The Transformative Power of Integrated Asset Models in Energy and Chemical Industries

Tushar Kamerkar, Jagadesh Donepudi, Michelle Wicmandy

Abstract

The article highlights the significance of Integrated Asset Models (IAM) in the energy and chemical industries, offering a holistic approach for efficient asset management, production optimization, and achieving sustainability goals.

Introduction

Currently, India produces only 15% of the indigenous crude production, leaving the remaining 85% to be imported, as reported by the Ministry of Petroleum & Natural Gas. To achieve self-sufficiency, both exploration and production require significant attention and investment. However, one of the key problems hindering production enhancement in the energy and chemical industries is lack of real-time visibility of operational data from remote wells. To sustain targeted production levels and optimize energy use, continuous monitoring and optimization are needed, especially considering the dynamic behaviour of reservoirs and the aging fields. These efforts are crucial as India aims to approach net zero targets by 2070.

In the energy and chemical industries, decision-making is complex influenced by various factors such as data, biases, and competing interests. With the increasing amount of data and the volatile business environment, decision cycles are being disrupted. Despite these challenges, it is crucial to make better and faster decisions with perfect execution to achieve superior and sustainable results.

Traditionally, reservoir, production and processing facilities have been managed in separate silos, as shown in **Figure 1**. Each silo operates with its own data models and simulation tools. This approach lacks a comprehensive understanding of the landscape, making it difficult to navigate unpredictable conditions and constraints. Dealing with interdependent problems in an isolated manner creates challenges in addressing boundary conditions, domain specific assumptions, and production constraints in both upstream and downstream processing.

To overcome these challenges, a unified platform is necessary. This platform can provide better insights into overall production in real time, such as through a Virtual Flow Meter (VFM) or Production Allocation system. It can also act as an advisor to proactively mitigate flow assurance issues such as hydrates and wax that prevent unwanted production downtime and enable further optimization. Implementing such a

Tushar Kamerkar is Technical Pre-Sales Senior Consultant. He has over 15 years of experience in oil and gas industry with strong simulation background, both steady state and dynamic modelling. Customization using programming and OLE automation, integration of graphical methods, mathematical modelling with process simulation are some of the unique skillsets he has been utilizing for effective implementation of digitalization/ optimization solutions.

Jagadesh Donepudi, (Ph.D Chem Engg, UDCT) serves as Director, India. In this role he focuses on adding value to refineries and upstream oil and gas companies via digitalization, digital twins, and energy transitions. With over three decades of experience in the hydrocarbon Industry, he has consulted with companies like HPCL, Saudi Aramco Engineering, Onward Technologies, INTERCAT AND KBC.

Michelle Wicmandy, DBA, is the Marketing Campaigns Manager. With a rich history spanning over two decades, she brings a diverse skill set cultivated in for-profit, non-profit, and academic environments, specifically in the realms of marketing and communications. She has contributed to both academic and trade publications such as Oxford University Press, Hydrocarbon Engineering, Houston Business Journal, and more.

All three authors are with KBC (A Yokogawa Company)

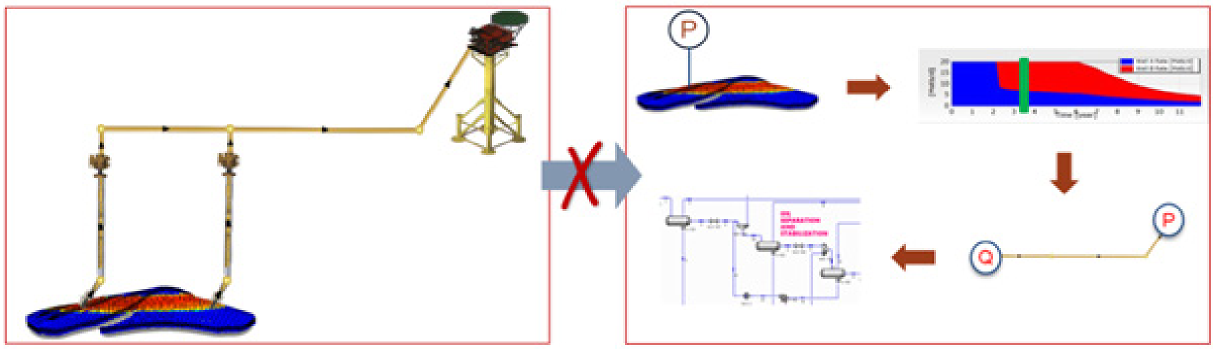

Figure 1: Traditional Approach

platform in this era of decarbonization enables hydrocarbon processing companies to efficiently reach their net zero targets.

