Plantwide AI optimisation and beyond

Case study shows how Big West Oil's digital transformation journey is spearheading AI-enabled optimisation for margin improvement while training the next generation

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Across the US refining landscape, digital transformation is well underway. Companies face mounting pressure to invest in new ways of unlocking value from the enormous amount of data generated by highly instrumented industrial processes. Continually decreasing data storage and compute costs are exacerbating these pressures. The digital strategies developed in response to this wealth of data have uncovered pathways to rethink unit operations, empowering operators and engineers with robust tools to make better, quicker decisions. These rich data streams can also be leveraged to automate process optimisation in new ways.

Moreover, machine learning (ML) and artificial intelligence (AI) present opportunities to exploit the inherent nonlinearity of refining processes, far beyond the capability of traditional step-testing or linear model-based methods. Yet, many early adopters have found that scaling from pilot programmes to full-plant implementations can be difficult without clear strategies for governance, data quality, and organisational change management.

Big West Oil LLC (Big West) operates a high-conversion 36 MBPD refinery located in North Salt Lake City, Utah. Its team identified the need for a modern process optimisation solution to enhance operational efficiency and help it stay competitive with larger oil and gas companies, benefiting from scale economies and vertical integration.

Big West partnered with AI optimisation (AIO) provider Imubit for this targeted digital transformation journey, beginning with the development and deployment of AI applications targeting key refinery constraints and operational pain points. What started as a means of doing closed-loop process optimisation quickly demonstrated potential in other areas. Beyond the direct economic benefits, the refinery operator has also capitalised on the AI models developed to build internal competencies, thereby training the next generation of operators and engineers.

Challenges

Initially, Big West put its primary focus on optimising the fluidised catalytic cracker (FCC) unit, which had historically been constrained by debutaniser throughput. It believed that alleviating the debutaniser bottleneck would allow operations to maximise conversion, capture higher-value product yields, and thereby improve the overall unit margin.

Beyond the FCC, a broader solution to optimise its diesel pool was desired. This included reducing ultra-low sulphur diesel (ULSD) flash giveaway, hydroprocessing reactor optimisation, molecular management improvements in the crude distillation unit (CDU), as well as correctly accounting for trade-offs between distillate hydrotreating feedstocks as seasonal specifications shifted.

Beyond the economic objectives of closed-loop optimisation, the refiner also recognised the role that technology plays in attracting and retaining the new generation of operators and engineers. Chemical engineers and process technicians experience the best-in-class technology in university programmes, and then frequently find themselves in industry roles operating on technology paradigms of past decades. Introducing AI to all levels of refinery employees in the context of process optimisation demonstrates a commitment to keeping employees and facilities up to date on the latest technological advancements.

Rapid deployment of this modern AIO technology overcame various organisational and technological hurdles along the way. These challenges fell broadly into the buckets of data governance and infrastructure, change management, and scale.

❶ Data quality and governance

High-fidelity historical data is crucial for training deep learning models. Data compression, missing data, and infrequent setpoint changes can limit the model's ability to capture the full range of useful process variability. Companies considering this type of solution should consider de-compressing data where resources allow. Since training deep learning controllers requires learning the process relationships between signals, it is best to have many years of historical data capturing different modes of operation in different economic cycles or feedstock incentives. This helps ensure that there is setpoint movement over time, which is key to creation of a robust data-based controller. If setpoints are stagnant over the full historised life of a unit, the AI model will fail to learn the full extent of potential process relationships. As Big West began exploring AIO solutions, it found that its historical data was compressed in a way that would hinder AI models from learning relationships. The team first had to overcome the hurdle of changing how data was stored before the project could move forward.

❷ Resistance to change

Despite the promise and proven success of AI solutions, there is inherent resistance to change when deploying any

