

OBIWAN Project : from Organic Waste to Advanced Chemicals via Biogas - an Integrated Carbon Cycle with CO₂ Recovery

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Introduction and Context

Anaerobic digestion (AD): decomposition of organic matter by a microbial consortium in absence of oxygen.

Generates **biogas** : methane (~50%), CO₂ (~50%), **impurities**.

Valorisation of biogas:

- Generate electricity and heat
- Be injected into natural gas networks
- Serve as precursor for sustainable chemicals

The OBIWAN Project: convert **organic waste** streams into **advanced chemicals** products through **anaerobic digestion**: mitigate climate change, prevent greenhouse emissions, generate valuable products, strategic autonomy.

Partners (Figure 1):

- **UTC & UniLaSalle:** Stabilize biogas composition and flow rate
- **Certech:** Characterize, purify and separate biogas
- **Ghent University:** Realize methane pyrolysis into H₂ and solid C
- **CNRS Lille:** Develop catalytic methanol synthesis from CO₂ and H₂

Methanol: Production of **aviation fuel** and **advanced chemicals**.

Solid carbon: **car tier fillers, activated carbon** (biogas purification)

Funding: European Territorial Cooperation Program

Interreg France-Wallonie-Vlaaderen (Interreg FWVL)

Engagement of 2.59 million euros, 1.56 million euros through

European Regional Development Fund (ERDF)

