Integrated Digital Twin for Enterprise-Grade Production Optimization

Aspen Technology – YPFB Andina Collaboration and AspenTech® Product Stack

By Taha Taha, Senior Product Owner, Aspen Technology & Emmanuel Gringarten, Sr Enterprise Solution Director, Aspen Technology

This white paper reflects the collaboration between YPFB Andina and Aspen Technology to apply an integrated digital twin approach for decline-stage gas asset optimization. YPFB Andina contributed the national-scale operating context, field knowledge and production engineering expertise, while Aspen Technology provided the modelling, orchestration, optimization, diagnostics and analytics capabilities to connect subsurface-to-surface decision-making into a single workflow.

The integrated digital twin capability described in this paper was implemented using the following AspenTech products:

Aspen HYSYS®: Process and facility simulation for plant and separation performance under changing operating pressures.

Aspen METTE™: Surface and pipeline network modelling to represent gathering systems, compression and pressure propagation across the value chain.

Aspen Tempest®: Orchestration, optimization and diagnostics, including automated scenario execution and analytics dashboards for unified decision support.

Executive Overview

This white paper presents a progressive, evidence-based narrative for integrated digital twins as a strategic capability for decline-stage gas asset optimization. The document is structured around two complementary case studies focused on Bolivia's south gas fields and Yapacaní and associated fields.

The first case study presents a proven, country-level deployment in Bolivia's south gas fields (based on SPE 224517), demonstrating production uplift and capital avoidance without new investment.

The second case study builds on those operational results and formalizes the methodology into a scalable, enterprise-grade digital twin framework, illustrated through Yapacaní and associated fields.

Industry Context and the Cost of Fragmented Modelling

Hydrocarbon assets are inherently interconnected systems where changes in one component can trigger cascading effects across the entire production chain. However, digital modelling practices often remain fragmented, resulting in:

- Limited cross-disciplinary collaboration
- Inconsistent data flows between models
- High manual effort in scenario evaluation
- Inability to quantify uncertainty effectively
- Suboptimal capital allocation and infrastructure design

As assets mature and production declines, these challenges intensify. Operators must balance reduced CAPEX availability with the need to maintain or enhance production levels. Integrated digitalization is therefore no longer optional but essential.

Integrated Digital Twin Concept

An Integrated Digital Twin is a dynamic, asset-wide digital representation that continuously connects and synchronizes multiple technical domains, including:

- Subsurface reservoir models
- Surface production networks
- Processing and separation facilities
- Economic/financial evaluation

Crucially, the goal is not "model aggregation." The value comes from orchestration: running end-to-end sensitivity, optimization, forecasting and diagnostics across the entire system, so decisions reflect true value-chain behavior rather than local optima.

Case Study 1 – Evidence in Practice: Country-Level Optimization Without Investment (South gas fields)

Bolivia's major Sub-Andean gas fields entered decline after ~15 years of intensive production. Conventional responses such as compression projects, well interventions or drilling are capital intensive and slow. YPFB Andina therefore pursued a non-investment optimization strategy using a national scale digital twin spanning reservoirs, wells, gathering systems, processing plants, sales and export pipelines and LPG facilities.

This case study summarizes the real-world application of an integrated digital twin across Bolivia's major gas-producing assets during decline stages. It is based on the SPE paper "Country-Level Gas Production Optimization at Decline Stage Without Investment Using a Digital Twin" (SPE-224517-MS) and documents validated production gains, capital savings and national-scale impact.

