KASHMIR
INTELLIGENCE

CASE STUDY

$2.53M Savings Through Simulation-Enhanced Efficiency in Natural Gas Processing

Industry - Oil and Gas

Goals

Processing natural gas into LPG, pentane, naphtha, and lean gas is a crucial operation in the energy industry. This study 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.

Results

Energy Consumption

19.57% reduction in energy intensity was achieved, representing a significant efficiency improvement.

Annual Cost Savings

Energy optimisation is projected to yield annual cost savings of **$2,528,656.72**

Yield Purity

Process optimisations improved yield purity by **7%**

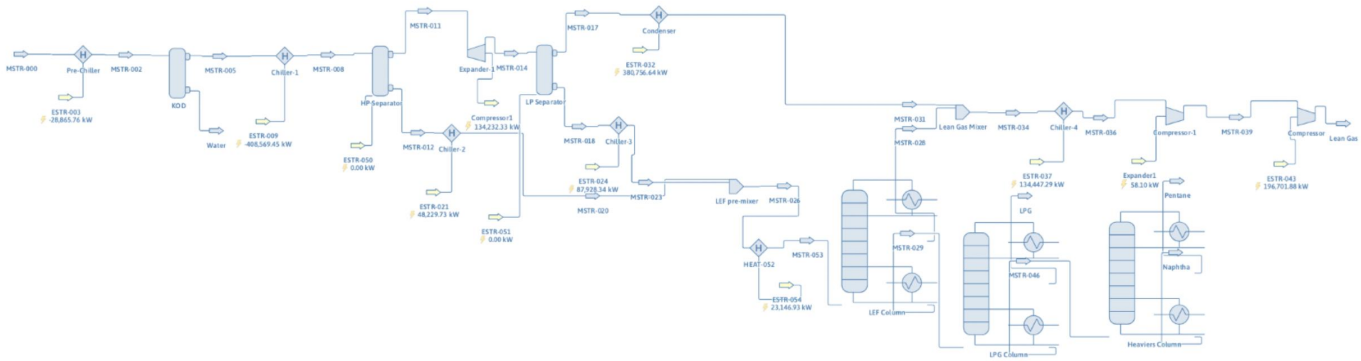
Challenges

- **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.

ORBITAL

Background

The Gandhar plant of GAIL processes natural gas supplied by ONGC to produce LPG, pentane, and lean gas. Designed by Engineers India Ltd. (EIL) and incorporating equipment from various licensors like SOLAR Turbines Inc., Linde, and others, the plant operates with a design capacity of 5.0 MMSCMD.



Orbital's Implementation

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

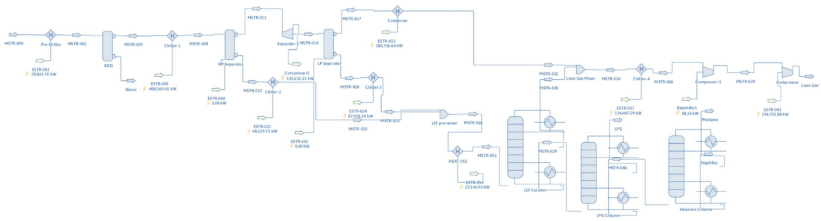
1 **Data Collection**

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)

Methane	0.86048371
Ethane	0.05636618
Propane	0.034579252
Isobutane	0
N-butane	0.015690586
Isopentane	0.0022986208
N-pentane	0.0022986208
N-hextane	0.0033979612
N-heptane	0
Nitrogen	0.0024985009
Carbon dioxide	0.022386568

Unit process parameters

	Outlet Temp (C)	Heat Added (KW)
Heater-A	475	797.09106
Heater-B	300	276.21157
Heater-C	35	37.86427

	Outlet Temp (C)	Heat Removed (KW)
Cooler-A	10	1045.4222
Cooler-B	30	272.99927
Cooler-C	25	-19.458895

	Reflux/Boil-Up Ratio	Molar Flow Rate
Distillation Col-A	10	6.7177154
Distillation Col-B	3	1.9519258
Distillation Col-C	5	6

	Temperature (C)	Molar Flow Rate
S-1	25	3

Input Energy (KW) per Unit

ORBITAL
FOUNDATION MODEL

Recommender

Product
(Mass Fractions)

