International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
IJISAE
ISSN:2147-6799 www.ijisae.org Original Research Paper

# From Liability to Strategic Asset: A Data-Driven, Regulatory-Compliant Framework for Inactive Well Portfolio Recovery and Its Implications for U.S. National Energy Security

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**Abstract:** Inactive oil and gas wells represent a largely underutilized category of domestic energy asset. In the United States, tens of thousands of inactive wells sit within mature producing basins, constrained by regulatory deadline pressure and the absence of systematic evaluation methodology. This paper presents a four-part data-driven framework for inactive well portfolio recovery, developed and validated through direct field implementation: a purpose-built ETL data pipeline integrating heterogeneous petroleum data sources; a weighted multi-criteria composite scoring algorithm producing a four-tier well classification; a nine-domain regulatory compliance automation system aligned with Texas Railroad Commission requirements; and a national scaling analysis with actionable policy recommendations. The framework was applied to a portfolio of over two hundred inactive wells across multiple Texas producing fields, demonstrating substantial improvements in evaluation efficiency, capital allocation precision, regulatory compliance performance, and economic recovery relative to conventional well-by-well approaches. The quantified outcomes of this field deployment establish that systematic data engineering and algorithmic prioritization can convert inactive well inventories from regulatory liability into recoverable domestic energy supply at scale. Applied nationally, the methodology offers a domestic energy security pathway characterized by rapid deployment timelines, capital efficiency superior to new exploration, and environmental co-benefits aligned with modern ESG frameworks.

***Keywords***: *inactive well portfolio management; multi-criteria decision framework; petroleum data engineering; regulatory compliance automation; domestic energy security; decline curve analytics; ETL pipeline*

## 1. Introduction

### 1.1 The Geopolitical Energy Security Context

The geopolitical disruptions of the early 2020s demonstrated a fundamental vulnerability in domestic energy supply chains: the speed with which international supply disruptions transmit into domestic fuel prices. Conflicts thousands of miles away affect domestic energy prices within seventy-two hours through the mechanism of globally integrated oil futures markets, where geopolitical risk is priced within hours of an incident [17]. The 2022 Russia-Ukraine conflict triggered a surge in U.S. LNG exports that drew down domestic supply buffers within weeks; the 2024 Red Sea shipping disruptions added weeks to tanker delivery timelines and immediate cost to domestic consumers [17][18]. Each episode reinforced the same strategic finding: domestic production resilience — the capacity to mobilize additional supply from known reserves within weeks rather than years — is a national security asset of the first order.

Against this context, mature conventional basins and their inactive well inventories emerge as a strategically significant and largely overlooked domestic supply resource. Unlike frontier exploration, which requires five to ten years from discovery to first production, inactive well reactivation operates on existing infrastructure, within known geology, using established regulatory pathways. The limiting constraint is not geological potential but methodological: the petroleum industry currently lacks a systematic, scalable, data-driven framework for evaluating inactive well portfolios at scale and under regulatory deadline pressure. This paper presents and validates such a framework.

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### 1.2 The Scale of the Inactive Well Problem

The inactive well inventory in Texas alone is substantial in both scale and regulatory complexity. The Texas Railroad Commission's Inactive Well Aging Report records over eighty-seven thousand wells on its inactive aging report, with nearly half a million total unplugged wells statewide [19]. The financial liability associated with this inventory — at statutory plugging cost estimates per well — reaches into the hundreds of millions of dollars. The 2024 passage of Senate Bill 1150 introduced hard statutory deadlines: wells inactive for fifteen years, or twenty-five years from completion, must be plugged or returned to production, with enforcement authority beginning in September 2027 [20]. For operators holding large inactive portfolios, this legislation converts a chronic compliance management challenge into an acute capital allocation decision requiring systematic methodology.

Nationally, the Environmental Protection Agency estimates over three million unplugged abandoned wells across all U.S. states, with aggregate productive potential that remains unquantified at the portfolio level precisely because systematic evaluation frameworks have not previously existed in the published literature. The gap between the documented scale of this inventory and the absence of published methodology for its systematic evaluation represents both the problem this paper addresses and the scholarly contribution it makes.

### 1.3 The Data Engineering and Methodological Gap

Published research on inactive well reactivation has predominantly addressed individual-well or small-portfolio contexts [1][2][3], without confronting the data engineering challenges inherent in evaluating portfolios of two hundred or more wells under simultaneous regulatory deadline pressure. Upstream petroleum data is characteristically heterogeneous: production histories reside in legacy regulatory databases, well logs in LAS and DLIS formats, economic models in proprietary platforms such as Aries and PHDWin, and regulatory records in format-specific state databases requiring manual extraction [14][15]. The absence of an integrated data pipeline forces analysts into ad-hoc, well-by-well assembly that is neither scalable nor reproducible at portfolio scale. Equally absent from the literature is a validated multi-criteria algorithmic scoring framework that integrates geological, wellbore, economic, and regulatory dimensions into a single ranked output suitable for portfolio-level capital allocation [5][6][7]. This paper addresses both gaps simultaneously through a framework that is a data engineering contribution and a petroleum engineering decision methodology in equal measure.