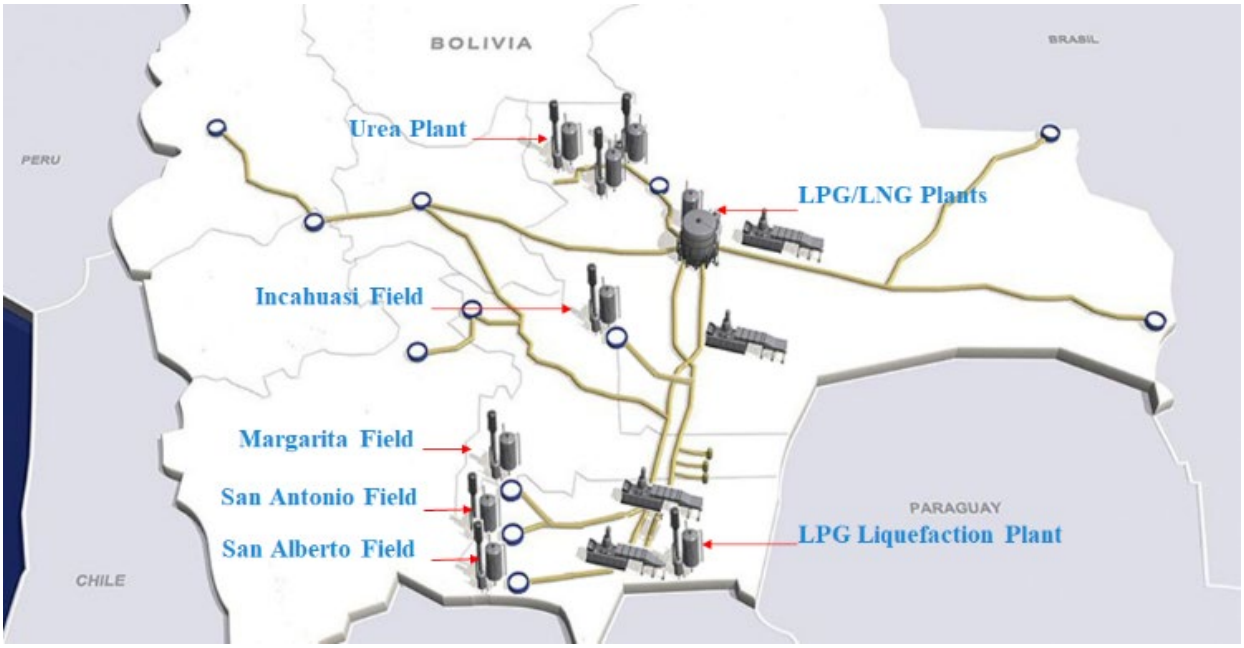

Figure 1. Schematic of Bolivia´s south gas fields and major pipeline systems.

Digital Twin Scope

The integrated model connected:

- Reservoir and well inflow performance
- Multiphase wellbore and gathering system hydraulics
- Gas processing plant performance under reduced operating pressure
- National and export pipeline compression systems

- Midstream LPG extraction plants and market delivery constraints

In this case study, Aspen HYSYS captured processing plant behavior at reduced operating pressure.

Optimization Strategy: Systematic Backpressure Reduction

The core optimization lever was systematic reduction of well backpressure through:

- Lowering sales point pressure using existing, underutilized pipeline compression
- Reducing gas processing plant operating pressure
- Validating equipment integrity, flow assurance and reservoir response
- Iterative nodal analysis across subsurface and surface systems

This approach enabled production gains without installing new compression or modifying well hardware.

