



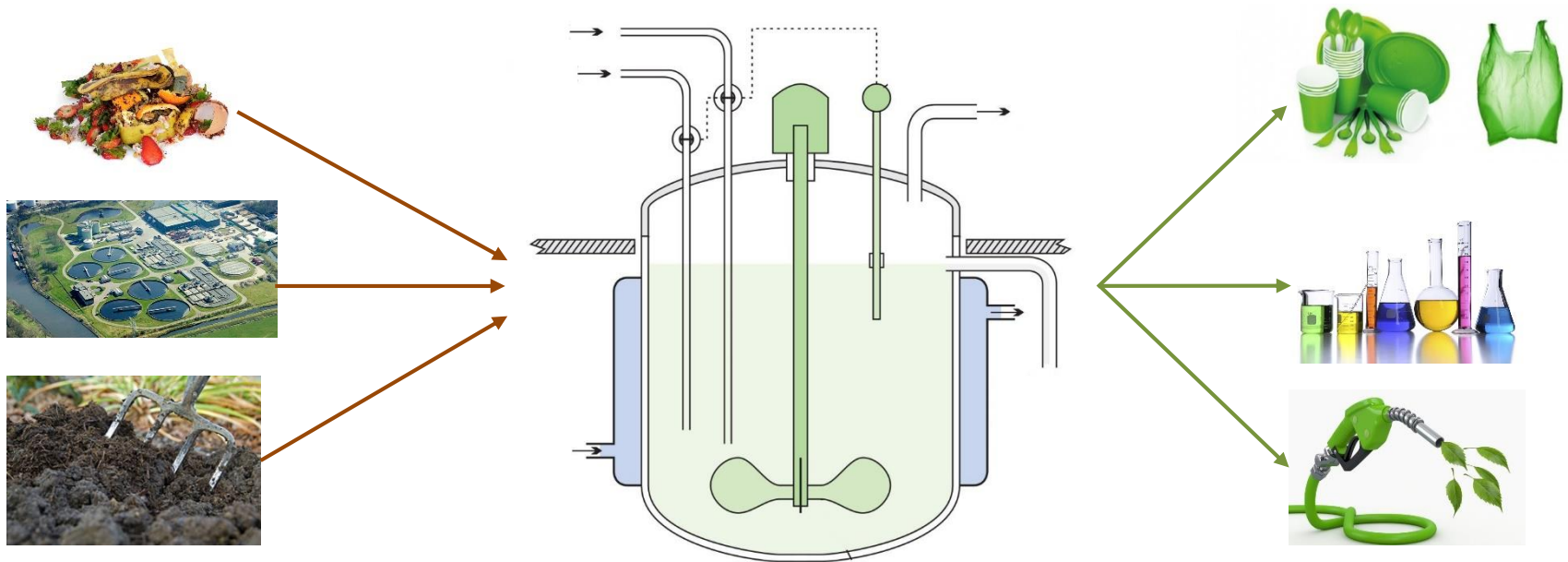
BIOCHEM: A new methodology for designing mixed-culture bioprocesses assisted with bioenergetics models

A. Regueira, M. Mauricio-Iglesias, M. Carballa, J. M. Lema

*Departament of Chemical Engineering
Universidade de Santiago de Compostela*

Mixed-culture processes for a circular economy

- From treating waste (remediation) to generate added-value products
- Microorganisms come with the substrate and environment
- Complex and complete community