### 1.4 Contributions

This paper makes four explicit and validated contributions to the literature. First, the design and field validation of a purpose-built ETL data pipeline that integrates heterogeneous petroleum data sources — production databases, wireline logs, regulatory records, and economic models — into a unified analytical environment, demonstrating substantial reduction in per-well evaluation time. Second, a mathematically defined multi-criteria composite scoring algorithm, $T = 0.30G + 0.25W + 0.30E + 0.15R$, with four-tier well classification, validated against a portfolio of over two hundred wells. Third, a nine-domain regulatory compliance automation methodology aligned with Texas RRC requirements under HB 2259, HB 3134, and SB 1150, demonstrating material reduction in administrative processing burden. Fourth, a national scaling analysis quantifying the domestic energy security implications of systematic inactive well recovery, with seven actionable policy recommendations.

### 1.5 Paper Structure

Section 2 establishes the energy security and regulatory landscape. Section 3 presents the full multi-criteria decision framework methodology. Section 4 details the regulatory compliance automation system and nine-domain checklist. Section 5 presents economic evaluation and capital efficiency methodology. Section 6 reports field validation results. Section 7 presents the national scaling analysis and policy recommendations. Section 8 discusses limitations and future research. Section 9 concludes.

## 2. Energy Security Framework and Regulatory Landscape

### 2.1 Defining Energy Security and the Domestic Production Imperative

Energy security encompasses four interconnected dimensions: availability (physical supply adequacy), affordability (price stability for consumers and industry), accessibility (reliable infrastructure for delivery), and acceptability (environmental and social sustainability) [17]. Domestic inactive well reactivation addresses all four simultaneously: it expands available supply from proven reserves at lower development cost than new exploration; it improves price stability through increased marginal supply responsiveness; it leverages existing gathering and pipeline infrastructure; and, executed under modern ESG operational standards, it generates environmental co-benefits through methane reduction and groundwater protection. The geopolitical context sharpens this case materially. Where new exploration supply takes years to reach market, reactivated wells can begin producing within months of workover execution — a lead-time differential that is the decisive advantage in a supply emergency [18].

### 2.2 How Geopolitical Shocks Transmit to Domestic Energy Markets

The transmission mechanism from geopolitical disruption to domestic pump price operates at the speed of financial markets. Oil futures contracts price in geopolitical risk within hours of an event; physical supply adjustments — tanker rerouting, refinery feedstock substitution, LNG cargo diversion — follow within two to four weeks [17]. Historical case studies illustrate the speed and severity of this transmission: the 1973 Arab Oil Embargo produced a four-hundred percent price increase within six months; the 1990 Gulf War doubled oil prices within weeks of Iraq's invasion of Kuwait; the 2022 Russia-Ukraine conflict triggered a European energy crisis within thirty days and sustained U.S. price pressure throughout 2022 [18]. Each episode underscores that the strategic value of domestic supply resilience is not theoretical — it is a realized economic protection mechanism for American consumers and industry.

### 2.3 Mature Conventional Basins as Strategic Domestic Assets

Texas's Permian Basin, Eagle Ford Shale, and Midcontinent formations are the backbone of U.S. onshore oil production. The infrastructure built across decades of development in these basins — pipelines, processing facilities, gathering systems, field roads — represents capital investment that can be leveraged immediately by reactivated wells without incremental midstream development cost. Inactive wells within these mature basins possess known geology from offset well production, documented production histories from regulatory databases, and established regulatory records: precisely the data inputs required by the analytical framework described in this paper. The gap between their documented potential and their current inactive status is, fundamentally, a data engineering and decision methodology gap rather than a geological or infrastructure gap.

### 2.4 Texas RRC Regulatory Framework

Texas inactive well compliance is governed by a layered regulatory framework built across three legislative milestones. House Bill 2259 (2009) established the foundational inactive well classification system and the W-3X annual certification requirement, mandating operators report the status of each inactive well and justify continued inactive status or commit to a reactivation or plugging timeline [19]. House Bill 3134 introduced increased obligations on financial assurances, linking the bond obligations to per-well liability cost estimations for plugging liabilities and introducing a financial incentive for getting out of inactive status. Senate Bill 1150 (2025) is the latest major development, making plug-or-produce decisions for wells inactive for fifteen years or longer and twenty-five years since completion, respectively, by RRC enforcement starting in September 2027 [20].For operators holding large inactive inventories approaching these thresholds, SB 1150 transforms portfolio evaluation from an optimization exercise into a statutory compliance imperative.

### 2.5 Federal Regulatory Overlay and Cost of Non-Compliance

Federal regulatory requirements overlay the Texas RRC framework for wells with applicable characteristics: EPA Underground Injection Control requirements under 40 CFR 146 for wells with injection history; SPCC plan obligations under 40 CFR 112 for sites with aboveground storage above threshold volumes; Clean Water Act discharge prohibitions; and TCEQ and EPA Clean Air Act restrictions on wellhead venting and emissions. Non-compliance with RRC inactive well requirements carries material and cascading consequences: administrative penalties accumulate on a per-well, per-day basis; permit holds suspend all new drilling applications; operator delisting bars future RRC-permitted activity in Texas; and bond forfeiture — triggered by abandonment without plugging — transfers liability to the RRC's orphaned well plugging fund. Beyond direct regulatory penalties, unresolved inactive well liability has become an ESG disclosure issue for operators accessing institutional capital markets.

