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WP7 Biokinetic Data, Modelling and Control

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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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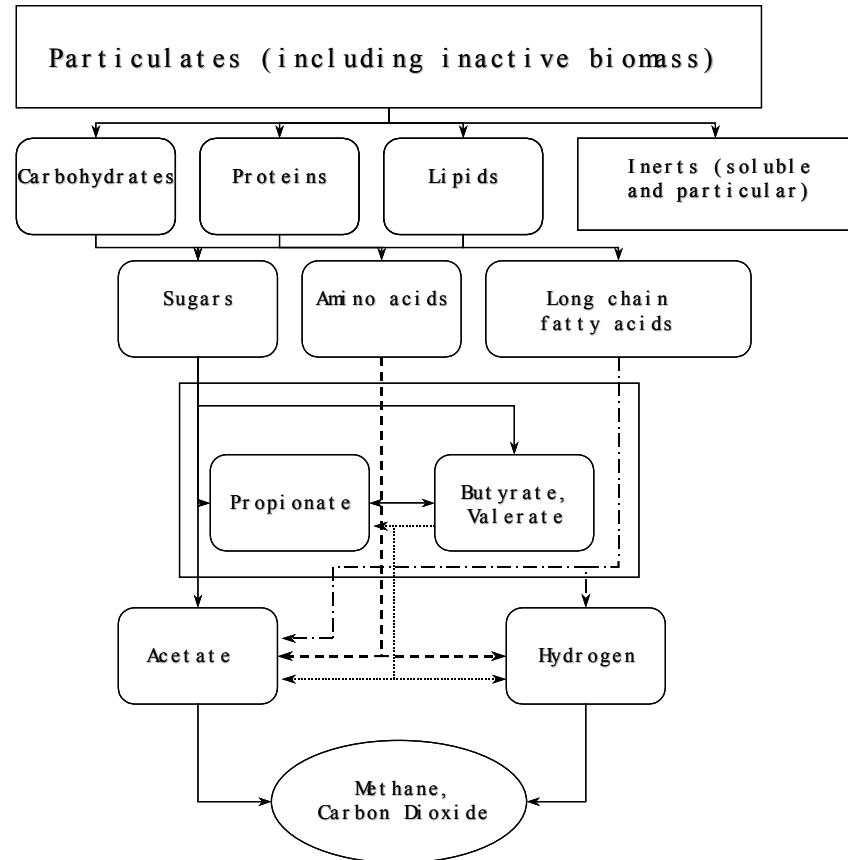


- Hydrolysis controlled Anaerobic Digestion (Jain *et al.*, 1991)
- Model for Dynamic Simulation of Complex Substrates - Focusing on Ammonia inhibition (Angelidaki *et al.*, 1993)
- Simulation Model <Methane> (Vavilin *et al.*, 1993)
- Comprehensive Model of Anaerobic Bioconversion of Complex substrates (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



Exclusions from the ADM1

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- 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



