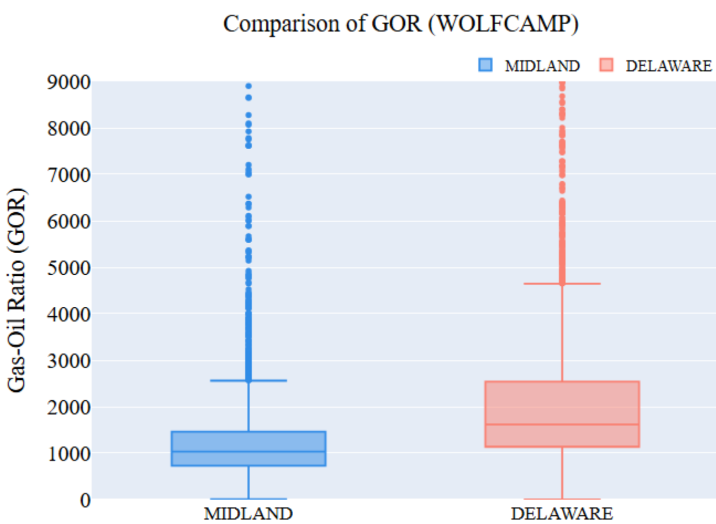
With Delaware basin being more deeper with higher GOR compared to midland basin suggests analysis and comparison of trends of both basins. With this analysis we should be able to tell how first production methods changes with depth and GOR. **Now I should mention the following steps and their main goals…**

