GAUSSIAN
WELLWORKS
RESERVOIR INTELLIGENCE

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RESERVES ESTIMATION

Gaussian Wellworks applies **Gaussian Pressure Transient (GPT)** technology as a closed-form, physics-based method for well-rate and cumulative-production forecasting. The service links engineering forecasts, uncertainty, and economic limits so reserve estimates are technically defensible, commercially useful, and ready for governance or investment review.

Four outcomes from one forecast basis:

1. PHYSICS-BASED FORECASTS Forecast startup, peak rate, decline, cumulative production, and economic well life using pressure-diffusion physics.	**2. TRANSPARENT UNCERTAINTY** Convert forecasts into deterministic and P90/P50/P10 EUR cases with documented assumptions and sensitivities.
3. DATA-MATURITY UPDATES Recalibrate production, pressure, completion and operating inputs as evidence matures and explain reserve movements.	**4. AUDIT + INVESTMENT SUPPORT** Provide reproducible technical evidence for governance, lending, transactions, IPOs, M&A, CPRs and investor communication.

Work is aligned with recognized reporting frameworks:

SPE-PRMS Petroleum Resources Management System classification and reporting.	**SEC** U.S. Securities and Exchange Commission reporting requirements.	**NI 51-101** Canadian National Instrument 51-101 requirements, where applicable.

CLIENT VALUE

Production forecasts determine the volume, timing, and cash flow that underpin reserve estimates. They influence:

BOOKED VOLUMES Technically supported recoverable volumes and classification.	**ASSET VALUE** Forecast timing and uncertainty linked to commercial value.	**LENDING CAPACITY** Downside-aware production and reserve support for financing.
DEVELOPMENT TIMING Evidence-based sequencing of wells, infill and capital.	**REGULATORY DISCLOSURE** Transparent assumptions, classifications and reserve movements.	**CAPITAL ALLOCATION** Comparable downside, base, and upside cases across assets.

In unconventional and complex reservoirs, the risk of over- or under-estimating recoverable volumes is amplified by complex flow regimes, limited early production history, changing completion practices, parent-child interference, and commodity-price sensitivity.

Gaussian forecasting connects:

PRODUCTION HISTORY Daily rate, cumulative production, and operating events.	**PRESSURE RESPONSE** Observed pressure behavior and pressure-diffusion calibration.	**RESERVOIR + FLUIDS** Rock, fluid, and hydraulic-diffusivity evidence.
COMPLETION GEOMETRY Fracture and well design linked to producing performance.	**OPERATING CONSTRAINTS** Chokes, shut-ins, curtailment, workovers, and facility limits.	**ECONOMIC LIMITS** Price, cost, ownership, entitlement, and commercial cutoffs.

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This leads to supporting decision outcomes:

DOWNSIDE / BASE / UPSIDE	KEY EUR DRIVERS	RESERVE REVISIONS	AUDIT-READY CLASSIFICATION
Quantify P90, P50, and P10 production and EUR cases.	Identify the assumptions and parameters that move reserves.	Update reserves and explain changes as evidence matures.	Connect data, forecast, economics and reserve class.

TRANSPARENT ASSUMPTIONS STRENGTHEN INVESTOR CONFIDENCE, FINANCING DISCUSSIONS AND INTERNAL GOVERNANCE.

APPLICATIONS AND DELIVERABLES

Our experts are specialized petroleum engineers and geoscientists with deep expertise in subsurface modeling, data interpretation, economic modeling, and regulatory compliance. Our work provides objective assurance to regulators, investors, and lenders that reserve figures are credible and technically sound.