Implementations, Extensions and Adaptations of the model

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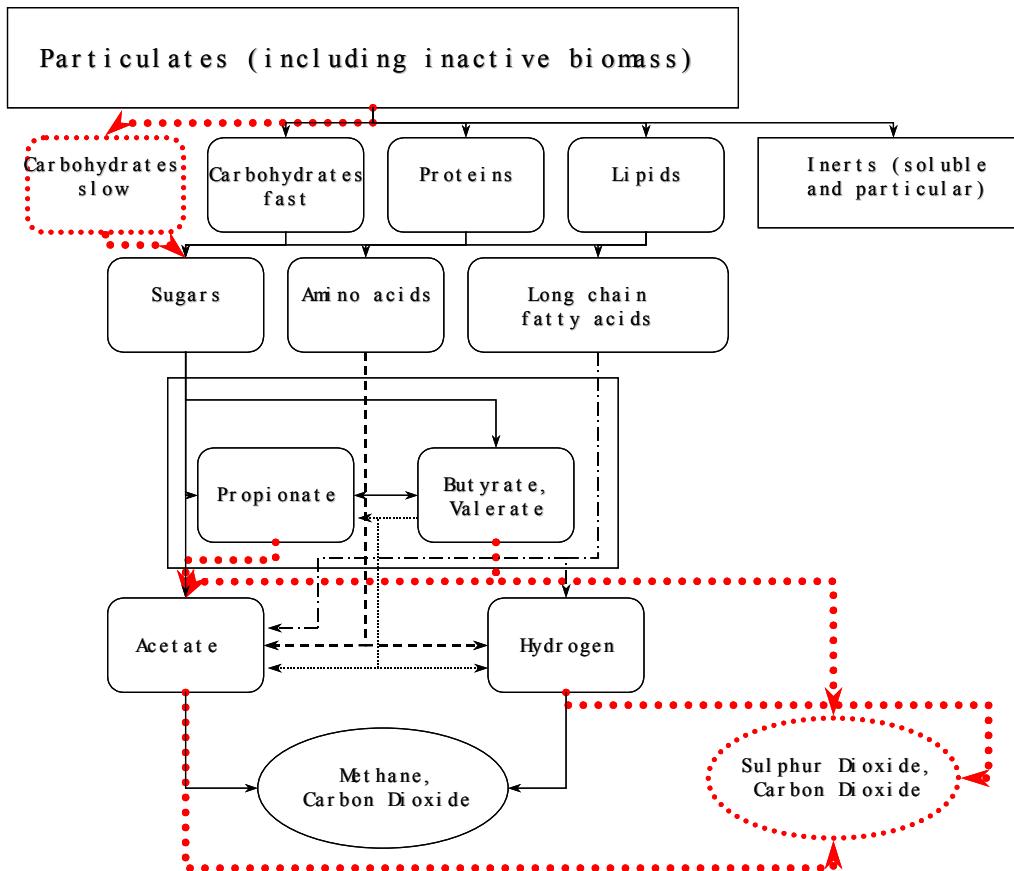
- CaCO_3 precipitation and the potential of anaerobic digestion in the thermophilic temperature range (Batstone et al., 2003)
- Modelling of two-stage anaerobic digestion using the IWA Anaerobic Digestion Model No. 1 (ADM1) (Blumenstaat and Keller, 2004)
- ADM1 based virtual plant for the validation 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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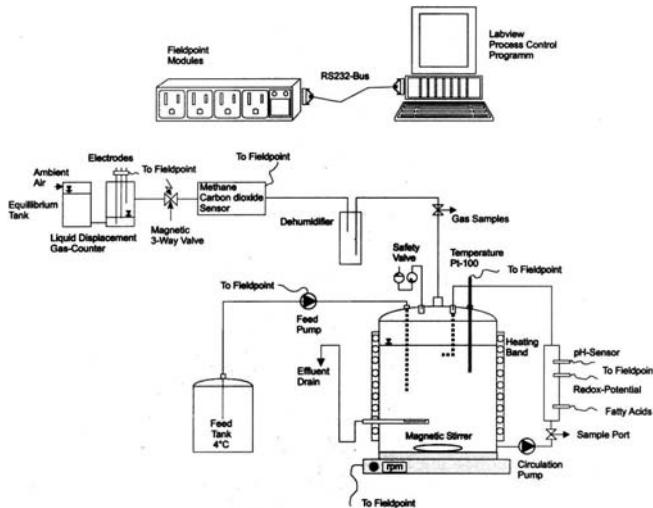


Laboratory Experiments



Lab-scale anaerobic CSTRs

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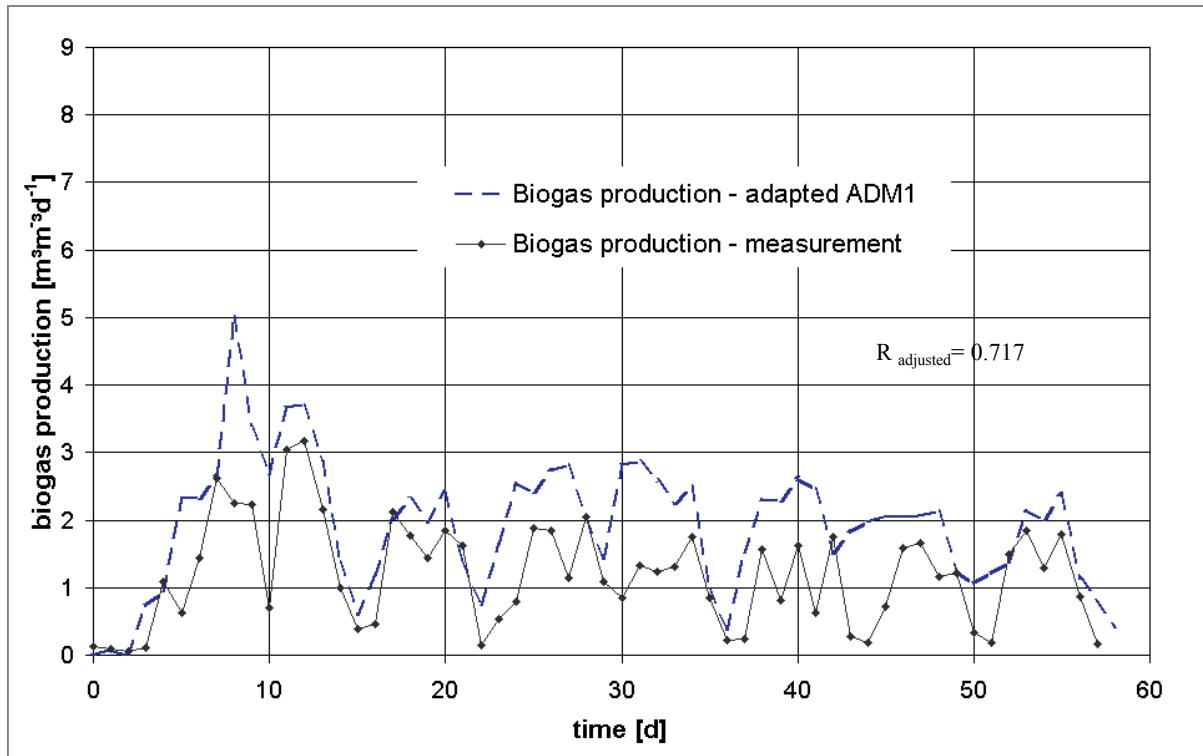


