ENERGY

How AI Is Chipping Away at Shale's Operating Costs

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Drill more, grow more. That was the basic premise that fueled the US shale revolution. But with Tier 1 inventory depleting, commodity prices becoming more volatile, and most basins in the Lower 48 approaching peak output, that premise no longer holds.

For independent operators, the question is how to effectively operate a maturing asset base. Growth-era strategies—prioritizing production volume, funding activity from the balance sheet, and deferring cost discipline—are no longer enough to win. Investors are increasingly rewarding

operators who demonstrate a visible path to low-cost, sustained production, not simply barrel volumes.

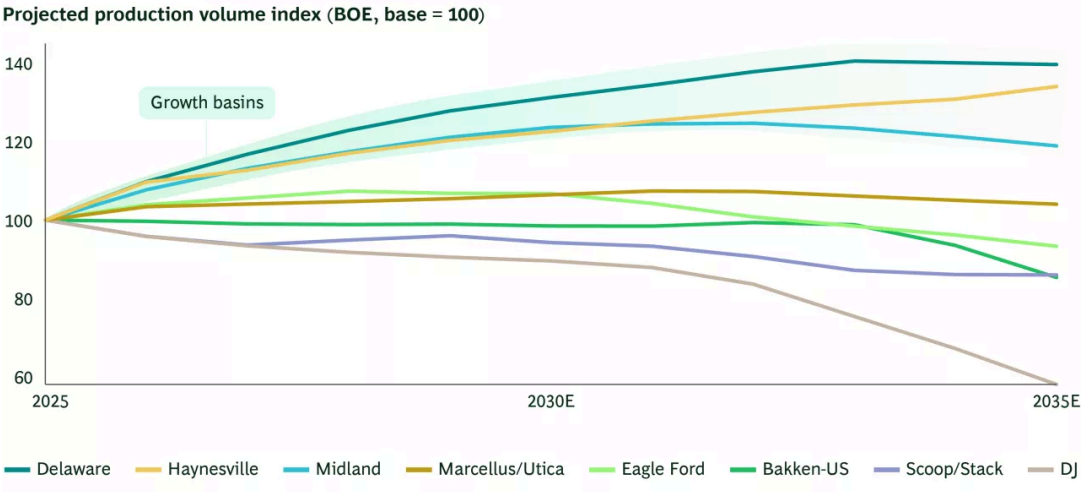
One highly effective path is through moderating operating costs, principally lease operating expenses (LOE) and general and administrative expenses (G&A). Both are controllable, and AI can help significantly with each. In this article, we focus on LOE, highlighting five of the many ways AI can help streamline LOE costs continuously to help operators prevail amid mounting challenges.

Shale's Growth Phase Is Over

Several basins in the Lower 48 are projected to reach peak production by 2030, with nearly all basins in decline within the following five years. This is not an outlier scenario; it is the mainstream view among major data providers. Growth is thus increasingly concentrated in a handful of basins. Only the Permian basin (which includes the Midland and Delaware sub-basins) and the predominantly gas-producing Haynesville sub-basin are expected to keep growing into the mid-2030s. Of the oil-producing areas, Midland is projected to reach maturity around 2032 and the Delaware around 2033. Eagle Ford will start to decline around 2028. The Bakken has already peaked, and the DJ and Scoop/Stack basins peaked years ago. (See Exhibit 1.)

EXHIBIT 1

Most Basins Will Likely Peak By 2030; Virtually All Will Be in Decline Before 2035



Sources: WoodMackenzie; BCG analysis.
Note: BOE = barrel of oil equivalent.

Importantly, for nine of the 14 largest US independent operators, more than 40% of production is in basins that are either approaching or are already past peak. And these operators face compounding challenges: declining reserve quality, rising well costs as the average well age increases, and shrinking opportunities for organic growth.

The Permian is now hitting its structural ceiling, having been depleted by years of concentrating capital on the best Tier 1 rock. The proportion of new wells of Tier 1 quality has fallen measurably over the past decade, despite production advances. Estimated ultimate recovery (EUR) per lateral foot has also weakened in the Delaware and Midland, even as laterals have lengthened.

