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Research for optimal waste management for flexible biogas production



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Conference flexibility biogas – OFATE – 13 October 2016



1. EIFER presentation
2. Biogas and territory energetic transition
3. Why biogas flexibility?
4. Thesis : digester limit for flexible waste management
5. Thesis first results
6. Conclusions and perspectives

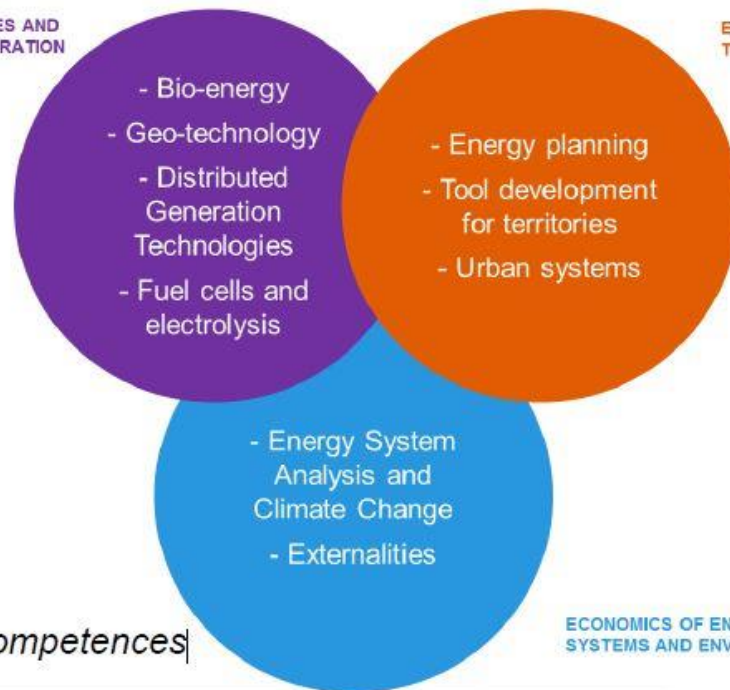


EIFER is an European Economic Interest Grouping

- Two equal Members: EDF - Electricité de France S.A.
KIT - Karlsruhe Institute of Technology
- Founded in September 2001, located in Karlsruhe
- 110 employees (46% German, 40% French, 14 other nationalities)
- 12 M€ annual budget



ENERGY RESOURCES AND DISTRIBUTED GENERATION



ENERGY, CITIES AND TERRITORIES

ECONOMICS OF ENERGY SYSTEMS AND ENVIRONMENT



Relationship between biogas, energy transition et territory sustainable development

- > Biogas makes a link between agriculture, waste treatment and energy.
- > Biogas gives one possibility to diversify farmer and agro-industry activities, and even municipalities.
- > Biogas can contribute to develop a new local organisation for a sustainable territory development: local heat, local electricity, local fuel and local waste management.
- > Biogas creates economic and social value, with local business and local employment.



Biogas: a predictive renewable energy

- > Biogas gives the possibility to be used when we have energy needs
 - In complementarity of solar and wind power,
 - Depending heat network needs and/or electricity market prices.
- > In micro-grid or local grid, biogas cogeneration can be use to limit storage capacity (eg. Micro-grid for access to energy in developing countries)
- > Biogas flexibility is already important in Germany: 1 800 MWe for 4 400 MWe cogeneration capacity in 2015 (Fachverband Biogas)

But if we need flexible biogas production

- How can we manage the feeding of waste depending on needs?
- What are the limits of the digester in flexibility?