## 3. Multi-Criteria Decision Framework Methodology

### 3.1 Program Design Philosophy and Context

The framework was developed and deployed by the author at Iskandia Energy, a Texas-based mature asset operator, across a portfolio of over two hundred inactive wells spanning seven producing fields in established Texas formations during the period 2017 through 2021. The program addressed a challenge that is representative of the industry condition described in Section 1: a large portfolio of inactive wells approaching regulatory deadlines simultaneously, with heterogeneous data distributed across multiple legacy systems, and no systematic framework for evaluating candidates at portfolio scale. Four design principles governed framework architecture throughout its development: systematic evaluation applying identical criteria to every well without exception; portfolio-level decision-making driven by comparative ranking across the full inventory rather than individual well merit in isolation; data-driven analysis with all inputs derived from verified, pipeline-assembled data rather than engineering judgment alone; and regulatory integration embedding compliance deadline pressure directly into the scoring algorithm as a primary decision variable rather than treating it as a secondary compliance check.

### 3.2 ETL Data Pipeline Architecture

The ETL pipeline — the framework's technological foundation — assembles all data required for the seven-step well evaluation process from six heterogeneous source systems into a unified, analysis-ready well master database. The ingestion layer interfaces with Texas RRC production databases exported as CSV and Excel files; LAS-format wireline log files containing petrophysical measurements; PHD wellbore mechanical records; regulatory PDF documents containing W-3X filings and environmental compliance records; Aries economic model outputs; and PHDWin reservoir performance databases. The transformation layer applies standardization operations that enable cross-well comparison: production volumes normalized to standard conditions at 60°F and 14.7 psia; depths converted to a consistent datum; cost bases harmonized to constant-dollar terms; and regulatory filing deadlines translated to days-remaining format for deadline-urgency scoring. A data quality validation module flags wells with missing or inconsistent records for manual review before scoring proceeds. The loading layer populates the unified well master database, structured to support both individual well drill-down analysis and portfolio-level filter-and-rank operations across the full inventory [14][15][16].

| Layer | Source Systems / Formats | Key Operations | Output |
|---|---|---|---|
| Ingestion | RRC CSV/Excel, LAS wireline logs, PHD files, regulatory PDFs, Aries economic outputs, PHDWin databases | Format parsing; completeness validation; quality flagging; API number verification | Raw well records (per-well) |
| Transformation | Normalized internal schema | Volume normalization to STB/MCF at 60°F and 14.7 psia; depth alignment; cost harmonization to constant-dollar basis; deadline conversion to days-remaining format | Standardized well attributes (portfolio-ready) |
| Loading | Unified relational schema | Portfolio-level ranking and filter indexing; tier score calculation; 90/30/7-day deadline alert triggers; cross-well comparison enablement | Well master database (portfolio-level) |

**Table 1. ETL Data Pipeline Architecture — Layer Summary**

**3.3 The Seven-Step Well Evaluation Process**

The process of assessing wells in the portfolio is done using a seven-step sequential process, where results of each step influence results of future steps and the overall score of the well through the composite scoring algorithm.

Step 1 – Data Gathering and Validation: The ETL process gathers all information about the selected well. Data from the Texas RRC database is gathered and verified in order to establish API number, well category, production history, W-3X filing and permits for the well. Data on logs, completions and workovers is retrieved and validated. Wells with incomplete data enter a remediation queue and are not considered for scoring until issues are fixed.

Step 2 – Geological and Geophysical Analysis: All available data on wireline logs, such as resistivity, porosity and gamma ray logs is compared with offset wells' production history.

Formation pressure depletion is estimated from production history and reservoir drive mechanism analysis. Structural position relative to proven productive areas and fluid contact mapping inform the geological confidence assessment. The output is a geological score G on a scale of zero to ten.

Step 3 – Wellbore Integrity Assessment: Wellbore mechanical integrity is evaluated based on cement bond logs, casing integrity logs, integrity tests according to RRC rule 3.46, perforation and workover records. Risks related to well integrity issues, such as water channels in poorly cemented zones, casing corrosion, and surface casing vent flow are determined and quantified as scores. This produces an output of wellbore integrity score W between zero and ten [1][3].

Step 4 – Historical Production Analysis: Decline curve analysis is carried out using the Levenberg-Marquardt nonlinear optimization algorithm to fit Arps decline parameters to well production history and get initial rate qi, decline rate Di, and hyperbolic exponent b [8][10]. Validation of goodness-of-fit includes applying thresholds of R-squared and RMSE for separation of automated fits from manual checks. k-means clustering of wells into production types — exponential, hyperbolic, and harmonic — makes it possible to compare with formation analogs and estimate EUR based on type curves.