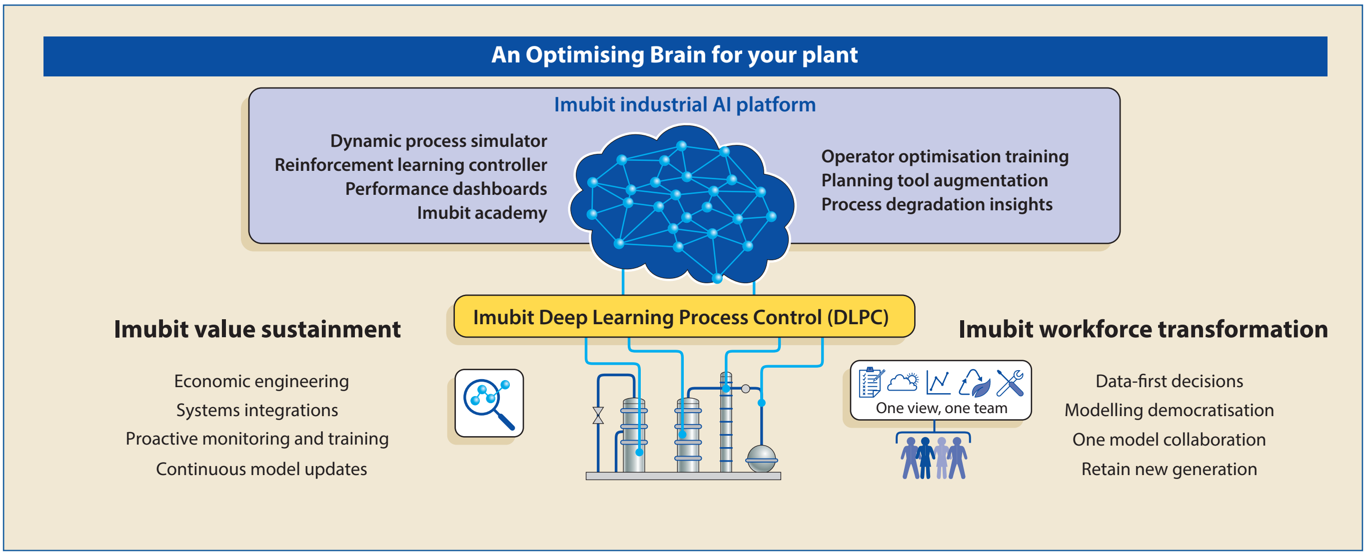

Figure 1 Architecture of the closed loop AI optimisation solution implemented sitewide at Big West

new technology. There is the familiar and comfortable status quo way of working and the need to understand any technology that could impact productivity, quality, reliability, or safety.

For some, it can be difficult to overcome the perception of AI as a 'black box'. Traditional, typically linear models are well accepted in refining, thanks to their well-understood and easy-to-explain nature. But the class of deep neural networks capable of solving the industry's toughest, most nonlinear problems are understood by a much smaller subset of the population. To overcome this complexity, AI solutions must build in explainability functionality, such as providing a sandbox for simulation and validation of process relationships.

The solution to overcome both of these change objections is conceptually simple. Build trust. Build it early and build it often. For AI-based closed-loop optimisation in particular, build the deepest trust with the people in the organisation who have the ability to turn off the technology – operations. Ensuring transparency, involving all affected people, and providing thorough training on the technology and explainability features throughout the project lifecycle is crucial. Without a well-planned change management strategy designed around building trust in technology, workforce scepticism may hinder or delay adoption.

Early buy-in was accomplished by first implementing a relatively simple model to debottleneck the debutaniser tower. The functionality of the model was easy to comprehend for the Big West team, who were newcomers to the technology. They intuitively understood the moves that the AI controller was making, and the results were immediate. Within a day or two, tower operation was significantly improved, leaving room to increase throughput in the tower. This built immediate confidence in the technology.

❸ Scalability

Big West envisioned sitewide implementation of AIO technology, which presented a need for foundational IT infrastructure and standard processes for application development and deployment. It also meant there would be variability in model complexity across units. One of the advantages seen in partnering with a technology provider for this venture was the ability to leverage the experience and best practices developed over technology deployments at companies of various sizes to ensure consistent governance across multiple projects in accordance with site change management practices. This proved essential for sustainable scale-up.

By addressing these challenges, this refiner was able to move forward with implementing a solution that would simultaneously boost profitability and establish a forward-looking operational culture – one equipped to handle evolving market demands and technological advancements.

Solution to process and people challenges

The challenges this refinery in Utah was looking to solve were centred around nonlinear, complex refining systems that, in some cases, overlapped several processing units. AIO technology (see **Figure 1**) was developed with these challenges in mind and has been proven, with more than 90 applications in the refining industry. The AIO model is developed in the following sequence:

❶ Inferentials

Built from years of operating and lab sample data, inferentials serve as continuous indicators of otherwise slow sampled variables. They may also be used to represent a parameter that is not instrumented but can be readily calculated from other correlated variables. Beyond their use in the development of the closed-loop optimiser, these inferentials are being leveraged in other ways, such as determining when products can be switched to on-spec rundown tanks during start-ups, saving hours of slopping valuable products.

