CASE STUDY

Orbital Achieves 53.7% Improvement in CO_2 Concentration Prediction Accuracy

Industry - Oil and Gas

Goals

The Imperial College ABB Carbon Capture Pilot Plant is a research-scale facility designed to demonstrate post-combustion CO_2 capture using monoethanolamine (MEA) solvent systems. This study aimed to:

- Improve upon CO_2 concentration prediction against Imperial's State-Of-The-Art Model
- Benchmark Orbital's performance against current state-of-the-art simulation-based optimisation and anomaly detection methods (e.g., TimesNet, DAE-LSTM).

Results

Anomaly Detection

Orbital's predictive models achieved **99.1%** accuracy in early failure detection, outperforming Anomaly Transformer and VAE-LSTM in both precision and recall.

CO_2 Concentration Forecasting

Orbital achieved a **53.7%** improvement in CO_2 concentration prediction versus internal models

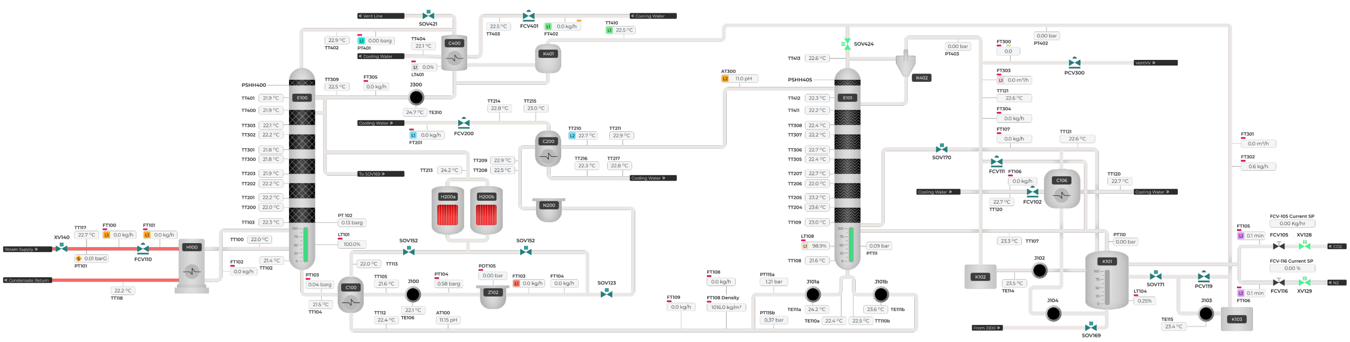
Challenges

- **Dynamic Process Behaviour:** The absorber and stripper columns operate under varying gas and solvent flowrates, requiring robust control strategies to maintain stable CO_2 capture.
- **Thermodynamic Complexity:** Accurate modelling of the CO_2–MEA–H_2O system requires reliable VLE predictions. The ENRTL framework was selected for its proven accuracy in simulating MEA systems.
- **Operational Constraints:** Flooding in absorber stages, solvent degradation, and energy penalties in the reboiler impose strict physical and safety limits.
- **Data Quality and Generalisation:** Ensuring the model performed reliably across diverse operating regimes is critical for producing trustworthy recommendations

IMPERIAL ABB ORBITAL

Process Background

The pilot plant simulates a full post-combustion carbon capture loop. Flue gas enters the absorber column (E101), where CO_2 is absorbed by lean MEA. The rich MEA is then pre-heated and sent to the stripper column (E100), where CO_2 is desorbed and sent to storage. The regenerated MEA is recycled back to the absorber.



Technical Architecture

Orbital was deployed on-premise and integrated with Aspen Plus for real-time simulation and optimisation. The system was trained using historical and simulated data from the pilot plant, including temperature, pressure, flow, and gas composition variables.

Steps to Run the Experiment:

1. **Data Collection**

   Time-series data from sensors (e.g., TIR, PIR, AIR tags) was collected under varying gas and solvent flowrates.

2. **Model Training**

   Orbital's foundation model was trained to predict CO_2 capture rate. The recommendation engine was tuned to suggest optimal flowrates and temperatures to maximise capture while minimising energy use.

3. **Anomaly Detection**

   Using labelled data (Classes 0–4), Orbital detected early-stage anomalies with high accuracy, enabling proactive maintenance and process stability.