Anaerobic Digestion model No.1



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Model Results

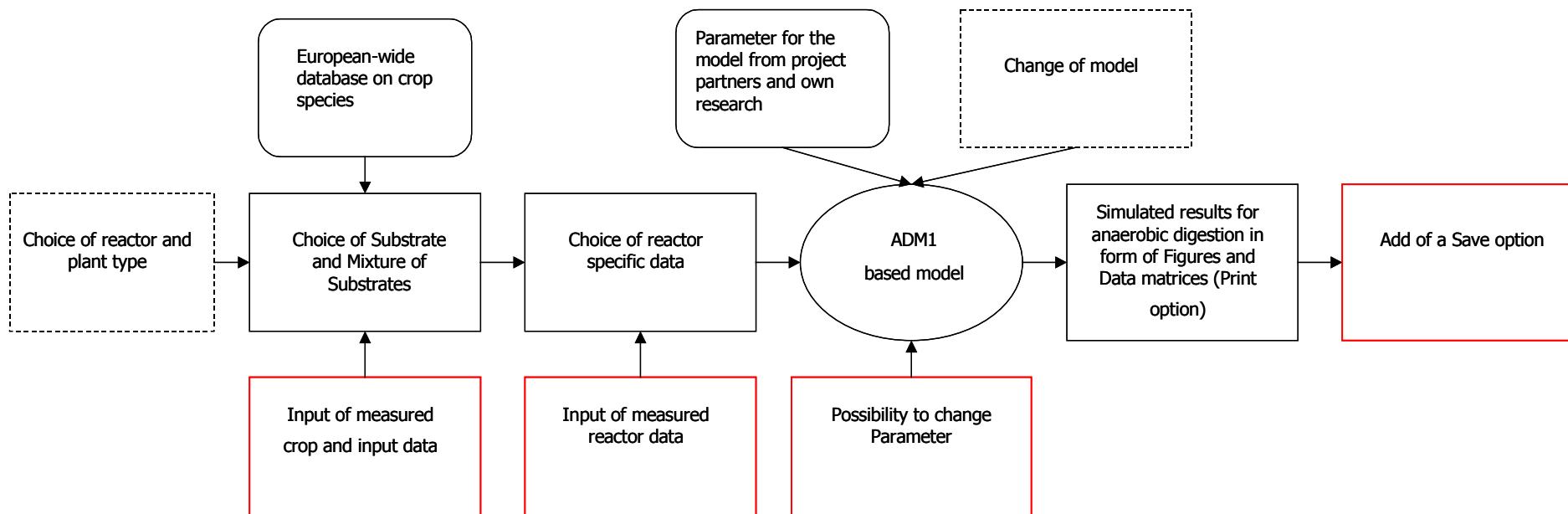


Virtual Laboratory



Structure

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Virtual Laboratory



Screenshot 1

Choise 1 Percent
Mais 100

Choise 2 Percent 2
no input 0

Choise 3 Percent 3
no input 0

Choise 4 Percent 4
no input 0

Sum percentage
0

Please put here the amount of feed as mass per day, volume per day or as organic loading rate. If your substrate input changes over time, please push the "Feed" button.