With LBE INRA laboratory, we decided to organize a thesis to answer these questions



Evaluation of physical limits of a biogas digester for flexible use in a local power generation network (start 01/2015)



Thesis





The 3 phases of the flexible digester thesis

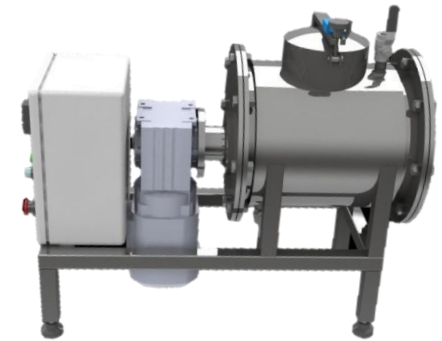
1. Laboratory test: evaluation of flexibility, response time and operating limits

- 3 reactors*, 15 L (useful capacity 10 L), perfectly mixed, 37°C

❖ **Fast-degrading reactor : Carrot + Grass**

❖ **Medium-degrading reactor : Grass + Cow manure**

❖ **Slow-degrading reactor : Cow manure + Pig slurry**

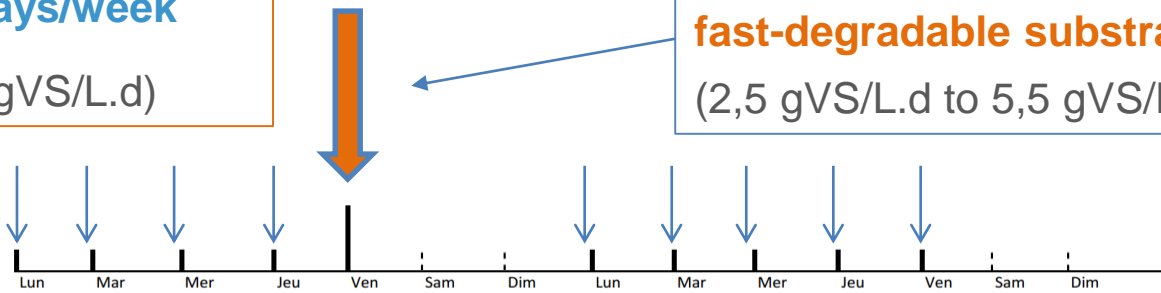


Feeding 1/day, 5 days/week

(1,5 gVS/L.d to 2,5 gVS/L.d)

Punctual overloads with mix or fast-degradable substrates

(2,5 gVS/L.d to 5,5 gVS/L.d)

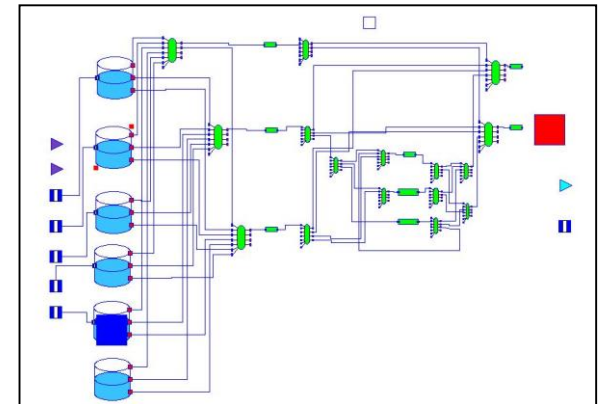
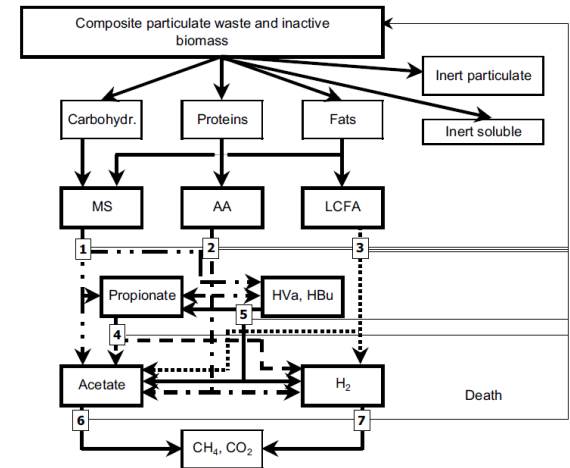




The 3 phases of the flexible digester thesis

2. Physical Model: ADM1

- Modeling of batch results,
- Extrapolation to continuous operation,
- Simulation of feeding strategies and multi-waste optimization.