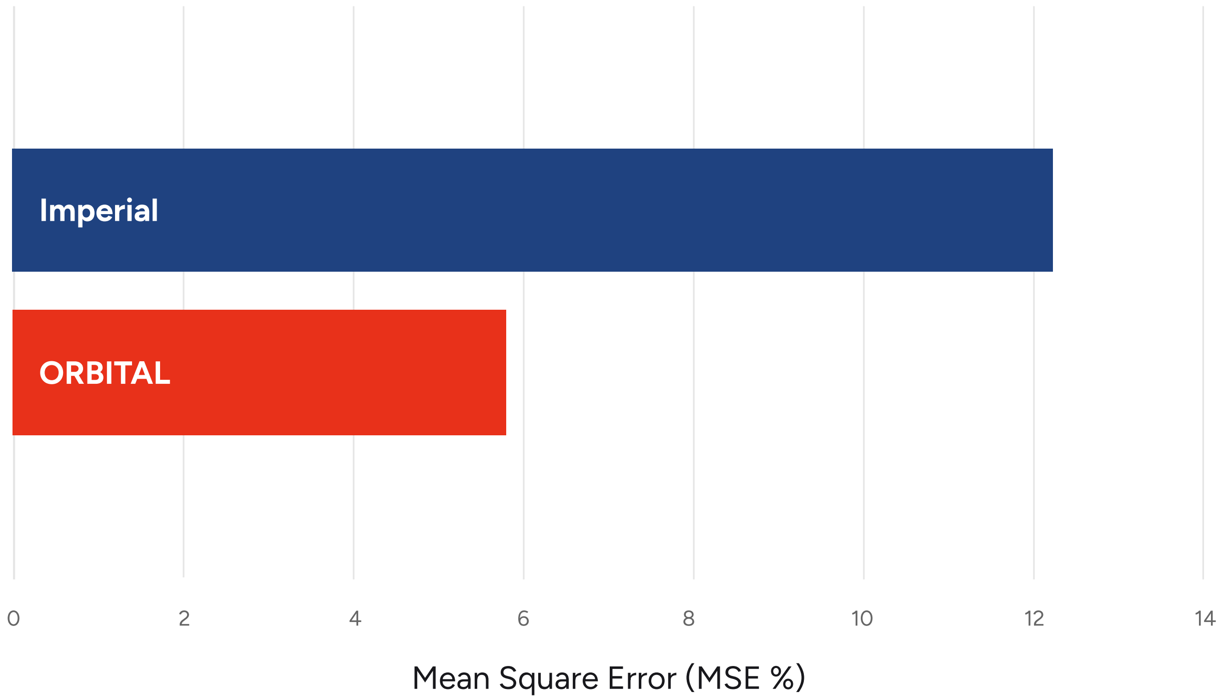
Conclusions

This pilot demonstrated the effectiveness of AI-driven optimisation in carbon capture. Orbital's foundation model enabled real-time recommendations that improved control, reduced false alarms, and stabilised operations

Model Performance

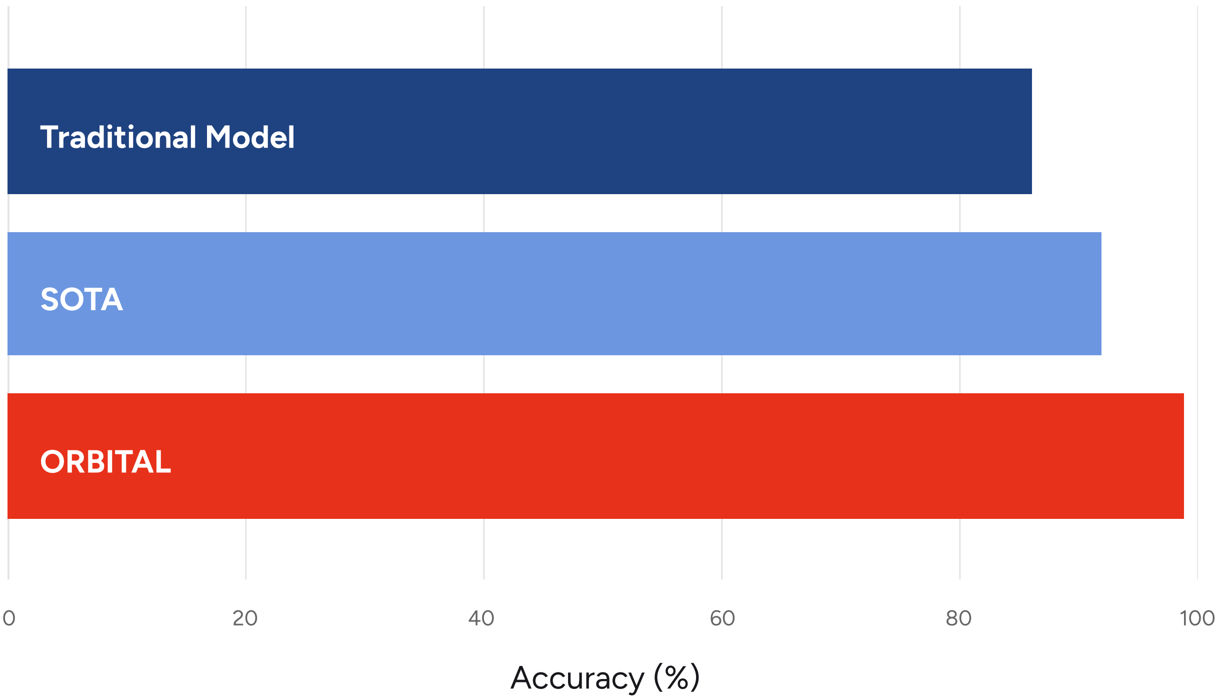
Metric	Internal Model	TimesNet	Orbital
CO_2 RMSE	0.123	0.089	**0.057**
Anomaly Detection Accuracy	93.6%	95.2%	**99.1%**

