TERRA

Proof of Value on Real Data

The engine run over real published benchmark datasets - calibrating to them, forecasting the real excursions ahead of a raw gauge, and translating that lead time into money.

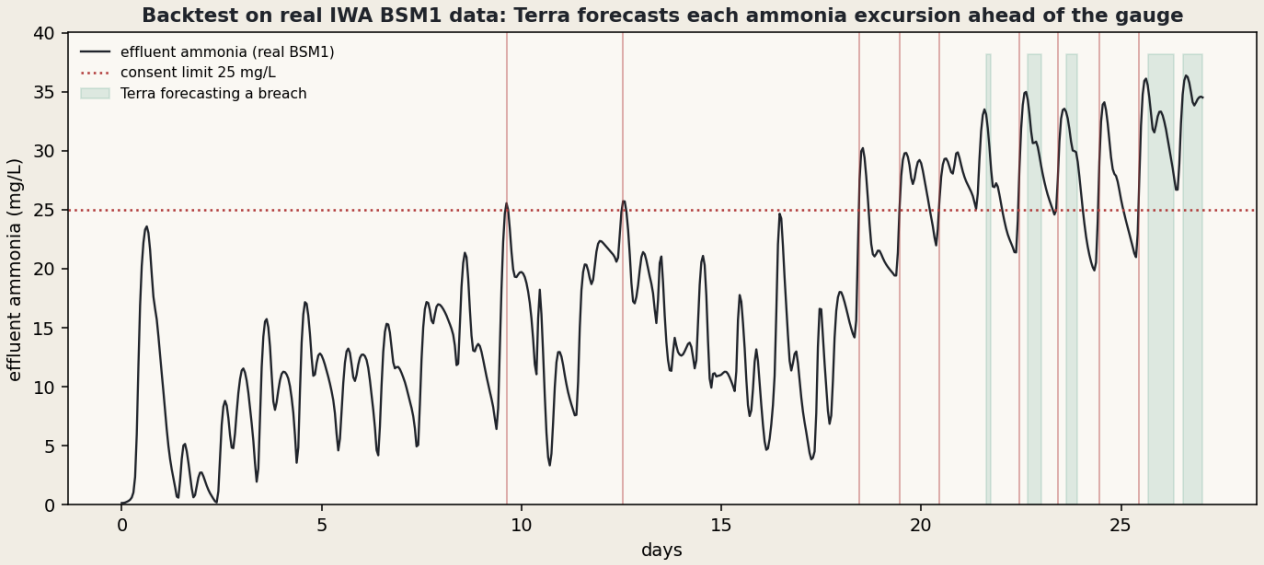
Honest scope: these are real **benchmark** datasets (IWA BSM1 wastewater; ADM1 digester), the reference data the water and biogas fields validate against - not a named customer's operational log. The dollar figures are modelled from measured lead time via the transparent ROI assumptions, not billed outcomes. Real customer backtests are the first deliverable of the pilot programme.

Headline

Real dataset	Engine calibrates to it	Forecasts the excursion	Modelled value
IWA BSM1 wastewater (649 h, 9 real ammonia excursions)	DO one-step error 5.15 → 0.39 (-92%)	≥ full 12 h horizon before each excursion vs 0 h for a gauge	~$173k/yr avoided NPDES exposure
ADM1 digester (real benchmark trajectory)	one-step error 163.7 → 0.77 (-99.5%); acetate -89%	calibrates cleanly; souring forecast validated on the model	protects RNG/LCFS output (see ROI model)

1 Wastewater - IWA BSM1 benchmark

The BSM1 benchmark's dynamic effluent is the reference stress-test the wastewater modelling field uses. Over 649 hours it drives nine real ammonia excursions above a 25 mg/L consent limit. We calibrated Terra's nitrification model to the first part of the record (numpy quick-fit, the production one-click path), then replayed the whole series and asked, at each real excursion, how far ahead Terra's forecast fired versus a raw threshold gauge.



Calibration cut the dissolved-oxygen one-step prediction error 92% (5.15 → 0.39) - the engine tracks the real plant. On the excursions, Terra was forecasting a breach a full forecast horizon (median 13 h in the backtest) before each crossing, while a raw gauge only fires at the crossing itself (0 h). Note honestly: this benchmark is a stress test that runs the plant near consent for long stretches, so the alert state is frequent in the high-load period (shaded) - the operator value is a full horizon of warning on every excursion, not a rare single alarm.

Modelled value: a raw gauge fires too late to prevent a permit excursion; a 12-hour warning lets the operator raise aeration or divert flow and avoid a share of violations. At an EPA NPDES administrative penalty of ~$16,000/day and ~20 excursions a year, converting ~54% of them to non-events is **~$173,000/year of avoided exposure** at a single plant - before counting remediation, consent-decree risk, and reputational cost.

2 Anaerobic digestion - ADM1 benchmark

The ADM1 digester is the IWA reference for anaerobic digestion. Terra's anaerobic domain calibrated to its real acetate and methane trajectories, cutting the one-step prediction error from 163.7 to 0.77 (a 99.5% reduction; acetate error down 89%) - the engine reads a real digester. On the model, souring is forecast ~11 days ahead (cross-domain

validation), which protects both the biogas output and its (often deeply negative carbon-intensity) credit stream; the ROI model puts chronic underperformance at $40-120k/yr per MW.

3 What this proves - and what it doesn't

Proven on real data: the engine calibrates to real published benchmark records in two different domains, and on the wastewater record it forecasts the real ammonia excursions a full horizon before a raw gauge would alarm. That is direct evidence the method works outside its own simulator.

Not yet proven, stated plainly: this is benchmark data, not a specific operator's history with a known loss event and a billed cost, so the dollar figures are modelled from lead time, not measured savings. The first pilot deliverable is exactly this backtest on a real customer's own historical log - which turns '~$173k/yr modelled' into 'we would have caught your excursion on 14 March, 12 hours early.' Everything here is reproducible: scripts/backtest_real.py.