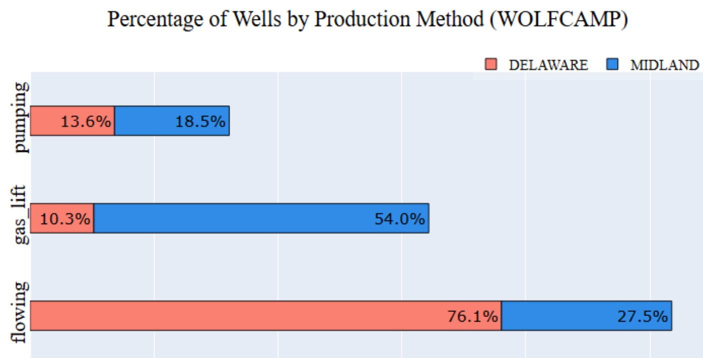


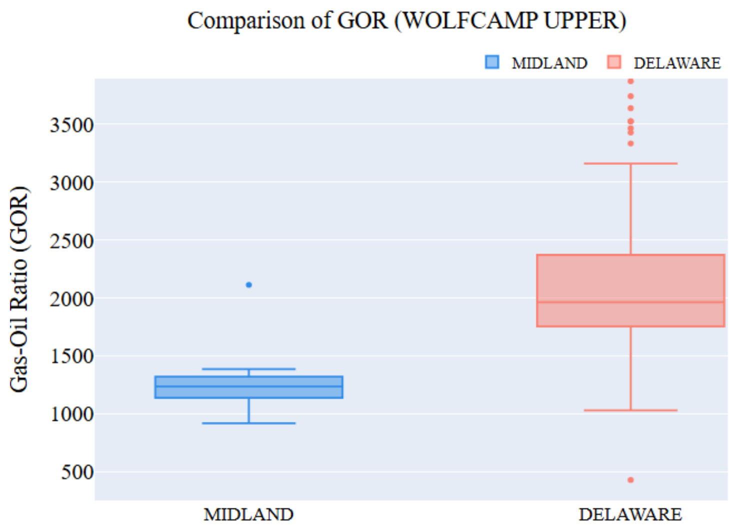


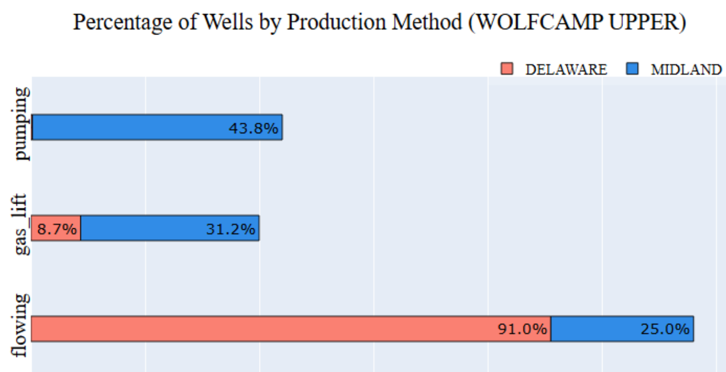
Formation Level comparison

Wolfcamp Formation

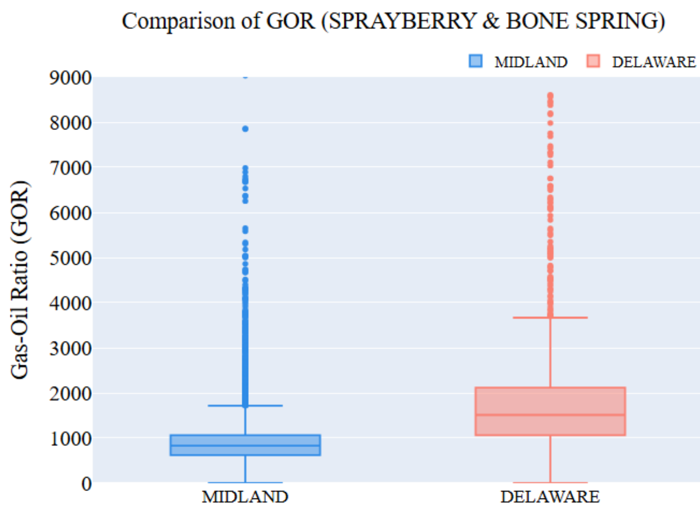

Comparison of GOR (WOLFCAMP)
MIDLAND
DELAWARE
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Gas-Oil Ratio (GOR)
MIDLAND
DELAWARE

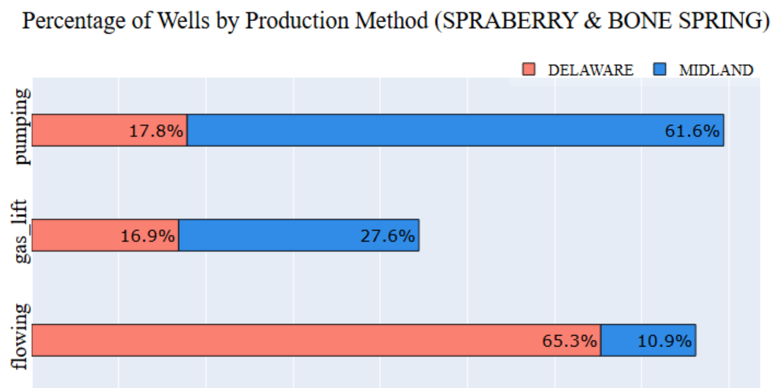

Percentage of Wells by Production Method (WOLFCAMP)
DELAWARE
MIDLAND
pumping
13.6%
18.5%
gas_lift
10.3%
54.0%
flowing
76.1%
27.5%