Digitalizing oil fields is an efficient way to turn the situation around. A wireless sensor system and Internet of things (IoT) captures field data in central locations. Using this data appropriately in conjunction with advanced analytics can provide better visibility on facility performance, enhancement, and optimization opportunities.

Each perspective is influenced by a series of unique cognitive biases. This situation highlights the need for a single version of truth and analytics to achieve a comprehensive situational awareness and effective organizational decision-making. Dealing with the increasing process plant complexities requires more sophisticated approaches to address key performance indicators (KPIs) and targets. Integrated Asset Models (IAM) and digital twins, which use analytics technology, emerge as a solution by considering multi-dimensional factors and non-linear trade-offs. These technologies overcome the challenges faced in effective decision-making.

Overview Of An Integrated Asset Model

An IAM is an essential tool for the energy and chemical industries. It provides a holistic view of the entire asset and facilitates efficient planning and optimal operations. The IAM breaks down barriers between sub-surface and surface domains and provides insights into complex interactions across these domains as noted below:

- The impact of changing reservoir conditions and fluid composition on the system.
- The interdependencies between wells sharing a common production system.

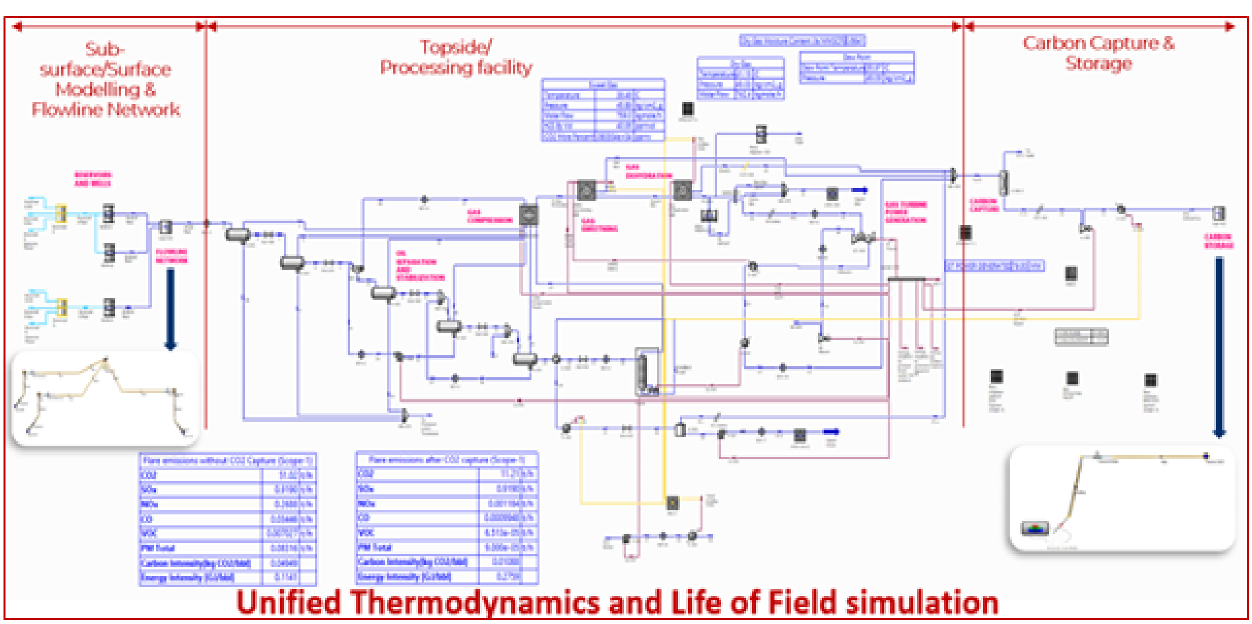

Figure 2: KBC Integrated Asset Model

- The dynamic nature of a field where multiple reservoirs are connected to a common surface facility.
- The impact of gas, water injection / reinjection
- Life-of-field forecast, including both short-term and long-term production forecasts.