ADM1 is complex but precise

- Calibrated on laboratory reactor and flexibility response
- Use Matlab in the first step
- Will be connect to Modelica / Dymola ThermoSysPro library



The 3 phases of the flexible digester thesis

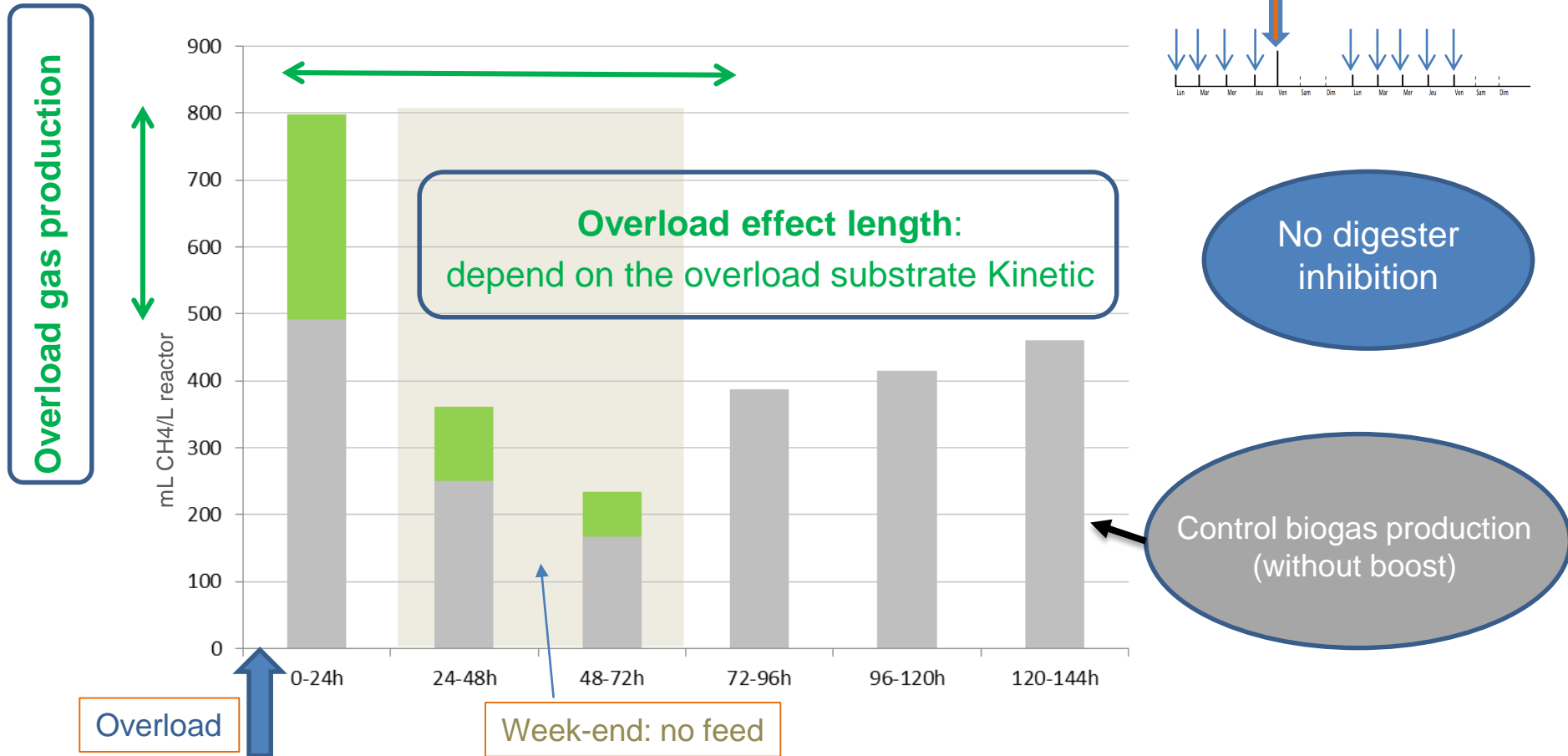
3. Tests in operating pilot: 1,5 m³ digester

