Algocell™

AI-Based Digital Twin for Cell Culture and
Precision Fermentation Optimization

Current State Of Bioprocess Optimization

Priorities

Costs

- Feeding Strategy
- Biomass/Titer ratio
- Limiting Factors
- Harvest Time

Scale Up

- Defining Systems
- Gas Management
- Shear Stress
- Perfusion Rate

Quality

- Viable Cells
- Metabolics
- Toxins
- Biological Activity

Challenges

Reliance on Trial and Error

Relies heavily on hypothesis-driven experimentation, where scaling up is achieved through trial and error. This process is slow, resource-intensive, and introduces variability as changes in volume and conditions are adopted during development. The lack of predictive insights often leads to inefficiencies and increased costs.

Lack of Data

Bioprocess optimization is constrained by insufficient and unreliable data. Every biological system is dynamic—changes in DNA, media composition, and growth factors makes historical data irrelevant. Without enough high-quality, real-time data, predictive models remain incomplete, making process improvements challenging.

Suboptimal Processes

Due to limitations in the number of experiments, available time, and resources, process development often results in suboptimal performance. Key parameters affecting scale-up, such as shear stress, gas management, and perfusion rates, are not fully optimized. This leads to inconsistent yields and lower efficiency in manufacturing

Digital Twin Technology for Bioprocess Optimization

Value Cross the Bioprocess Lifecycle

Accelerating time to market

Optimizing production

No need for vast amount of data

Small data set is only required for model calibration and no for its training.

Engineering Models

Integrates engineering models, systems and constraints,

Domain Expertise

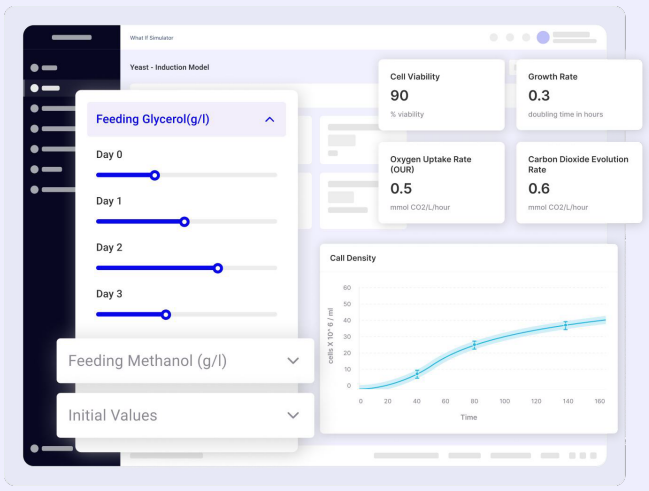
Combines mechanistic models with AI.

Precision

Precise bioprocess models, continuosly optimizing for scalability, adaptability, and accuracy.