A robust thermo-dynamic engine forms the backbone of IAM. Companies with an asset-integrity strategy, supported by IAM/digital twins, not only gain a commercial advantage, but they can also show regulatory compliance while reducing the risk of major incidents.

The success of any simulation model rests on its ability to accurately predict fluid behavior and thermophysical properties across the complete operating range. Effective and accurate fluid modeling is important for all types of simulation models, including reservoir, well, surface and facility models. However, the requirements of each discipline may vary depending on its application. For instance, the detailed composition required for a facility model might be too detailed for reservoir simulation. Therefore, for IAM, fluid behavior and smooth transition between fluid streams are consistently predicted with accuracy across simulation models. The most efficient way to achieve the required consistency is by standardizing the underlying thermodynamic engine throughout IAM.

The IAM is a powerful tool. As demonstrated in **Figure 2**, it can provide accurate and reliable results by evaluating the impact of interdependencies. This capability allows for a comprehensive assessment of a wider spectrum of scenarios, uncertainties, and development opportunities.

An IAM system is instrumental in achieving engineering and production objectives more efficiently. It achieves this by providing a holistic approach to the entire asset, which is vital to deliver the required return on capital, as shown in **Figure 3.**

The IAM's unique feature is its ability to capture the end-to-end simulation of the assets, from the reservoir-to-market, throughout the life-of-the-field. This is accomplished by seamlessly integrating the tools, which facilitates a more effective economic evaluation and portfolio management decisions by employing date-based modelling coupled with cumulative production.

Furthermore, the IAM serves as an operational model designed to maximize production as reservoir and well conditions fluctuate throughout the life of the field.

IAM's capability to run in life-of-field mode enables users to simulate all possible production scenarios in a single run. This unique feature is particularly beneficial for both short-term and long-term field development and planning. It allows for a comprehensive overview of all potential outcomes, thereby enabling more informed decision-making processes.

Furthermore, the IAM functions as a swift and reliable tool for identifying system bottlenecks. It can verify and validate possible debottlenecking measures before they are actually implemented. This preemptive approach provides a reliable means of preventing potential issues before they occur, thus saving time, resources, and potentially averting significant operational disruptions.

Finally, the IAM connected to real-time production data can act as an advisory system in an open-loop mode or be used as an integral part of the closed-loop control system for optimal facility operation.

- **Well Surveillance and Performance Monitoring** IAM enables automated continuous monitoring of well performance, as shown in **Figure 4**. This feature facilitates safe and reliable operation in an efficient manner. Timely alerts on production deferment provide detailed operational insights for well-informed decision. This helps to avoid unwanted facility downtime and production losses, thereby enhancing overall operational efficiency.
- **Production Allocation using VFM** Production allocation is a critical aspect for every operating organization from an accounting perspective. Traditionally, production metering involves using costly instrumentation for multi-phase flow metering. However, a first principle-based simulation modelled approach with minimum instrumentation requirement is gaining intertest for virtual flow measurements.

  The IAM provides flexibility to users to configure the simulation model to be used as a VFM. The outcome of VFM can then be populated on desired dashboarding platform, ERP systems and more. As a result, costs are reduced while data accuracy and reliability are increased, making the operation more efficient.
- **Hydrate formation and Wax Deposition Prediction** enable the IAM to provide solutions for predicting hydrate formation and wax deposition for varying operating conditions in production systems, aiding in flow assurance and pro-

