WP7 Biokinetic Data, Modelling and Control

University of Natural Resources and Applied Life Science, Vienna
Universität für Bodenkultur Wien

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Objectives

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- Further development of an existing Anaerobic Digestion Model
- Implementation of this model in a web-based Virtual Laboratory (VL)
- Basis of the VL is the Anaerobic Digestion Model No.1 (Batstone *et al.,* 2002)
- Creation of a Decision Support System
- Identification of process-control strategies and fermentation mixtures

Anaerobic Digestion Models

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- Hydrolysis controlled Anaerobic Digestion (Jain *et al.*, 1991)
- Model for Dynamic Simulation of Complex Substrates - Focusing on Ammonia inhibition (Angelidaki *et al.*, 1993)
- Simulation Model <Methane> (Vavilin *et al.*, 1993)
- Comprehensive Model of Anaerobic Bioconversion of Complex substrates (Angelidaki *et al.*, 1998)
- Model for Meso- and Thermophilic Anaerobic Sewage Sludge (Siegrist et al., 2002)
- Anaerobic Digestion Model No.1 (ADM1) (Batstone *et al.*, 2002)

Anaerobic Digestion model No.1 (ADM1)

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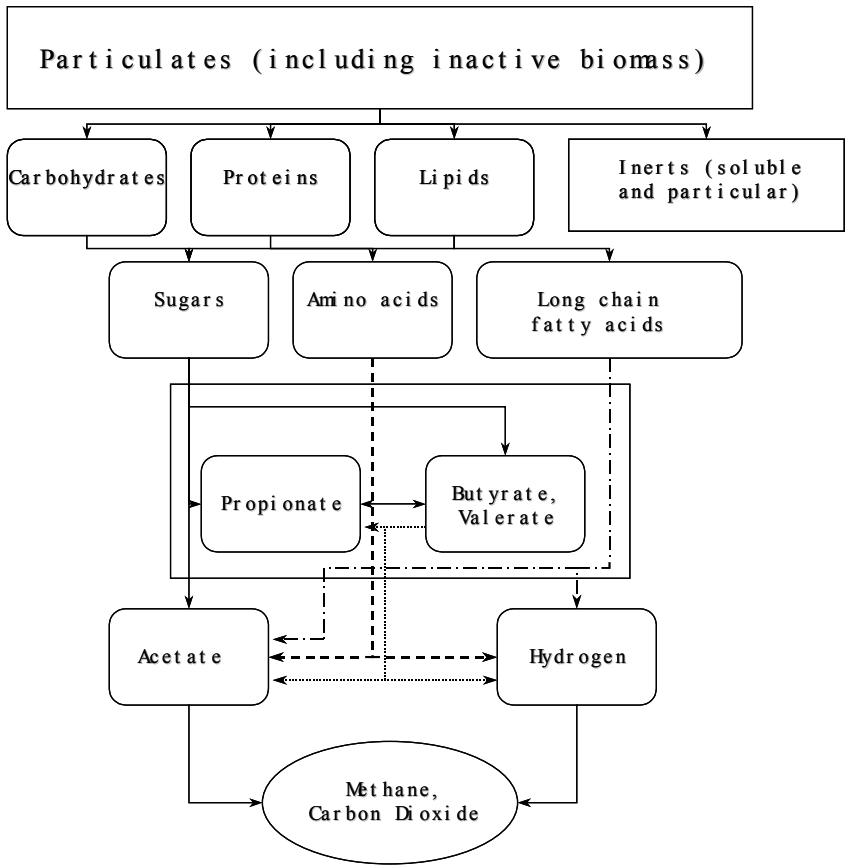

- Model is structured in several steps characterising the biochemical processes
- DAE: 26 dynamic state variables
  19 biochemical kinetic processes
  3 gas-liquid transfer kinetic processes
- DE: 32 dynamic state variables
  6 acid base kinetic processes
- Implementation in a CSTR

Anaerobic Digestion model No.1

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Advantages

- First unified model
- Unified Nomenclature and Kinetics
- Basis for further model approaches
- Describes Process Details
- Lower overall data amount compared to Neuronal Networks