Feed
0 kg/d

Please choose a temperature between 30 °C and 60 °C

Temperature
0 °C

Pressure
1,0325 bar

Volume reactor - liquid phase
0 m³

Volume reactor - gas phase
0 m³

STOP

OK

STOP

A screenshot of a virtual laboratory interface. On the left, there are four sections labeled 'Choise 1' through 'Choise 4', each with a dropdown menu and a percentage input field. Below these is a 'Sum percentage' field set to 0. In the center, there is a text box with instructions about feed input and a 'Feed' button. To the right of the feed button is a large text box for temperature and pressure inputs, with 'Temperature' set to 0 °C and 'Pressure' set to 1,0325 bar. At the bottom, there are fields for 'Volume reactor - liquid phase' and 'Volume reactor - gas phase', both currently at 0 m³. On the far right are two large buttons: 'OK' and 'STOP'. The entire interface is set against a grid background.

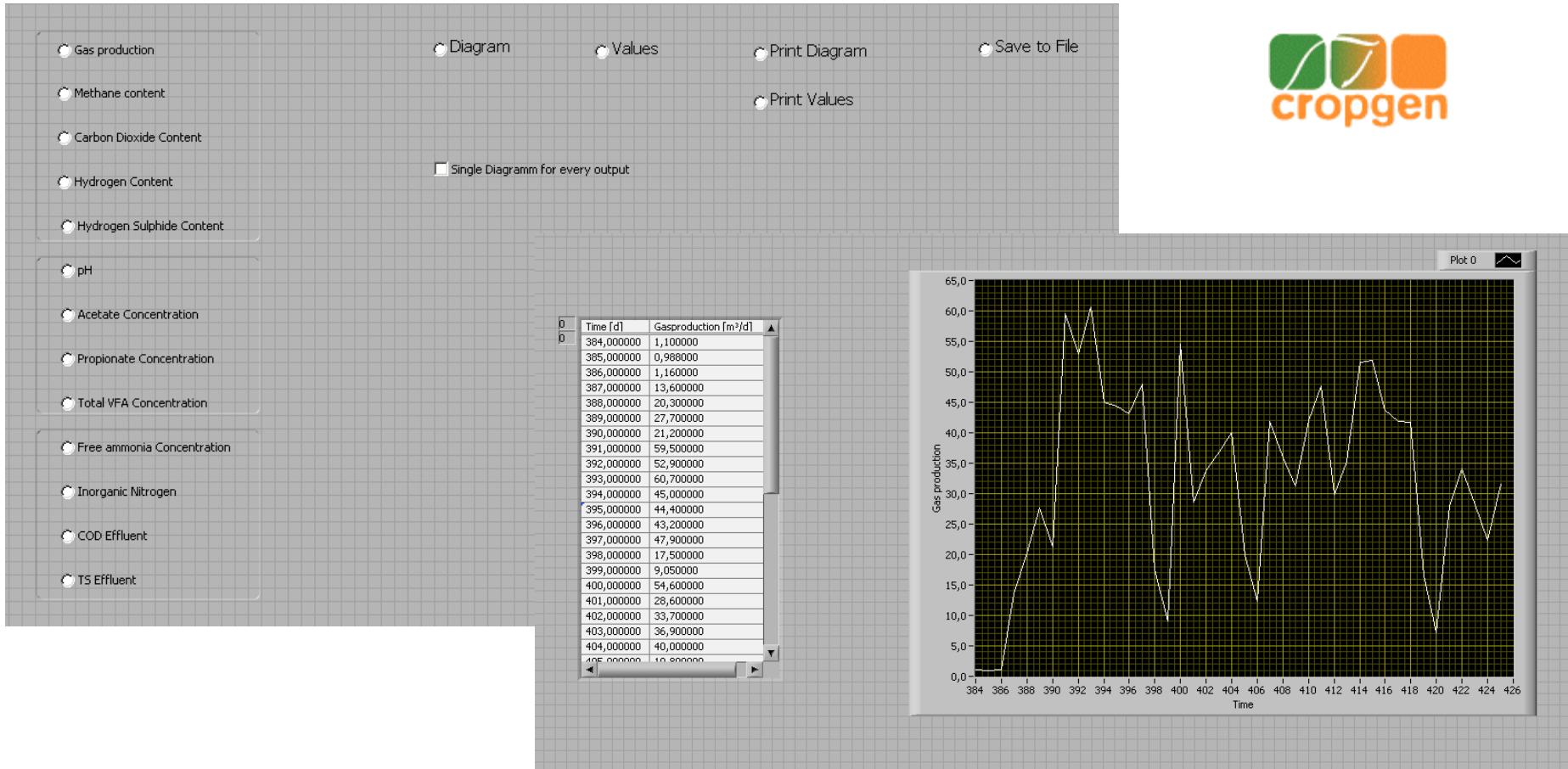
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Virtual Laboratory



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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