



KASHMIR
INTELLIGENCE

CASE STUDY

\$119K Annual Savings Through Simulation-Driven Process Optimisation in Hydrotreater Operations

Industry - Oil and Gas



Goals

Hydrotreating is a widely used chemical process for removing sulfur from natural gas and refined petroleum products. This study, using a simulation of the Reliance Jamnagar Refinery, aims to:

- Optimise the process using the Orbital foundation model within the DWSIM simulator, comparing its performance against best-in-class alternatives, including Linear Programming and Ensemble methods.
- Leverage Orbital's recommendation engine to optimise for reduced total input energy while maintaining consistent product quality specifications.

Challenges

- **Complexity:** Modeling the intricacies of the refinery process presents significant challenges due to its inherent complexity.
- **Physical Constraints and Interpretability:** Refinery processes are governed by physical and chemical laws. Deep neural networks are often black-box models, making it difficult to incorporate domain knowledge or ensure they obey these constraints.
- **Generalisation:** Refinery processes may face unseen conditions (e.g., changes in feedstock or equipment). Neural networks can struggle to generalize to unseen or rare scenarios.

Results

Energy Consumption

16.56% reduction in energy intensity was achieved, representing a significant efficiency improvement.

Annual Cost Savings

Energy optimisation is projected to yield annual cost savings of **\$118,634.70**.

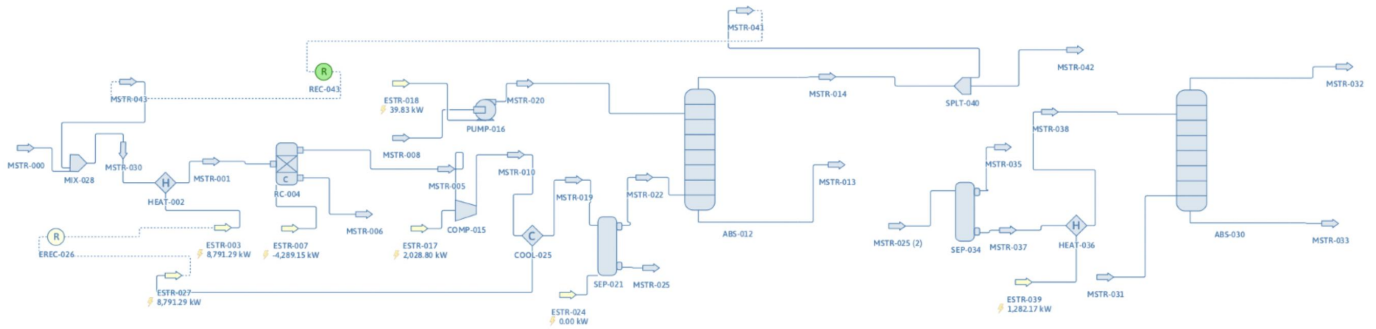
Carbon Emissions

Based on the energy optimisation, an estimated reduction of **967.95** metric tonnes of CO₂ emissions annually.



Process Background

The high sulphur content in crude oil presents major challenges in refining, particularly in processes like fluidised catalytic cracking and platforming, where it can poison catalysts and hinder efficiency. Furthermore, stringent regulations on SOx emissions require the effective removal of sulphur from fuels to meet environmental standards and improve product quality.



Technical Architecture

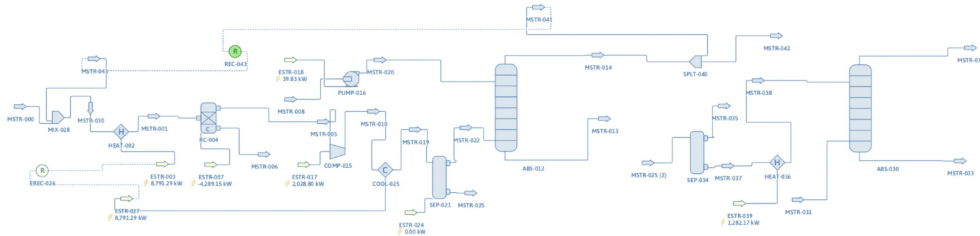
Orbital is an on-prem foundation model that can operate on small edge devices. It is designed to learn generalisable representations from all refinery data, which are then repurposed for recommendations and process optimisation. Orbital was deployed within the DWSIM Chemical Process Simulator, enabling the modelling and optimisation of the process to reduce energy intensity while ensuring that all purity standards were met.