Anaerobic Digestion model No.1

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Disadvantages

- Need to understand the model
- The model is simplifying the AD process
- No validation of biological parameters
- No information on the effect of inhibitory compounds
- No information on the effect on kinetics in different temperature ranges
- Requirement of detailed substrate definition
- The COD flow is rather complex

Anaerobic Digestion model No.1

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Exclusions from the ADM1

- Solid Precipitation
- Homoacetogenesis
- Acetate Oxidation
- Lang Chain Fatty Acids Inhibition
- Weak Acid and Fatty Acid Inhibition
- Denitrification
- Sulphate Reduction and Sulphide Inhibition
- Glucose Fermentation

Anaerobic Digestion model No.1

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Parameter

	Min	Max	
k_{dis}	0,25	1	$[d^{-1}]$
$k_{hyd,ch}$	0,041	106	$[d^{-1}]$
$k_{hyd,pr}$	0,0096	10	$[d^{-1}]$
$k_{hyd,li}$	0,0096	10	$[d^{-1}]$
$k_{m,su}$	4	5067	$[kg_{cod}kg_{cod}^{-1}d^{-1}]$
$k_{m,aa}$	0,5033	53	$[kg_{cod}kg_{cod}^{-1}d^{-1}]$
$k_{m,fa}$	0,6	363	$[kg_{cod}kg_{cod}^{-1}d^{-1}]$

- Parameters quoted in the ADM1 have a high range of margin
- Parameters suggested from the Task group are suitable for sewage sludge
- Not suitable for energy crops

Anaerobic Digestion model No.1

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Implementations, Extensions and Adaptations of the model

- $CaCO_3$ precipitation and the potential of anaerobic digestion in the thermophilic temperature range (Batstone et al., 2003)
- Modelling of two-stage anaerobic digestion using the IWA Anaerobic Digestion Model No. 1 (ADM1) (Blumenstaat and Keller, 2004)
- ADM1 based virtual plant for the validation of a controller [TELEMAC] (Mailleret et al, 2004)
- Benchmark study Modelling Sulphate Reduction using NN and ADM1 (Strik *et al.*, 2004)
- Application of the Adm1 model to advanced anaerobic digestion (Parker, 2005)

First International Workshop on the IWA Anaerobic Digestion Model No.1 (ADM1), 2nd – 4th September 2005 in Lyngby, Denmark

Adaptation of the ADM1

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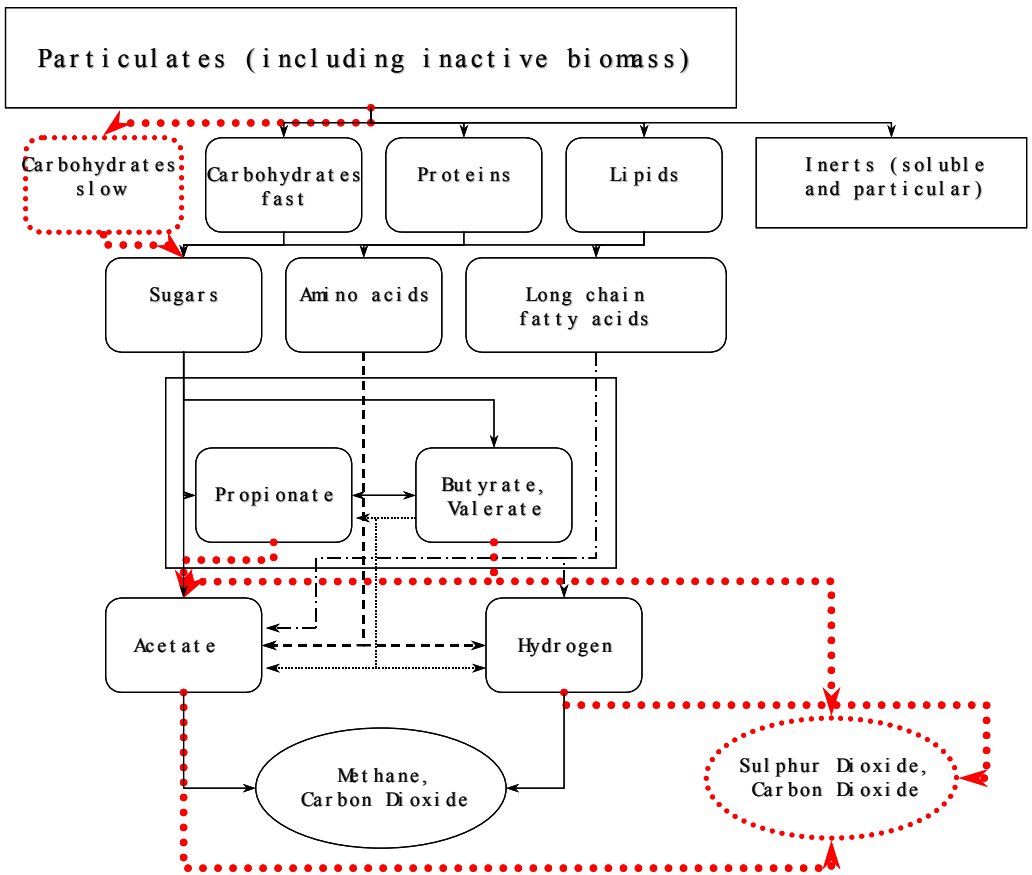