Experimental DATA

Algocell biological and engineering hybrid models



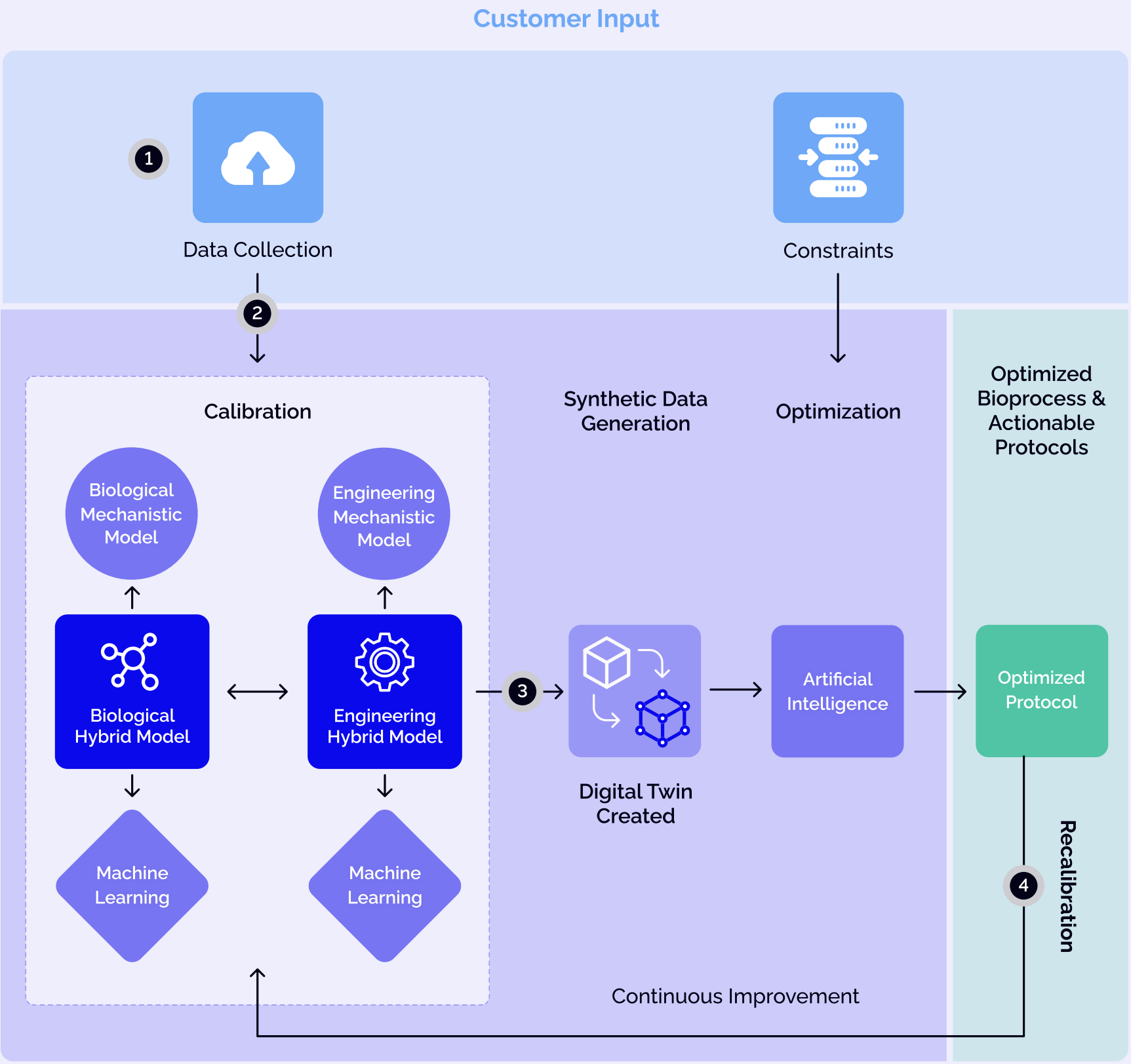
Algocell Platform

Examples of what the Algocell Digital Twin optimizes for include:

- Feeding strategy
- Perfusion rates
- Transitioning to fed batch
- Toxin control
- CPP optimization
- Incoculum size
- Temp shift/induction timing
- Harvest timing
- Product quality

Hybrid Model Digital Twin Platform

By extrapolating from limited datasets, the Algocell Platform can accurately predict bioprocess outcomes in new or evolving scenarios. This allows it to provide reliable recommendations for process optimization, even when faced with sparse or fluctuating data inputs.



Algocell Platform

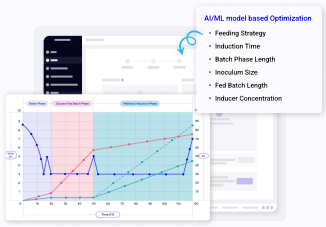
1. The Digital Twin is validated through real-world calibration, ensuring **accurate process control** by capturing specific consumption rates for glucose, oxygen, and other key variables
2. Algocell begins by capturing **fundamental biological behaviors** such as oxygen consumption, cell growth, and metabolic pathways before applying AI.
3. Unlike traditional AI, which depends on large datasets, Algocell's AI **learns from small experimental data** and extrapolates missing values, revealing biological relationships that standard AI models cannot detect.
4. Algocell's models **continuously improve** based on new experimental and production data, ensuring long-term bioprocess optimization.

Bioprocess Optimization Software Platform

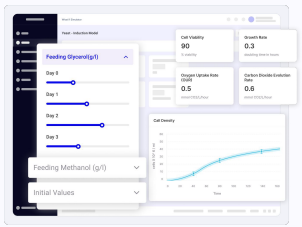
A modular solution for cell-based companies to select, integrate, and customize tools that best fit their bioprocess needs. From R&D to full-scale production.