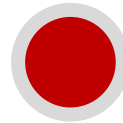
Mixed cultures: pros and cons



No sterilisation



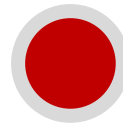
Complex and not fully understood



Treat complex substrates



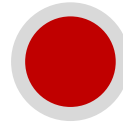
Very variable outcome



Robust



Novel bioprocesses are hard to design

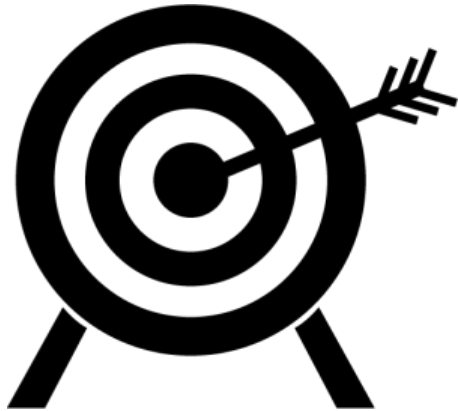


Biochem Project helps designing novel bioprocesses



BIOCHEM

2017-2020



To provide tools for designing novel mixed-culture bioprocesses



Biochem Project helps designing novel bioprocesses



Select the microbial population

Protein-rich substrates

Carbohydrate-rich substrates

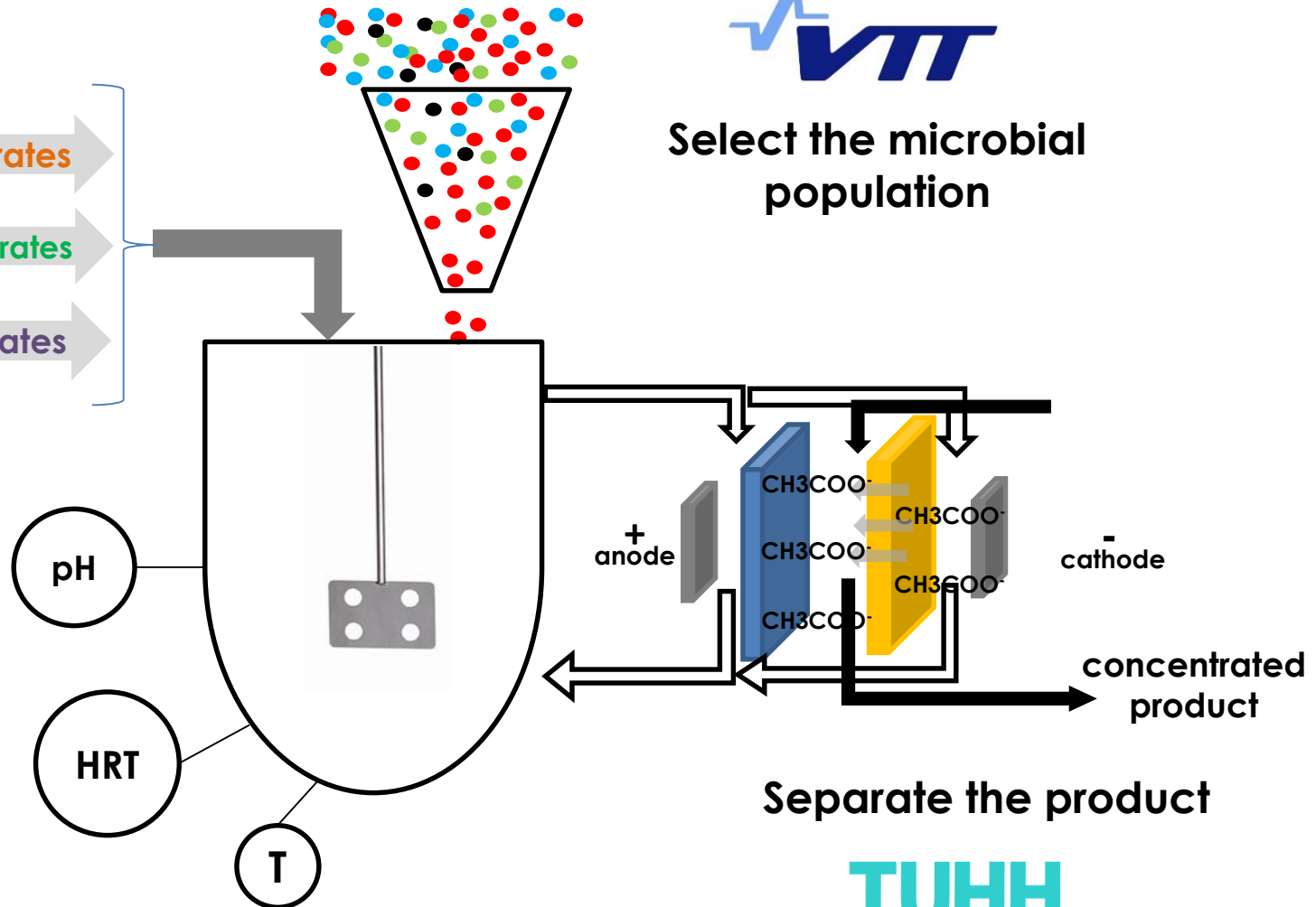
Lipid-rich substrates

Select the operating conditions

pH

HRT

T



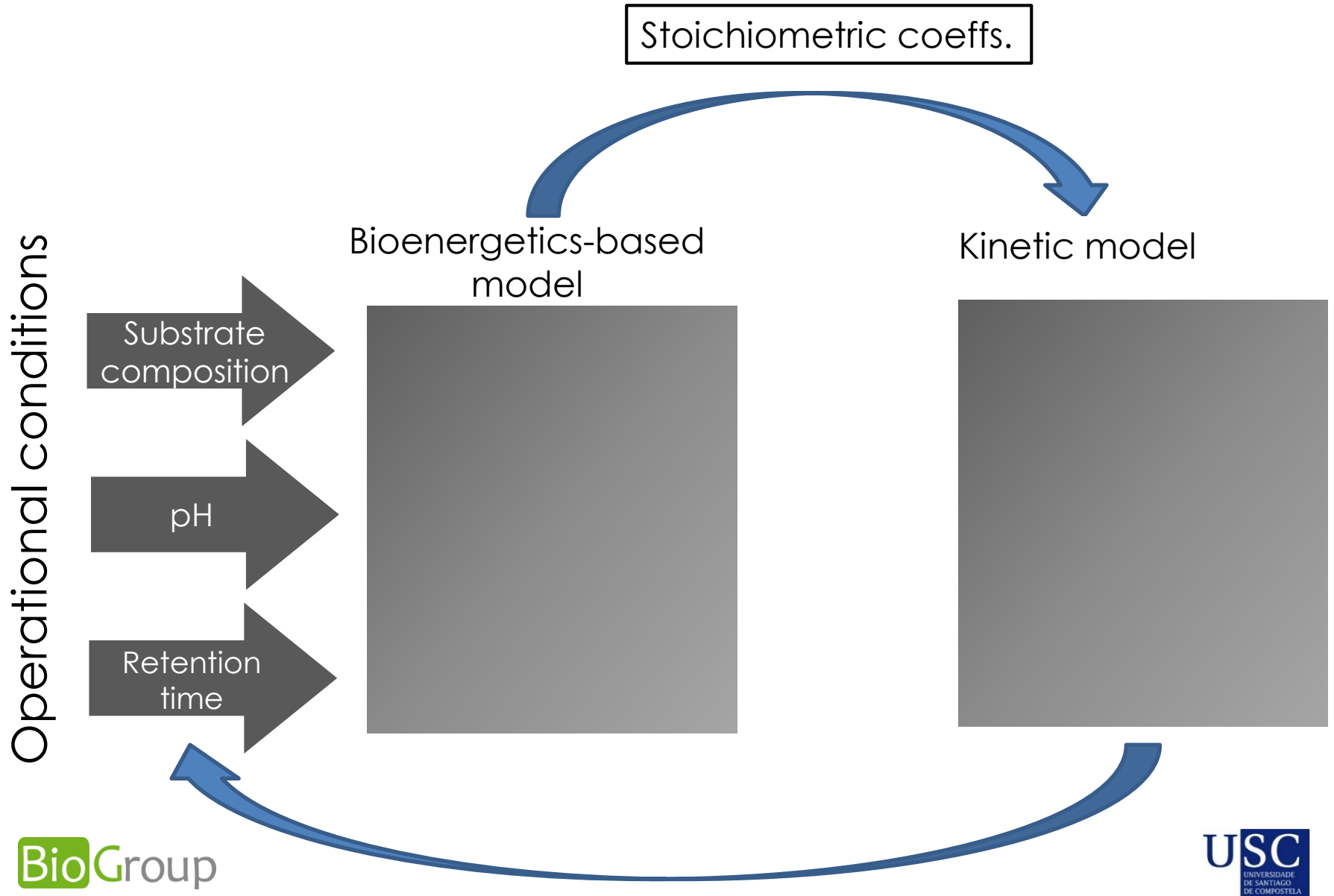
Separate the product

TUHH

Technische Universität Hamburg-Harburg



Selecting operational conditions with the help of models

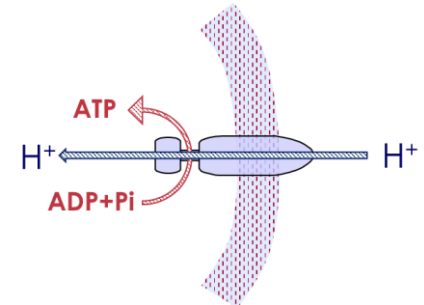
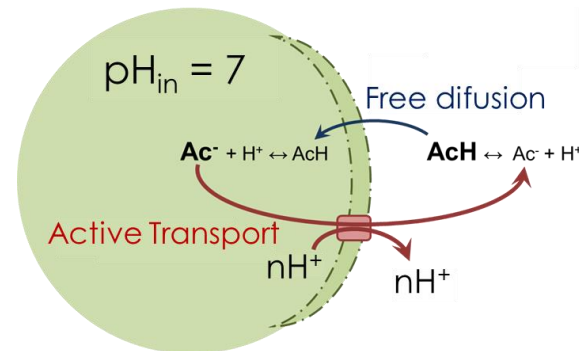
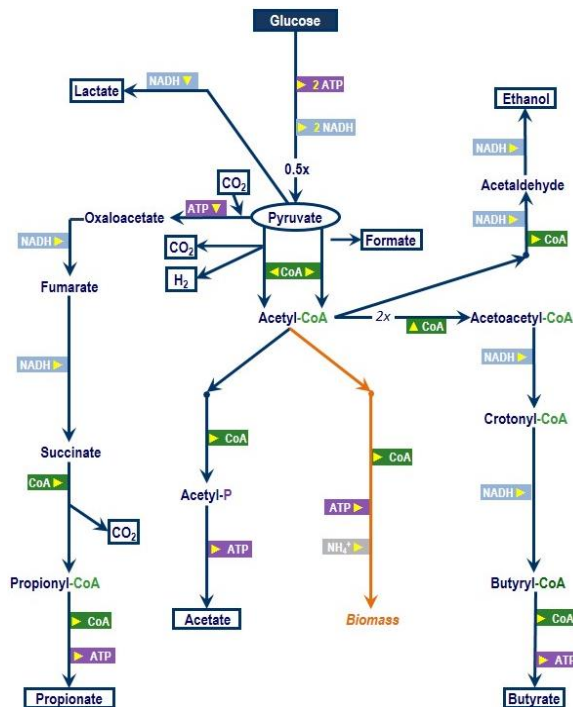