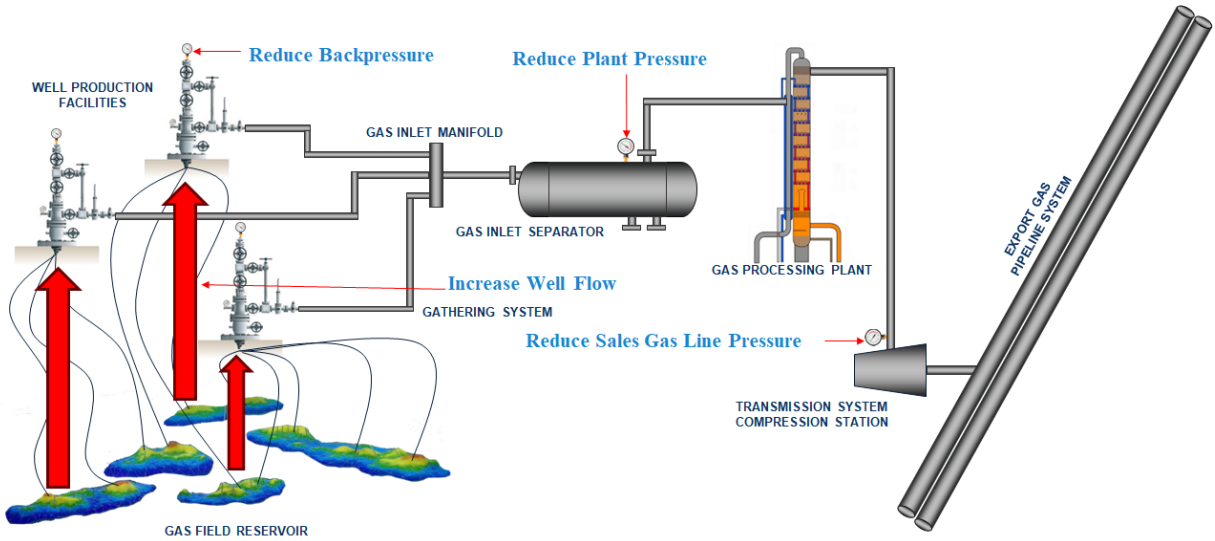

Figure 2. Optimization strategy: Systematic backpressure reduction.

Field Results

San Alberto Field:

- ~8% production increase (≈28 MMscfd) from ~350 psi plant pressure reduction
- Zero capital investment prior to compression project
- Generated ≈ $280MM USD/year in incremental revenue

San Antonio Field:

- ~10.5% production increase (≈46 MMscfd) from ~300 psi sales pressure reduction
- Delayed and downsized compression project
- ≈$70MM USD CAPEX savings

Additional Benefits

- Compressor reuse between fields reduced CAPEX by ≈$30MM USD
- Avoided shutdown of Bolivia's largest LPG extraction plant, saving ≈$255MM USD/year in LPG imports
- Forecast compression savings >$380MM USD across Margarita and Incahuasi fields

This case study demonstrates that integrated digital twins are not theoretical constructs but operational tools capable of delivering national-scale production optimization, capital efficiency and energy security.

Case Study 2 – From Case Study to Capability (Yapacaní and associated fields)

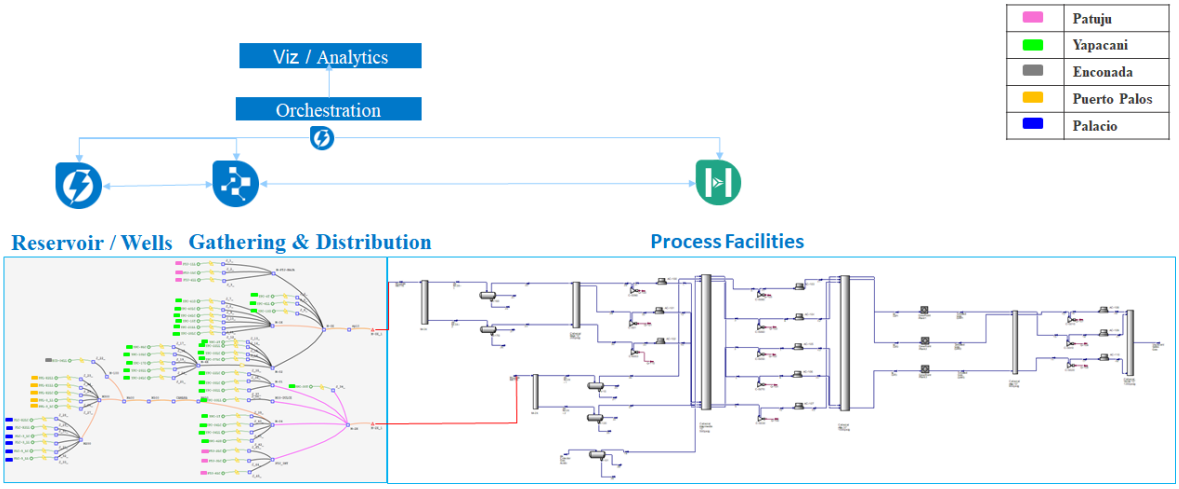

Figure 3. Integrated framework orchestrating simulation models across the suppy chain.

This case study validates the core principles outlined in this white paper:

- Asset-wide orchestration outperforms siloed optimization
- Surface-network constraints often dominate decline-stage performance
- Bayesian and scenario-based optimization can unlock non-obvious value
- Enterprise digital twins enable executive-level, cross-sector decision-making

Core Architecture

The integrated framework is built around an Orchestrator responsible for:

- Connecting simulation tools across domains

- Executing sensitivity and optimization workflows
- Managing computational runs and failure recovery
- Feeding results into unified dashboards
- Evaluating large design spaces efficiently

In the enterprise-grade framework described here, Aspen Tempest serves as the orchestrator for sensitivity studies, Bayesian-style optimization loops, diagnostics and unified analytics dashboards, while Aspen METTE and Aspen HYSYS provide the network and process simulation layers integrated into the end-to-end workflow.