Laboratory Experiments

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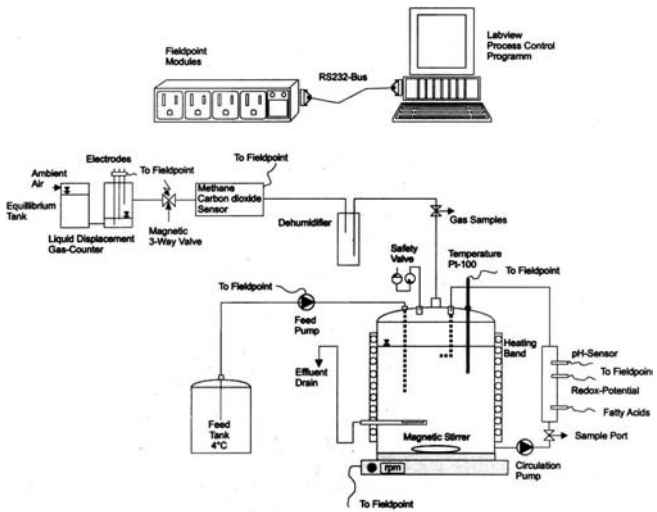
Lab-scale anaerobic CSTRs



Anaerobic Digestion model No.1

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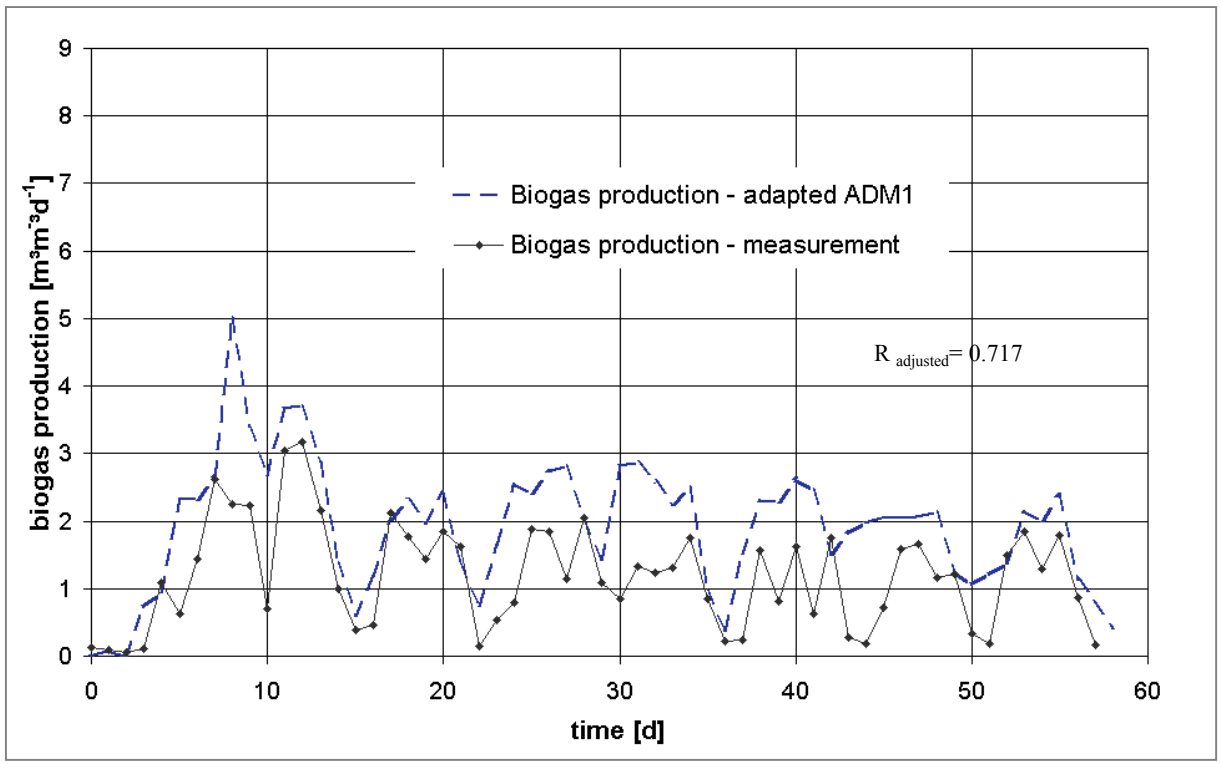
Model Results