CLIENT USE CASE	ANALYSIS PERFORMED	CLIENT RECEIVES
Annual reserves reporting and governance	Estimate and classify reserves/resources; reconcile production, economics, ownership and development assumptions.	Reserve tables by well, reservoir, field and corporate level; effective-date assumptions register; audit-ready backup.
Independent certification, audit, and CPR support	Review internal reserves, methods, data quality, classifications and economic assumptions.	Certification or audit opinion letters; CPR sections; third-party review notes; reproducibility package.
Reserve-based lending, financing, M&A, and IPO diligence	Test downside, base and upside cases; review booked volumes, undeveloped inventory and valuation assumptions.	Investor/lender-ready technical summary; risk commentary; defensible reserve and valuation cases.
Unconventional forecasting	Apply GPT under deliverability, bottomhole-pressure, production-system and uncertainty constraints.	Well- and program-level production forecasts; EUR tables; P90/P50/P10 ranges where supported.
Field development and completion-design decisions	Evaluate infill, parent-child effects, spacing, interference, completion efficiency and alternatives.	Forecast scenarios; spacing/interference screening; capital allocation and development comparison visuals.
Portfolio risk management and reserve consistency checks	Aggregate uncertainty, test correlations, compare reserve-class logic and identify reserve-movement drivers.	Portfolio distributions; movement explanations; risk register; board and executive visuals.

GAUSSIAN METHODOLOGY: ENGINEERING-GROUNDED AND STATISTICALLY RIGOROUS

Gaussian forecasting is built on a closed-form pressure-diffusion solution. A history match constrains hydraulic diffusivity (Dh), then the calibrated model projects well rates and cumulative production. Deterministic or probabilistic forecasts are converted to reserve estimates only after phase allocation, economic limits, ownership, commerciality, and reporting definitions are applied.

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Five-step workflow:

1. DEFINE THE RESERVE SYSTEM	Reservoir geometry, stratigraphy, contacts, faults, wells, ownership, development status, and operating constraints.
2. DATA INTAKE + QC	Review production, pressure, completion, and operating history. Flag shut-ins, choke changes, workovers, curtailment, interference, and missing data.
3. PROBABILISTIC UNCERTAINTY	Parameterize uncertainty in reservoir, well, completion, recovery, cost, and price. Model correlations and aggregation effects.
4. FORECAST RESERVE SCENARIOS	History-match total-fluid behavior and cumulative production; estimate Dh; reconcile with logs, laboratory data, and comparable wells; generate deterministic and P90/P50/P10 forecasts under economic or technical constraints, and identify key risk drivers.
5. CLASSIFICATION + AUDIT PACK	Map volumes to 1P/2P/3P or required categories under PRMS, SEC, or NI 51-101 and document assumptions, methods, economics, and reproducibility.

Over-booking and under-booking are controlled by:

SEPARATE OPERATIONS FROM RESERVOIR RESPONSE Remove or explain shut-ins, choke changes, workovers, curtailment, and interference before decline analysis.	**CALIBRATE PROPERTY DISTRIBUTIONS TO FIELD BEHAVIOR** Use field history to constrain hydraulic-diffusivity distributions before probabilistic forecasting.
CONFIRM RESERVE CLASS Evaluate data maturity, development status, entitlement, economics and reporting definitions alongside forecast results.	**DOCUMENT THE FORECAST BASIS** Record forecast assumptions, economic limits, classification logic, sensitivity and reproducibility evidence.

EVERY RESERVE NUMBER REMAINS LINKED TO DATA, CALIBRATION, UNCERTAINTY, ECONOMICS AND CLASSIFICATION.

GAUSSIAN APPROACH VS. TRADITIONAL METHODS (COMPARISON MATRIX)

COMMON APPROACH	TYPICAL LIMITATION	GAUSSIAN ENHANCEMENT
TRADITIONAL ARPS DCA	Empirical three-parameter fit; can require high assumed initial rate and may produce non-unique long-term tails.	Uses a physical D_h parameter and represents startup, peak, and decline.
POST-ARPS METHODS	Duong, PLED, SEPD or LGM may fit selected regimes, but model choice and empirical parameters can materially change EUR.	Provides an interpretable diffusivity parameter and a direct link to pressure propagation.
TYPE CURVES + ANALOGS	Fast and practical, but dependent on analog similarity in reservoir, fluid, completion and operations.	History-matches the subject well; analogs constrain uncertainty rather than replace well evidence.
NUMERICAL SIMULATION	Powerful but data-intensive, grid-dependent and slower for rapid screening or large portfolios.	Closed-form and gridless for fast scenarios; complements simulation when full-field complexity matters.