R&D and Scale Up

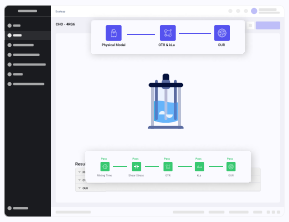
Bioprocess Simulator

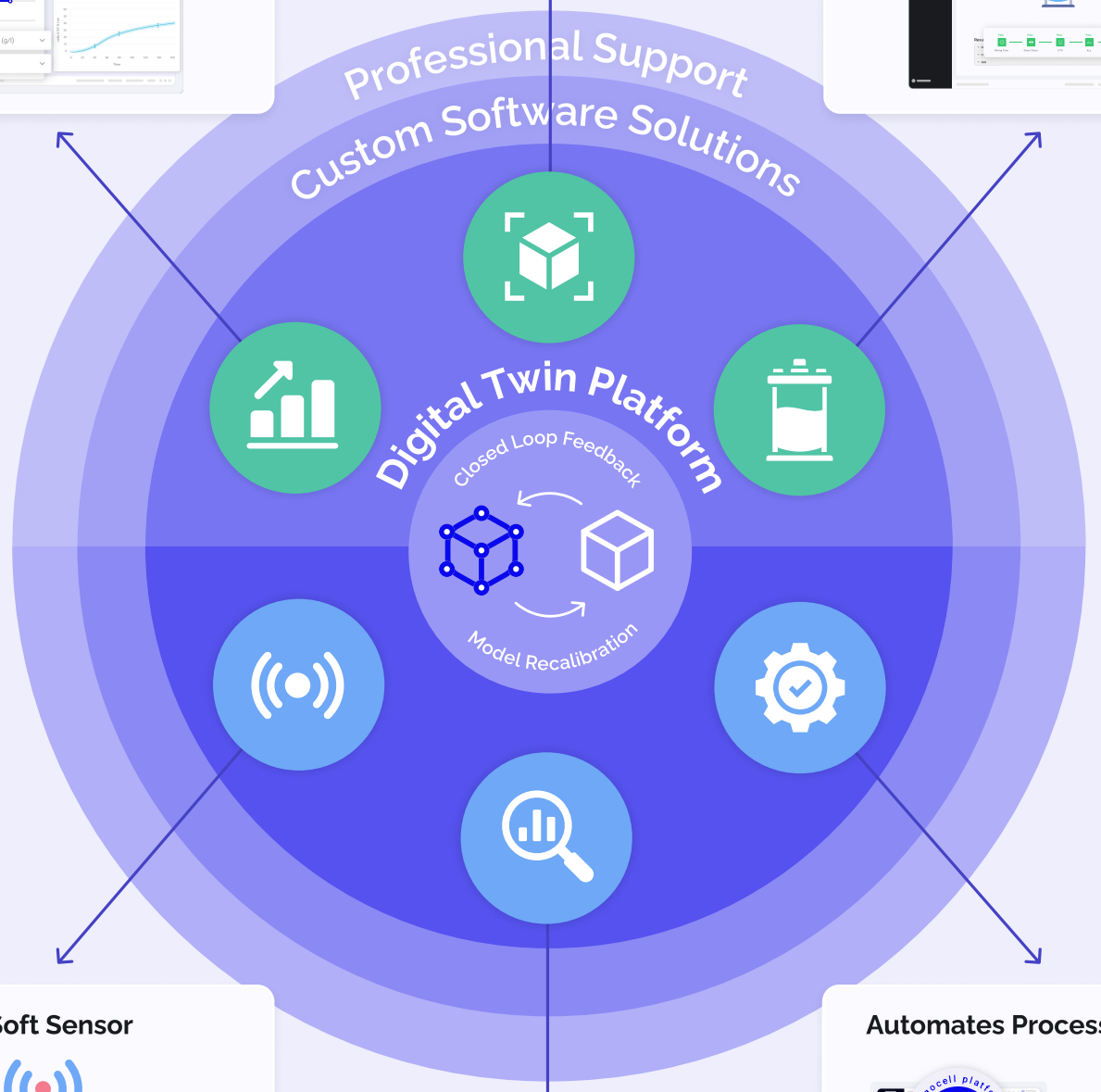


Advanced Process Optimizer



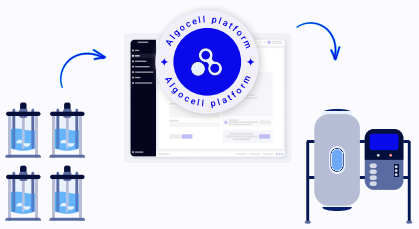
Process Scale Up Management





Soft Sensor

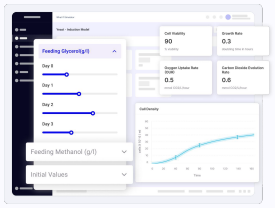
Real Time Insights



Automates Process Control

Production Optimization

R&D and Scale Up

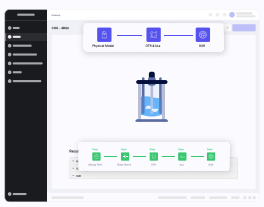


Advanced Process Optimizer

Utilizes advanced algorithms to identify optimal bioprocesses conditions. Dynamically adjusts parameters such as feeding rates, incubation time, and nutrient levels to achieve peak performance.

Bioprocess Simulator

Models critical factors like oxygen supply, shear forces, and heat transfer, ensuring smooth and efficient transitions from R&D to full-scale production without compromising process efficiency or product quality.



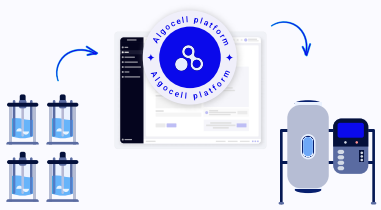
Process Scale Up Management

Conduct virtual experiments that mimic real-life bioprocess scenarios in a computational environment. Significantly reduces need for physical trials, saving time and resources.

Production Optimization

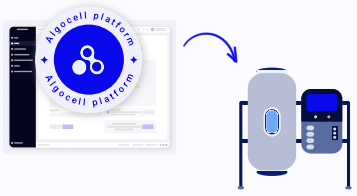
Soft Sensor

Uses real-time sensor inputs to infer data on parameters not directly measurable, like nutrient concentrations, providing insights for process optimization.