- Validation of the results obtained in laboratory
- Validation and adaptation of the ADM 1 model for a 1,5 m³ digester
- Necessary step before the industrial validation (change of scale)





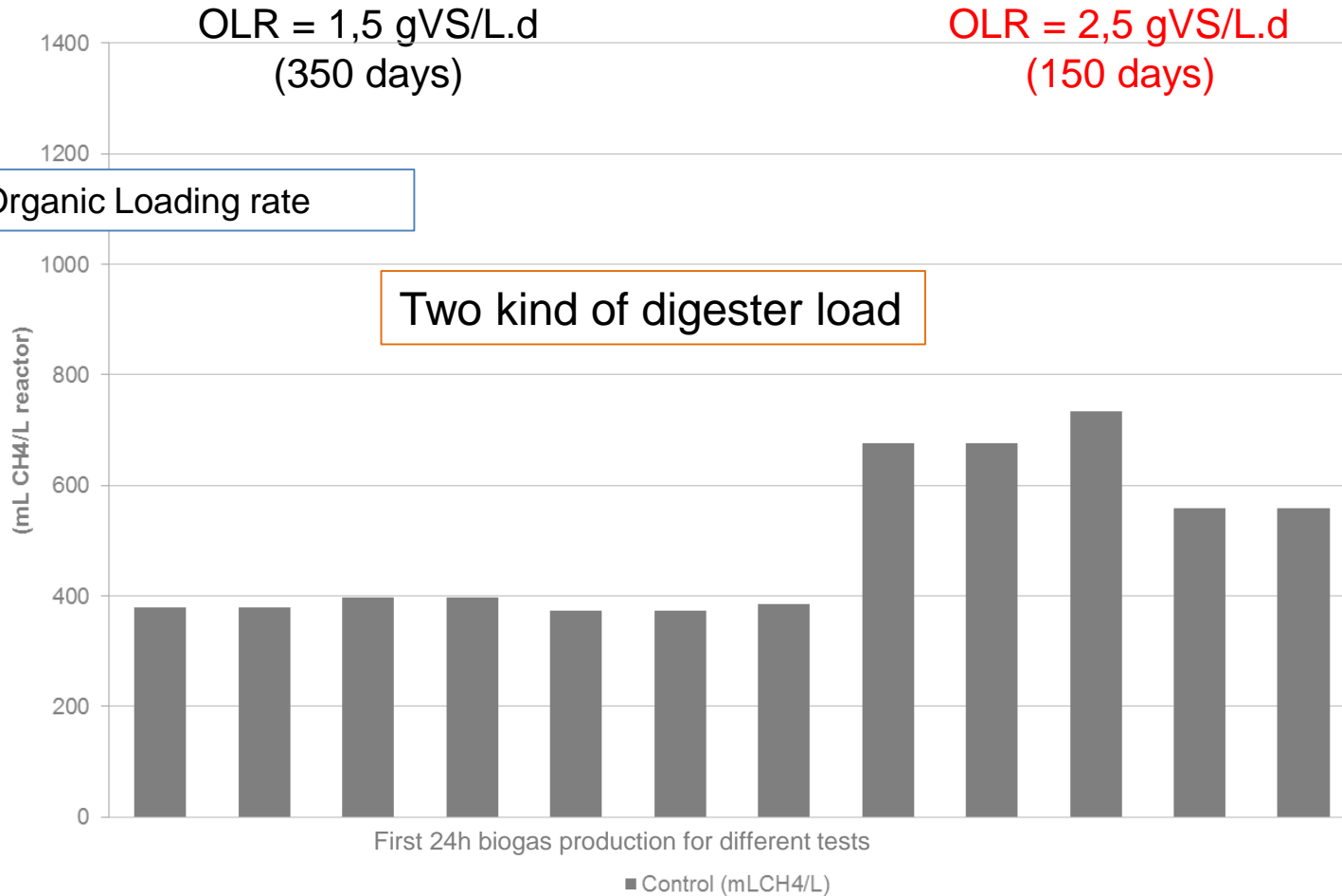
Different behaviors depending on the kind of digester (fast, medium or slow) and substrate used for overload



