

Real Time Optimisation of the Cat Cracker

Key Performance Indicators

+2.3%

unit margin per barrel

+1.7%

gasoline yield

-3.2%

energy per barrel

-2.6%

dry gas make

-2.9%

carbon intensity

 $R^2 > 0.985$

agreement of the historian surrogate with the mechanistic unit model, confirmed before it is trusted to advise

 $< 0.4 \text{ s}$

to re optimise every set point, against the minutes a conventional two step optimiser needs to solve

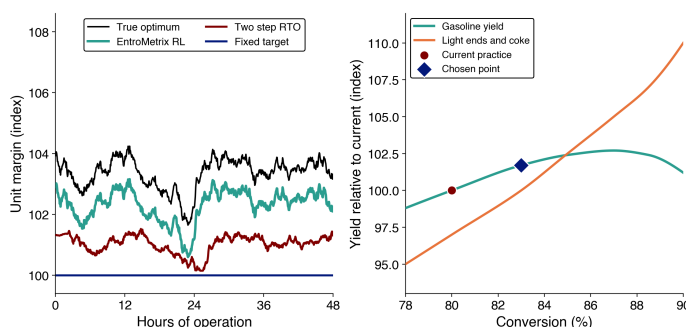
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constraint violations across validation runs, with the hard limits held by construction rather than by penalty

The most profitable way to run a fluid catalytic cracker moves constantly. The optimum shifts with feed quality, catalyst activity and the relative prices of gasoline, LPG and distillate, and it sits against several competing limits at once. In practice operators hold fixed targets chosen for a typical day and leave margin on the table to stay clear of the wet gas compressor, the regenerator air blower and product quality. Conventional two step real time optimisation reconciles a steady state model and then solves an economic problem on a slow cycle, so by the time it advises a move the feed and catalyst have already drifted and the recommended point lags the true optimum.

EntroMetrix builds a physics informed surrogate of the unit from the plant historian and pairs it with a reinforcement learning agent that continuously re optimises set points across the competing objectives. The surrogate learns the riser and regenerator response from operating data and is checked against the mechanistic model before it is trusted. The agent trades gasoline and LPG yield, unit margin, energy, coke and carbon, and honours the full operating envelope through safe reinforcement learning rather than a penalty added after the fact. It returns a Pareto set of feasible operating points, from which the plant chooses one.

Tracking the moving optimum



On the left the best operating point moves as the feed and catalyst drift; the agent stays within about one percent of it while a two step cycle and a fixed target lag, and the gap is margin given away. On the right gasoline yield peaks with conversion and then falls to light ends and coke; the agent holds the unit near that peak, where pushing harder would trade gasoline for coke, while the fixed target sits at lower conversion.

What the Optimiser Does

- **Reads the whole unit:** ingests historian tags across feed preheat, riser, regenerator, fractionator and gas plant to see the unit as one coupled system.
- **Trades the objectives:** balances gasoline and LPG yield, margin, energy, coke and carbon in a single reward, not one target at a time.
- **Honours the envelope:** keeps reactor temperature, pressure, catalyst to oil ratio and compressor load inside limits through safe reinforcement learning.
- **Tracks the moving optimum:** re optimises set points continuously as feed, catalyst activity and prices drift, not on a slow fixed cycle.
- **Offers a choice:** surfaces a Pareto set of feasible points, so the plant selects where the trade off should sit that day.
- **Transfers across units:** the same surrogate and agent carry to the catalytic reformer and the hydrocracker with unit specific retraining.

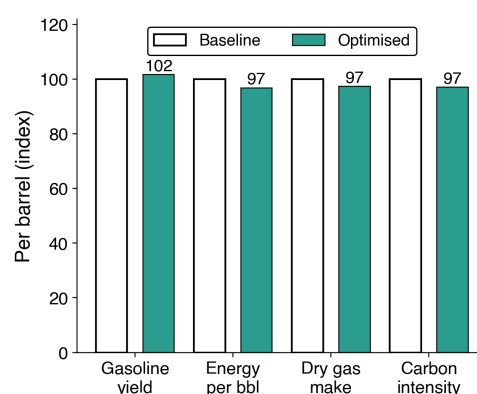


Figure 1. Gasoline yield, energy, dry gas and carbon, baseline against the optimised policy. Yield rises while energy, dry gas and carbon fall, the shape a moving optimum captures that a fixed target cannot.