Optimization Methodology

The workflow employs Bayesian Optimization supported by stochastic surrogate models (emulators). This approach enables:

- Efficient exploration of control parameters
- Reduced simulation run requirements
- Quantification of geological and operational uncertainty
- Continuous refinement of predictive accuracy

Key optimization objectives typically include:

- Net Present Value (NPV)
- Gas and oil production rates
- Facility utilization efficiency
- Emissions and energy consumption

Pilot Implementation Overview

The pilot project focused on gas production optimization in declining fields using a fully integrated workflow. The scope included:

- Multi-field subsurface modelling
- Shared surface network integration
- Processing plant simulation

- Economic performance evaluation

Two principal sensitivity scenarios were evaluated:

Scenario 1 – Pipeline Looping

- Analysis of pressure propagation across the entire supply chain
- Impact on compressor performance and gas flow rates
- Identification of high-influence pipelines
- Delivering up to ~15% gas production increase

Scenario 2 – Separator Redirection

- Evaluation of redirecting selected wells from high-pressure to low-pressure separators
- Comparative production performance across network configurations
- Quantified additional ~6% in gas production

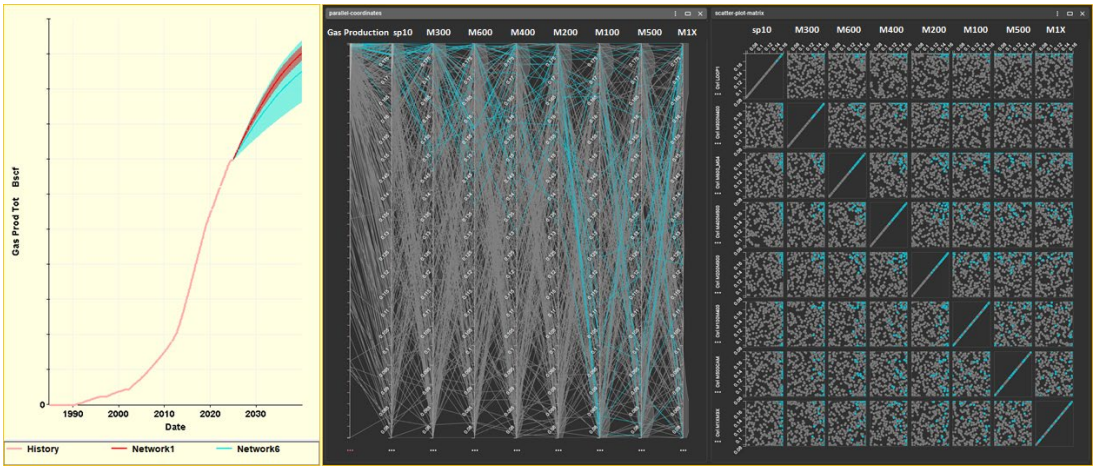

Figure 4. Gas production increased by 15% through pipeline looping (Network 1). Further 6% increase by reducing separator gas pressure (Network 6). Best pipeline candidates for looping are highlighted in cyan.

Key Findings

- Up to ~15% gas production increase from optimized pipeline looping
- Additional ~6% improvement through optimized separator redirection
- Identification of a limited subset of highly influential pipelines
- Enhanced economic returns through improved NPV performance
- Improved decision clarity via unified dashboards

Business Impact

The integrated digital twin approach enables:

- Faster and more reliable decision-making
- Reduced CAPEX through targeted infrastructure investment
- Improved collaboration between technical and management teams
- Scalable deployment across multiple assets
- Risk mitigation under geological and operational uncertainty

Conclusion

Integrated digital twins represent a transformative shift from isolated modelling to asset-wide optimization. By combining Bayesian optimization, multidisciplinary workflows and unified analytics, operators can unlock significant production and economic value even in mature or declining assets. Across the two case studies, Bolivia's south gas fields and Yapacaní and associated fields, the results validate the feasibility, scalability and strategic importance of this approach for national and enterprise-level energy optimization initiatives.

**** Acknowledgments:***

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About Aspen Technology

Aspen Technology, now part of Emerson, is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in asset-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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