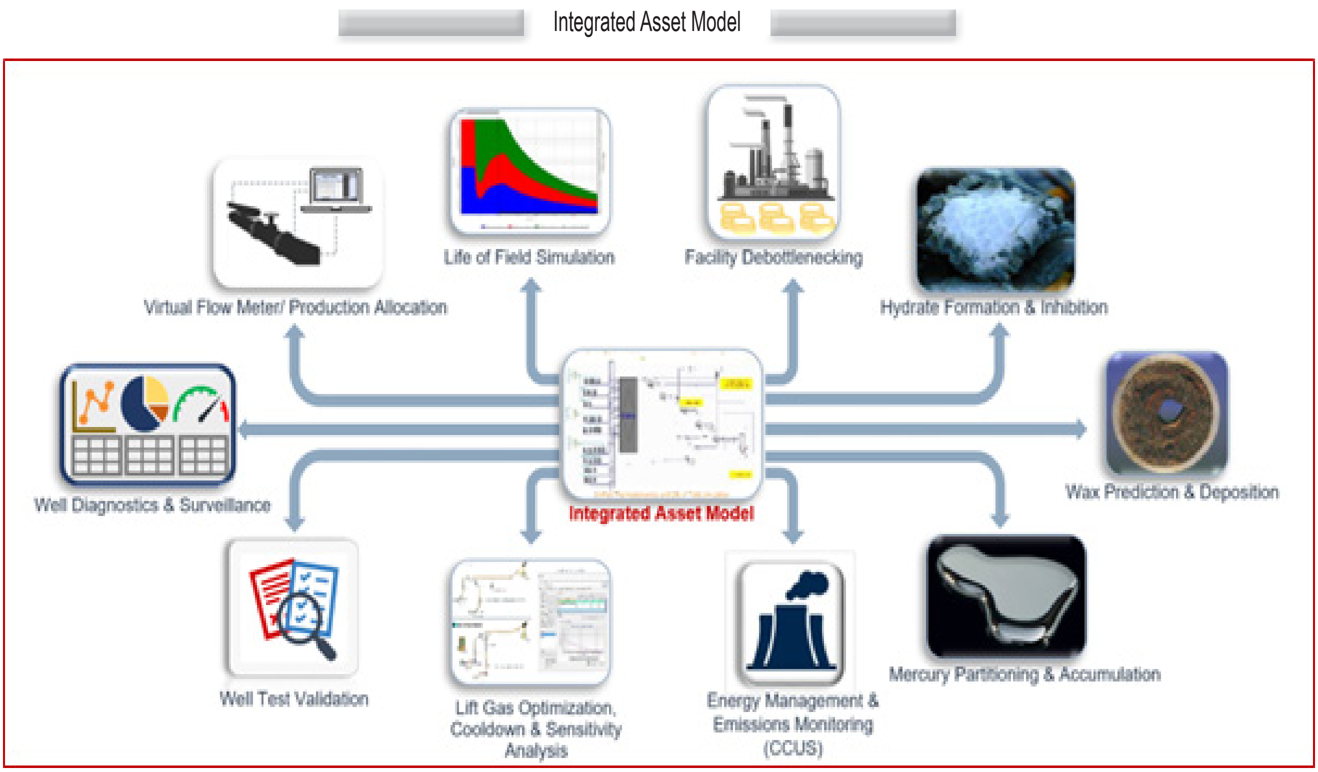

Figure 3: KBC IAM Applications – One Model Many Uses

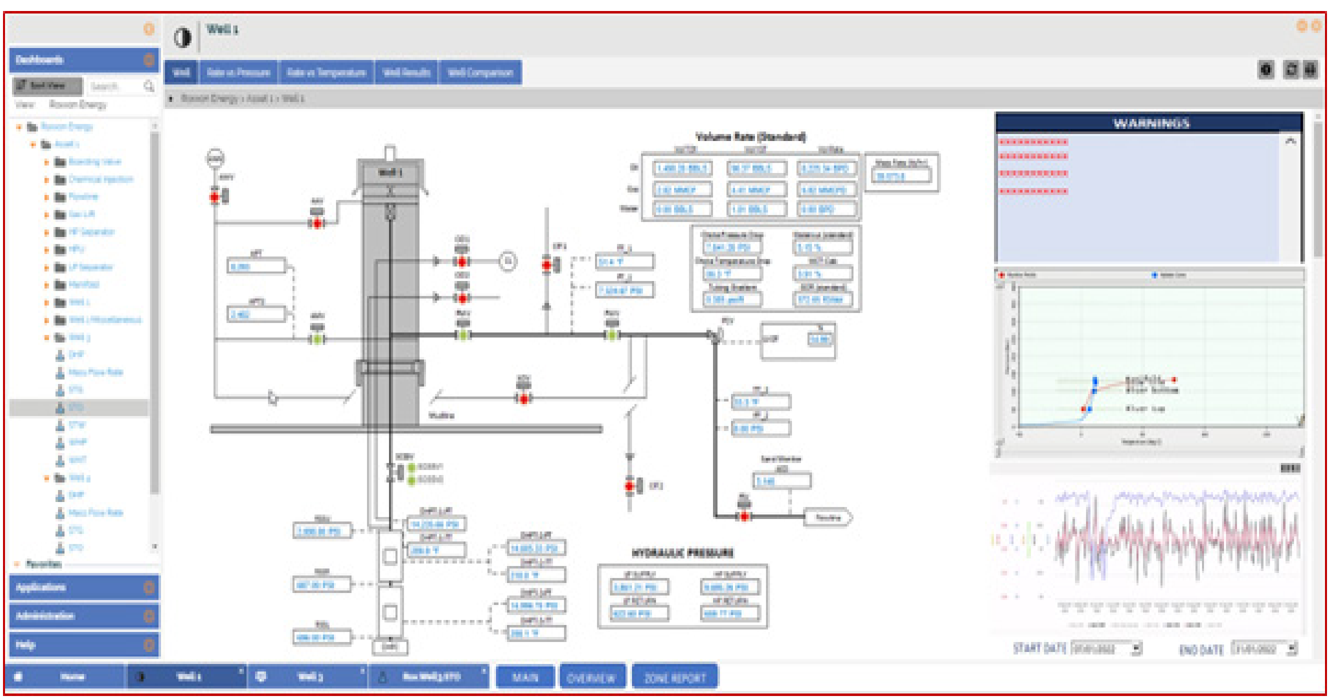

Figure 4: Well and Facility Health Monitoring

duction applications, as shown in **Figure 5.**

- **Hydrate Risk Management Solution** offers a visual integration of simulated and field data to provide operators with valuable production and flow assurance insights. The intricate details of the model are hidden behind the dashboard. Users can access relevant, customized information directly