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COMMON APPROACH	TYPICAL LIMITATION	GAUSSIAN ENHANCEMENT
DETERMINISTIC SINGLE CASE	Hides uncertainty and may encourage false precision in reserves and valuation.	Supports bootstrap and Monte Carlo workflows for P90/P50/P10 EUR distributions.
GPT	Requires appropriate input quality, engineering review, and calibration to the subject reservoir and well conditions.	Rapid physics-based forecast with auditable assumptions and a parameter linked to reservoir performance.

PLED = Power Law Exponential Decline | SEPD = Stretched Exponential Production Decline | LGM = Logistic Growth Model

CLIENT DELIVERABLES

OPERATORS

- Well-, reservoir-, field-, and corporate-level reserve tables.
- Production forecasts, cumulative recovery, EUR estimates, and sensitivity cases.
- 1P, 2P, and 3P estimates, with P90, P50, and P10 ranges.
- Development comparisons covering well spacing, infill timing, parent–child interference, completion design, and capital allocation.
- Portfolio distributions, reserve-movement analysis, risk registers, and executive visuals.

INVESTORS & LENDERS

- Independent technical summary of reserve volumes, forecast assumptions, and economics.
- Downside, base, and upside reserve and valuation cases.
- Risk commentary on undeveloped inventory, parent-child effects, development timing, and key reserve drivers.
- Technical support for reserve-based lending and borrowing-capacity assessments.
- Due-diligence materials for M&A, IPOs, financings, and asset transactions.
- Investor-ready portfolio distributions and traceable links between reserves, production performance, and economics.
- Distributions linking production performance, forecast uncertainty, reserves, and valuation.

AUDITORS & REGULATORS

- Classification and disclosure support under applicable SPE-PRMS, SEC, or NI 51-101 requirements.
- Effective-date assumptions register and audit-ready technical documentation.
- Certification or audit-opinion letters, CPR sections, and third-party review notes, as applicable.
- Reproducibility package covering scope, data, methods, assumptions, economics, calculations, and key uncertainties.
- Quality, consistency, and reserve-movement checks covering production data, ownership, development plans, and developed or undeveloped status.

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CASE STUDY—PROBABILISTIC RESERVES ESTIMATION WITH GAUSSIAN DCA (WOLFCAMP SHALE)

Summary

Production data from two Wolfcamp shale oil wells, 4H and 31H, were history-matched with both Gaussian DCA and traditional Arps DCA. The calibrated models generated 40-year total-liquid and oil EUR forecasts. Gaussian DCA used hydraulic diffusivity as its key matching parameter, captured the early production peak, and supported probabilistic EUR estimation through bootstrapping and field-calibrated diffusivity distributions.

Objective

Test whether Gaussian DCA can produce reliable, transparent reserve estimates from noisy real-well data, reduce history-match error, and show how uncertainty changes when the analysis expands from a single well to a field-calibrated reservoir-property distribution.

Provided solution

The study quality-controlled daily total-liquid and cumulative production, history-matched both methods, compared residual error and deterministic EUR, and converted total liquids to oil using water cut. It then generated P90/P50/P10 oil EUR ranges using bootstrapping and Monte Carlo simulation. A second workflow combined history-matched D_h with log and laboratory inputs plus 11 nearby HFTS-1 wells, creating a broader field-calibrated uncertainty distribution for reserves estimation.