Step 5 – Multi-Criteria Economic Analysis: Calculating net present value at three WTI price scenarios – fifty, seventy, and ninety dollars per barrel – is done using capital and operating cost estimates from Aries economic models. Monte Carlo simulation runs one thousand iterations per well, modeling uncertainty in production rate, commodity price, and workover cost to generate probability distributions of NPV and payback period [11][12][13]. The portfolio Pareto frontier — wells maximizing NPV per workover-dollar invested — is algorithmically identified to support capital constraint optimization. The output is an economic score E on a scale of zero to ten, calibrated to the seventy-dollar base case NPV rank within the portfolio.

Step 6 - Tiering: The overall T value is determined using the following formula: $T = 0.30G + 0.25W + 0.30E + 0.15R$, where R is a regulatory urgency value between 0 and 10 based on how close the RRC deadline is to being met in accordance with SB 1150 [19][20]. Weight assignments reflect the relative decision importance of each criterion: geological confidence and economic viability share the highest combined weight at sixty percent, reflecting their dominant influence on reactivation value; wellbore integrity receives twenty-five percent as the primary execution risk factor; and regulatory urgency receives fifteen percent as a tiebreaker and deadline-driven accelerator. Tier assignments follow mathematically defined cutoffs as shown in Table 2.

**Table 2. Multi-Criteria Composite Scoring Algorithm and Tier Classification**

| Criterion | Weight (w) | Score Range | Description |
|---|---|---|---|
| Geological Confidence (G) | 0.30 | 0 – 10 | Formation quality, structural position, pay thickness, offset well analog performance |
| Wellbore Integrity (W) | 0.25 | 0 – 10 | MIT result, casing corrosion condition, cement bond quality, SCVF status |
| Economic Score (E) | 0.30 | 0 – 10 | NPV rank within portfolio at $70/bbl base case; IRR vs. hurdle rate |
| Regulatory Urgency (R) | 0.15 | 0 – 10 | Years remaining before SB 1150 statutory plug-or-produce deadline |
| Composite Score (T) | — | 0 – 10 | $T = 0.30G + 0.25W + 0.30E + 0.15R$ |

**Table 3. Tier Classification — Capital and Regulatory Action Matrix**

| Tier | Composite Score (T) | Classification | Capital Action | Regulatory Action |
|---|---|---|---|---|
| Tier 1 | $T \geq 7.5$ | Immediate Reactivation | Prioritize workover budget allocation | File W-3X extension; initiate reactivation permit |
| Tier 2 | $5.0 \leq T < 7.5$ | Conditional Reactivation | Additional diligence; schedule within 12 months | File W-3X extension with reactivation timeline |
| Tier 3 | $3.0 \leq T < 5.0$ | Further Evaluation | Data gathering; feasibility study | Maintain W-3X compliance; monitor deadline |
| Tier 4 | $T < 3.0$ | Systematic Plugging | Execute plug-and-abandon program | File Form W-3; notify RRC; restore site |

Step 7 — Execution and Performance Monitoring: Workover plans are developed for Tier 1 and Tier 2 wells selected for execution, specifying scope, contractor requirements, timeline, and regulatory filing obligations. Post-workover production is monitored against the Step 4 forecast for a minimum ninety-day period to validate commercial success, calibrate the predictive model, and provide actual-versus-predicted data for ongoing algorithm improvement.

### 3.4 Algorithmic Classification and Predictive Scoring

To improve consistency of within-tier prioritization, a logistic regression model was trained on historical workover outcomes from the seven-field portfolio to predict commercial success probability for Tier 1 and Tier 2 candidates. Input features included the composite score T, wellbore depth, estimated reservoir pressure at time of evaluation, perforation interval length, formation type classification, and duration of inactivity. The model was calibrated against executed workover outcomes, enabling probability-of-success ranking within the Tier 1/2 candidate pool for capital scheduling purposes [8][9] [21].

### 3.5 Workover Technique Selection

Workover techniques deployed across the program were matched to well-specific conditions identified through the seven-step evaluation: wellbore cleanout for removal of scale, paraffin, and debris restricting production tubing flow; selective re-perforation of bypassed pay zones identified through carbon-oxygen log evaluation of remaining saturation; acid matrix stimulation to restore near-wellbore permeability in carbonate formations exhibiting scale or damage; sand control remediation for unconsolidated formation intervals; artificial lift optimization including rod pump resizing, gas lift valve replacement, and ESP selection for reduced reservoir pressure conditions; and remedial cementing for wells exhibiting water channeling through compromised cement bonds between casing and formation [1][2][3].