through the interface. Process engineers can monitor pump efficiencies on their dashboard to visualize the selectivity of their acetylene reactor. Separation efficiencies can be tracked. Utility consumption or even losses can be evaluated. Unit monitoring by visualizing performance parameters that are otherwise invisible can be

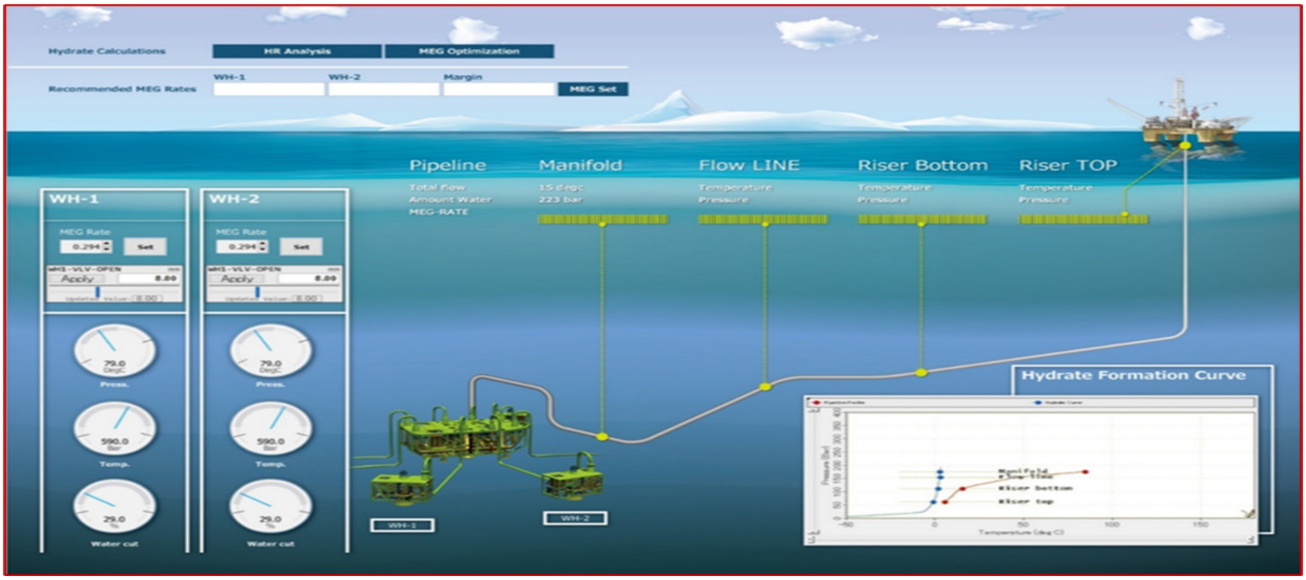

Figure 5: : Flow Assurance Issues Mitigation

enhanced. The IAM aids in identifying additional opportunities for profit improvement to achieve sustainable growth.