The optimiser is built from the unit's own historian. Tags across the riser, regenerator, fractionator and gas plant train a surrogate of how the unit responds, and the surrogate is checked against a mechanistic model before it is trusted. The operating envelope and the economics are set with the plant's engineers, and the assumptions are written down before any advice is given.

On this unit the surrogate reproduces the rigorous model to within roughly one percent and re optimises every set point in under a second, against the minutes a two step optimiser needs, so it stays with the optimum as the feed drifts rather than lagging behind it. Across validation runs the policy held every hard limit without a single violation, because the limits are built into the agent rather than added as a penalty afterwards.

The work is retrospective and offline first. The agent is trained and tested on the plant's own history and validated before it advises, and every recommendation is delivered with the yield, margin, energy and carbon it implies, so the operator stays in the loop. The same surrogate and agent transfer to the catalytic reformer and the hydrocracker with unit specific retraining, so one method covers the conversion block.

What the Optimiser Does (cont.)

- **Historian first:** trained and tested on the plant's own historian, so the surrogate reflects this unit, not a generic model.
- **Surrogate checked:** its agreement with the mechanistic unit model is confirmed above 0.985 before any advice leaves the tool.
- **Safe by construction:** hard limits are built into the environment by action shaping, soft limits policed by a cost network held below threshold.
- **Advises, does not act:** recommendations go to the board and the operator stays in the loop, offline first before any closed loop step.
- **Fast enough to keep pace:** re optimises in under a second, so it stays with the optimum as the feed drifts.
- **Adapts to the feed:** watches its own prediction error to detect a feed change and refreshes the policy without a full retrain.

What the Optimiser Delivers

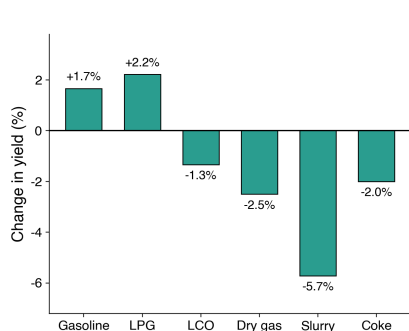


Figure 2. Change in the product slate by lump. Gasoline and LPG rise while the low value dry gas, slurry and coke fall, as the agent lifts conversion to the point that pays without over cracking.

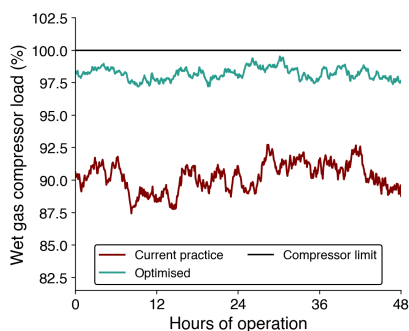


Figure 3. Wet gas compressor load over a run. The agent holds the unit closer to the active limit because it keeps the envelope by construction, recovering the band a fixed margin leaves idle.

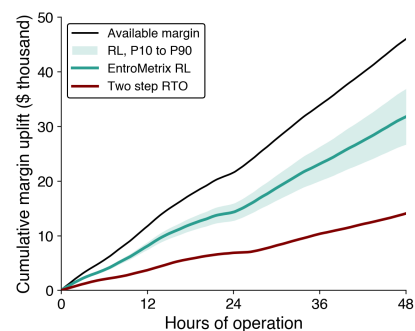


Figure 4. Cumulative margin uplift over the run as the feed varies; the band is the P10 to P90 range across feed and price conditions. The agent captures the bulk of the available margin and stays well ahead of a slow two step cycle.

Always at the Moving Optimum

Delivered on a fluid catalytic cracking unit

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