A new concept for a multiple feedstock biorefinery

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Agenda

- Introduction
  - Objectives of our research
  - Our concept of an integrated biorefinery

- Our research work
  - 1. Bioethanol
  - 2. Biogas
  - 3. “Next generation” Biodiesel

- Conclusions outlook

Objectives of our research

……………

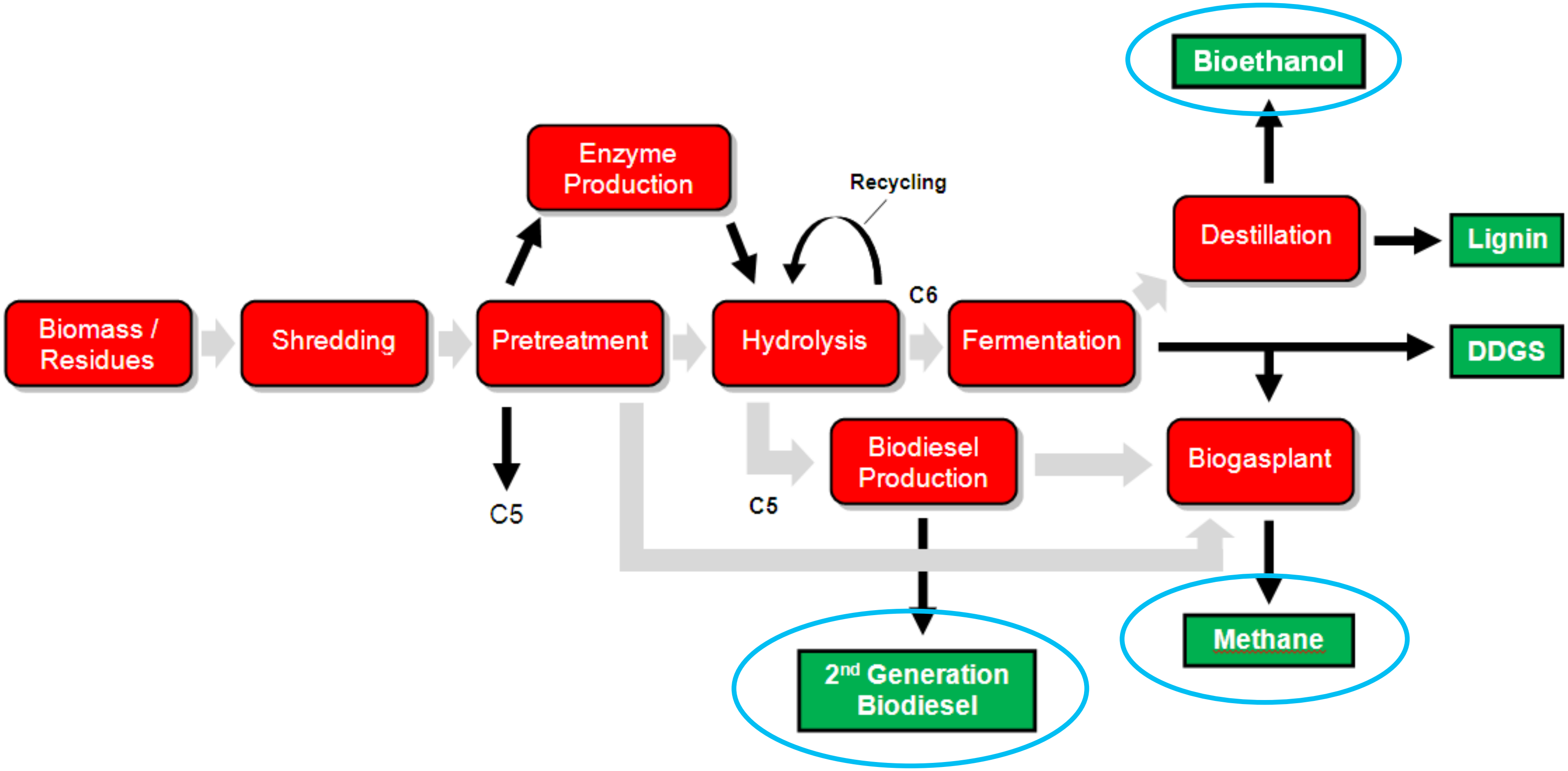
……………

To get fully reliable figures on:
Feedstocks
Yields
Enery needs

➔ to make an unassailable LCA

Wels Lignocellulosic biorefinery

Integrated bioethanol, biogas, biodiesel production



Feedstock

Wheat straw

Corn straw

Corn cobs

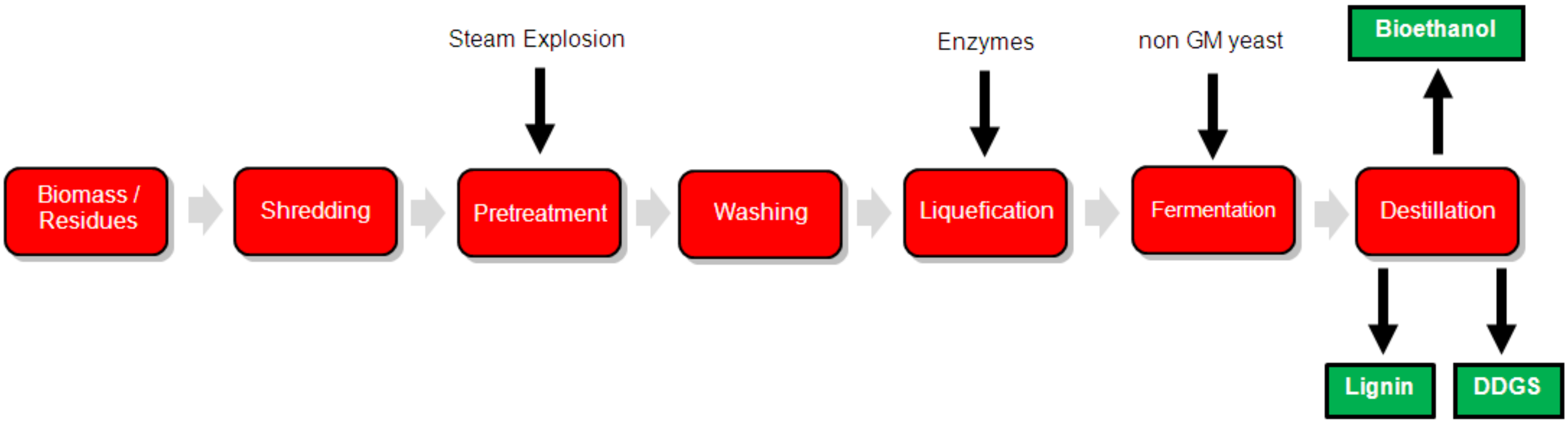
Rye straw

Oat straw

Miscanthus

Sun flower

Concept
Lignocellulosic Bioethanol



Research topics Lignocellulosic Bioethanol