## 4. Regulatory Compliance Automation and the Comprehensive Checklist

### 4.1 The Compliance Automation Innovation

Managing W-3X annual filings, extension requests, mechanical integrity test schedules, and bond adequacy assessments across a portfolio of over two hundred wells is operationally demanding at a scale that renders manual, well-by-well preparation neither practical nor error-proof. The compliance automation system developed as part of this framework addresses this challenge through three mechanisms that collectively produced a material reduction in administrative processing time relative to the manual baseline [19][20]. First, batch W-3X template generation populated directly from the unified well master database eliminates redundant data entry and ensures consistency across filings. Second, standardized extension justification narratives drawn from pre-approved language libraries developed through direct RRC liaison engagement reduce per-well narrative preparation time while maintaining regulatory acceptability. Third, automated deadline tracking with ninety-day, thirty-day, and seven-day alert triggers integrated into the compliance calendar enables proactive rather than reactive compliance management — ensuring that no filing deadline approaches without advance preparation time.

### 4.2 The Comprehensive Nine-Domain Regulatory Compliance Checklist

The nine-domain checklist presented in Table 4 consolidates Texas RRC requirements under HB 2259, HB 3134, and SB 1150 with applicable federal standards — EPA Underground Injection Control requirements, SPCC regulations, Clean Water Act discharge prohibitions, and TCEQ air emission restrictions — into an operator-actionable format organized by compliance domain. The checklist was developed through field implementation across the seven-field inactive well portfolio and validated through direct engagement with RRC compliance staff. It is designed for annual completion for each inactive well and at any change in well status. Items are organized by domain with applicable regulation and recommended review frequency [19][20].

**Table 4. Nine-Domain**

| Domain | Key Requirements | Primary Regulation | Automation Level |
|---|---|---|---|
| 1. Well Documentation & Records | Production history, completion records, log data current and accessible; operator of record verified | HB 2259; RRC Rule 3.15 | Automated — database-linked |
| 2. W-3X Annual Reporting | Annual inactive well certification filed; extension requests submitted before deadline; years of inactivity calculated | HB 2259; SB 1150 | Batch-automated |
| 3. Mechanical Integrity & Well Control | MIT conducted per schedule; wellhead pressure integrity confirmed; SCVF within allowable limits | RRC Rule 3.46; Rule 3.14 | Manual — checklist-driven |
| 4. Environmental Compliance | No unauthorized discharges; SPCC plan current; zero venting/flaring compliance; produced water disposal authorized | EPA 40 CFR 112; TCEQ | Semi-automated — inspection log |
| 5. Groundwater & Freshwater Protection | Surface casing depth verified to protect usable-quality water; cement integrity behind surface casing confirmed; UIC Class II compliance | RRC Rule 3.13; EPA UIC | Manual — regulatory record |
| 6. Site Security & Surface Conditions | Wellhead locked and valved shut; site fenced and posted with operator contact; flow lines removed or purged if permanently inactive | RRC Rule 3.14; Rule 3.8 | Manual — field inspection |
| 7. Plugging & Abandonment Planning | P&A cost estimate current; P&A plan on file for Tier 4 wells; SB 1150 threshold calculated annually | HB 3134; SB 1150; Rule 3.14 | Automated — cost model |
| 8. Financial Assurance | P-5 Organizational Report current; bond amount reflects current plugging liability; W-3C filed if equipment removed | HB 3134; RRC P-5 | Automated — bond tracker |
| 9. Reactivation Readiness | RRC approval obtained before workover; post-workover MIT completed; production metering established before first sales; well classification updated | RRC Rule 3.46; SW Rule 15 | Semi-automated — permit tracker |

**Regulatory Compliance Checklist — Domain Summary**

## 5. Economic Evaluation and Capital Efficiency Optimization

### 5.1 Full-Cycle Economic Framework

The economic analysis model employs a cyclical process by incorporating all costs associated with the reactivation process, which include costs of geological evaluation, workover investment cost, operation costs throughout the expected productive life of the well, and abandonment costs.PHDWin decline curve parameters by well class and formation type provide the production forecast foundation. Aries economic models project monthly cash flow over the producing life using field-specific operating cost assumptions calibrated to the relevant Texas formation and artificial lift configuration. The price scenario framework — stressed at fifty dollars per barrel WTI, base case at seventy dollars, and upside at ninety dollars — captures the range of commodity price environments relevant to mature basin reactivation economics and ensures that only wells with robust cross-scenario economics reach the highest tier classifications [5][6][7].

### 5.2 Portfolio-Level Capital Allocation

The decisive advantage of the portfolio-level framework over well-by-well evaluation lies in its capacity to allocate capital across the full inventory simultaneously, rather than sequentially. All Tier 1 and Tier 2 candidates are ranked by risk-adjusted NPV — incorporating the Monte Carlo probability distribution from Step 5 — to produce a capital allocation priority list that can be adjusted dynamically as workover budget, commodity price environment, and regulatory deadline urgency evolve. Bond savings realized through early reactivations of high-confidence Tier 1 candidates are reinvested into subsequent workover capital, creating a self-funding program dynamic that does not require front-loaded capital commitment for the full candidate pool [11][12].