Bioenergetics model predicts product spectrum

Limited energy environments

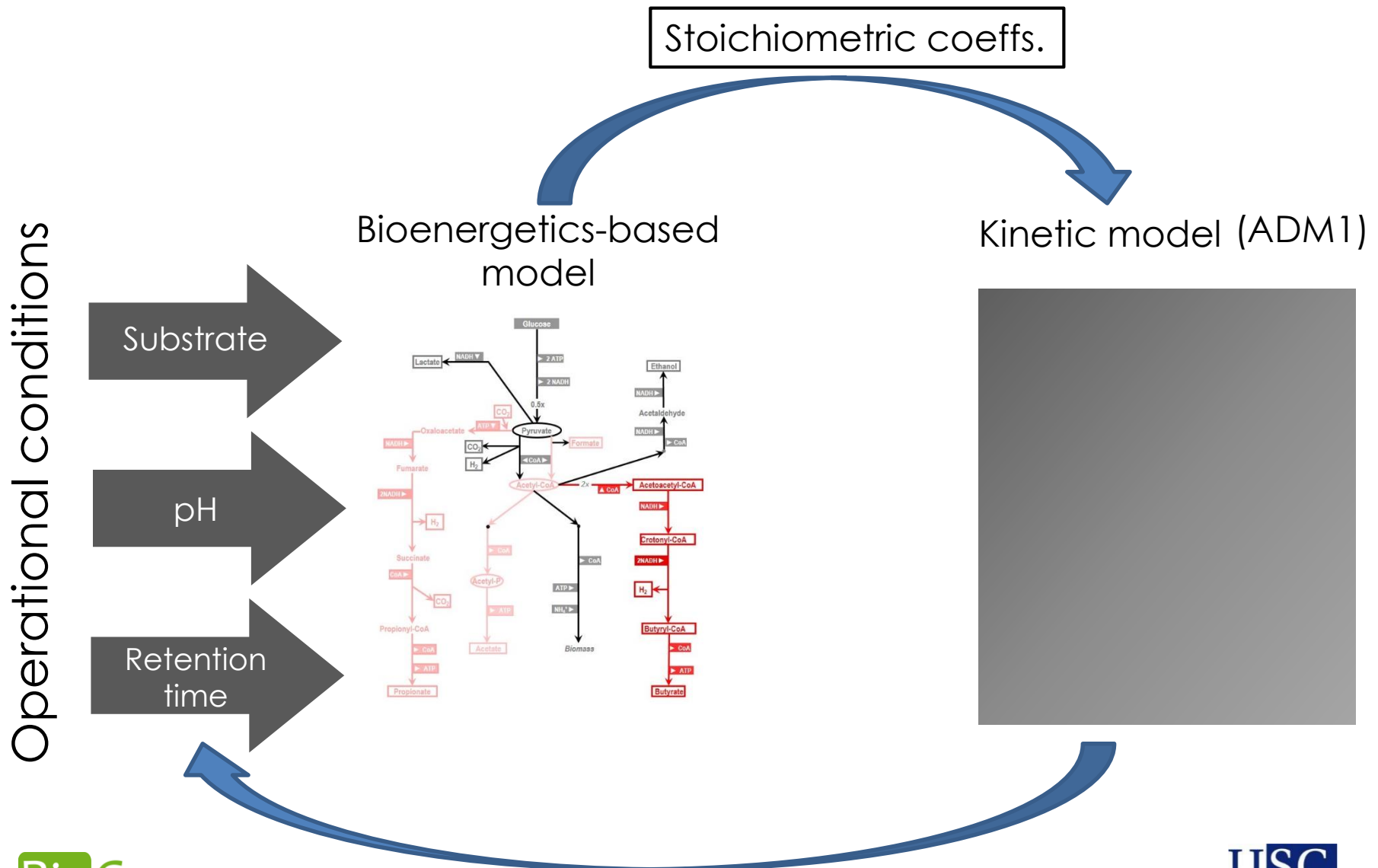
$\text{Max}(r_{\text{ATP}})$

$$r_{\text{ATP}} = r_{\text{CAT}} + r_{\text{TRANSPORT}} + r_{\text{PMF}} + r_{\text{MAINTENANCE}} + r_{\text{HOMEOSTASIS}}$$



González-Cabaleiro et al. (2015). Plos One

Selecting operational conditions with the help of models



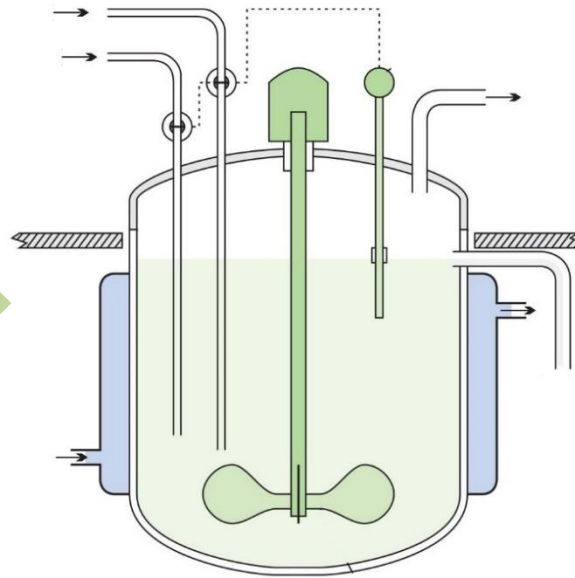
Proof of concept: Case study

- Butyrate production from glucose-rich waste

pH: ?