Example of behavior for the medium reactor (grass - manure)



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Control (without overload): same biogas production value for the same OLR

Example of behavior for the medium reactor (grass - manure)

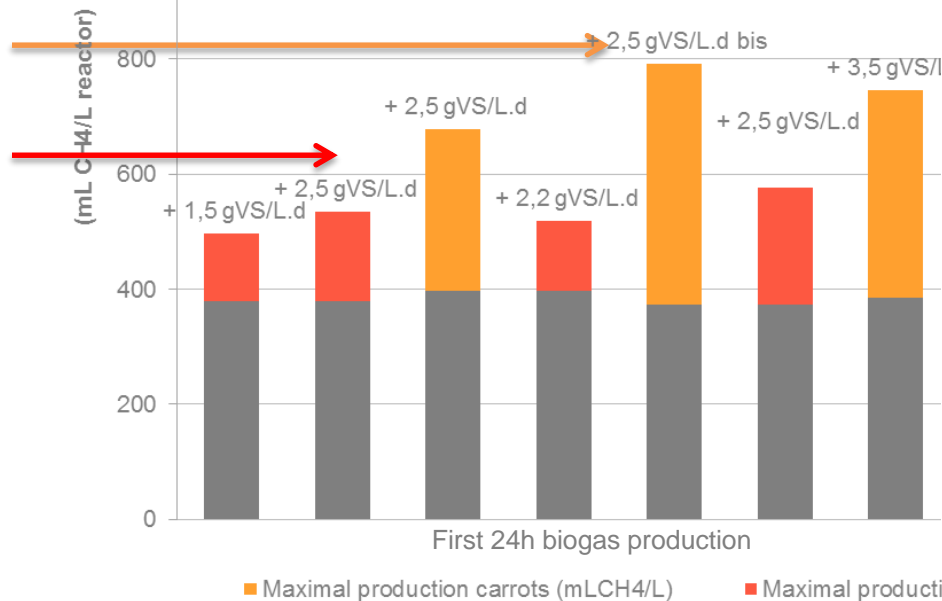


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First Days overload view

OLR = 1,5 gVS/L.d
(350 days)