Predictor

Feedback

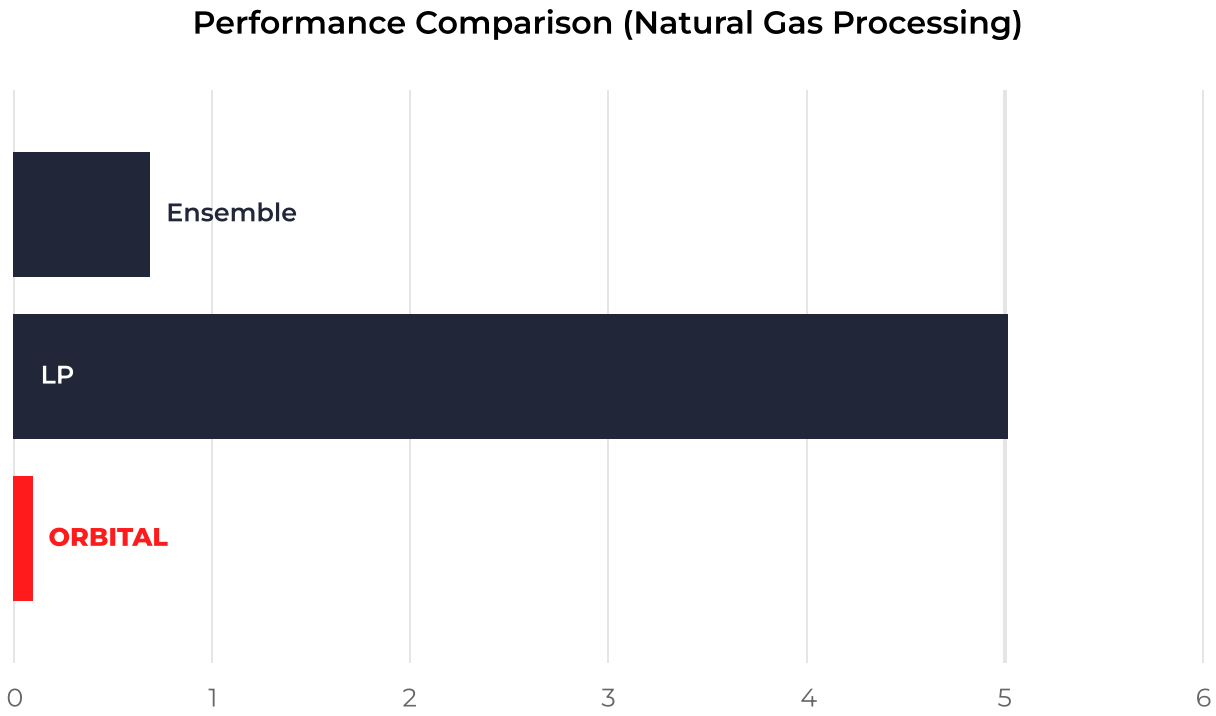
New Unit Process Parameters

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

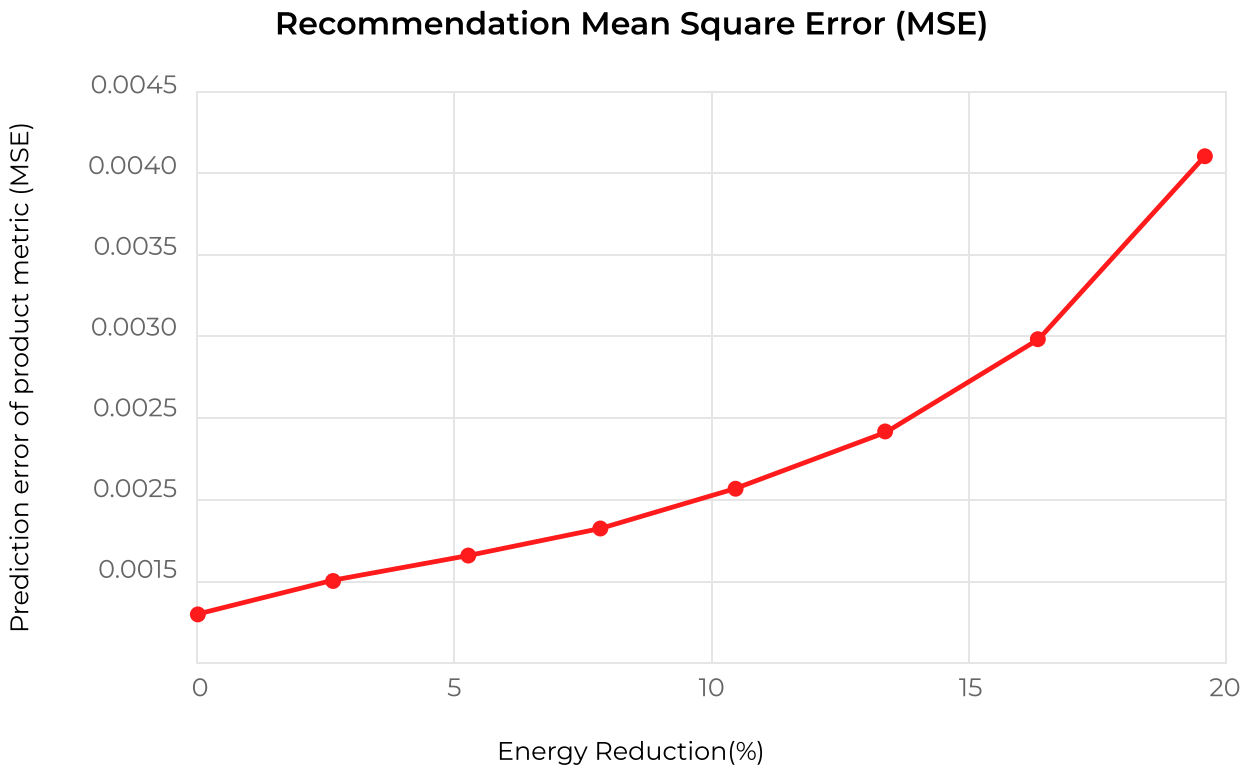
- **98%** improvement over linear programming (LP) methods in predicting product metrics and energy usage.
- **86%** improvement over ensemble methods in predicting product outcomes and energy savings.



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 **19.57%** in energy intensity. This reduction was achieved while maintaining all purity requirements, demonstrating the effectiveness of AI-driven solutions in energy optimisation.



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.

Product Purity Performance

Orbital's optimisations led to significant improvements in product purity. Yield purity increased by **7%**, demonstrating enhanced quality in the final products. Additionally, the model exhibited exceptional predictive accuracy, with a **99.3%** precision in forecasting yield.

Projected Cost Savings

The projected energy savings equates to an annual cost savings of **$2,528,656.72**, 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.

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Edge AI infrastructure for the Energy Industry

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