Despite the desire to continue Tier 1 drilling to generate cash flow, inventory is clearly depleting, driving the push for cost efficiencies. So while the traditional drivers of total shareholder return (TSR)—production growth, EV/EBITDA multiple, EBITDA margin, and dividends or buybacks—still apply, their relative importance is shifting.

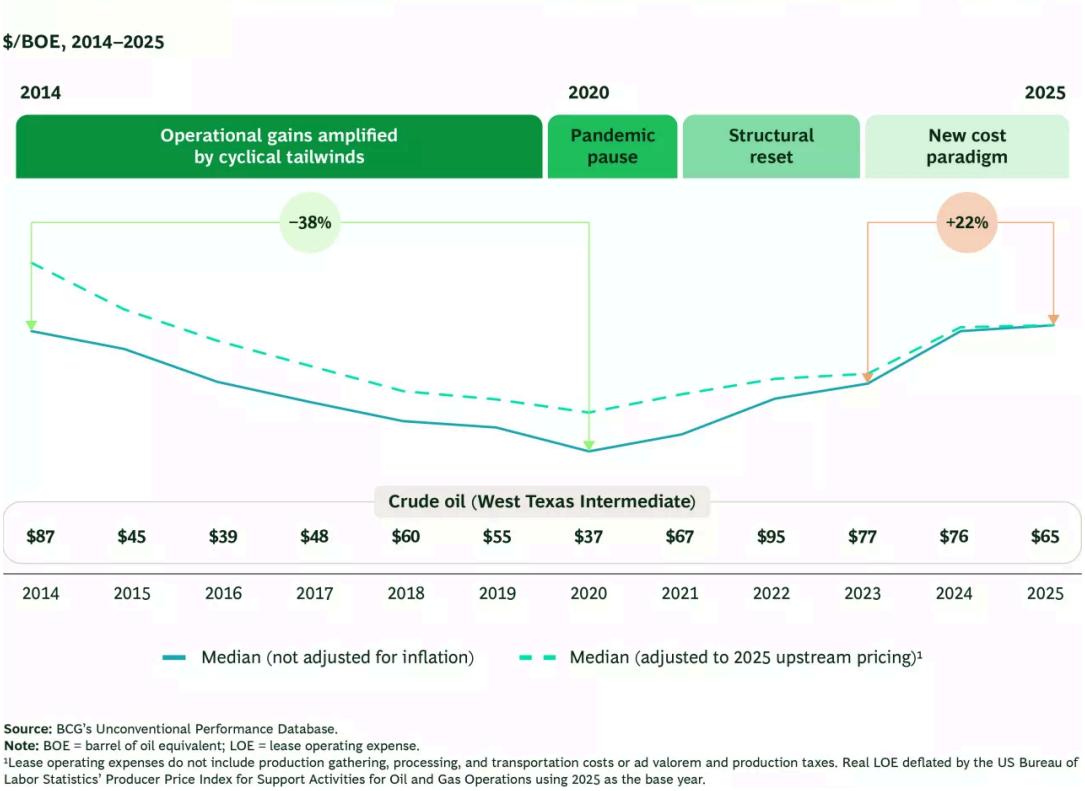
As organic growth has become increasingly difficult without high-quality inventory, the TSR leaders of the last three years have grown largely through targeted M&A. But this strategy has its limits. With volume growth constrained, margin and cost leadership have become the primary differentiators.

Operating Costs Are Now a Strategic Variable

For much of the shale growth era, development costs related to drilling and completions got more attention than LOE. These costs, not LOE, were the priority. But after a decade of decline, Permian LOE has been returning to its 2014 highs. (See Exhibit 2.)

EXHIBIT 2

After a Decade of Decline, Permian LOE Is Rebounding to 2014 Highs



Source: BCG's Unconventional Performance Database.
Note: BOE = barrel of oil equivalent; LOE = lease operating expense.
¹Lease operating expenses do not include production gathering, processing, and transportation costs or ad valorem and production taxes. Real LOE deflated by the US Bureau of Labor Statistics' Producer Price Index for Support Activities for Oil and Gas Operations using 2025 as the base year.

