INNOVATIVE POTENTIAL

PRODIGIO will innovate:

i) by developing an innovative methodology for the identification of early-warning signals based on the analysis of causal interaction networks, a versatile methodology that will be applicable to any other artificial (bioreactor) system driven by microbial communities, and

ii) by generating a base of knowledge for the development of scalable, reliable and affordable system failure prediction technologies that, integrated into comprehensive monitoring and control systems, help improve the performance of microalgae biomass production and anaerobic digestion systems.

EXPECTED IMPACTS

Expanding the genomic database of pathogens infesting microalgal culture systems and of anaerobes residing in anaerobic reactors for facilitating biotechnological advances.

Gaining further understanding of the genes, gene expression patterns and stress response patterns of industrially-relevant microbial guilds involved in microalgae biomass production, microalgal fermentation and bio-methanisation.

In summary, PRODIGIO will contribute to increasing the efficiency of solar energy conversion into biogas, paving the way for the development and future implementation of a truly sustainable microalgae-based biogas production industry.

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Prodigio Consortium

CSIC Consejo Superior de Investigaciones Científicas

AWI

MINES ParisTech

institute IMDEA energy

NMBU Norwegian University of Life Sciences

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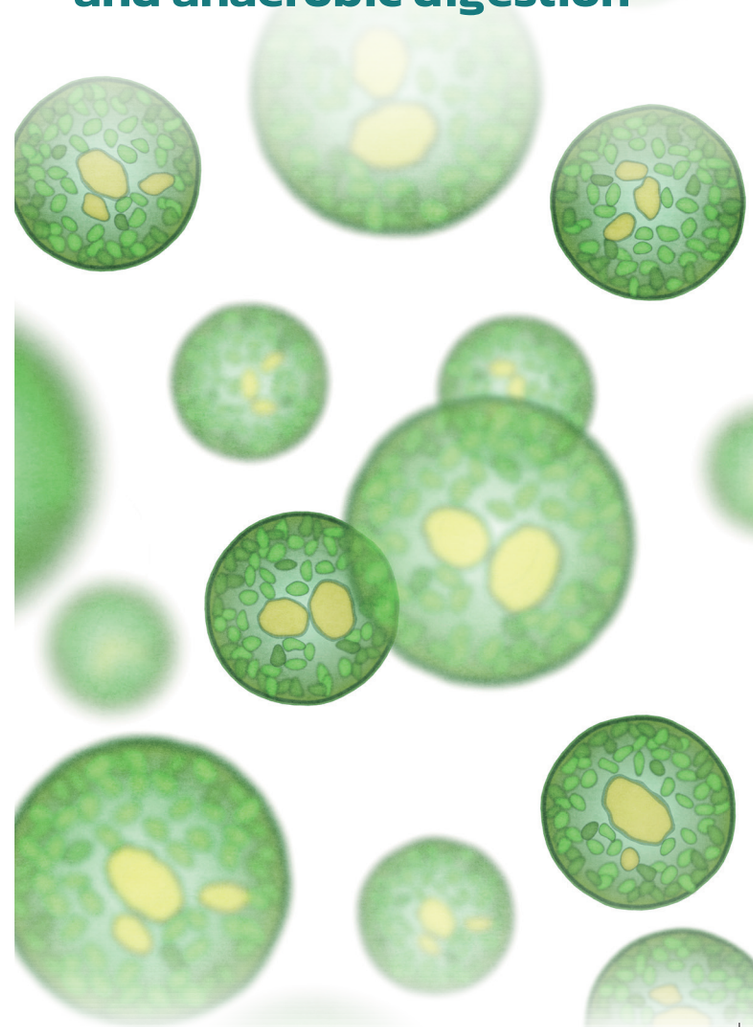
Developing early warning systems for improved microalgae production and anaerobic digestion



OBJECTIVE

PRODIGIO is developing a system failure prediction technology that will increase the performance of microalgal biomass production and anaerobic digestion systems and move towards morefavourable techno-economic, environmental and social performance to achieve more sustainable biogas from microalgae. PRODIGIO will:

- Simulate the failure of microalgae production and biomass conversion processes in lab-scale bioreactor systems.
- Develop an innovative framework for the identification of early warning signals based on the analysis of causal interaction networks.
- Identify early-warning signals, define threshold values and calculate warning times.
- Evaluate the potential of early warnings to improve the economic, environmental and social sustainability of the microalgae to biogas production chain.

The CONCEPT

Process failure is critical in nonlinear dynamical systems, such as bioreactors, where the functioning of complex microbial communities controls their performance. These systems undergo state transitions where the system shifts from one stable state to another at a critical threshold, also called the tipping point. Because critical state transitions alter the efficiency of microbial communities for the provision of services, anticipating the failure of the system is crucial for the timely implementation of prevention measures that ensure process stability and technology profitability (Figure 1).

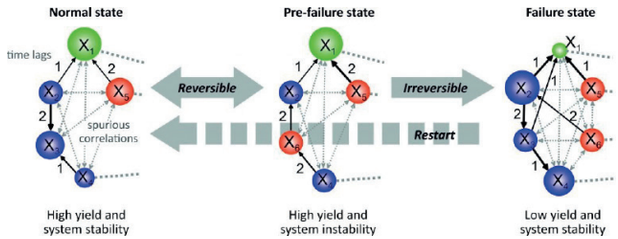


Figure 1. Theoretical scheme showing a complex, non-linear dynamical system transiting from the normal state to the failure state. Colors denote different components of the system, such as, the end-product (green), keystone microorganisms (blue), environmental conditions (red), interacting among them (arrows). PRODIGIO aims to identify early warning signals that allow us to anticipate as far in advance as possible when the system is going to crash.

By combining 'big data' acquisition from perturbation experiments in bioreactor systems, omics and chemical fingerprinting technologies, state-of-the-art bioinformatic tools, and novel methods for the analysis of causal interaction networks, PRODIGIO will decode triggers, identify early-warnings, define threshold values,and calculate warning times for critical state transitions in bioreactor systems.

MICROALGAE: A SOURCE OF BIOMASS FOR THE FUTURE

Microalgae are some of nature's finest examples of solar energy conversion systems, transforming carbon dioxide into complex organic molecules. Due to their outstanding photosynthetic yields, microalgae are a truly sustainable source of nutritional and bioenergy feedstock.

ANAEROBIC DIGESTION: A SOURCE OF RENEWABLE BIOGAS

Anaerobic digestion is a natural biomass degradation process carried out by microorganisms, which very efficiently transform biomass into methane-rich biogas under anaerobic conditions.

EARLY WARNING TECHNOLOGIES

Progress in bio-analytical chemistry has resulted in a vast array of chemical probes and biosensors, which enable the process engineer to monitor a wide variety of parameters. However, the advancement of system failure prediction technologies requires knowing the most effective process parameters with which to guarantee failure prediction as far inadvance as possible.

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