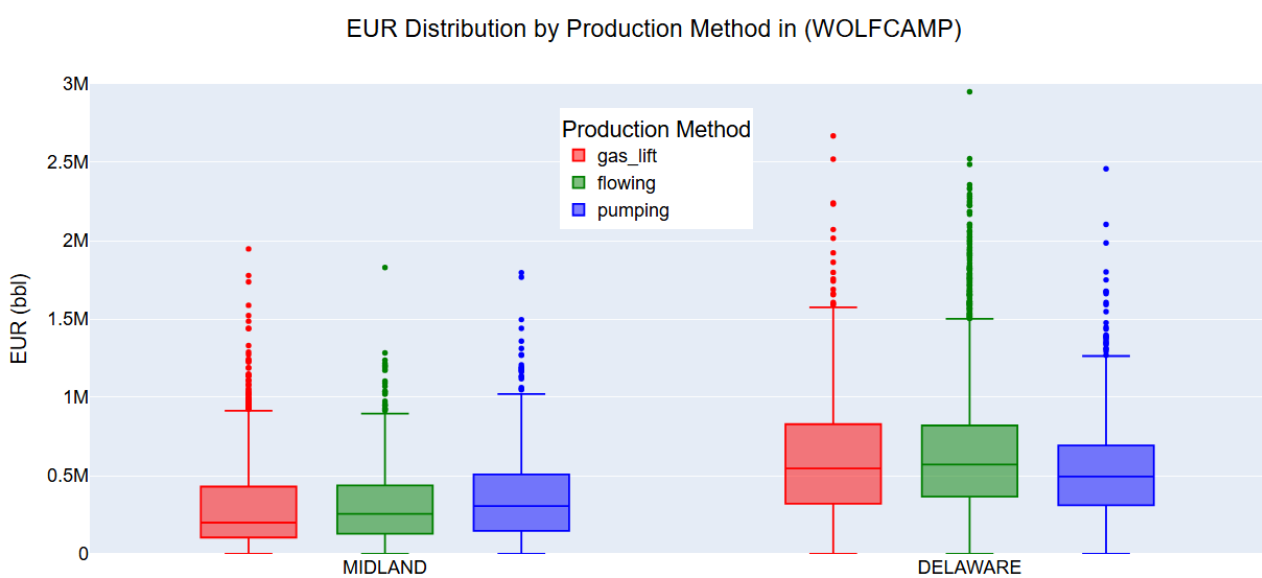


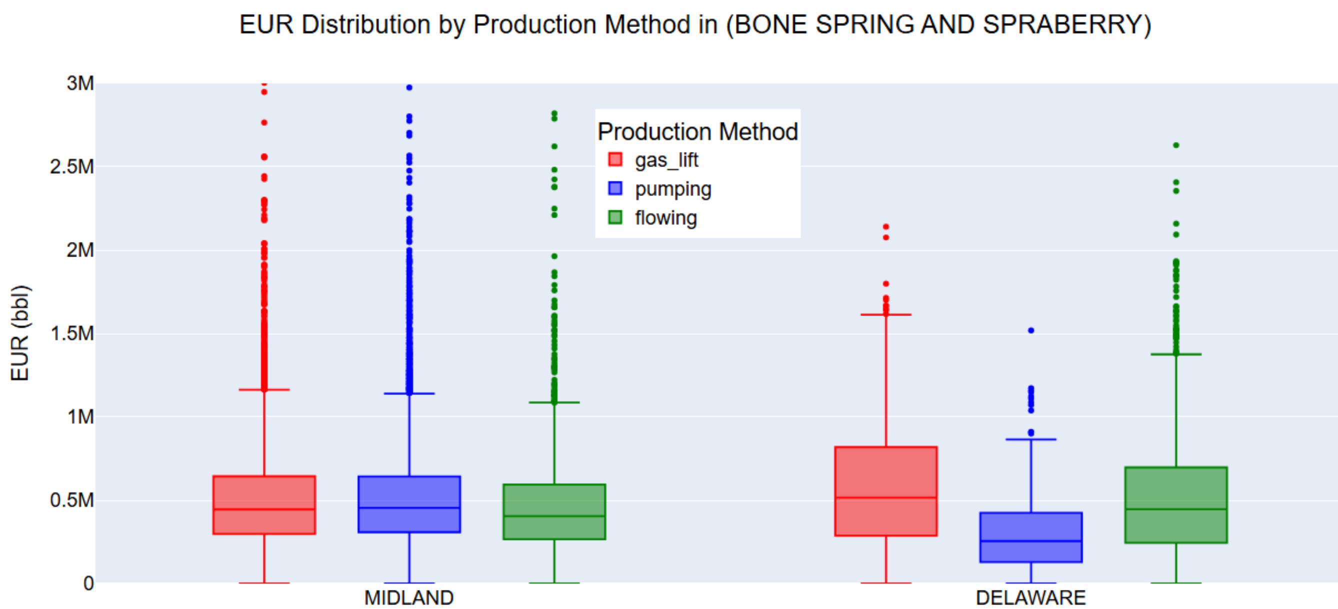
Sprayberry & Bone Spring Formations…





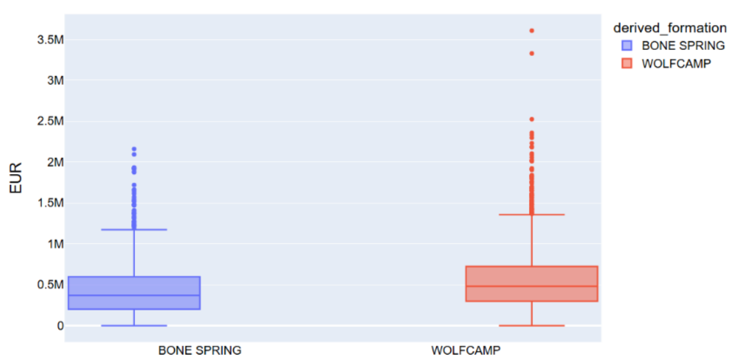
ESTIMATED ULTIMATE RECOVERY ON FORMATION LEVEL…