Steps necessary to run the experiment were as follows

- 1 Data Collection**
Process data was generated by running the simulator with varying input feeds at set intervals, capturing data for both training and testing phases.
- 2 Model Training**
Orbital's patented learning algorithms were used to train the foundation model, along with the prediction and recommendation submodels. The goal was to predict product purity and recommend unit variables to reduce energy consumption. The condition was set to achieve a product purity deviation of less than 0.005 MSE from the actual value, while lowering energy usage for each simulation run.



Process flow simulation
(Data Generation)



Feed Composition
(Mole Fractions)

| | |
|-----------------------|-----------|
| Hydrogen Sulfide | 0.0754572 |
| Methylethanolamine | 0 |
| Methyl DiEthanolAmine | 0.923249 |
| Water | 0 |

Unit process parameters

| | Temperature (C) | Pressure (bar) |
|----------|-----------------|----------------|
| MSTR-000 | 25 | 1.01325 |
| MSTR-043 | 14.623 | 90 |

| | Heat Added (kW) | Efficiency (%) |
|----------|-----------------|----------------|
| HEAT-002 | 2569.1 | 100 |

| | Rotation Speed (RPM) | Outlet Pressure (bar) |
|----------|----------------------|-----------------------|
| COMP-015 | 1500 | 90 |

| | Outlet Pressure (bar) | Efficiency (%) |
|----------|-----------------------|----------------|
| PUMP-016 | 80 | 100 |

| | Outlet Temperature (C) | Efficiency (%) |
|----------|------------------------|----------------|
| COOL-025 | 25 | 100 |

Input Energy (KW) per Unit



Product
(Mass Fractions)



Feedback

New Unit Process Parameters



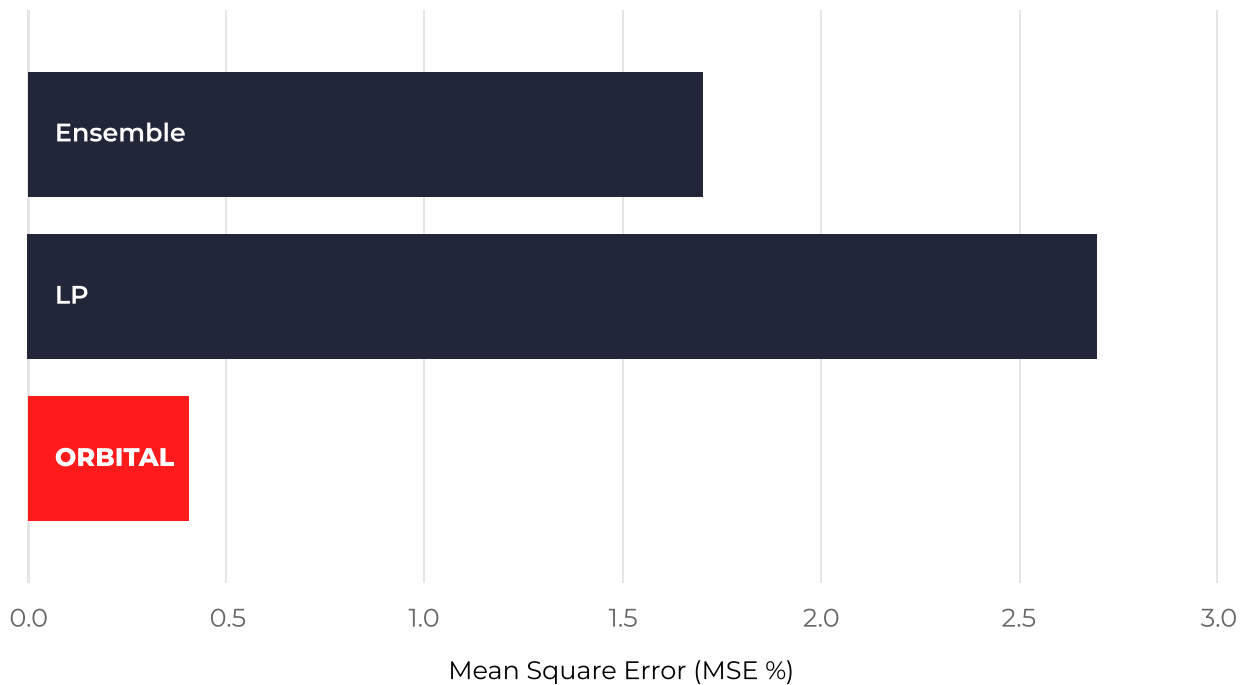
Conclusions

This simulation-based study demonstrated the significant potential of decentralised deep learning in reducing energy intensity in refinery operations. Orbital's predictive models outperformed traditional methods, providing a more efficient approach to optimising energy use.