- **Estimating wax appearance and wax deposition profile** Wax deposition in the pipeline normally results from a decrease in temperature. As the temperature drops below the wax appearance temperature (WAT), waxes may precipitate from the fluid, forming a separate solid phase. However, the mere appearance of a wax phase might not be sufficient for waxes to form a wax deposit in the pipeline. Wax will deposit along the pipeline, and subsequently may pose a challenge to flow assurance and production, provided the flow conditions allow for such a deposit to form.

As illustrated in **Figure 6**, predicting wax deposition in the pipeline is a result from combining two main factors. The first is the thermodynamic wax precipitation model, and the second is the fluid flow model, which includes the wax deposition mechanism in the pipeline.

The IAM is a robust modelling tool used to estimate the deposition of waxes along pipe branches for multi-phase or single-phase flows in flow assurance and production applications. Leveraging the thermo-hydraulic modelling capabilities and the accurate wax thermodynamics modelling capabilities, the IAM provides flow assurance and production engineers with several key insights. These include accurate estimates of wax deposition location, thickness and volume along the pipeline, pressure and temperature of the

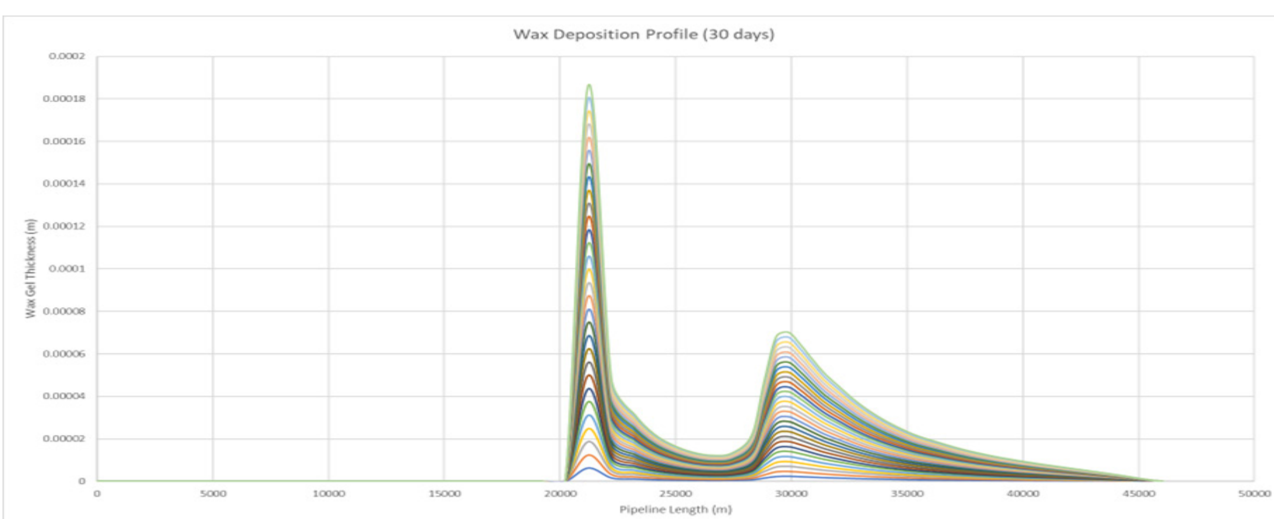

Figure 6: : Prediction of Wax Deposition Along the Pipeline Length

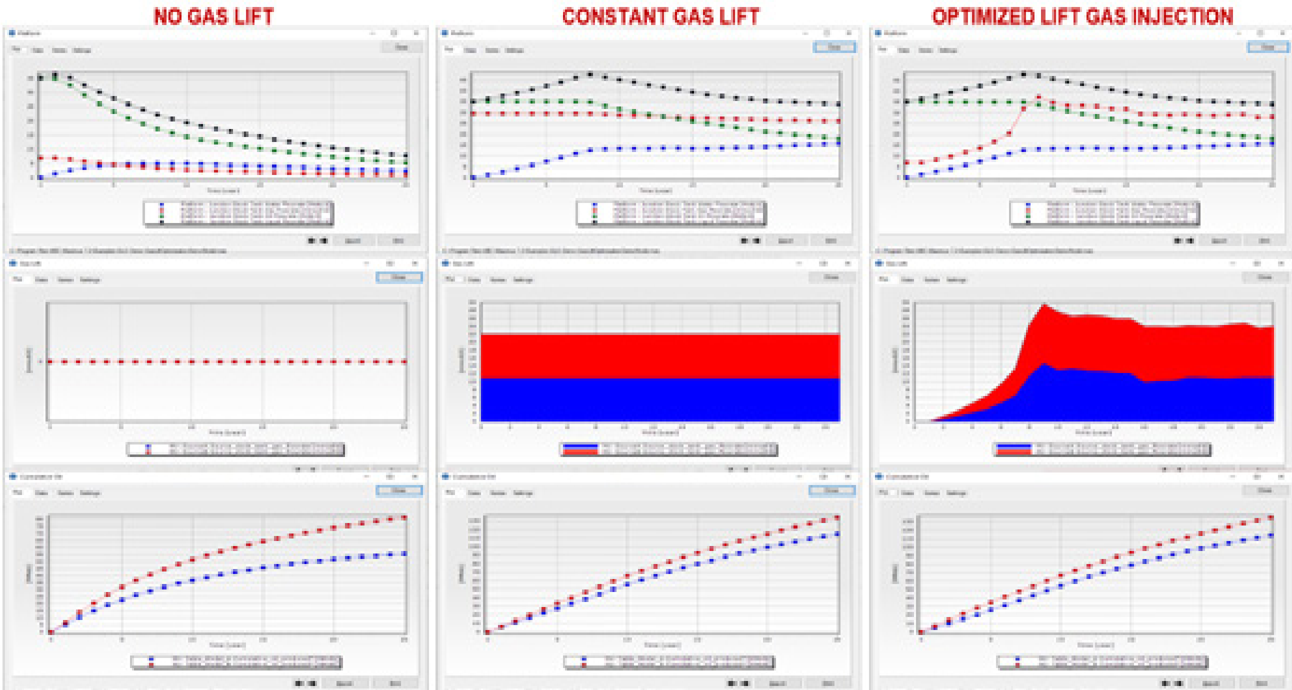

Figure 7: Gas Lift Optimization Benefits Over Asset

bulk fluid, and physical properties such as density, speed, molecular weight, viscosity, and hold-up of the gas, hydrocarbon liquid, and aqueous phase. It also provides information on the evolution of the velocity profile and the frequency of pigging.