Performance Comparison

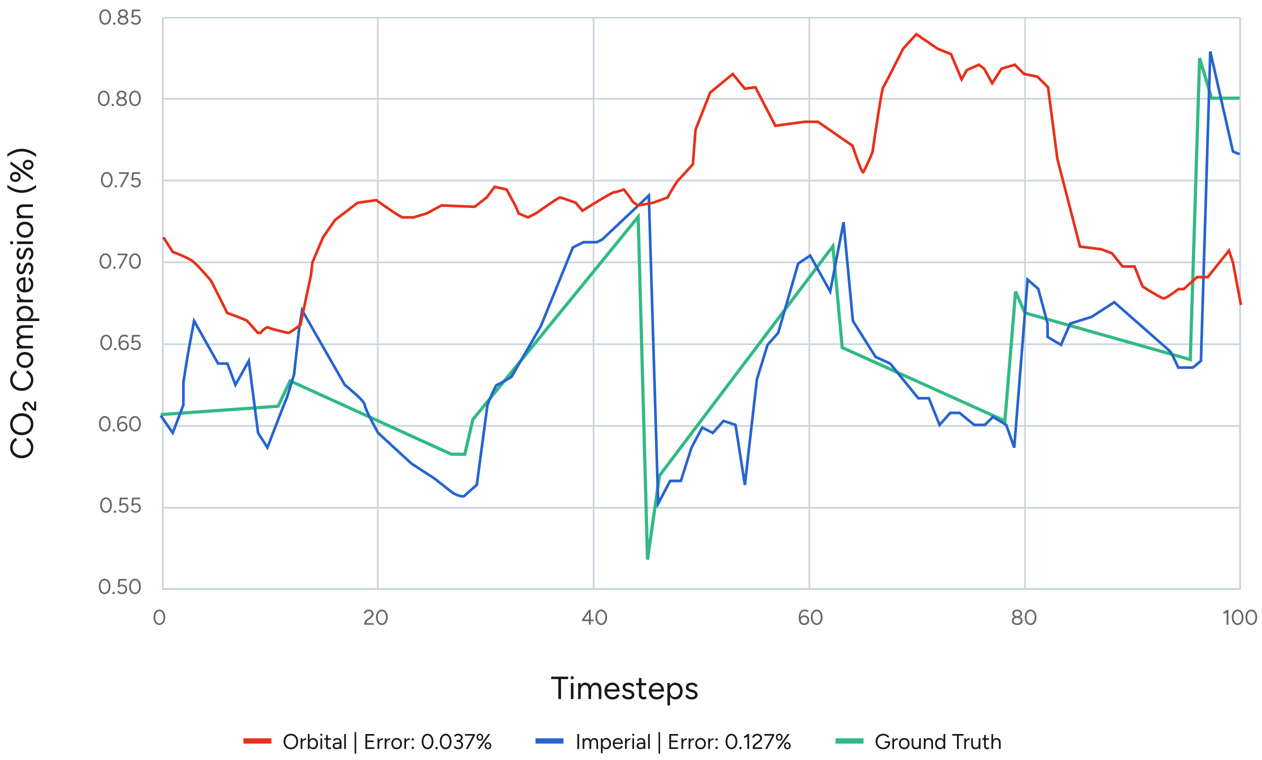


Displaying the % error of models predicting product metrics with unit process parameters as inputs. Evidently Orbital is able to replicate the simulation with less than 6% error

Performance Comparison (Anomaly Detection)



Forecasting Results



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