### 5.3 Reactivation vs. New Drill Economics

The economic case for inactive well reactivation over new well drilling in the same formation rests on four structural advantages. Cost per BOE added is materially lower for reactivation given the absence of drilling and well construction costs. Time to production is substantially faster: workover execution timelines of weeks to months versus new well permitting, drilling, and completion timelines of one to two years or more. Geological risk is lower: the reactivation candidate has a documented production history from a proven wellbore in a known formation, eliminating the exploration and appraisal risk inherent in new well targets. Infrastructure cost is lower: existing surface facilities, wellheads, flow lines, and gathering connections require refurbishment rather than new construction [4].

### 5.4 Plugging Cost Integration as Economic Decision Variable

A distinctive feature of the economic framework is the explicit integration of plugging cost as the economic alternative to reactivation. For each well evaluated, the NPV of the plug-and-abandon path — incorporating current statutory plugging cost, site restoration requirements, and bond release — is calculated alongside the reactivation NPV. Wells where plug-and-abandon NPV exceeds reactivation NPV across all price scenarios are classified Tier 4 and entered into the plugging program. This explicit comparison ensures that capital is deployed on reactivation only where it generates superior value to the plugging alternative — an important discipline in portfolio capital allocation that conventional reactivation-focused approaches frequently omit.

## 6. Results and Field Validation

### 6.1 Portfolio Overview and Classification Outcomes

The framework was deployed across the full inactive portfolio of over two hundred wells in seven Texas producing fields during the period 2017 through 2021 [19][20]. Wells in the portfolio spanned a range of inactivity durations — from recently inactive wells of one to three years to long-term inactive wells of ten or more years approaching SB 1150 deadline thresholds — and represented vertical conventional completions in sandstone and carbonate reservoirs across established Texas formations. Application of the tiered classification algorithm yielded over one hundred fifty wells classified as Tier 1 or Tier 2 reactivation candidates, representing approximately seventy-five percent of the evaluated portfolio. A smaller number of wells were classified Tier 4 and entered the systematic plugging program; the balance were classified Tier 3 for further evaluation pending additional data or remediation work.

### 6.2 Reactivation Execution and Commercial Outcomes

Workover operations were executed on the prioritized subset of Tier 1 and Tier 2 candidates during the program period. All executed workovers achieved commercial production rates, and post-workover monitoring confirmed sustained production through the minimum ninety-day validation period in all cases. This commercial success rate materially exceeds the rates reported in the published literature for conventionally selected inactive well workover candidates, which typically range from sixty to eighty percent [2][3]. The discriminating effect of the Tier 1/2 classification threshold — by design excluding marginal candidates that conventional approaches might pursue — is the primary explanatory factor for this outcome differential. The predictive logistic regression model's within-tier prioritization further concentrated execution on the highest-confidence candidates within the Tier 1/2 pool.

### 6.3 Economic, Efficiency, and Regulatory Outcomes

Program outcomes across economic, operational efficiency, and regulatory compliance dimensions are summarized in Table 5. Time taken to evaluate each well was greatly reduced by removal of manual data collection process bottlenecks due to which portfolio analysis could be done in the stipulated program timeframe [14]. Cost savings with respect to bond and plugging obligations were achieved by way of reclassifying the reactivated wells from mandatory plug and abandon list to active production wells.Incremental revenue contribution from reactivated wells across the seven-field portfolio represented a material economic outcome. Regulatory compliance performance was maintained at a level of zero violations and zero bond forfeitures across the entire portfolio for the full program duration, with administrative processing efficiency improved through the batch-automated compliance system [19][20].

**Table 5. Quantified Program Outcomes — Field Validation Summary**

| Metric | Outcome | Baseline / Comparator | Primary Mechanism |
|---|---|---|---|
| Portfolio scale | 200+ wells, 7 Texas fields, 2017–2021 | No equivalent published at this scale | ETL pipeline enabling full-portfolio evaluation |
| Tier 1/2 candidates identified | 150+ (≈75% of evaluated portfolio) | Ad-hoc selection: no portfolio-wide ranking | Composite scoring algorithm T = 0.30G + 0.25W + 0.30E + 0.15R |
| Workovers executed | 50+ (selected from Tier 1/2 pool) | Budget-constrained conventional approach | Algorithmic prioritization within Tier 1/2 by risk-adjusted NPV |
| Commercial production success rate | 100% of executed workovers | Published literature range: 60–80% | Tier 1/2 threshold eliminates marginal candidates before capital deployment |
| Per-well evaluation time | 80–90% reduction vs. conventional (8–12 hrs → <1 hr) | Industry-typical manual data assembly | ETL pipeline automation and unified well master database |
| Bond & plugging obligation savings | $3.5M | Mandatory P&A cost if no reactivation path identified | Reactivated wells exit mandatory plug-and-abandon queue |

| Metric | Outcome | Baseline / Comparator | Primary Mechanism |
|---|---|---|---|
| Regulatory processing time | 50% reduction in W-3X administrative burden | Manual per-well W-3X preparation baseline | Batch-automated filing templates and standardized extension narratives |

## 7. National Scaling Analysis and Policy Recommendations

### 7.1 National Scaling Potential

The national scaling implications of systematic inactive well recovery are significant. Applying the program's conservative reactivation rate to the Texas inactive well inventory recorded in the RRC IWAR yields a substantial candidate pool in Texas alone [19]. Extended to the national EPA estimate of inactive and abandoned wells across all producing states, the same methodology implies a national reactivation candidate pool measured in the tens of thousands of wells. Even at modest average production rates per reactivated well, this candidate pool represents incremental domestic supply with lead times measured in months — materially faster than any frontier exploration pathway and at capital intensity significantly lower than new well development. The strategic case for inactive well recovery as a domestic energy security mechanism rests precisely on this combination of speed, capital efficiency, and geological certainty that distinguishes it from all conventional supply expansion alternatives [17][18].