A) **Improvement of the pretreatment** by means of increase of solid (straw) concentration and lowering the water addition in the steam explosion process and decrease of the formation of inhibitors during pretreatment.

B) **Virtual” increase of the substrate concentration** during enzymatic hydrolysis by means of recirculation of the formed sugar solution.

C) **Adaptation of yeast** with the aim of the creation of yeast which can simultaneously utilize C-6 and C-5 sugars by means of adaptation (not by genetic modification) as well as creation of stability towards inhibitors, high temperatures (SSF process!) and high ethanol concentrations

A) Pretreatment with Steam Explosion

Steam explosion:

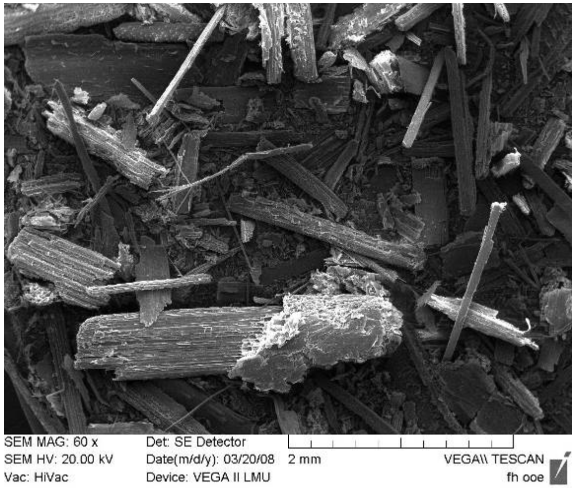
High temperature and pressure ranging from 180°C- 200°C,