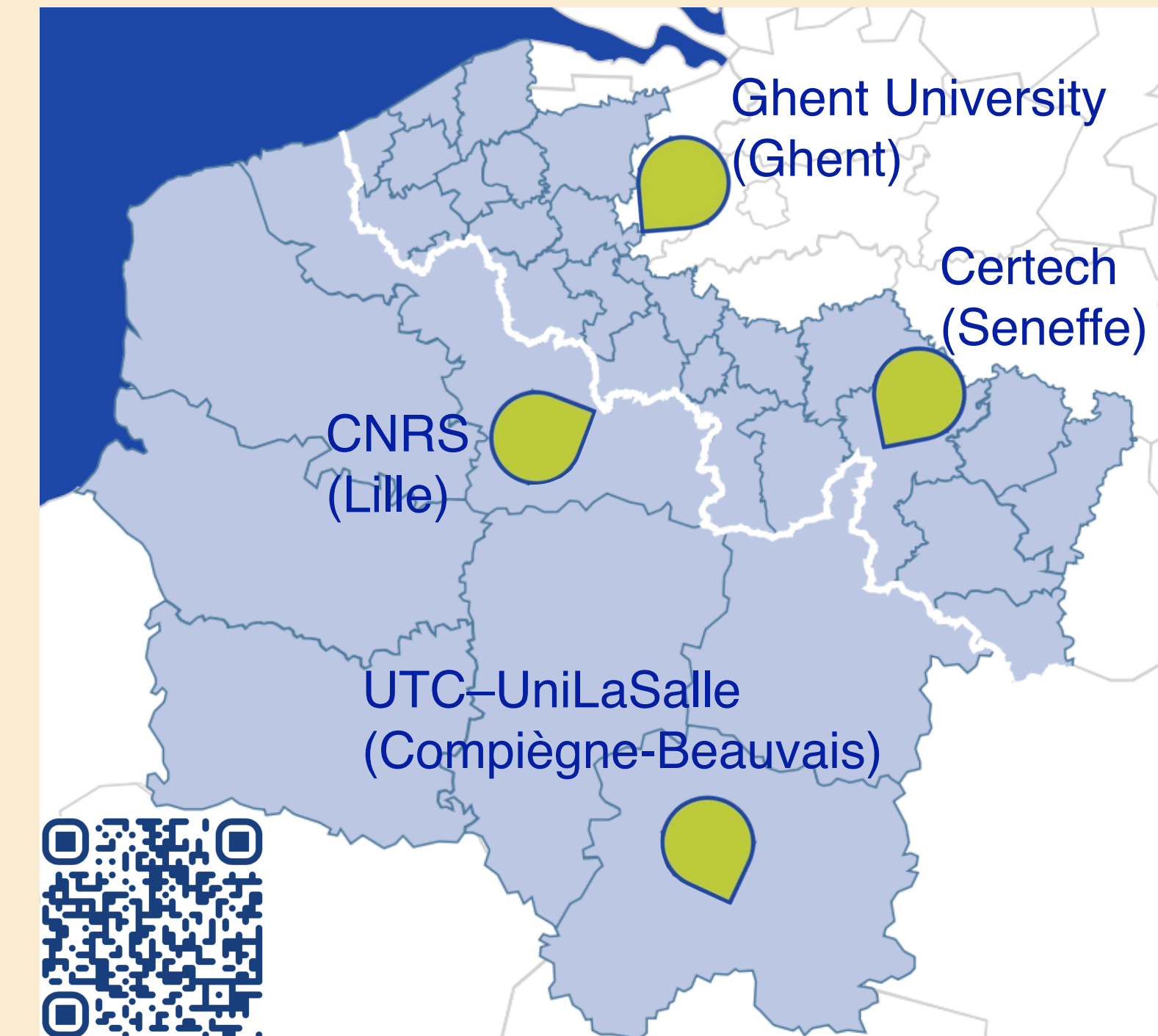


Figure 1. OBIWAN project partners and website.

Doctoral Research Project

The objective:

- To stabilize the biogas composition and flow rate produced during anaerobic digestion of variable feedstock

The workflow:

- Establishing a **model** of the anaerobic digestion process based on a balanced **reaction scheme** accounting for **bio-kinetics, mass transfer** and **hydrodynamics**
- **Experimentation** : model calibration and validation, optimizing monitoring strategy
- Developing a **dynamic control system** capable of **maintaining process and biogas production stability** by adjusting **operational parameters** (Figure 2).

The issue:

- Existing models are not well suited for **substrate variability**
- **Carbon balance** and environmental impact accountability at heart of the OBIWAN Project
- Precise prediction of biogas composition and flow rate demands energy and mass **balance closure**