Real Time Insights

Analyzes real-time data to detect inefficiencies and suggest improvements. Offers actionable recommendations like adjusting feeding schedules or changing temperatures.



Automates Process Control

Transforms bioprocess management from manual adjustments to autonomous execution. Detects and responds to anomalies, maintaining optimized performance.

Value Across the bioprocess Lifecycle

R&D and Scale Up

Faster Time-to-Market

Shortens development timelines by replacing trial and error experiments with simulations using synthetic data based on hybrid models.

Cost-Efficient Development

Reduces costs by minimizing the use of materials, labor, and experimental setups, streamlining process development with precise simulations.

Flexibility for Scaling

Models adapt seamlessly to changing bioreactor volumes and cell lines. The result: faster and more reliable scalability from R&D to production.

Production Optimization

Maximizes Yield

Boosts productivity by adjusting feeding, harvesting, and environmental parameters in real time based on simulations of key factors like toxicity thresholds and nutrient consumption rates.

Improves Stability and Quality

Reduces batch-to-batch variability with real-time insights into sensitive biological systems. Predicts feeding rates and environmental conditions to maintain consistent product quality.

Drives Revenue Growth and Gross Margins

Lowers costs by reducing resource consumption and waste through more efficient use of materials and optimized production protocols.

Success Stories Summary:

Offline optimization:

✓ 20% yield increase in biomass.

✓ 70% faster development.

AI-based Soft Sensors for precision fermentation:

✓ Methanol soft sensor – 98% accuracy.

✓ Biomass soft sensor – 95% accuracy.

In production insights:

✓ 60-day bioprocess prediction – 93% accuracy.

✓ Potential of 250% extra yield in some of the cases.

Mammalian cells perfusion systems modeling:

✓ MAPE (mean absolute percentage error) of 2.59%.

E.coli bioprocess optimization:

✓ 250% yield increase in protein production.

✓ 25% production time saved.

Use case 1: Optimizing E. coli-Based Protein Production

2.5X Increase in Protein Yield on a small scale:

Algocell successfully optimized the company's protein production results within two months, achieving a ~2.5X increase in protein yield during the upstream process, while also reducing production time by 25%. This is a significant milestone on the path of process optimization.

Optimization was achieved without any genetic modifications or media changes—purely through process parameter refinement.

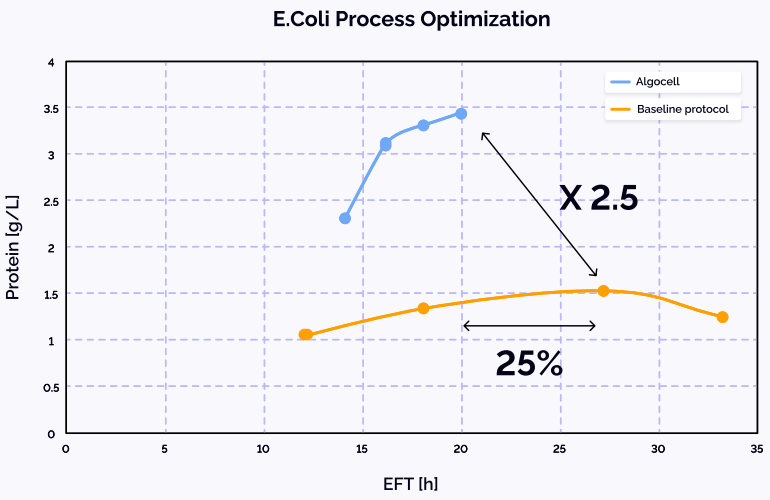
Algocell's platform modeled key factors:

- Cell carbon and oxygen consumption rates
- Doubling time and productivity
- Metabolite production and inhibition
- Maximum intracellular protein capacity

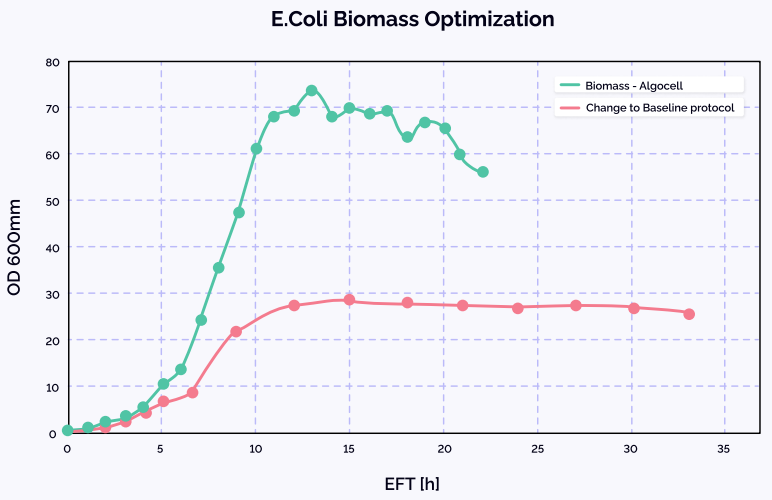
It generated optimized protocols by adopting:

- Inoculum size
- Induction timing
- Feed rates
- Gas management

Graphical Analysis:



Graph 1: Biomass increase



Graph 2: ~2.5X increase in protein yield while reducing production time by 25%

Use case 2: Phicia Pastoris Feeding Strategies Simulations

Simulation Results Following Methanol-Induced Protein Expression in Pichia pastoris

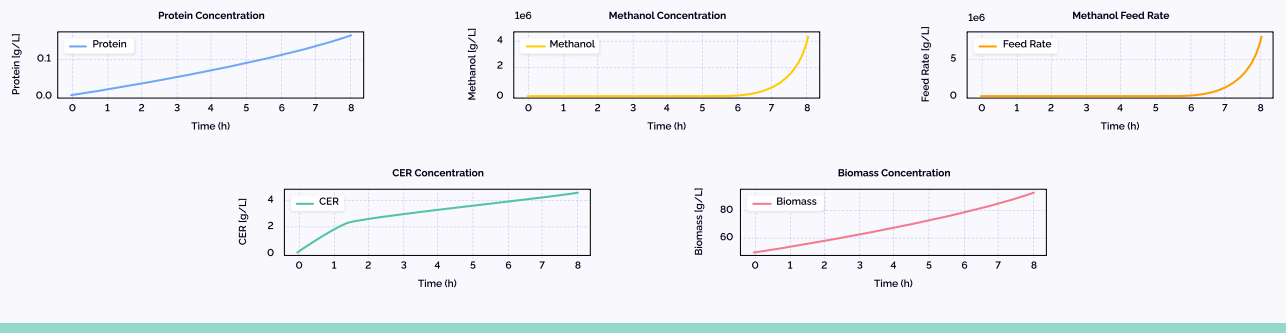
The simulation illustrates significant differences in outcomes under various feeding conditions. These variations highlight the importance of optimizing feed strategies to enhance protein production efficiency.

The model incorporates a range of key parameters to reflect realistic bioprocess dynamics, including:

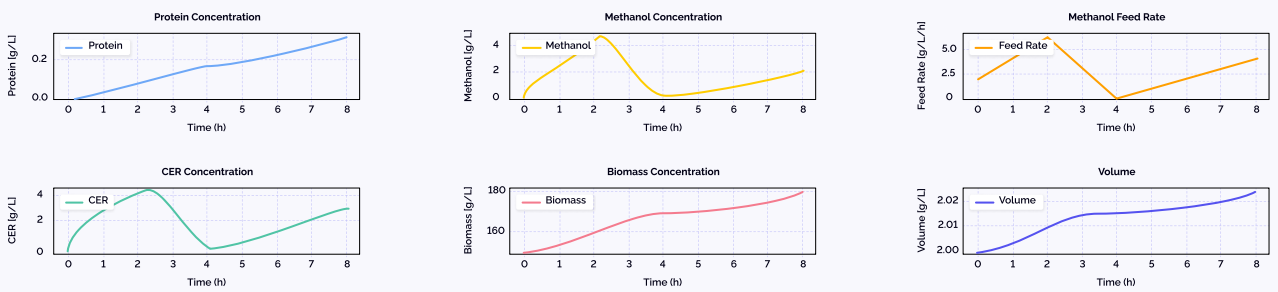
- Consumption rates of carbon and oxygen sources
- Productivity rates in different conditions
- Toxicity and inhibitors related to different feed compositions
- Cell density to protein expression rates correlation

By capturing the complex interplay between these factors, the model provides valuable insights for the design and optimization of high-yield fermentation processes.