Model Performance

- **85%** improvement over linear programming (LP) methods in predicting product metrics.
- **76%** improvement over ensemble methods in predicting product metrics.

Performance Comparison (Hydrotreater)



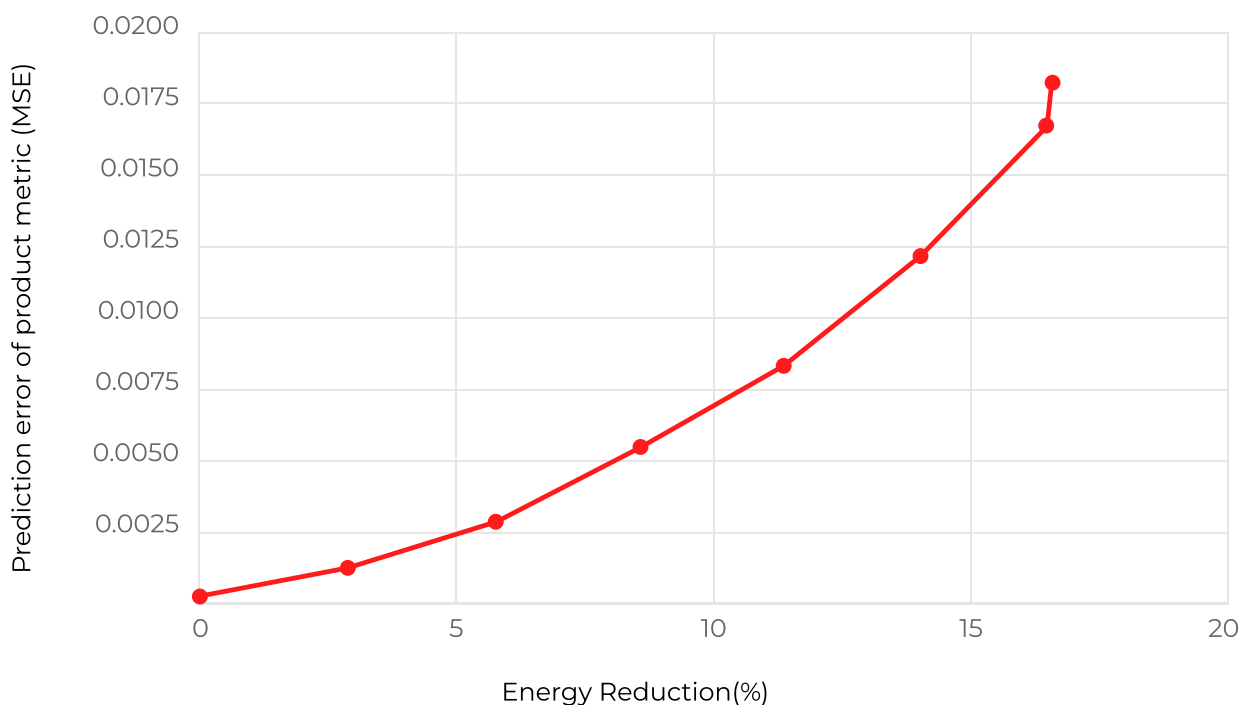
Displaying the % error of models predicting product metrics with unit process parameters as inputs. Evidently Orbital is able to replicate the simulation with less than 1% error



Energy Consumption Performance

Orbital's deep learning models optimised the process, leading to a projected reduction of **16.56%** in energy intensity. This reduction was achieved while maintaining all purity requirements, demonstrating the effectiveness of AI-driven solutions in energy optimisation.

Recommendation Mean Square Error (MSE)



Showing predicted vs. actual product metric deviation using Orbital's recommended process parameters, with energy controlled in 5% steps. Orbital reduces energy by 18% with only a 0.0030 deviation in mass fraction.

Projected Cost Savings

The projected energy savings equates to an annual cost savings of **\$118,634**, alongside a significant reduction in carbon emissions. Orbital's recommendation system was able to suggest operational inputs that aligned with energy-saving objectives while ensuring optimal product performance.

Emissions Reduction

Showcasing the effectiveness of AI-driven optimisation in reducing the carbon footprint of refinery operations, Orbital's deep learning models optimised the process. The reduced energy usage leads to an estimated annual reduction of **967.95** metric tons of CO₂, based on natural gas as a fuel source.





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