Ceiling value of overload biogas production

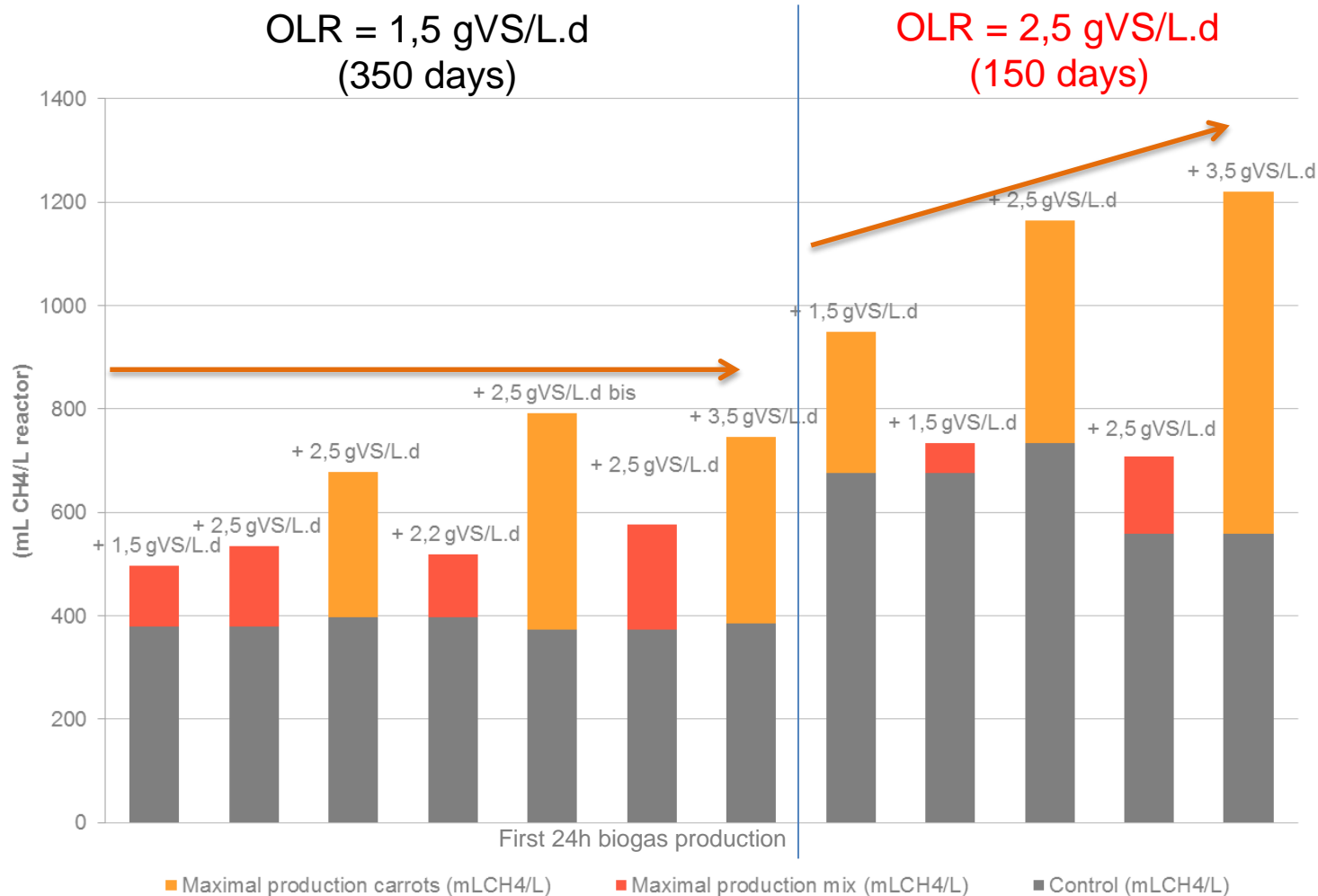


- The maximal of biogas production is fixed, even with different level of load
- With carrots overload the ceiling value is higher than mix (grass and manure)

Example of behavior for the medium reactor (grass - manure)



