# 2SC5293 – Advanced supervision of biogas production from waste

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**Language of instruction:** FRANCAIS
**Campus:** CAMPUS DE PARIS - SACLAY
**Workload (HEE):** 40
**On-site hours (HPE):** 27,00

## Description

Anaerobic digestion is a natural process of degradation of organic substances by micro-organisms (bacteria and archaea) in the absence of oxygen (anaerobic conditions).
This process makes it possible to recover a fraction of the energy contained in the waste in the form of biogas, a mixture of methane and CO2.
The widespread use of these technologies would on the one hand considerably reduce the energy demand necessary to treat waste (10% of the energy used on the planet) but could in the long term constitute a source of energy.

However, the anaerobic digestion process is complex and involves several hundred species of microorganisms. Moreover, it is unstable, and intermediate compounds (volatile fatty acids) can, under certain conditions, accumulate and lead to the total shutdown of the reactor. To avoid this, very precise and costly monitoring is necessary.

The objective of the Challenge Week is to propose and develop monitoring and control strategies to reduce the risk of reactor acidification and to optimize energy production from waste.

## Quarter number

ST5

## Prerequisites (in terms of CS courses)

There are no specific prerequisites.

## Syllabus

Students will first need to understand an anaerobic digestion model that will be provided and simulate it for different conditions.
In particular, they will need to simulate reactor acidification under conditions of overloading the reactor.

They must propose a simulator with a simplified model for this complex system, for the purpose of implementing control and estimation strategies. In a second step, they will have to develop observers to evaluate certain intermediate compounds, and in particular volatile fatty acids. It is desirable that a self-calibration dynamic is introduced to take into account the slow drifts of certain model parameters.
Other groups will use the models to develop control strategies. Different approaches will be implemented (e.g. PID, feedback control).
In the end, a supervisor will be proposed by associating an observer(s) to a control law. The performances of the different supervisors will be compared for different reactor operating scenarios.

**Class components (lecture, labs, etc.)**
Students will be divided into groups. The project will be carried out by organizing the internal work of each group in order to address the different themes of the specifications.
Analytical and numerical tools will have to be developed by the students in order to address the problems raised.
The hypotheses and data considered must be questioned; these elements will lead the students to iterate on their design choices in order to obtain relevant solutions.

**Grading**
The evaluation will include a continuous assessent, a final report, and an oral presentation.

**Course support, bibliography**


- Anaerobic Digestion Model No. 1, PWA Publishing, 2002.
- Dynamical Model Development and Parameter identification for an anaerobic wastewater treatment process, O. Bernard et al., *Biotechnology and bioengineering*, *75*(4), 424-438, 2001.

- On-line Estimation and Adaptive Control of Bioreactors, G. Bastin, D. Dochain, Elsevier, 1990.

- Automatic Control of Bioprocesses, éditeur D. Dochain. Wiley-ISTE, 2008.


**Resources**

- Simulator of the bioprocess to be studied,
- State-of-the-art and a description of the studied bioprocess.

- Supervision: researchers from INRIA (Sophia-Antipolis), teacher-reseacrhers of CentraleSupélec, with regular contact with the industrial partner.

- Work in group.

**Learning outcomes covered on the course**

At the end of the Challenge Week, the students will be able to:

- Model a bioprocess for the culture of a microorganism for environmental application
- Design software sensors to reconstruct variables not available online
- Design control laws to maintain the system at desired operating conditions (pH, temperature, concentrations, etc.) to maximize the productivity of the bioprocess.
- Analyse the proposed solution (including economic analysis and ecological footprint) and be critical of the results obtained.

**Description of the skills acquired at the end of the course**

– C1.1, Analyze: study a system as a whole, the situation as a whole. Identify, formulate and analyze a system within a transdisciplinary approach with its scientific, economic, human dimensions, etc. Milestone 1
– C1.2, Modeling: using and developing the appropriate models, choosing the correct modeling scale and the relevant simplifying assumptions. Milestone 2
– C2.3, Identify and independently acquire new knowledge and skills. Milestone 2
– C4.2, Propose one or more solutions answering the question rephrased in terms of value creation and complemented by the impact on other stakeholders and by taking into account other dimensions. Quantify the value created by these solutions. Arbitrate between possible solutions. Milestone 1
– C7.1, Basically: Structure ideas and arguments, be synthetic (assumptions, objectives, expected results, approach, and value created). Milestone 2
– C7.2, On the relationship with others: Understand the needs and expectations of his interlocutors evolutionarily. Encourage interactions, be a teacher, and create a climate of trust. Milestone 2