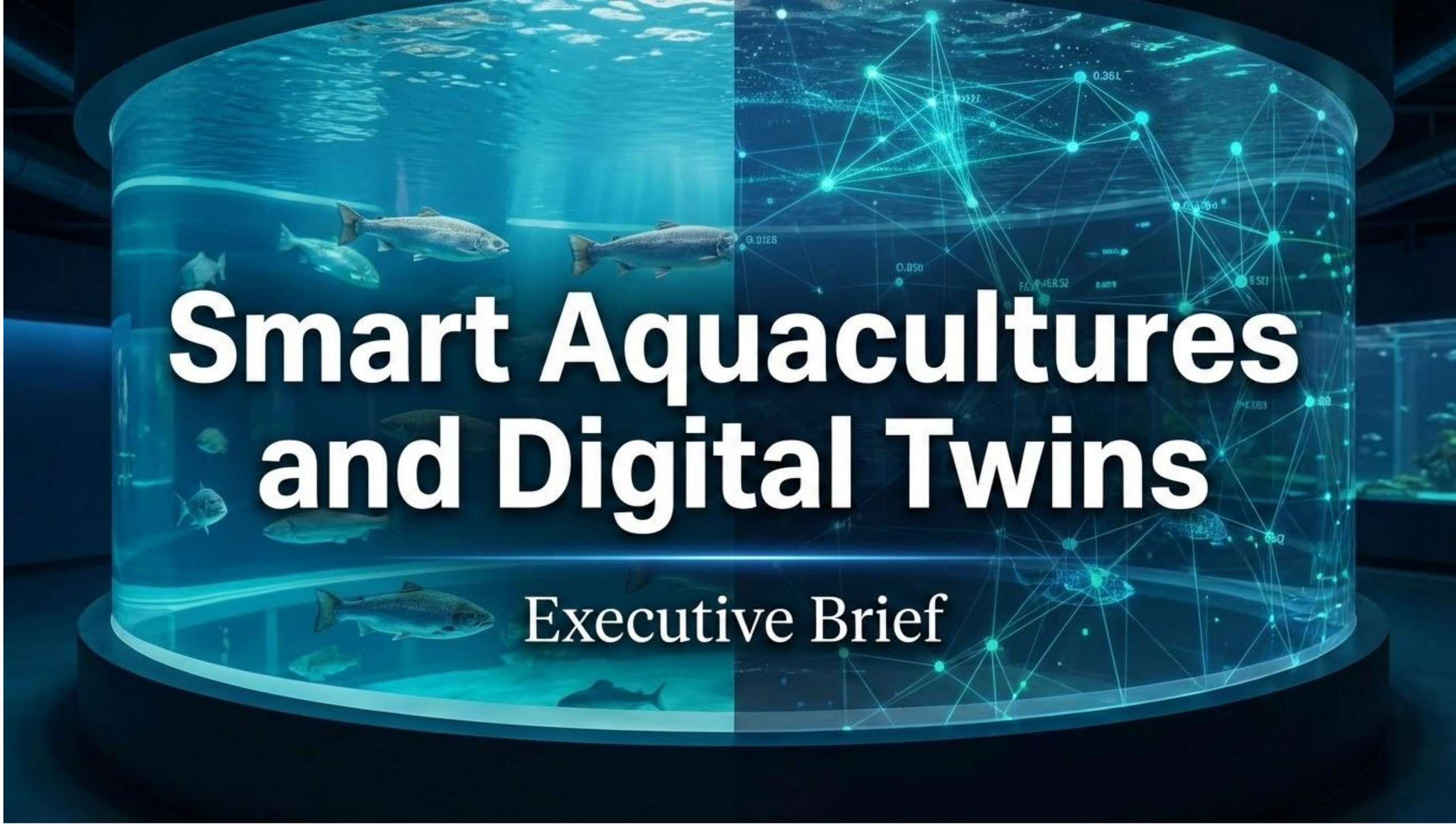


Smart Aquacultures and Digital Twins

Executive Brief

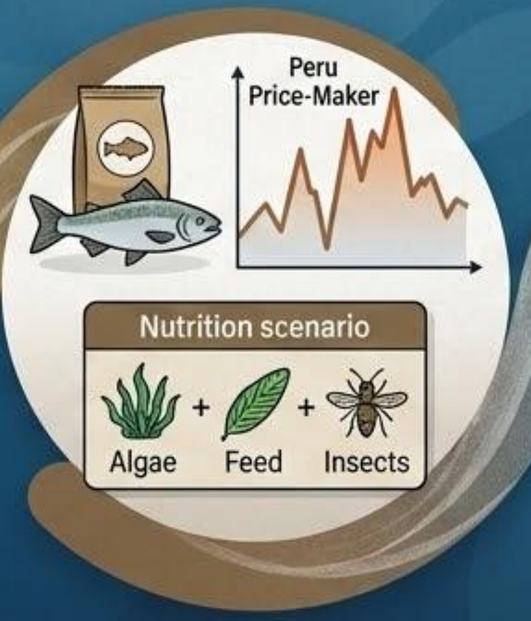
Market Update — from 2021 to today

Global Production Shift

Aquaculture Surpasses Capture. Record aquatic production achieved.