HRT: ?

Substrate: Glucose



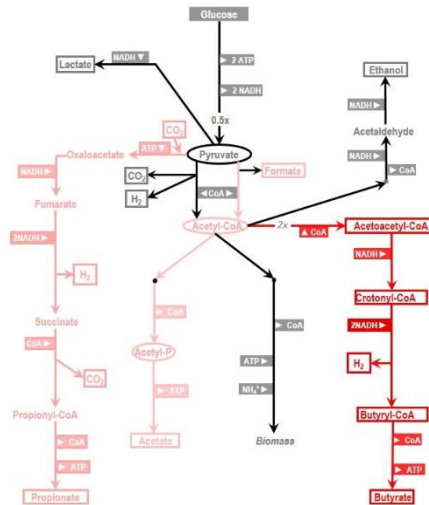
Butyrate: ? g/L d

Bioenergetics model to determine pH

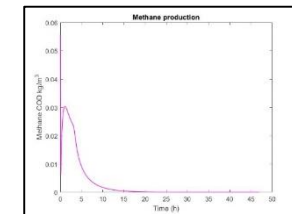
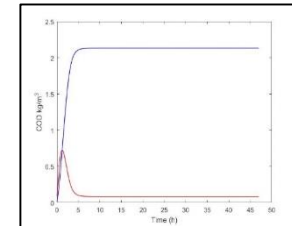
Operational conditions