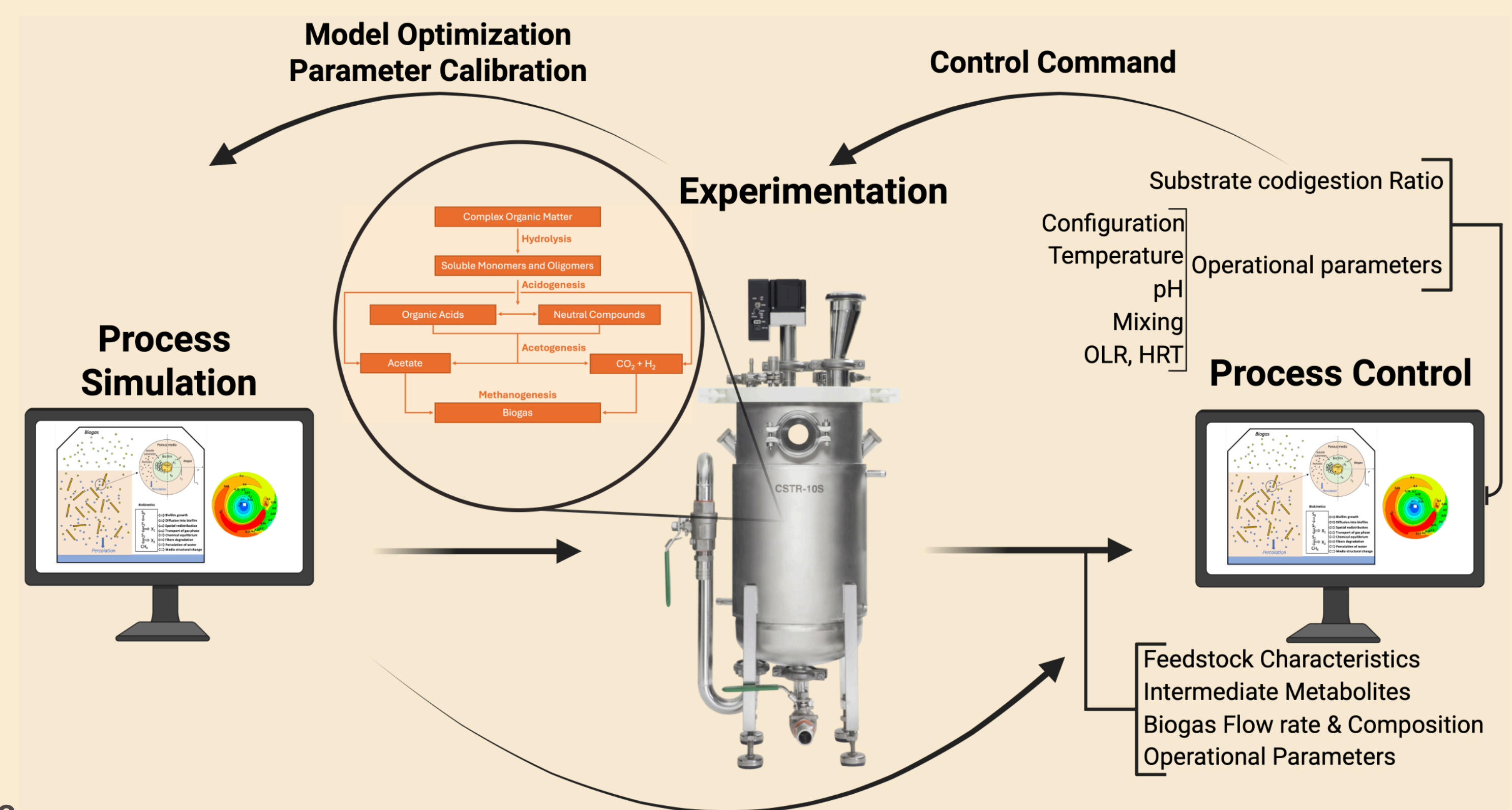


Figure 2. The workflow of the PhD project

Mathematical Modeling of AD : Carbon and COD Balances

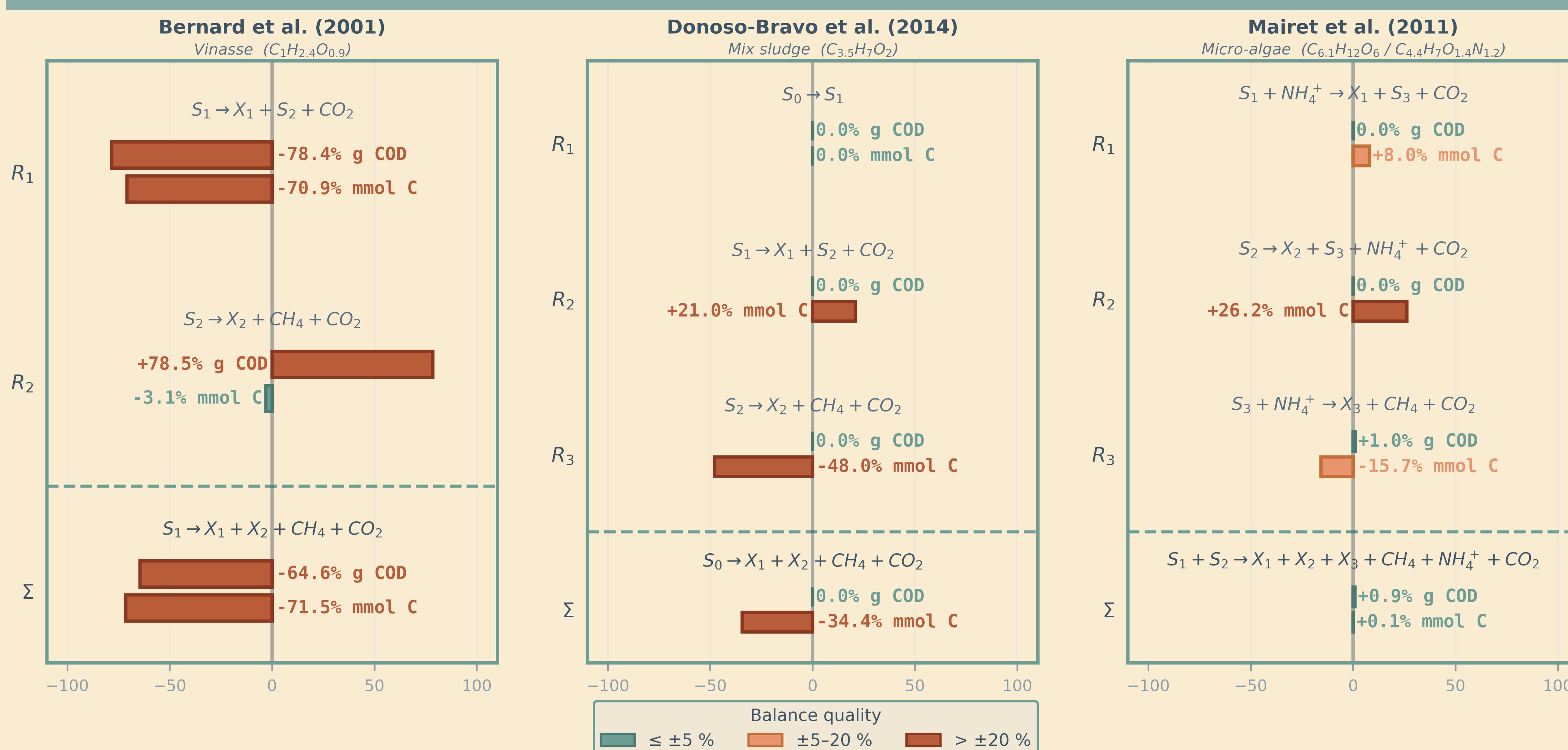


Figure 3. Carbon and Chemical Oxygen Demand (COD) Balances of major anaerobic digestion models derived from AM2

Steps of mass Balance Modeling:

- Defining Reaction Scheme
- Determining appropriate Kinetics
- Validating the model

Anaerobic Digestion models

- **ADM1** (Batstone et al, 2002): generate knowledge
- **AM2** (Bernard et al, 2001): process control

Elemental (Carbon) and Energy (COD) balances: robustness of the reaction scheme, soundness of biogas composition predictions, often neglected in the literature (Figure 3)

Balance inaccuracies: insufficient characterization of feedstock, imprecise pooling of various chemical species, faulty reaction schemes

⇒ **Stoichiometrically balanced reactions, accounting for enough variability and parsimony**

Conclusion & Perspectives

The **OBIWAN project** aims at converting organic waste into advanced chemical products. As such, this doctoral research project focuses on **stabilization of biogas flow rate and composition** produced during anaerobic digestion, thus facilitating valorization. Through comprehensive **SSAD modeling** and **experimental validation**, this research addresses the challenge of proposing **process control tools**.

References

- (1) O. Bernard, Lect. Notes Mass Balance Modeling of Bioprocesses (ICTP) 8 (2001)
- (2) O. Bernard, Z. Hadj-Sadok, D. Dochain, A. Genovesi, J. Steyer, Biotech & Bioengineering 75 (2001) 424–438.
- (3) A. Donoso-Bravo, S. Pérez-Elvira, F. Fdz-Polanco, Environmental Technology 36 (2015) 1334–1346.
- (4) F. Mairet, O. Bernard, E. Cameron, M. Ras, L. Lardon, J. Steyer, B. Chachuat, Biotech & Bioengineering 109 (2012) 415–425.