EU Market Pressure

Spend ↑ while volumes pressured. Critical need for efficiency & bankable KPIs.



Feed Supply Volatility

FM/FO supply & prices volatile (Peru as price-maker). Nutrition scenarios are essential.

Land-based RAS Scaling

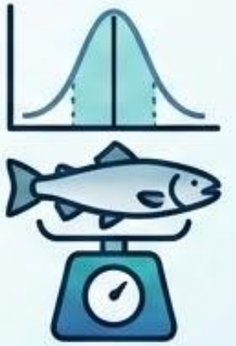
Significant opportunities coupled with execution and energy risks.

Pilot Objectives & Architecture

Predict Failures & Thresholds

Predict concentrations & time-to-threshold under failure scenarios.

Estimate Biomass & Dispersion



Estimate biomass/growth; predict weight dispersion for grading.

Optimize Operations & QA

Optimize feeding/oxygenation & energy per kg; raise QA & traceability.

Data Schema — minimum set & frequency

Sensor & Environmental Data

Minimum Set

Temperature (°C)
Dissolved Oxygen (mg/L)
pH
Salinity (ppt)
TAN (Total Ammonia Nitrogen)
Water Flow Rate (L/min)
Tank Level (cm)

Frequency

Real-time / High Freq. (1-5 min)

Biological & Operational Data

Minimum Set

Feed Amount (kg) & Type
Mortality Count (fish/day)
Biomass Estimate (kg - periodic)
Grading Data (weight dist.)
Energy Consumption (kWh)

Frequency

Daily / Batch / Event-based

Model & Output Data

Minimum Set

Predicted Concentrations
Time-to-Threshold Estimates
Growth Rate Projections
Weight Dispersion Forecast
Optimization Recommendations

Frequency

Near Real-time / Scheduled

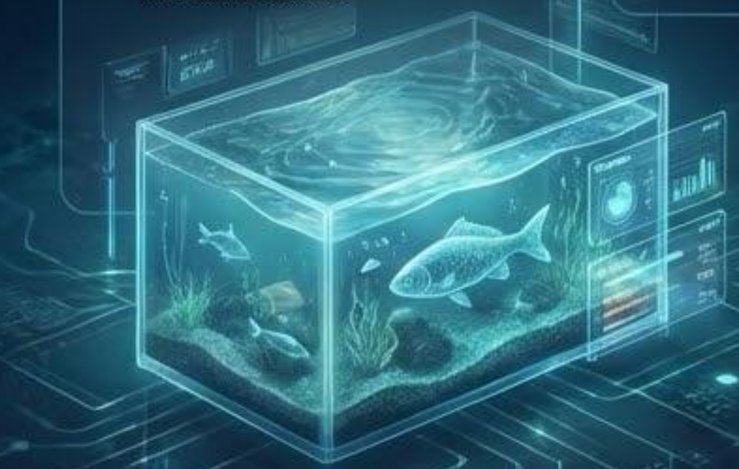
Dashboards & Alerts

FWFEU × CLIENT — Executive Brief (RAS Modelling Pilot)

Smart Aquaponics & Digital Twin Initiative

SUMMARY

- **Digital-Twin-ready** aquaponics/RAS pilot combining sensors + mathematical modelling + ML/Computer Vision.
- Predicts water quality (O_2/CO_2/NH_4^+...), biomass and weight dispersion; computes time-to-threshold for failures.
- **Goal:** reduce losses & opex, optimize feeding/oxygenation, and enable QA/traceabllity KPI dashboards.



MARKET SIGNALS (Since 2021)

- Aquaculture surpassed capture in global animal aquatic production (record highs).
- EU households' spend up while volumes pressured → efficiency focus & bankable KPIs.
- FM/FO volatility persists → need feed/energy optimization & scenario analysis.
- Land-based/RAS scaling shows execution/energy risks → governance & data matter.

PILOT PLAN @ CIIMAR

Mass-balance multi-node model + growth; calibration & cross-validation.

FRESH WATER FARMS EUROPE — WE TRULY CARE ABOUT IT!