Since 2022, double-digit increases in lifting costs for US independents have eroded margins, especially as commodity prices have softened. Median cash balances among major US independents fell roughly 47% in less than three years. Meanwhile, median leverage ratios rose from 20% to 33% in just under four years. This apparent reliance on the balance sheet for capital returns rather than on free cash flow is now unsustainable.

Some operators have already taken steps to counter these performance trends by targeting LOE costs, with encouraging results. Operators that have reduced lifting costs by $1 to $2 per barrel of oil equivalent (BOE) have generated greater EBITDA margins than peers with rising cost structures.

How Permian LOE Stacks Up

A closer look at LOE composition in the Permian's two basins reveals where the greatest opportunities for improvement lie (see Exhibit 3). (Our benchmarking data covers operators representing 55% to 70% of production in each basin.)

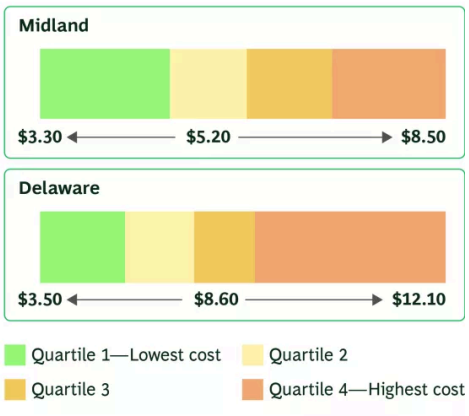
EXHIBIT 3

Operator Execution, Not Basin, Determines LOE Performance

Year-over-year percentage change in LOE cost, by category, 2024–2025

LOE category	Midland	Delaware
Surface maintenance	–3%	–2%
Water disposal and hauling	+5%	–6%
Subsurface maintenance	–3%	–5%
Power and fuel	**+34%**	**+16%**
Field labor	+9%	–4%
Chemicals	–4%	+2%
Other	–7%	–1%

LOE quartile spread by basin, 2025 ($/BOE)



Source: BCG analysis.
Note: BOE = barrel of oil equivalent; LOE = lease operating expense.

Across both the Midland and Delaware basins, LOE is concentrated in a consistent set of cost categories. Maintenance and water disposal and hauling represent the largest share of spend. The massive portion of total LOE represented by maintenance costs reflects the intensity of effort required to sustain production. Water disposal and hauling remain another major cost driver as water costs increase with asset maturity.

The distribution of LOE across operators highlights significant and persistent performance gaps within each basin. In 2025, the spread between top- and bottom-quartile operators in the Midland exceeded $5.20 per BOE, while in the Delaware, it exceeded $8.60. This disparity underscores the extent to which cost outcomes vary across the peer group. This variation is not the result of geology or asset vintage; rather, it reflects differences in operational execution.

Importantly, these differences reflect how well operators balance a common set of forces. Rising volumes, longer laterals, automation, and better lift reliability push costs down, while infrastructure gaps and the vulnerability to power-grid reliability push them up.

Structural Pressures Will Persist

Even for high-performing operators, LOE will become increasingly difficult to control, primarily for the following reasons.

Power Cost Inflation. Power costs saw the highest year-over-year increase across both basins, rising 34% in the Midland and 16% in the Delaware, and emerged as the primary driver of LOE cost increases. Grid infrastructure has not kept pace with production growth or with competing demand from data centers and industrial users. The electrification of field operations adds further load. ERCOT congestion and expiring fixed-price contracts are pushing costs higher, while grid-

connection lead times of up to four years are forcing operators onto generators and microgrids—a constraint that is unlikely to ease quickly. The lower-cost operators are those who locked in favorable long-term power agreements during earlier, lower-price periods.

Growing Water Management Complexity. Permian disposal volumes now top 20 million barrels per day, and disposal infrastructure is not keeping up. As development pushes into secondary intervals and fringe acreage, more water and chemicals are required; and accordingly, produced water volumes and chemical complexity climb. Water costs in the Midland alone rose 9% year-over-year. Capacity is tightening at the same time: seismicity concerns are constraining saltwater disposal permits across both basins, and new Texas disposal rules since 2023 add further pressure. Heightened provider specifications, such as pretreatment for H_2S and solids, add costs that were insignificant five years ago. Together, these dynamics intensify handling and treatment, especially where infrastructure is limited.