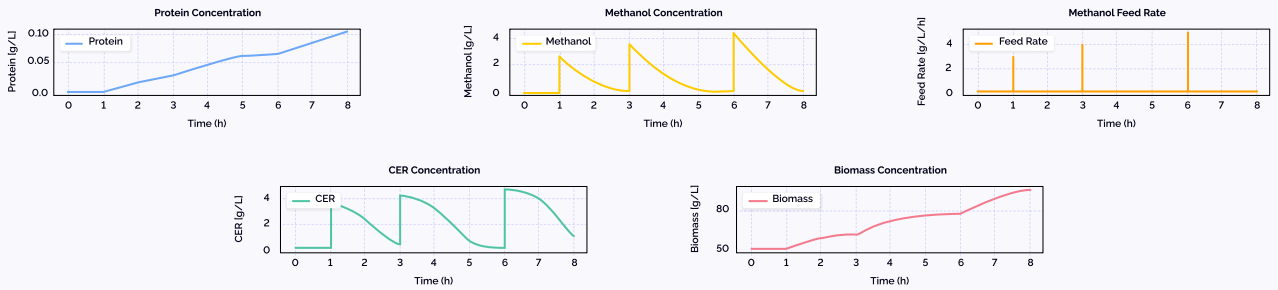
Exponential Feed



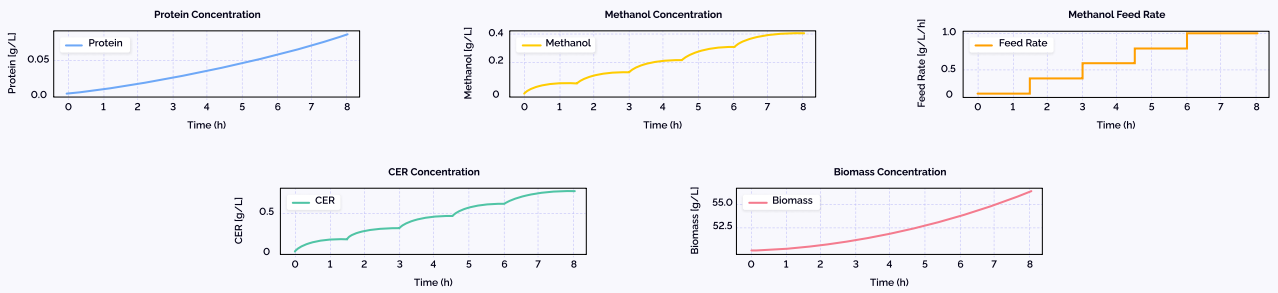
Linear Feed



Bolus Feed



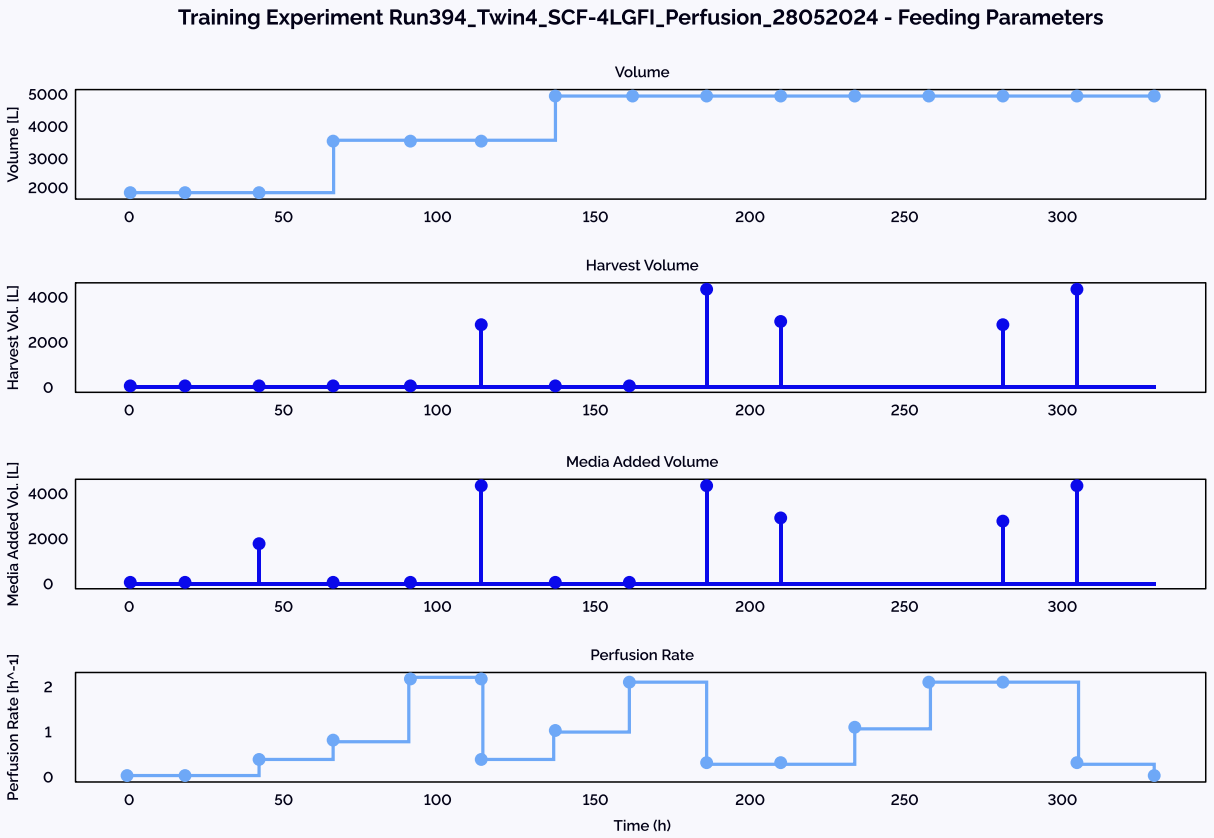
Step Feed

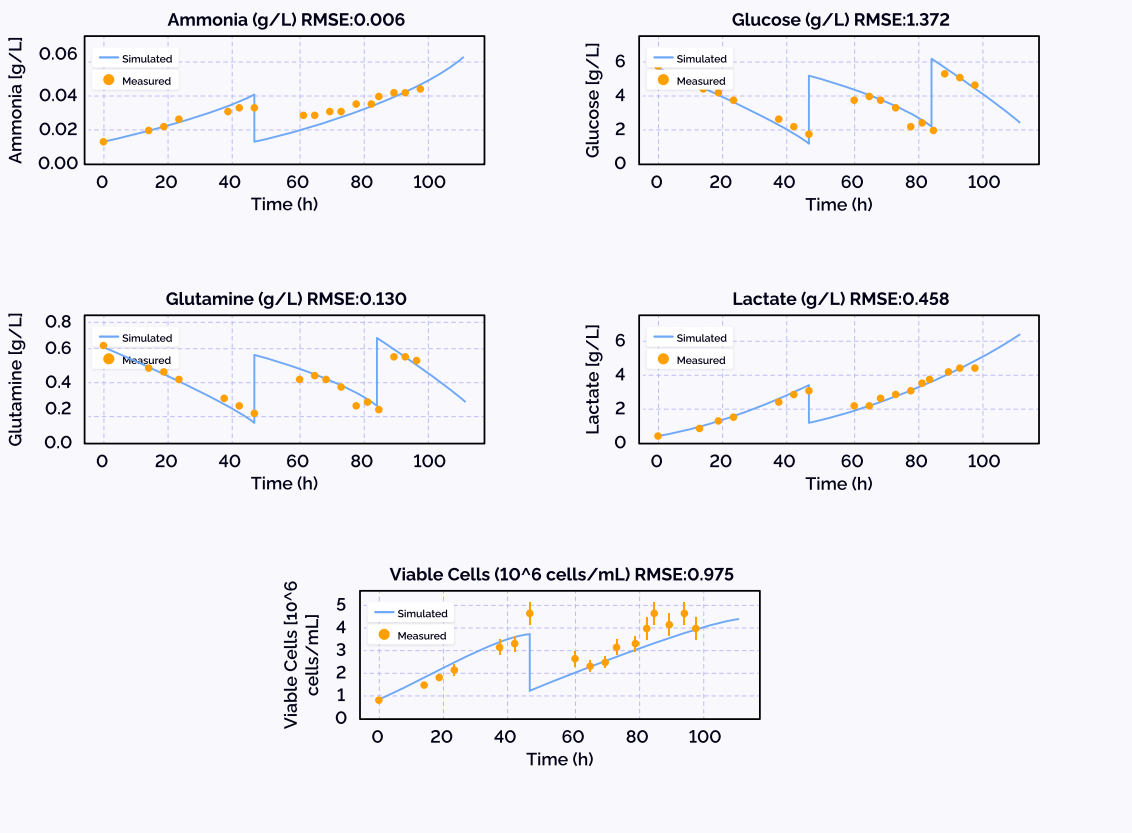


Use case 3: Mammalian Cells Perfusion Process Simulation

Problem: Optimize feeding and harvest regime in an optimal way that balance yield and costs

- What: We developed hybrid model for glucose, glutamine, lactate, ammonia and biomass.