Substrate:
Glucose

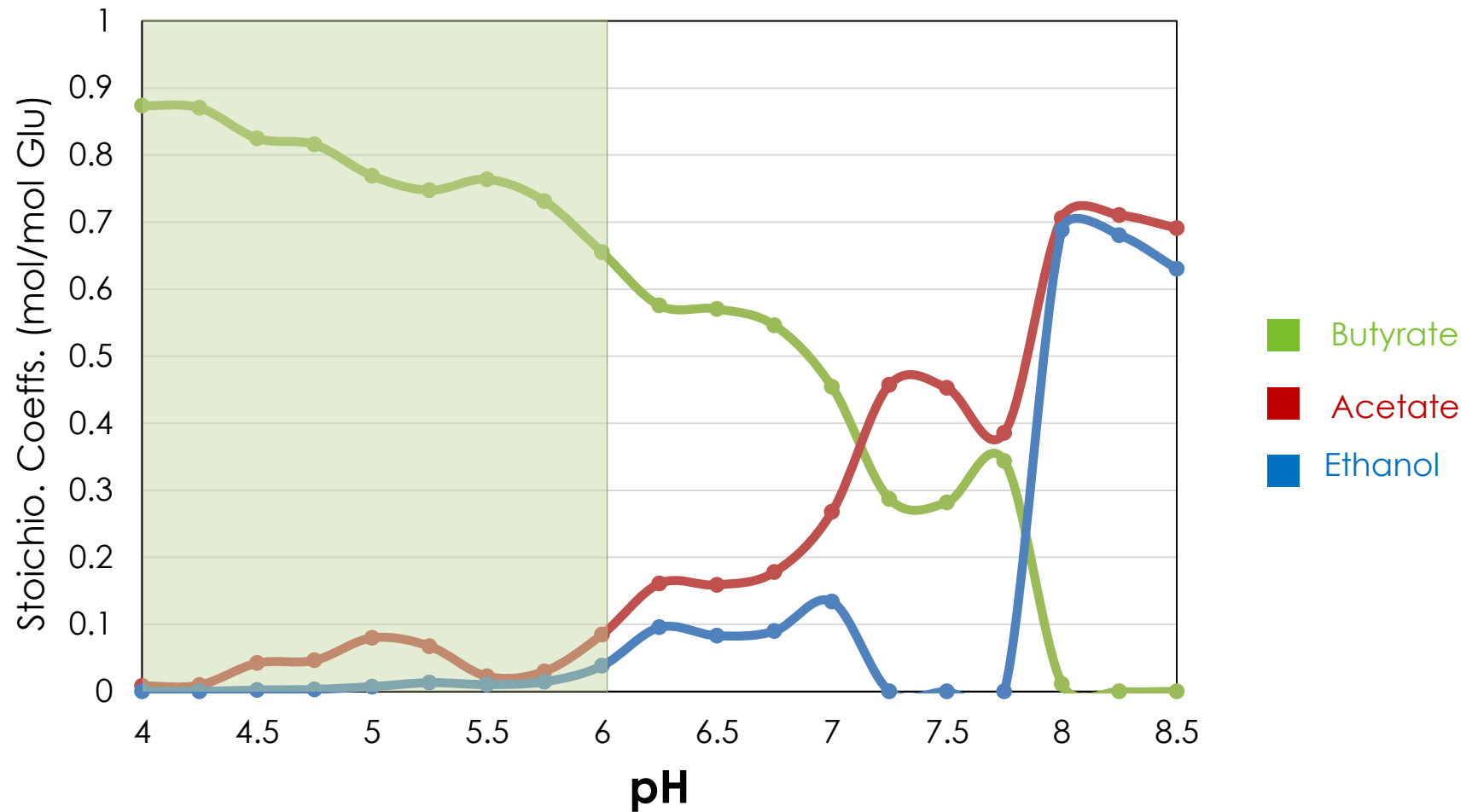
Bioenergetics-based
model



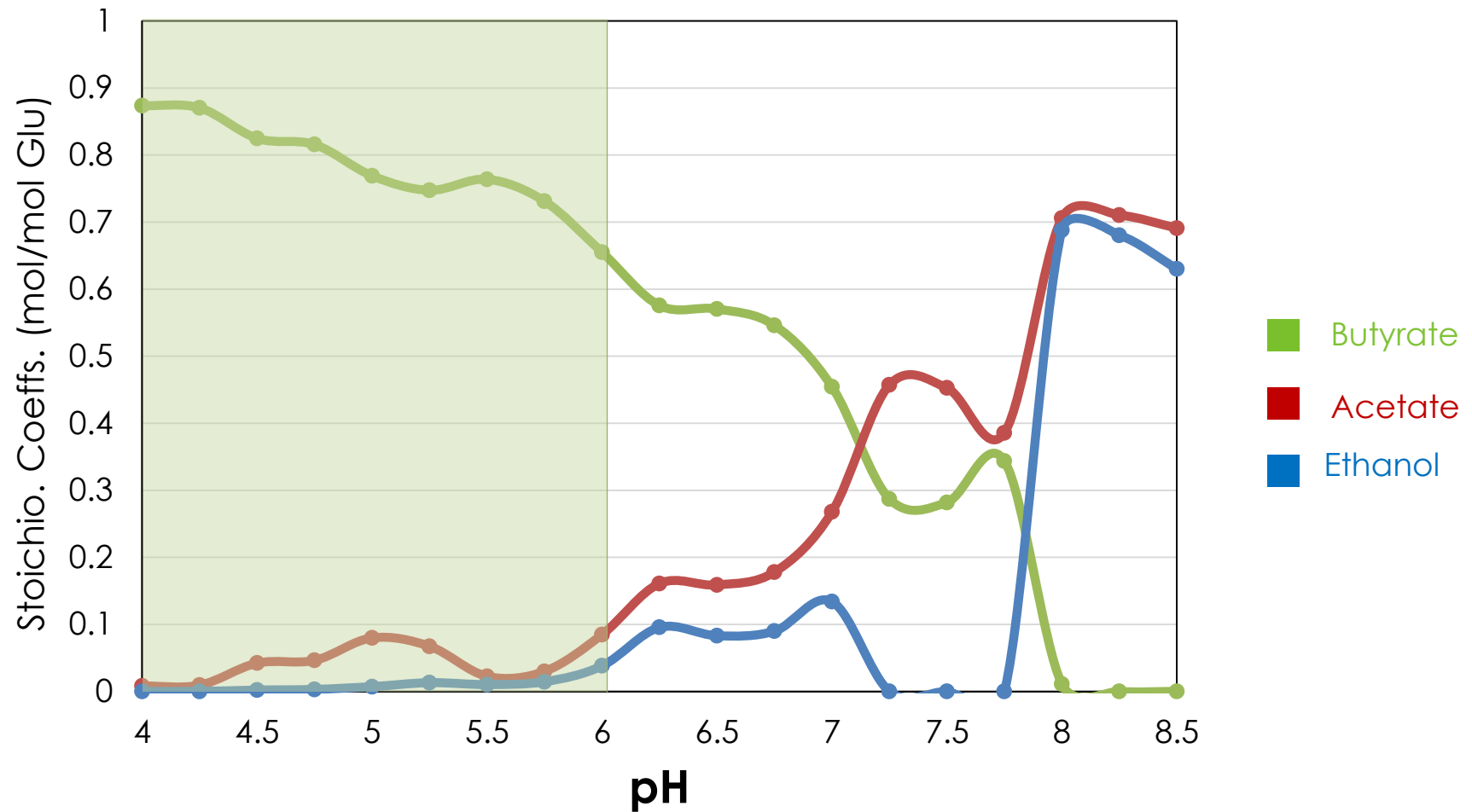
Kinetic model (ADM1)



Bioenergetics model suggests pH < 6



Bioenergetics model suggests pH < 6



Kinetic model to determine HRT

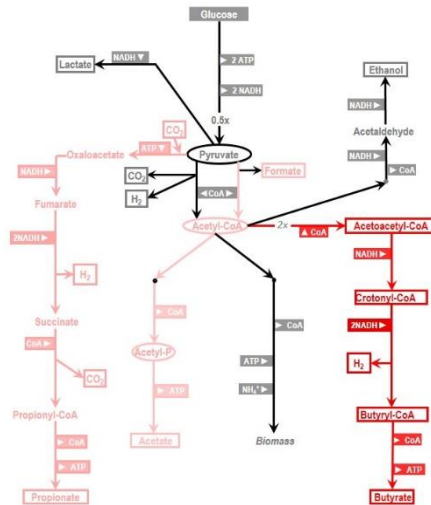
$$y_{\text{But}} = 0.76 \text{ mol But/mol Glu}$$