Results and Findings

For the two study wells, Gaussian DCA produced lower residual squared error than Arps by 99.99% for Well 4H and 98.35% for Well 31H. Deterministic 40-year oil EUR was 201 Mbbl versus 196 Mbbl for Well 4H, and 340 Mbbl versus 307 Mbbl for Well 31H. Gaussian also represented the observed startup and early peak, which the Arps formulation could not reproduce (**Figures 1a, b)**. These results demonstrate the value of a physics-linked forecast when reserve volumes depend heavily on early production behavior.

The single-well bootstrap produced relatively narrow 40-year oil EUR ranges. Well 4H returned P90/P50/P10 values of approximately 203/204/219 Mbbl, while Well 31H returned 320/322/325 Mbbl. The exercise showed that a simple one-parameter Gaussian match can be resampled efficiently to quantify uncertainty from the production history. It also showed why a deterministic forecast should be viewed in the context of a probability distribution rather than treated as a stand-alone reserve answer.

When log, laboratory, and nearby-well evidence were introduced through a calibrated Dh distribution, the uncertainty range widened substantially. The resulting 40-year oil EUR ranges were 39/166/320 Mbbl for Well 4H and 36/145/361 Mbbl for Well 31H on a P90/P50/P10 basis. The broader range reflects reservoir-property uncertainty that a single-well bootstrap cannot capture.

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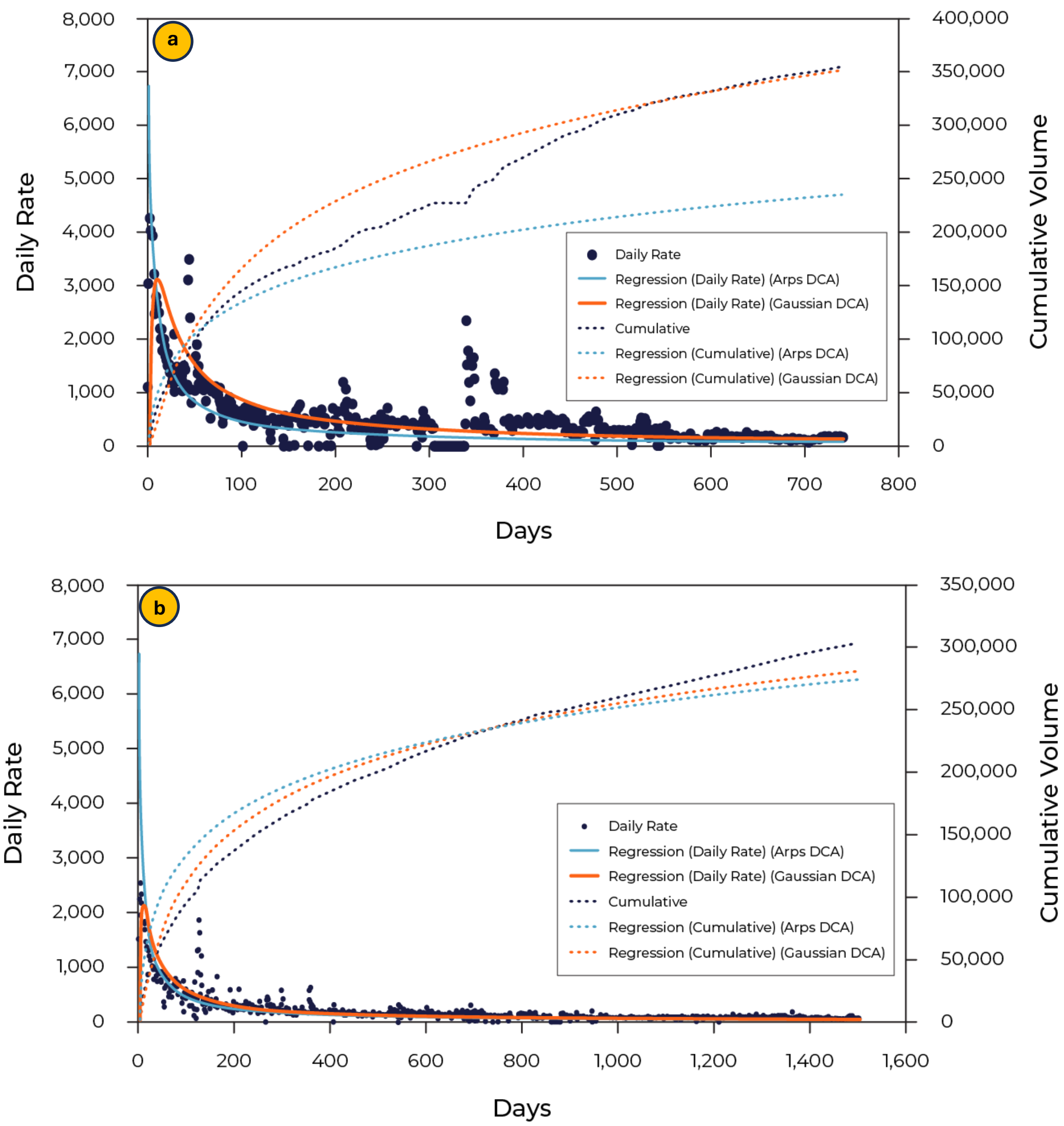