- How: Integrating biological aspects with process control parameters (perfusion rate, harvest vol. and times, media added vol.)
- Outcome: Customers can now implement optimized feeding and harvest strategies for max biomass and optimal media conversation rate.





Use Case 4 : Model-Based AI Soft Sensor

→ Challenge

Suboptimal feeding strategies due to the lack of real-time, in-line monitoring.

→ What we did

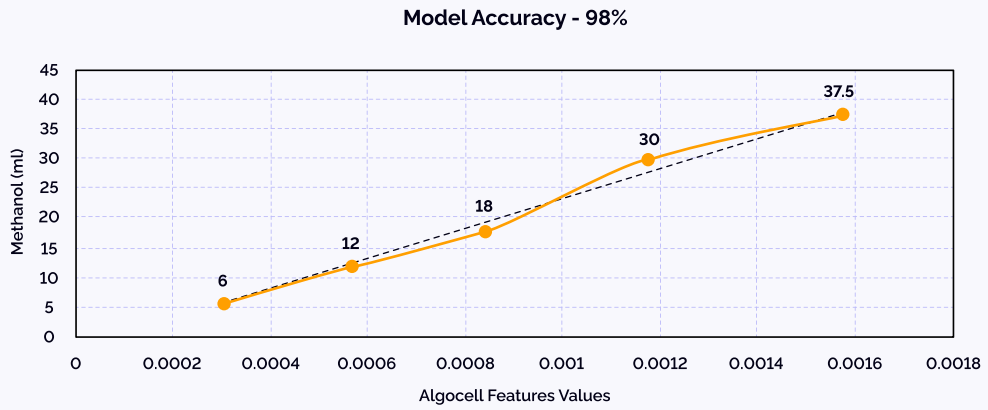
We developed accurate and continuous in-line measurements for key parameters such as methanol, glycerol, and biomass.

