



# The BMP Module

## Audience and Processes

Target Audience, The module is designed for a multidisciplinary group of professionals, including:

- **Bioprocess Engineers and Researchers:** Looking to standardize biomethane potential assays.
- **AD Plant Operators:** Needing to validate substrate suitability before full-scale feeding.
- **Environmental Consultants:** Tasked with assessing the viability of organic waste-to-energy projects.
- **Laboratory Technicians:** Seeking to automate the transition from raw gas production data to standardized reports.

### Target Industrial Processes:

- **Waste-to-Energy (WTE):** Evaluation of municipal solid waste and agricultural residues.
- **Wastewater Treatment (WWT):** Assessing the digestibility of primary and secondary sludges.
- **Industrial AD:** Optimization of co-digestion recipes for food processing or distillery waste.

## Functionality

The BMP Module acts as a bridge between raw laboratory data and actionable kinetic intelligence.

### Current Features:

- **Data Processing:** Automatic conversion of raw biogas volume and methane concentration into standardized NmLCH<sub>4</sub>/gVS.
- **Kinetic Fitting:** Integration of mathematical models to describe the degradation rate.

### Users can fit data to:

- **First-order models:** For hydrolysis-limiting substrate and further parameter use in more complex mechanistic model.
- **Modified Gompertz:** To identify lag phases and maximum methane production rates ( $R_{max}$ ).
- **Logistic function:** Specifically used to describe the sigmoidal increase in methane production, effectively capturing the acceleration and deceleration phases of microbial growth.
- **Statistical Engine:** Comprehensive analysis including R<sup>2</sup> values, Root Mean Square Error (RMSE), and 95% confidence intervals for all fitted parameters.

## Future Projection:

- **Multi-Substrate Co-Digestion Analysis:** Predictive modeling for “synergy effects” between mixed feedstocks.
- **Inhibition Threshold Detection:** Automated flagging of potential ammonia or VFA (Volatile Fatty Acids) inhibition based on kinetic deviations.

## Benefits

- **Standardization:** Eliminates manual calculation errors, ensuring all BMP tests are processed using a consistent methodology.
- **Predictive Insight:** Moving beyond the “final methane yield” to understand how fast methane is produced, which is critical for determining hydraulic retention time (HRT) in full-scale reactors.
- **Optimized Decision Making:** Provides a scientific basis for selecting feedstocks based on both total energy potential and degradation kinetics.
- **Audit-Ready Reporting:** Generates high-quality statistical summaries suitable for peer-reviewed research or industrial compliance reports.

## Concepts and Assumptions

### Fundamental Concepts:

The module operates on the principle that methane production is a direct proxy for the biological degradation of organic matter under anaerobic conditions. It treats the batch reactor as a closed system where substrate availability is the limiting factor.

### Key Assumptions:

- **STP Normalization:** It is assumed that gas volumes provided are corrected to Standard Temperature and Pressure (0C, 1 atm).
- **Inoculum Subtraction:** The module assumes that a blank (inoculum-only) assay has been performed to subtract endogenous methane production from the sample results.
- **Homogeneity:** The substrate is assumed to be evenly distributed within the batch reactor.

### Limitations:

The module provides batch kinetics; extrapolating these results to continuous stirred-tank reactors (CSTR) requires

adjustment for “washout” and steady-state conditions.

Kinetic models cannot account for mechanical failures or sudden temperature fluctuations not captured in the data.

## Usage

Using the BMP Module follows a streamlined four-step workflow:

- **Data Upload:** Input your time-series biogas data (Time vs. Cumulative Methane) via a CSV or Excel template. Ensure you include the volatile solids (\$VS\$) mass of the substrate.
- **Model Selection:** Choose the kinetic model (e.g., First-order or Gompertz) that best reflects the observed production curve.
- **Parameter Estimation:** Run the fitting algorithm. The module will iteratively adjust the constants until the error between the experimental data and the model is minimized.
- **Review and Export:** Analyze the statistical significance of the fit and export the summary tables and high-resolution plots for your documentation.

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