Failure simulations: filter/O_2 outages → time-to-limit and risk curves.

Vision/ML: sizing & weight-dispersion from images/videos.

FRESH WATER FARMS EUROPE — WE TRULY CARE ABOUT IT!

Dashboards: BI KPIs (FCR, SGR, Δbiomass, mortality, energy/kg, days-of-safety).

Interreg

DATA DICTIONARY

- **Core sensors:** O_2, CO_2, pH, ORP, temp, TAN/NH_4^+, NO_2^-/NO_3^-, salinity, flow.
- **Ops logs:** biomass/stocking, feeding (type/amount), mortality, cleaning/backs, alarms.
- **Energy:** pump, aeration/O_2, UV/O_3; runtime & kWh.
- **Metadata:** P&ID, volumes, turnover, media specs; event timestamps.

DELIVERABLES & ASKS

- **Deliverables:** data plan (QA/QC), prototype model, dashboard demo, draft data agreement (no conflict with Interreg).
- **Asks:** 8–12 months of RAS data; P&ID & maintenance/alarms logs; joint-publication permission (with commercial embargo).

FRESH WATER FARMS EUROPE
WE TRULY CARE ABOUT IT!

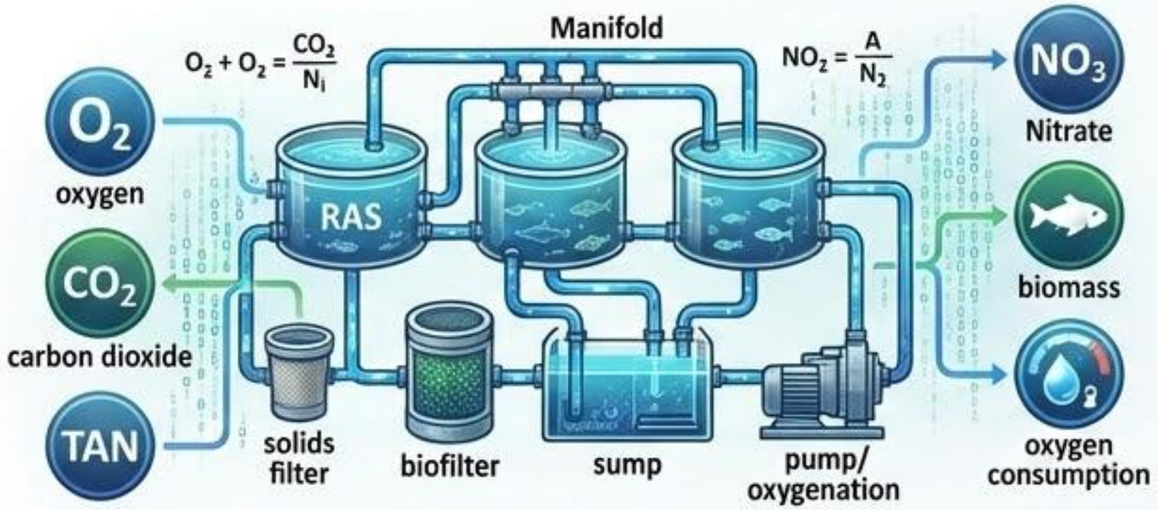
CLIENT

Table 1. Categories of mathematical modelling

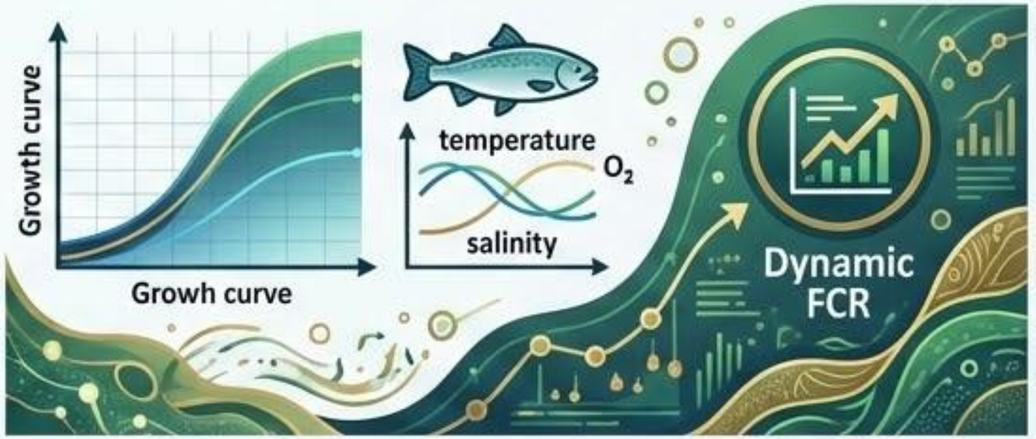
	Model category			
	White-box	**Light-grey**	**Dark-grey**	**Black-box**
Governing physical laws	+	+/-	+/-	-
Parameters	+	-	-	-
Model structure	+	+	-	-
Examples/features	Set of linear/ non-linear differential equations.	Set of linear/non-linear differential equations with parameters estimation. Transfer function with parameters estimation. State-space model with parameters estimation.	Neuro-fuzzy models with parameters estimation.	Artificial neural networks.