Figure 1 – History-matches for daily and cumulative production for Wells 31H (a) and 4H (b), using both Arps and Gaussian DCA methods.

The reserves-estimation lesson is practical. Hydraulic diffusivity is the key Gaussian performance parameter, but property-based distributions should be calibrated to field history before use in probabilistic forecasting. Bootstrapping is useful when only one well is available; a multiwell, field-calibrated distribution is more appropriate for portfolio decisions. P90, P50, and P10 forecast volumes inform reserves cases, but final classification still requires commerciality, development status, entitlement, economics, and the applicable reporting framework.

The client benefit is a forecast that is fast to update, physically interpretable, and easier to audit. Gaussian workflows expose the assumptions that drive EUR, show the difference between well-history uncertainty and reservoir-property uncertainty, and provide a clearer basis for avoiding both over-booking and under-booking. The workflow helps clients avoid optimistic booking, improves child-well forecasting, and provides a clearer technical basis for reserve classification, development timing, and capital allocation.

READ THE FULL CASE STUDY

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ADDITIONAL EVIDENCE

Explore peer-reviewed studies validating Gaussian approaches for Reserves Estimation.

[1]. Tian, Y. and Weijermars, R., 2026. Computation of pressure depletion and well productivity of multi-fractured wells with variable fracture spacing using a fast and accurate solution method. Petroleum Research. DOI

[2]. Weijermars, R., and Afagwu, C., 2024. Pressure-Transient Solutions for Unbounded and Bounded Reservoirs Produced and/or Injected via Vertical Well-Systems with Constant Bottomhole-Pressures. MDPI Fluids 2024, 9(9), 199; DOI

[3]. Weijermars, R., 2023. Production Forecasting of Unruly Geoenergy Extraction Wells Using Gaussian Decline Curve Analysis. Geofluids, 2023, 5534305. DOI

[4]. Weijermars, R., 2022. Gaussian Decline Curve Analysis of Hydraulically Fractured Wells in Shale Plays: Examples from HFTS-1. Energies, 15, 6433. DOI

[5]. Weijermars, R., 2022. Production Rate of Multi-Fractured Wells Modeled with Gaussian Pressure Transients. Journal of Petroleum Science and Engineering, 210, 110027, Elsevier B.V. DOI

[6]. Weijermars, R., Tugan, M.F., and Khanal, A., 2020. Production Rates and EUR Forecasts for Interfering Parent-Parent Wells and Parent-Child Wells: Fast Analytical Solutions and Validation with Numerical Reservoir Simulators, Journal of Petroleum Science and Engineering, Volume 190, July 2020, 107032. DOI

[7]. Weijermars, R., 2012. Jumps in proved unconventional gas reserves present challenges to reserves auditing. SPE Economics & Management, Vol. 4, No. 3, p. 131-146 (SPE 160927-PA). DOI