❷ Dynamic process simulator

Using historical data and advanced modelling techniques, a deep neural network is created to provide a high-fidelity representation of the process. This process model serves as the training environment for the controller to acquire the necessary knowledge to always drive to a global optimum. The simulator has also served as an offline sandbox at the facility, where engineers can run 'what-if' scenarios to simulate the outcome of potential operating scenarios before making recommendations to operations.

❸ Reinforcement learning controller
The dynamic process simulator is used as the training environment for the application of advanced reinforcement learning techniques, which teach the controller how to manipulate key control handles to optimise the process within user-defined constraints. The controller undergoes hundreds of thousands of simulations in this process model, enabling it to learn not only from every operating scenario experienced in the recorded history of the plant, but also from hypothetical scenarios. Once trained, the controller takes two forms: the on-premises model connected to site advanced process control (APC) or distributed control systems (DCS), and an offline copy in the cloud. The on-premises model is fully isolated from the cloud training and development environment, ensuring compliance with site safety and cybersecurity standards. The offline model provides another playground for operators and engineers to use the trained AI model to explore different strategies while anticipating the system response to new constraints or conditions.

Success
Collaboration with the technology partner on application design drew on the expertise of console operators, process engineers, and leadership. This scoping process helped define true operational pain points while fostering ownership and buy-in. During commissioning, they received hands-on training for operators, focusing on interactions with the application, such as setting constraints and targets effectively and understanding how to interpret controller adjustments. Meanwhile, the engineering team used the cloud-based industrial AI platform for real-time monitoring and 'what-if' scenario analysis.

Unlike one-time optimisation projects, this AIO solution incorporates ongoing support through routine check-ins with operations, engineering, and leadership teams. This collaborative support process identifies new opportunities, addresses model performance shifts, and maintains alignment with the refinery's key performance indicators (KPIs). By embedding governance structures and open feedback channels, Big West has been able to sustain high application engagement and ensure continuous value generation from the technology.

Case studies
One of the keys to successful sitewide adoption of AIO was its ability to capture and communicate its positive outcomes. Some of these successes drove curiosity across units at the site through significant operations improvements to throughput or quality. Other times, the benefits were softer. Operations began to question the status quo and leverage the AI models to answer questions like What if we could push more flow through this valve that's always constraining us? What would that do for overall unit throughput and our objective function? With the technology necessary to optimise to the current physical constraints of the unit, operations and engineering were quickly identifying the next debottlenecking opportunity.

Case study 1: Debutaniser throughput optimisation
The FCC debutaniser provides a final separation of the heavier components of the fractionator overhead stream, producing a cat (catalytic cracker) gas stream and an olefin stream. Since cat gas is typically a more valuable product, there is an economic incentive to minimise excess olefin production, beyond what is required to fill the alkylation (alky) unit. Furthermore, cat gas Reid vapour pressure (RVP) minimisation is critical for maximising the volume of butane upgraded into the gasoline pool. Historically, these two incentives drove operators to maximise debutaniser reflux while simultaneously maximising reboiler duty to product specifications or flooding constraints.

- **Challenge:** The undersized debutaniser tower almost constantly ran near or beyond the flood point, leading to difficulty maintaining clean separation and producing on-spec products. The debutaniser bottleneck frequently limited the FCC conversion, and a more conservative operational approach was taken that prioritised keeping the tower out of flood and maintaining stable operation over pushing to constraints. However, this approach lacked both consistency and robustness. Operators frequently adjusted tower operation due to unpredictable flooding, leading to additional suboptimal time following the event, dialling in the tower to bring products back on spec. There was no consistent framework to address these issues, which led to variability in results depending on the operator running the console at the time.

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- **Solution:** Big West had two primary control handles – reboiler duty and the temperature at the reflux return – to address flood control and yield optimisation. Collaboratively with Imubit, the team designed an AIO application for the debutaniser, leveraging the previously mentioned process. It calculated the necessary inferentials, created a process model, and put that model through the rigour of years of simulated experience via reinforcement learning. The result was a closed-loop optimiser that leveraged that experience to control the debutaniser and achieve the desired economic strategy. Operations engagement was imperative to this model-building process. Senior operators validated model predictions and participated in training sessions, which boosted confidence and buy-in.
- **Results:** As a result, the debutaniser achieved a 2% increase in throughput, mitigating previous FCC conversion

limits. By shifting more C_5 material into cat gas, excess olefin production was also reduced, improving gasoline blending flexibility. This early success with the debutaniser established credibility for AI-driven optimisation and paved the way for subsequent successes.