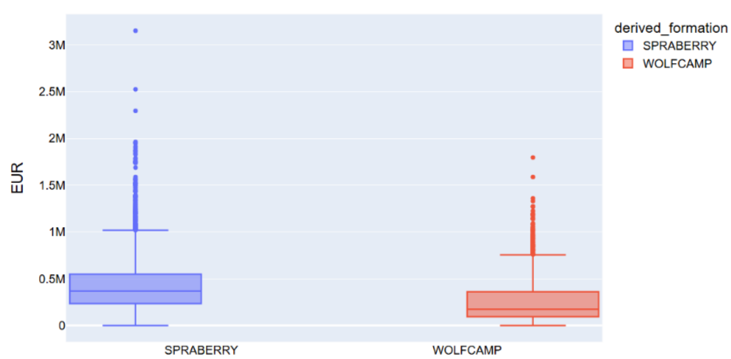


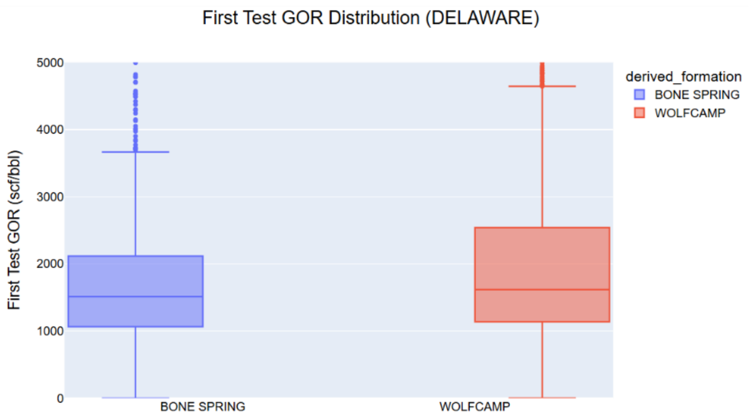
EUR AND GOR FOR DIFFERENT FORMATIONS:

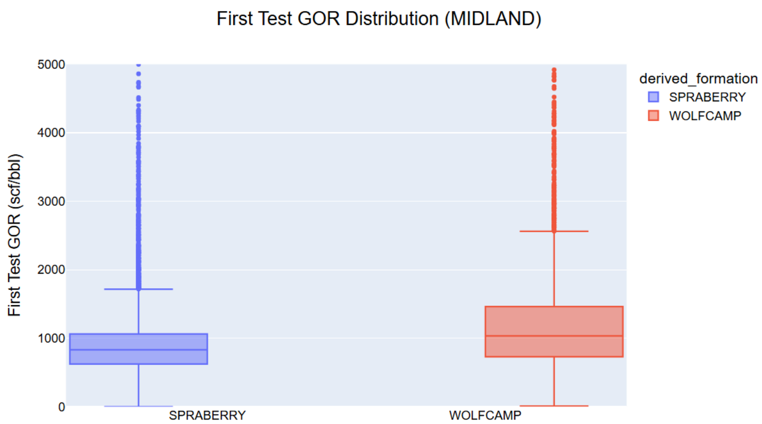
EUR (DELAWARE BASIN)



EUR (MIDLAND BASIN)




First Test GOR Distribution (DELAWARE)
First Test GOR (scf/bbl)
0
1000
2000
3000
4000
5000
BONE SPRING
WOLFCAMP
derived_formation
BONE SPRING
WOLFCAMP


First Test GOR Distribution (MIDLAND)
First Test GOR (scf/bbl)
0
1000
2000
3000
4000
5000
SPRABERRY
WOLFCAMP
derived_formation
SPRABERRY
WOLFCAMP