Labor Intensity in Legacy Assets. Remote monitoring and autonomous surveillance can materially reduce field labor costs, as Delaware operators have shown. But the Midland's wells are far older—roughly 14 years on average versus about eight years in the Delaware—and its more fragmented surface infrastructure, including many legacy vertical wells, is much less amenable to centralized control rooms and exception-based operating models. Aging wells also require more frequent maintenance and workovers per barrel—and as production declines outpace cost reductions, maintenance cost per barrel continues to rise.

Although the figures cited here are for the Permian basin, operators outside the Permian face the same trajectory on LOE, even where the specifics look different.

Where AI Can Deliver Impact

AI is potentially useful across the entire exploration and production cost structure, including in capital allocation, G&A efficiency, production optimization, and operating costs. In operations, its applications can be grouped into three broad categories that BCG devised for its AI framework:

- **Deploy applications** include tools that automate report generation or invoice reconciliation as well as AI-powered assistants that help engineers troubleshoot equipment in real time.
- **Reshape applications** involve redesigning end-to-end workflows and processes such as implementing the autonomous scheduling of maintenance or inspections.
- **Invent applications** entail innovating new models and products; for example, personalized AI agents that help clients optimize consumption or tools that support real-time price adjustment.

Deploy use cases are typically the fastest to implement but deliver only marginal gains, generally productivity improvements of between 10% and 15%. The companies that gain the most value from AI concentrate roughly 80% of their AI investment in reshape and invent use cases, according to BCG's AI work across industries. For upstream operators, invent use cases are still early stage. Reshape use cases, however, can already produce meaningful structural cost reduction—a benefit that could not be timelier.

Here, we focus on LOE for several reasons. As the Permian's asset base matures, water costs climb, interventions are needed more frequently, and lifting costs creep upward. LOE is thus the cost line most affected by age and the one where improvement compounds. Secondly, LOE offers the foundation AI needs to truly perform: large volumes of repetitive, standardized data generated every day across thousands of wells and tied directly and measurably to cost outcomes at a scale and frequency that human review cannot possibly match. Finally, within LOE, not all categories are equally controllable. Power and fuel costs are driven chiefly by structural constraints such as grid access, capacity, and pricing—costs AI can mitigate but not eliminate. Maintenance, labor, and water handling are more directly improvable and also where the data is richest.

> "LOE offers the foundation AI needs to truly perform.

How AI Can Reshape the LOE Cost Structure

The select use cases described below—all of them real examples—illustrate how dramatically AI can reconfigure LOE costs near term, without the company needing to overhaul its operating model.

Enhanced AI-Enabled Predictive Maintenance. Unexpected failures in critical surface equipment can lead to production outages, costly repairs, and emergency maintenance. By combining high-frequency sensor data (such as temperature, pressure, and flow rates) with maintenance records, equipment history, and inventory information, machine learning models detect patterns that predict potential equipment failure up to weeks in advance. Moreover, the system prioritizes assets by criticality and recommends targeted interventions. This not only reduces downtime, but it also extends equipment life, optimizes parts inventory, and lowers maintenance costs.

Artificial Lift Performance Optimized via Real-Time Well Data. Artificial lift systems, essential for sustaining shale well production, require continuous optimization as reservoir conditions evolve. Yet periodic engineering reviews and threshold-based alarms limit operators' ability to respond in real time. AI-enabled optimization analyzes high-frequency operational data (such as motor current, vibration, and pump performance), along with maintenance history and equipment information, to identify efficiency and equipment issues. Optimization models then recommend adjustments that maximize output while minimizing equipment wear and energy consumption. The result is fewer sudden failures, longer equipment life, greater well uptime, and improved hydrocarbon recovery across mature shale assets.