### 7.2 ESG and Environmental Co-Benefits

Systematic inactive well reactivation under modern operational standards generates environmental co-benefits that reinforce rather than conflict with energy transition objectives. Reactivated wells under active production management eliminate venting and fugitive methane emissions associated with long-term inactive wellbore status [4]. The zero-venting, zero-flaring operational model applied across the Iskandia Energy program demonstrates the compatibility of commercial production and environmental stewardship in the mature basin context. Groundwater protection — a primary public concern associated with improperly abandoned wells — is directly addressed by the nine-domain checklist's Domain 5 requirements, mandating freshwater zone isolation verification before any reactivation proceeds. These co-benefits position systematic inactive well recovery as aligned with ESG transition frameworks increasingly applied by institutional capital allocators to energy sector investments.

### 7.3 Data Infrastructure as National Energy Security Asset

A finding of the program with implications extending beyond operational outcomes is the critical dependence of systematic inactive well evaluation on the availability of historical subsurface data. The ETL pipeline described in Section 3.2 can function only when production histories, wireline logs, completion records, and regulatory filings are accessible, complete, and in parseable formats. Corporate consolidations, operator bankruptcies, and aging legacy data systems are actively destroying irreplaceable subsurface data archives across the U.S. producing basin inventory. When an operator enters bankruptcy, decades of log data and production records frequently disappear with the entity. This data preservation crisis represents a secondary but equally important dimension of the inactive well problem: the inability to systematically evaluate wells for reactivation is not only a methodological gap but, increasingly, a data availability gap that is compounding over time [14][15].

### 7.4 Seven Policy Recommendations

Recommendation 1 — Federal Reactivation Incentive Program: Tax credits for inactive well reactivation — analogous in structure to existing enhanced oil recovery credit frameworks — combined with SBA loan programs for smaller operators lacking reactivation capital, and DOE grants targeting strategically located candidates near existing infrastructure.

Recommendation 2 — Regulatory Standardization Across State Jurisdictions: Adoption of systematic portfolio evaluation frameworks as a model for state regulatory agencies across all producing states; interstate compact for inactive well data sharing; and standardization of W-3X-equivalent inactive well reporting requirements to enable cross-state portfolio analysis.

Recommendation 3 — National Inactive Well Registry: A federally funded database integrating all state-level inactive well records in standardized formats, with public-private partnerships for evaluation of orphaned wells where the original operator is defunct, and DOE funding targeting strategically located reactivation candidates near existing infrastructure.

Recommendation 4 — Strategic Energy Planning Integration: Incorporation of inactive well reactivation capacity into DOE national energy security planning models alongside SPR drawdown capacity and new production forecasts; identification of rapid-response portfolios deployable within ninety days of a supply emergency; and coordination with SPR replenishment planning.

Recommendation 5 — ESG Framework Integration: SEC climate disclosure recognition for responsible inactive well management programs; carbon credit mechanisms incentivizing zero-venting, zero-flaring reactivation; and ESG rating criteria incorporating inactive well compliance performance to align capital market incentives with systematic portfolio resolution.

Recommendation 6 — National Subsurface Data Registry: Federal mandate for preservation of wireline logs, production records, and completion data from all wells regardless of operator financial status; DOE-funded national well data archive accessible to regulators, researchers, and qualified operators; and standardized data format requirements including LAS 3.0 for log data and standardized production reporting formats across all state regulatory agencies.

Recommendation 7 — Data Engineering Workforce Development: Federal investment in petroleum data engineering education building the specialized workforce — combining petroleum engineering domain knowledge with ETL pipeline design, decline curve analytics, and algorithmic scoring competency — required to deploy systematic inactive well evaluation frameworks at national scale.

## 8. Discussion

### 8.1 Framework Differentiation from Conventional Approaches

The systematic, data-driven framework presented in this paper differs from conventional inactive well evaluation practice along three critical dimensions that explain its superior measured outcomes. The first is scale capacity: the ETL pipeline enables portfolio-level evaluation of over two hundred wells within program timelines that conventional well-by-well manual assembly would have made impractical, enabling true portfolio-level capital allocation rather than the sequential, individually-motivated decisions that characterize conventional practice [14][15]. The second is decision multidimensionality: the composite scoring algorithm integrates four criteria simultaneously — geological confidence, wellbore integrity, economic viability, and regulatory urgency — resolving trade-offs that single-criterion approaches leave unresolved and producing a ranked output that reflects the full decision context rather than optimizing on one dimension at the expense of others [5][6][7]. The third is regulatory integration: embedding regulatory urgency directly in the T-score formula ensures that compliance deadline pressure shapes prioritization before capital allocation decisions are made, rather than being treated as a subsequent compliance exercise that may conflict with the capital allocation outcome already determined [19][20]. The one hundred percent commercial success rate on executed workovers — materially exceeding the published literature range — empirically validates the discriminating power of the Tier 1/2 classification threshold that these three differentiating factors produce.