Case study 2: Diesel flash optimisation

- **Background:** Crude distillate and light cycle oil (LCO) from the FCC are dewaxed and desulphurised at the facility through a series of hydrotreating steps. The hydrotreated distillate is then stripped of light material in the hydrodesulphurisation (HDS) stripper, where the net overhead is routed to the reforming unit.
- **Challenge:** Typically, there are significant economic implications of minimising HDS stripper naphtha to a ULSD flash specification limit. Historically, the site operated with a 5-10°F buffer above specification due to frequent tower flooding and concerns of measurement variability. This conservative operation limited diesel throughput, raising naphtha production.
- **Solution:** Big West engineers worked with Imubit's delivery team to identify the two critical handles: reboiler return temperature and overhead temperature. These two handles together drive tower separation through manipulating the tower's heat balance. As part of the application delivery, a robust ULSD flash inferential was built, a key enabler that provided accurate real-time flash predictions.
- **Results:** Upon deployment of the HDS stripper AIO application, flash variability decreased significantly. These consistent, accurate predictions gave the operations team the confidence to run less conservatively, methodically lowering the flash target closer to the specification limit. The incremental closing of the gap between the flash target and spec limit ultimately reduced giveaway by approximately 4-5°F.

Case study 3: Operator optimisation training

- **Challenge:** Big West's prior operator training programme involved on-the-job learning, shadowing others on shift. This led to a new operator's development being restricted to the knowledge and experience of the person who came before them. There was awareness of the operator training simulator (OTS) market. However, these solutions tended to be costly and generic to a type of unit operation rather than a site's specific operations. Large, integrated energy companies often maintain these systems through a centralised team, which was not feasible for a single-site refinery like Big West.
- **An 'aha' moment:** As the console operators gained familiarity with the FCC debutaniser AIO application, they began to recognise that a solution to tower optimisation could involve a combination of simultaneous, continuous adjustments, which outperformed the legacy approach of making step changes followed by resampling. This new way of approaching distillation optimisation began spreading to other operating consoles where AIO had not yet been rolled out. To further institutionalise this data-driven culture, Big West sought to incorporate its cloud-based AIO models for formal operator training in process optimisation.
- **Solution:** By embedding common operational scenarios, such as feed rate changes, cooling disruptions, and reflux limitations, directly into the existing AIO controllers, operators could then run these 'what-if' scenarios in a controlled, offline environment, inputting how they would respond to specific upsets to get the unit back to a stable and optimal state while still meeting product specifications.
- **Results:** As operators competed to achieve the best economic outcome, training sessions became interactive and engaging. This hands-on learning approach not only improved practical skills but also shifted the refinery's culture to embrace AI-supported optimisation. Big West has since extended this training methodology to other process units, further enhancing its workforce development strategy.

Conclusions

By moving beyond traditional linear controls and siloed strategies, the refiner consistently identified and relieved bottlenecks, such as the debutaniser constraint, while tightening key specifications, like diesel flash, to reclaim lost margins. Equally important, the refinery successfully integrated a robust change-management framework, enabling operators and engineers to trust, adopt, and fully leverage advanced AI-based applications.

Moreover, a holistic approach to AI adoption extends well past the immediate closed-loop gains. By utilising the cloud-based platform for operator training and scenario planning, the refinery has cultivated an environment where data-driven decision-making is the norm. This investment in workforce development ensures that both current and future teams are prepared to navigate increasingly complex refining conditions.

Looking ahead, refinery management aims to expand the scope of its AIO deployment, applying AI-enabled optimisation solutions to additional refining units. As market demands shift, whether due to seasonal product specification changes, opportunistic feedstocks, or decarbonisation initiatives, refiners that harness next-generation technology solutions will be best positioned to adapt. In that sense, Big West Oil's experience offers a roadmap for any refinery seeking to enhance margins, reduce downtime, and build an agile, tech-savvy workforce ready to tackle tomorrow's challenges.

Travis Legrande is Operations Technical Specialist at Big West Oil LLC. His current role builds on 14 years of expertise and a demonstrated history of working in the oil and energy industry. He is a seasoned process engineer with a chemical engineering degree from the University of Utah. Legrande has a proven track record of optimising unit economics, ensuring safety compliance, and successfully managing complex projects to enhance refinery efficiency, safety, and profitability.

Mitchell McCloud is a Solution Manager Portfolio Lead at Imubit. With nearly a decade of experience in refinery process engineering, operations, and industrial optimisation, he has led AI-driven optimisation projects and customer success initiatives, helping industrial clients maximise value through advanced technology. His work focuses on process optimisation, AI applications, and strategic efficiency improvements. McCloud holds a BS in chemical engineering from Mississippi State University and an MBA with business analytics focus from Auburn University.