Virtual Laboratory

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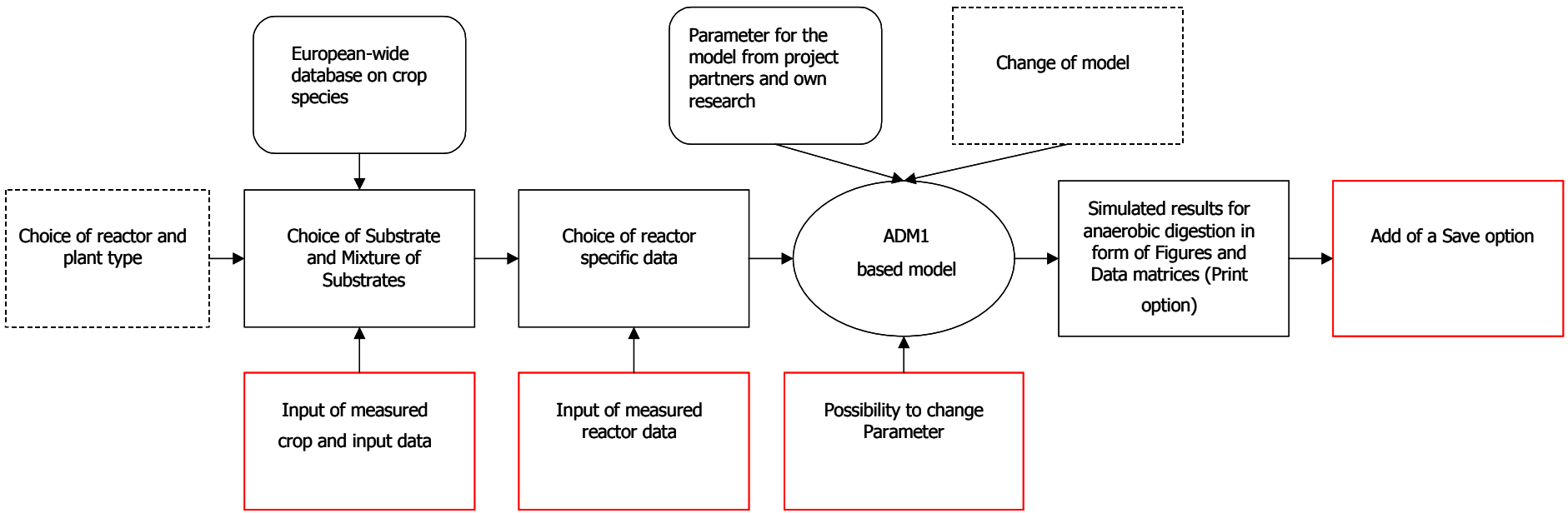
Structure