Annex - Technical

Multi-node mass balance

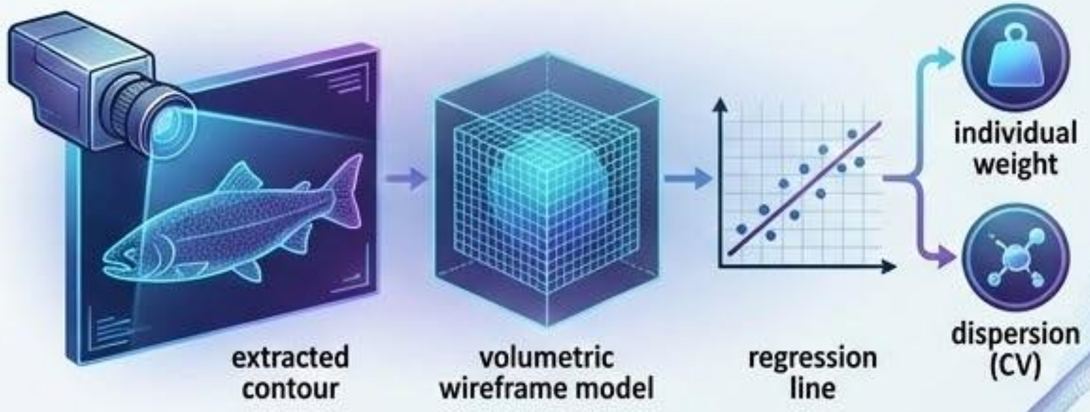


Growth/ingestion



Failures

ML/Vision




Real Data Comparison Dashboard
CURRENT SYSTEM (SIMULATED)
TAN: 0.12 mg/L
O2: 8.5 mg/L
CO2: 6.2 mg/L
NO2: 0.05 mg/L
NO3: 45.0 mg/L
FCR: 1.15
SGR: 2.5%
Mortality: 0.5%
Energy: 12.5 kWh
INDUSTRY BENCHMARK (REAL DATA)
TAN: 0.30 mg/L
O2: 7.0 mg/L
CO2: 8.0 mg/L
NO3: 60.0 mg/L
NO3: 60.0 mg/L
FCR: 1.30
SGR: 1.8%
Mortality: 2.0%
Energy: 12.5 kWh

FWFEU

System and KPI Dashboard

System Parameters

TAN: 0.12 mg/L

O2: 8.5 mg/L

CO2: 6.2 mg/L

NO2: 0.05 mg/L

NO3: 45.0 mg/L

Key KPIs

FCR: 1.15

SGR: 2.5%

Mortality: 0.5%

Energy: 12.5 kWh

Risk & Safety

Time to failure:

120h 30m

Predicted harvest: 5500 kg (Oct 26)

Uniformity and Alerts

- Alert: Setpoint drift in Tank 3 (02)
- Warning: Abnormal pattern in Biofilter 1
- Alert: Setpoint drift in Tank 3 (02)
- Alert: Setpoint drift in Tank 3 (02)
- Alert: Setpoint drift in Tank 3 (02)
- Warning: Abnormal pattern in Biofilter 1
- Alert: Setpoint drift in Tank 3 (02)
- Alert: Setpoint drift in Tank 3 (02)
- Alert: Setpoint drift in Tank 3 (02)
- Alert: Setpoint drift in Tank 3 (02)
- Alert: Setpoint drift in Tank 3 (02)

FWFEU

Working Plan

Month 1

- Data access setup + QA/QC; P&ID review; initial data exploration; data pipeline setup.

Months 2-3

- Calibration + initial dashboard build; failure scenario simulations; feature engineering; iterative feedback with stakeholders.

Months 4-5

- ML/vision model integration; KPI definition & tuning; system refinement; advanced analytics implementation.

Month 6

- Validation report generation; joint paper outline; roadmap presentation and handoff; final system deployment and training.

Asks & Next Steps

Provide 6–12 months of data, P&ID, maintenance & alarms logs.

Agree NDA/data use (no Interreg conflict); publication plan.

Hands-on working session at FWFEU to connect data & run first sims.