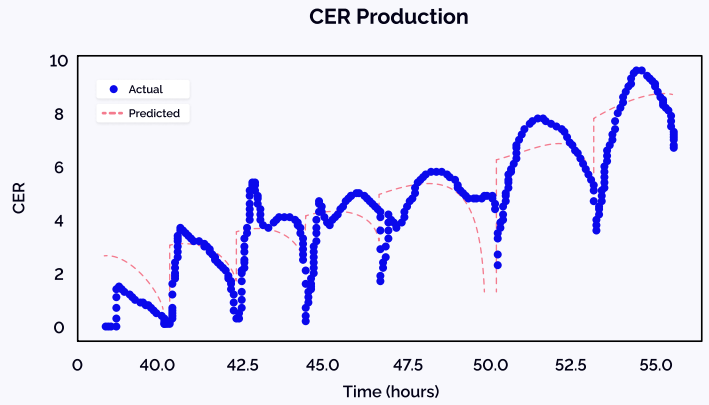
→ How we did it

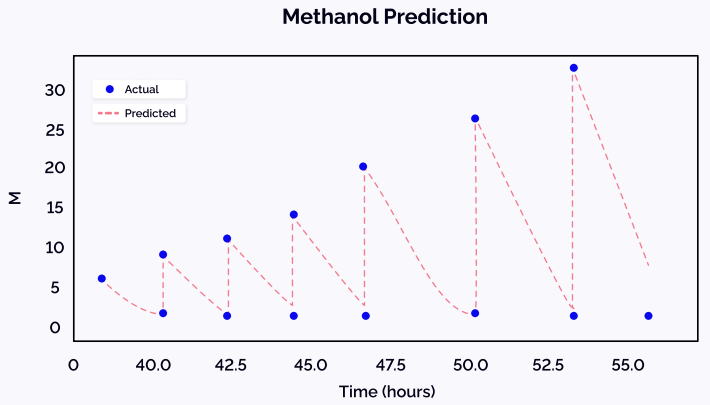
We integrated data from multiple low-cost, easy-to-use sensors and processed it using our AI models to generate reliable insights.

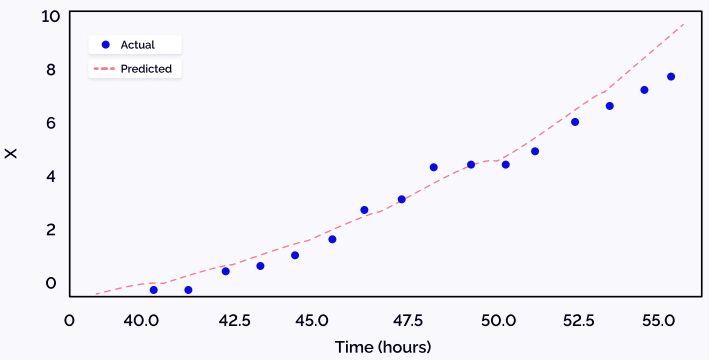
→ The result

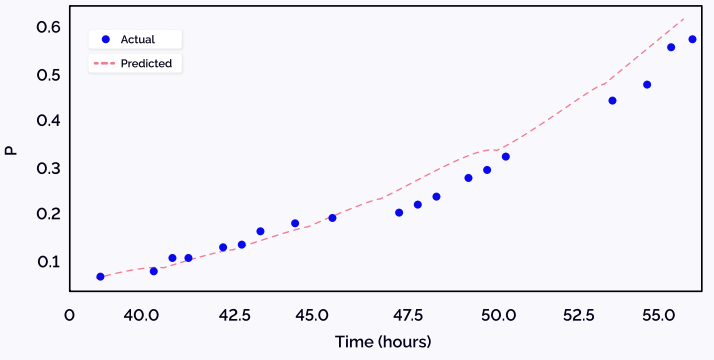
Customers are now able to implement optimized feeding strategies that maximize protein productivity while keeping costs low.











About Algocell

Industry 4.0 has transformed many industries, but cell-based manufacturers have been slow to adopt innovations in IoT, AI, and automation for bioprocessing optimization.

Both R&D and Production still rely on outdated methods, including trial-and-error experimentation and limited analytical tools. The result? Lengthy development cycles, inefficient processes, and reactive adjustments.

Algocell was founded to revolutionize bioprocessing - accelerating development and enabling precise process control. At the core of this vision is Algocell's AI-powered Digital Twin, a breakthrough solution that combines biological and engineering expertise with AI. Unlike conventional AI models that require vast amounts of data, Algocell's AI learns from small datasets, extrapolating insights to optimize bioprocesses dynamically.

The Algocell Platform is used by cell-based manufacturers to make faster, data-driven decisions - streamlining experimentation, scaling bioprocesses efficiently, and ensuring consistent product quality.

Algocell sets a new standard for AI-powered Digital Twins in Bioprocessing Optimization.

Schedule a Meeting

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