Virtual Laboratory

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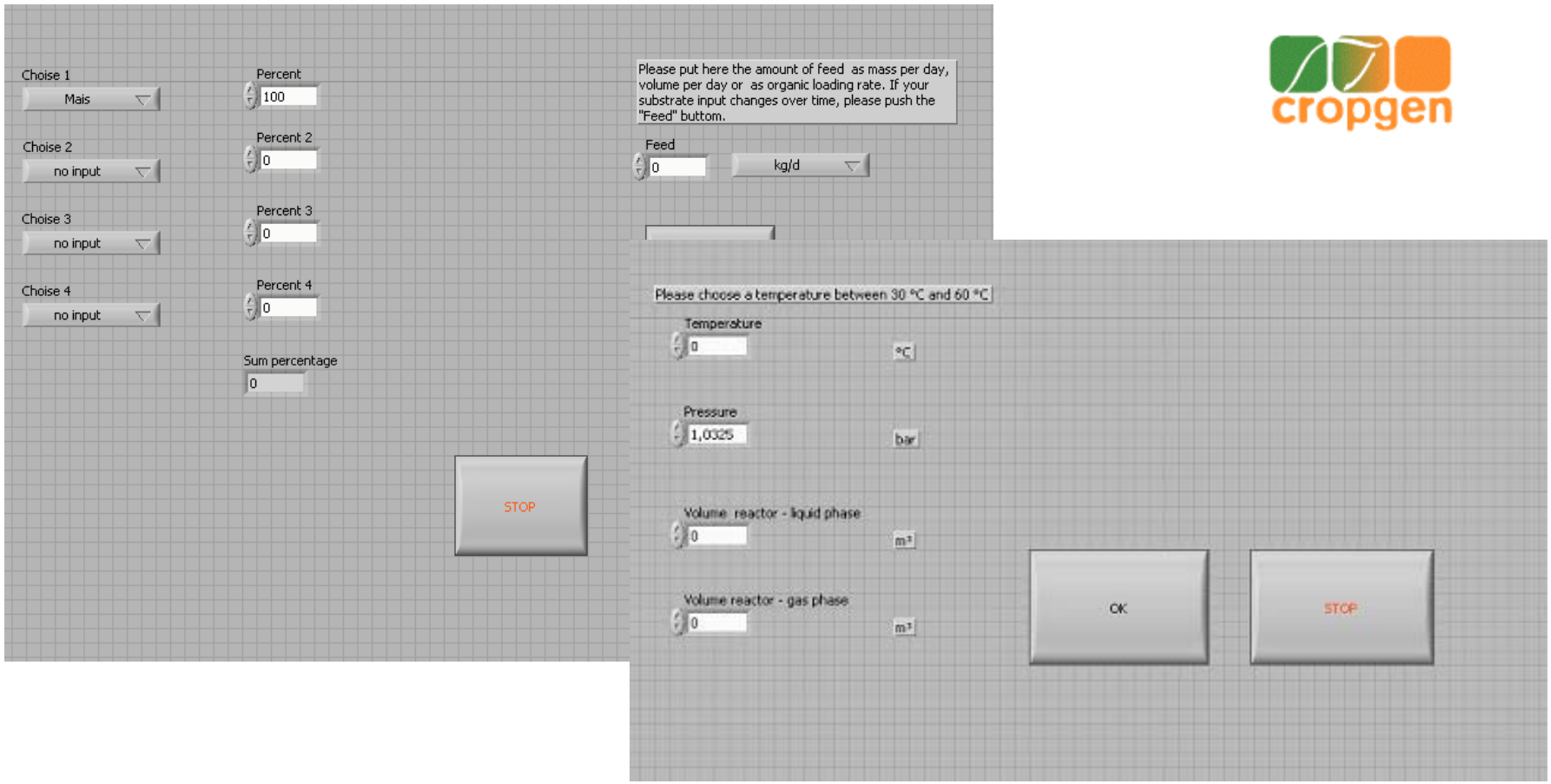
Screenshot 1