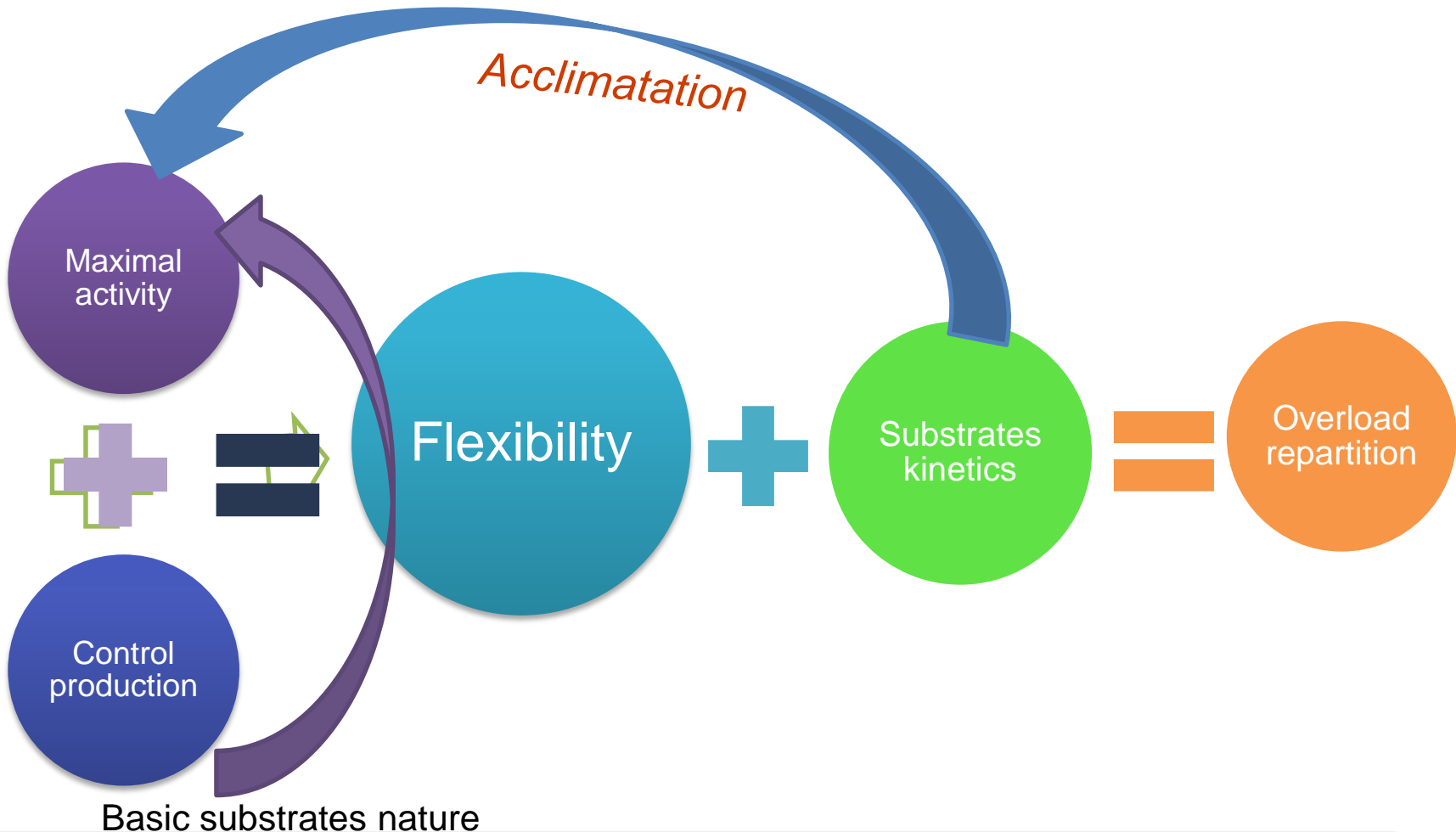
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Raising of the Maximum overload biogas production, evolution of the ceiling



- No inhibition during our experiments
- Flexibility = margin between basic activity and a maximum activity





- For a better level of instantaneous flexibility in biogas production:
 - Low OLR (Organic Loading rate)
 - Various substrates natures in basic feed
 - Fast-degrading substrates

Results of the thesis might be:

- ✓ Digesters driving instructions for flexibility according to:
 - the substrate and their families degradation kinetics,
 - the state of the digester



NEXT THESIS STEPS

- ADM1 modelling calibration
- Scale-up (1m³)
- Guidelines for flexible exploitation of digesters

And after

industrial validation, transfer to simulation and monitoring tools



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**Merci
pour votre attention**

**Vielen Dank
für Ihre Aufmerksamkeit**

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