Produced-Water Handling Optimized Through AI-based Modeling. The cost of handling produced water is a growing component of lease operating expenses that has escalated as shale assets mature. Using historical data on production, well performance, infrastructure capacity, and water generation, machine learning models forecast produced water volumes at the individual well level. These forecasts feed optimization engines that determine the most cost-effective routing strategy across saltwater disposal wells, recycling facilities, and transportation networks, while accounting for capacity, distance, and operational constraints. This application reduces mileage, hauling, and disposal costs as well as minimizes idle capacity and limits infrastructure bottlenecks. It also enhances recycling, dispatch, and water logistics throughout the field.

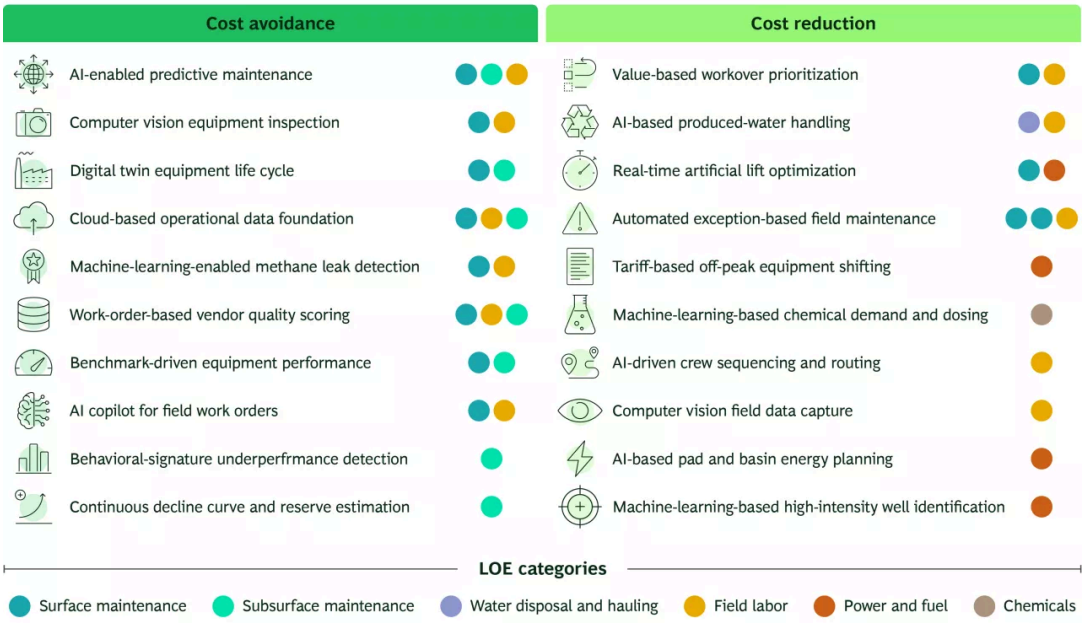
Automated Exception-Based Field Maintenance. Routine field inspections and maintenance comprise a significant share of LOE. With real-time supervisory control and data acquisition (SCADA) and sensor data, AI continuously learns each well's normal operating behavior, so meaningful anomalies can be detected before problems arise. Alerts are prioritized according to severity, production impact, and location, and work schedules and technicians' routes are then optimized and generated automatically. Technician copilots recommend diagnostic steps and corrective actions. The move to exception-based field maintenance not only reduces unnecessary site visits and the associated costs, but also improves technician productivity. Smaller field teams are now able to manage substantially larger well portfolios.

Off-Peak Equipment Shifting Through Real-time Data-Based Forecasting. Power and fuel costs are a significant part of LOE. AI models analyze real-time equipment loads, production demand, electricity tariffs, fuel prices, and operational constraints to forecast energy demand and identify the lowest-cost operating strategy. Operators can shift flexible loads to lower-cost periods. They can also balance on-site generation against grid power and coordinate the operation of multiple energy-intensive assets without compromising production requirements. By continuously optimizing energy consumption, AI solutions improve electricity and fuel efficiency, thereby lowering overall LOE.

Exhibit 4 shows a sample of high-value opportunities that can relieve pressure across the six main LOE cost categories, either by avoiding or reducing costs.