### 8.2 Limitations

Three limitations merit explicit acknowledgment. First, geographic and geological scope: the framework was validated in Texas mature conventional fields under the commodity price conditions of 2017 through 2021. Application to unconventional shale completions with materially different decline profile characteristics, offshore well environments, or commodity price regimes substantially outside the validation range would require recalibration of scoring weights, Monte Carlo price scenario bounds, and the predictive logistic regression model. Second, selection and reporting bias: the commercial success rate reported reflects only the subset of Tier 1/2 candidates selected for workover execution; unexecuted Tier 2 candidates, whose economics or timeline did not support immediate execution within the program period, may exhibit different success characteristics if subsequently executed. Third, longitudinal performance bounds: the ninety-day post-workover monitoring period validates the achievement of commercial production rates but does not capture long-term production decline behavior or the accuracy of EUR estimates over the full producing life of reactivated wells.

### 8.3 Future Research Directions

Three directions for future research emerge from the validation outcomes and limitations identified above. First, machine learning augmentation: replacing the linear composite score with a gradient-boosted or neural network classifier trained on a larger multi-field historical dataset would improve predictive accuracy, reduce weight-assignment subjectivity, and enable dynamic recalibration as new workover outcomes accumulate [21]. Advances in generative AI models further offer pathways for automated subsurface report synthesis and data interpretation support within the evaluation pipeline [23]. Second, real-time regulatory integration: the RRC's 2024 LoneSTAR platform launch creates an API-accessible pathway for continuous portfolio monitoring against regulatory deadlines, enabling dynamic program management responsive to deadline changes without the periodic batch evaluation cycle required by the current framework. Third, longitudinal outcome tracking: five-year post-workover production performance data would validate EUR estimates, calibrate the Levenberg-Marquardt decline curve models for specific Texas formation types, and provide the expanded training dataset needed for the machine learning augmentation described above. A fourth direction — integration with adaptive geological modeling frameworks for enhanced subsurface characterization of reactivation candidates — is explored in a companion article addressing the Cervart methodology for giant field reservoir characterization.

## 9. Conclusion

Inactive oil and gas wells are a strategically misclassified domestic energy asset. Treated by prevailing regulatory framing primarily as a compliance liability — subject to escalating deadline pressure to plug or produce — they represent, in aggregate, a portfolio of productive opportunities whose recovery requires not geological risk capital or frontier exploration investment, but systematic data engineering and algorithmic decision methodology. The framework presented in this paper provides that methodology, validated at operational scale through direct field implementation.

The four contributions of the framework — an ETL data pipeline resolving the heterogeneous data integration barrier; a multi-criteria composite scoring algorithm enabling systematic portfolio-level candidate prioritization; a nine-domain regulatory compliance automation system converting compliance burden into operational discipline; and a national scaling analysis with actionable policy recommendations — collectively address the methodological gap that has left the inactive well inventory as a strategic resource without a systematic recovery framework.

The field validation outcomes demonstrate that the gap between the inactive well inventory's documented potential and its current productive contribution is not geological, infrastructural, or economic in its fundamental nature. It is a data engineering and decision methodology gap. The framework closes that gap. Its replication at state and national scale, supported by the seven policy recommendations, constitutes a concrete, evidence-based, and immediately deployable domestic energy security strategy — one whose strategic value is measured not only in incremental production volumes but in the speed, capital efficiency, and supply resilience it provides relative to all conventional alternatives.

Systematic inactive well recovery is not a marginal contribution to domestic energy supply. Properly scaled and systematically executed, it is among the most strategically consequential and deployable domestic energy security mechanisms available to the United States in the geopolitical environment of the twenty-first century.

**Ethics Statement**

Conflict of Interest: The author declares no conflict of interest in the preparation or submission of this manuscript.

Human and Animal Rights: This research involved no human participants, animal subjects, clinical trials, or personally identifiable data. No institutional ethics board review was required.

Informed Consent: Not applicable.

Data Availability: The field data supporting the quantified outcomes in this paper were generated through the author's direct professional engagement with the described portfolio evaluation program. Proprietary data are not publicly available; the methodology is fully described to enable independent replication.

AI-Use Disclosure: AI-assisted language tools were used for manuscript preparation and editing. All research design, data collection, analysis, interpretation, and intellectual contributions are the author's own.

**Author Contributions (CRediT)**

Vijay Bhalani: Conceptualization; Methodology; Software (ETL pipeline design, scoring algorithm implementation); Validation; Formal Analysis; Investigation; Data Curation; Writing — Original Draft; Writing — Review and Editing; Visualization; Project Administration.

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