- Lift Gas Optimization Gas injection is one of the most deployed enhanced oil recovery (EOR) methods. However, the volume of gas injected plays vital role in optimizing operational expenses. Under-injection of gas can result in sub-optimal oil recovery, whereas over injection not only implies excessive use of injection gas but also leads to additional energy, fuel consumption, and emissions.

The IAM's built-in functionalities enable users to optimize lift gas operation over entire lifecycle of an asset. This is a crucial aspect of the overall process, ensuring efficiency and cost-effectiveness, as shown in **Figure 7**.

Conclusion

In the rapidly evolving oil and gas industry, the IAM system emerges as an essential tool for companies in the oil and gas sector. This comprehensive system allows for efficient management and optimization of assets throughout their lifecycle, from reservoir to market. The IAM's robust thermo-dynamic engine ensures accurate fluid behavior prediction, reducing risks and guaranteeing regulatory compliance.

The system's unique feature of simulating all potential production scenarios in a single run facilitates well-informed decision-making processes both in the short and long term. It also allows for the prevention of system bottlenecks and potential operational disruptions by validating debottlenecking measures in advance.

Furthermore, the IAM connects to real-time production data, serving as an advisory system or part of the closed-loop control system for optimal facility operation. With functionalities like continuous well performance monitoring, production allocation through virtual flow metering, and prediction of hydrate formation and wax deposition, it enhances operational efficiency, reduces costs, and increases data accuracy and reliability.

The IAM is an invaluable tool for energy and chemical companies seeking to maximize their return on capital and achieve sustainable growth.