EXHIBIT 4

Sample AI-Enabled Optimization Opportunities Across the LOE Cost Stack



Source: BCG analysis.
Note: LOE = lease operating expense.

Getting Started

Adopting AI for LOE management calls for strategic focus, workflow redesign, and enablement rigor. That may well explain why only 31% of oil and gas companies today qualify as AI leaders—those future-focused companies using AI to support enterprise objectives and value. These leaders are already innovating with AI or have an AI strategy and advanced capabilities and are scaling AI effectively. But 31% is considerably lower than the 40% of companies worldwide spanning 25 sectors that fit the bill. And the gap isn't due to technological access or complexity; it's nearly always due to a flawed approach.

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What are the most common reasons operators stumble? Often, it's that they choose their AI tool before clearly identifying the problem it is supposed to solve. Some companies launch too many

use cases at once. Others bolt the technology onto processes without changing the underlying workflow. Some don't clean their data before inputting it, which creates problems after the fact. For still others it's a change management issue: they don't bring their people along while they're building the AI tools and capabilities, and adoption post-build is much harder.

Operators who successfully apply AI to scale follow a disciplined approach in which change management takes place in parallel with the building and implementation. They recognize the 70/20/10 rule: 70% of the effort involves people, processes, and ways of working, while 20% entails getting the data right, and 10% involves the technology and algorithms.

Consider these key elements that underpinned AI leaders' approach.

Establish your goals before choosing your tool(s). Companies with a dedicated AI program that shows a clear path to financial goals are more than three times as likely to report transformation success as those running single, short-term initiatives. Before deciding on a tool and funding a pilot, define the outcomes you want, such as a specific $/BOE figure, hours per week, or spend targets on LOE costs. If the tool doesn't drive traceable outcome, it shouldn't get funded.

Pick only a few focus areas. Leading operators run roughly half as many concurrent AI solutions as laggards, and generate about twice the ROI per use case. For LOE, that means that workflows where spend and data are already concentrated (like water hauling ticket capture and pumper dispatch) should be prioritized over launching pilots in several workflows simultaneously.

Redesign end-to-end workflows under executive leadership. Capturing AI's full potential requires redesigning end-to-end workflows, including roles, handoffs, decision rights, controls, and performance metrics. For LOE, this means reimagining high-impact workflows such as maintenance planning, field crew dispatch, and water hauling logistics around AI rather than simply automating today's bottlenecks. This level of transformation requires a senior executive with the authority and accountability to drive change across functions. Yet upstream operators lag; only 13% have appointed a chief data or AI officer, compared with up to 37% of companies in such sectors as power and utilities and renewables. Without executive ownership, AI is layered onto legacy processes and rarely produces transformative impact.

Build the data foundation strategically, not on the fly. AI leaders are three times more likely to have standard, reusable data templates in place before scaling their program. Operators should plan for eight to 16 weeks of disciplined digital field capture on priority workflows (for example, job duration, failure mode, crew location) before launching the transformation. Skipping this step is the single most common cause of stalled pilots.

Treat adoption as the main event. More than two-thirds of AI programs fall short because adoption does not happen at scale. In oil and gas, managers at AI-leading companies are three times more likely to actively role-model AI use and drive adoption within their teams, reinforcing that successful AI transformations are ultimately leadership transformations. Beyond setting top-down transformation guardrails, leaders should build AI tools alongside the field crews who will

act on the output. Visible wins—and shared ownership across leaders, end users, IT, and business teams—turn AI adoption into an operating discipline and support sustainable scaling.

The industry may not be in crisis yet, but current conditions are not a temporary phase. The cost gap between top- and bottom-quartile Permian operators already exceeds $5 per BOE, and with every dollar that West Texas Intermediate trades below $70, the performance gap widens.

AI has a significant role to play in reinforcing operators' financial vitality. Lease operating costs are a good place to start. Those companies that prevail over the coming decade will be those that embed AI into their daily operations to structurally lower the costs they still control. The leading operators are already moving. The rest should follow before the next consolidation wave decides the question for them.

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