Operational conditions

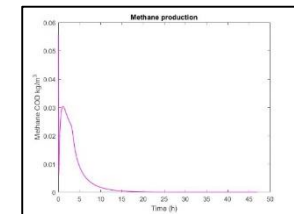
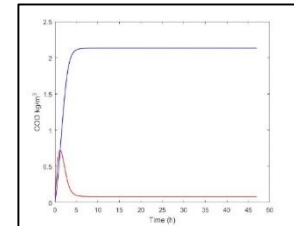
Substrate:
Glucose

pH: 5.5

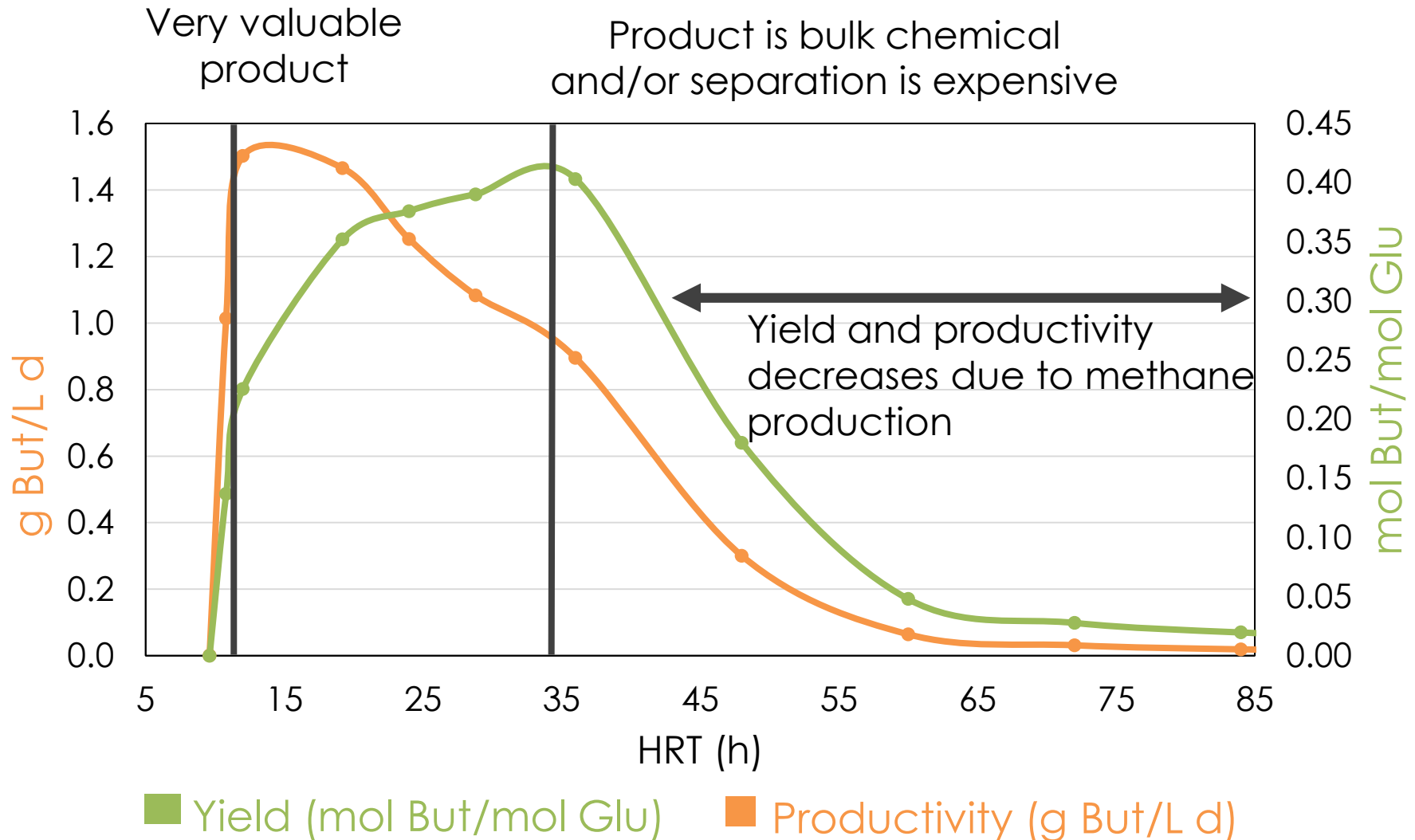
Bioenergetics-based model



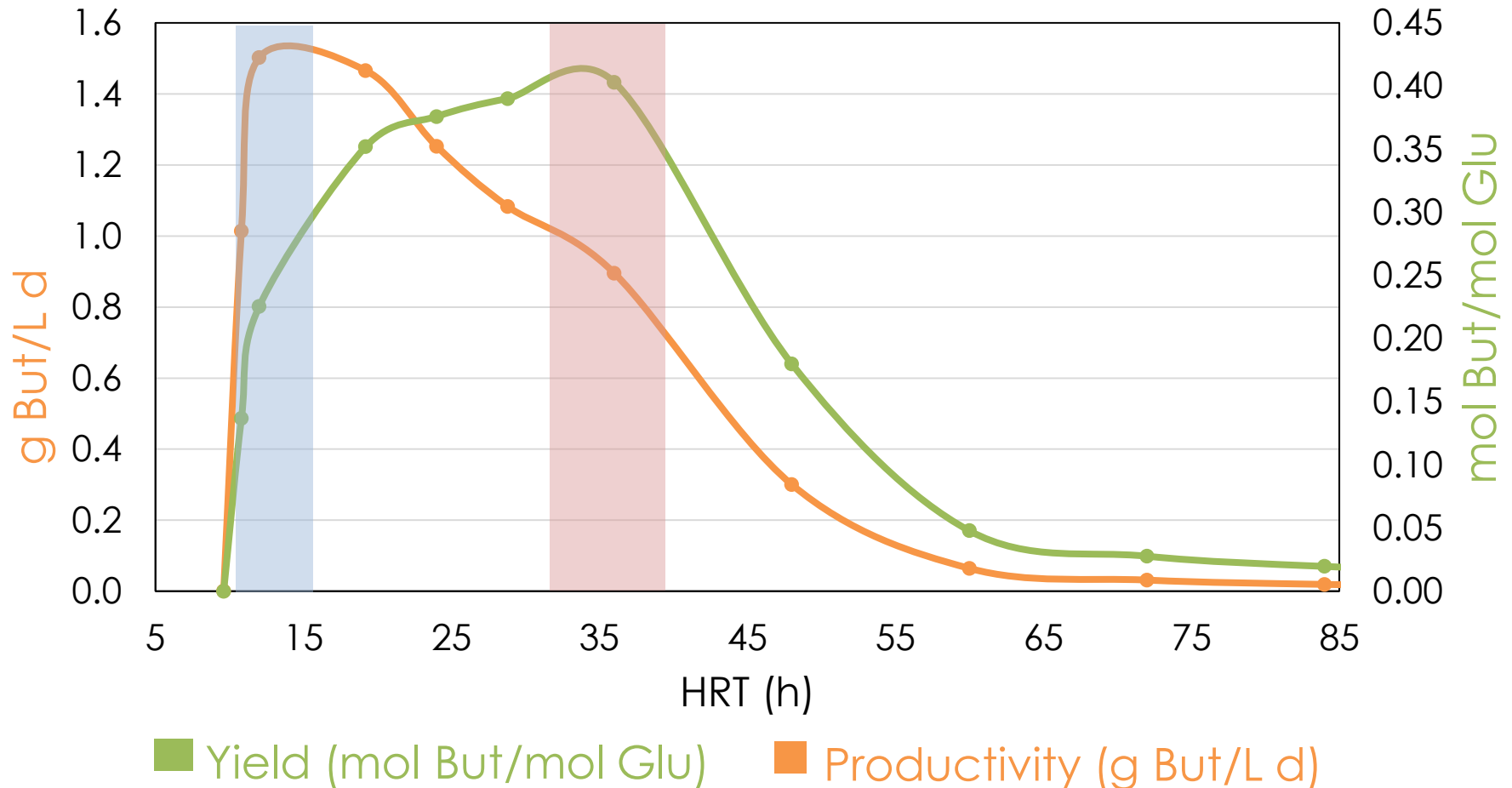
Kinetic model (ADM1)



Different operating windows depending on product



Different operating windows depending on product

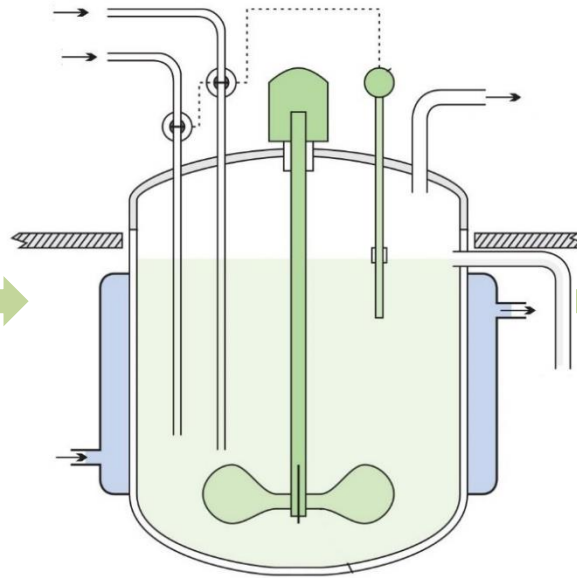


Design facilitated by suitable modelling tools

pH: 5.5

HRT \approx 35 h

Substrate: Glucose



Butyrate

\approx 1 g/L d

\approx 0.4 mol But/mol Glu

Future perspectives in BioChem

- ✓ Extend model for more complex substrates
- ✓ Integrate separation in the framework
- ✓ Developing a virtual plant for early stage simulation of mixed culture fermentations.

BIOCHEM

BIOCHEM: A new methodology for designing mixed-culture bioprocesses assisted with bioenergetics models

A. Regueira, M. Mauricio-Iglesias, M.

Carballa, J. M. Lema

alberte.regueira@usc.es

www.usc.es/biogrup/biochem

This activity is supported by **ERA-IB-2 project BIOCHEM** (PCIN-2016-102), funded by **MINECO**, and by the **Spanish Ministry of Education** through the **FPU scholarship** (FPU14/05457)