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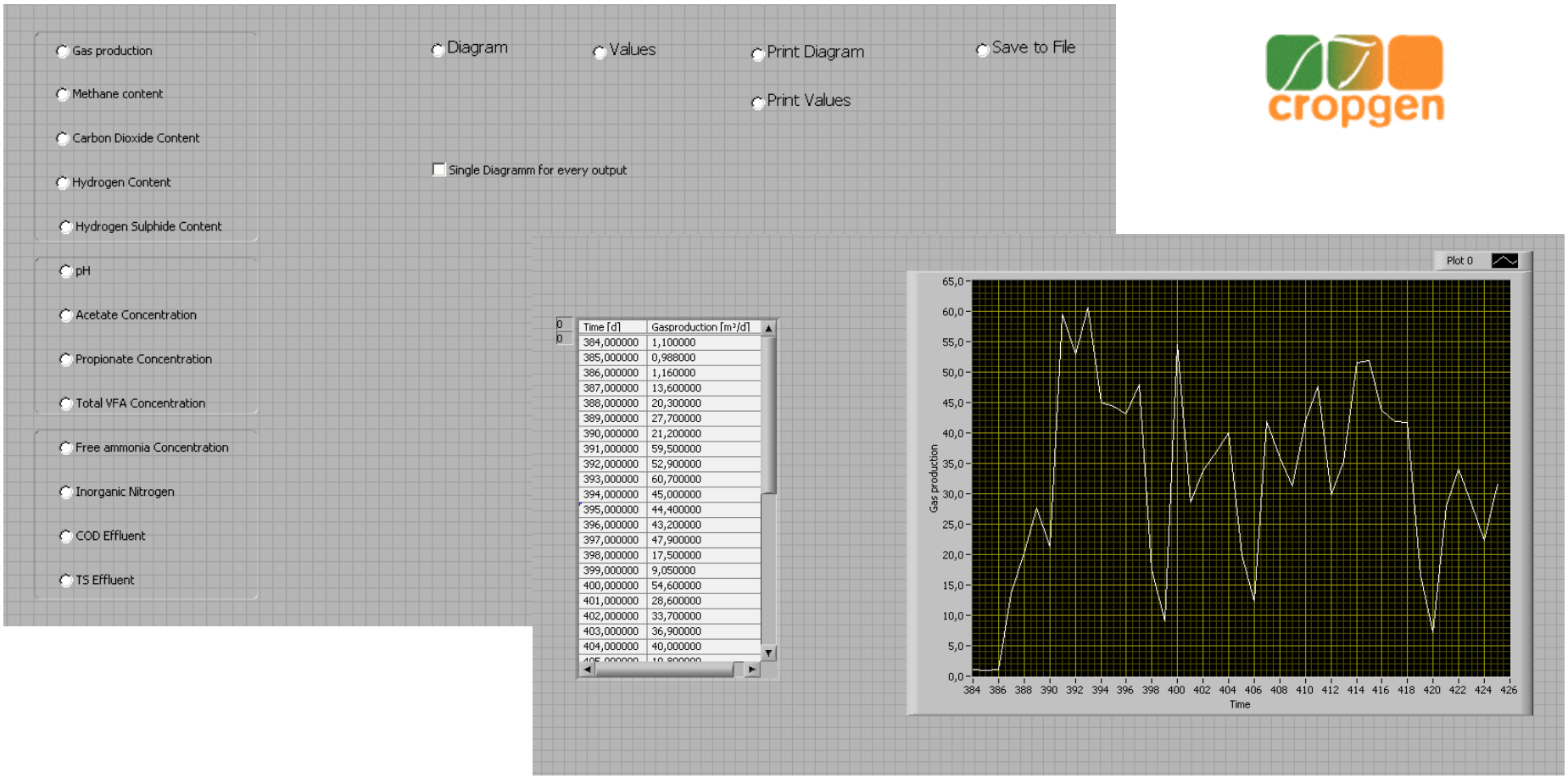
Screenshot 2



Summary & Conclusion

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- Since 60s large amount of different AD models
- ADM1 as first unified model
- Adaptation of the model
- Required parameters and measurement
- Adapted ADM1 as basis for a Virtual Laboratory
- 2 Versions of the VL (Simple and Advanced)
- Mathematical model as basis for a control tool

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Thank you for your attention.

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