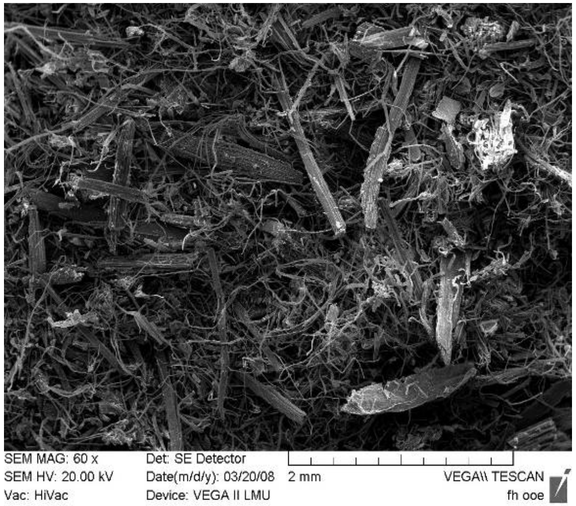
5´ to 20´ at ~ 15 bar and

sudden release effects –

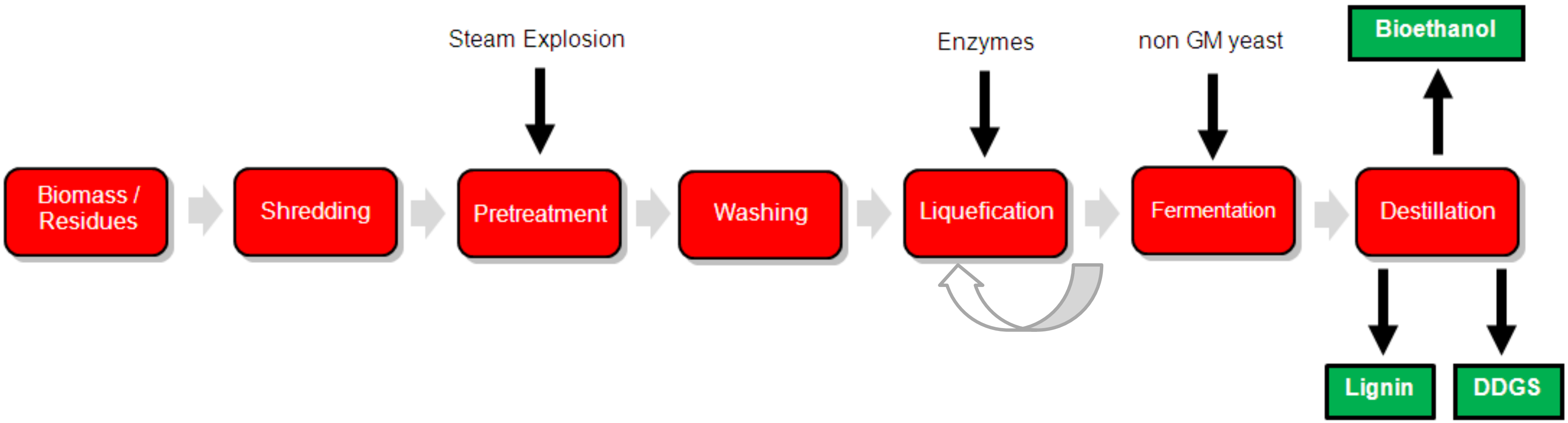
High / Low content of inhibitors

Partially removal / separation of the hemicelluloses

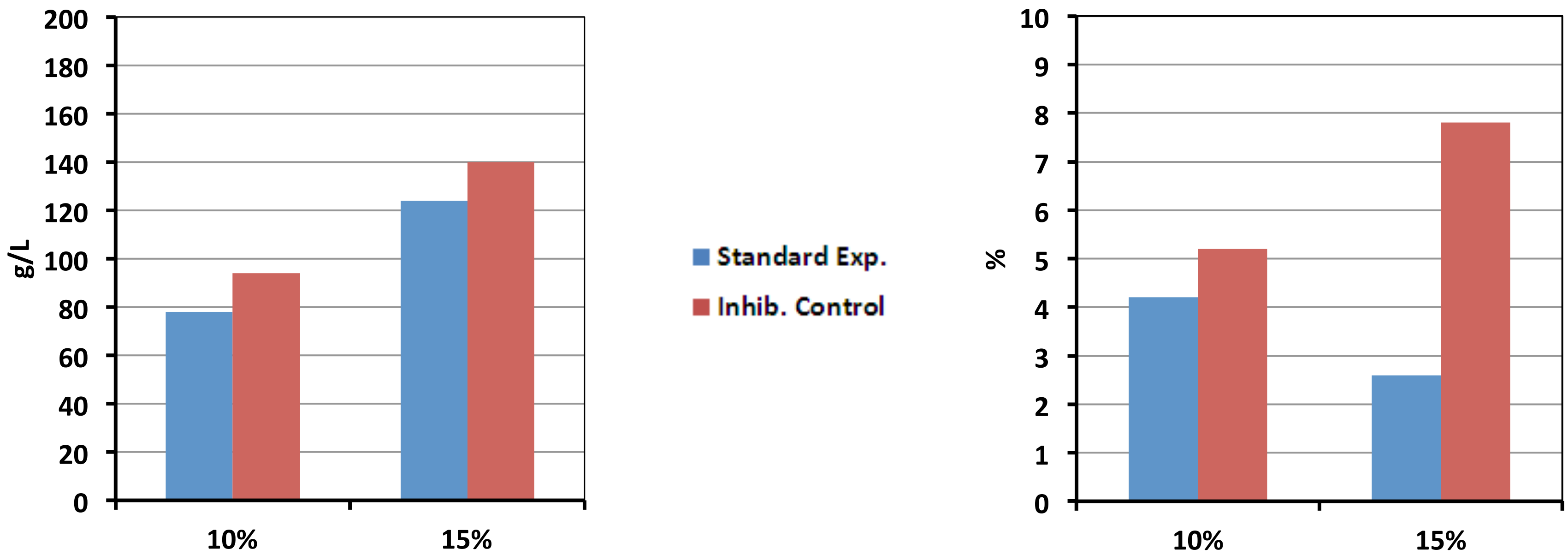




B) Virtual" increase of substrate concentration



Results



Glucose **Production**

Ethanol Production

Lignocellulosic Bioethanol Conclusions + Outlook

- Different optimal pretreatment conditions could have been determined for bioethanol productionwith low concs. of inhibitors
- Virtual Increase of substrate concentration is feasible
- ➔ Simplified reactor design for liquefication
- Adapation of C 5 fermenting yeast underway

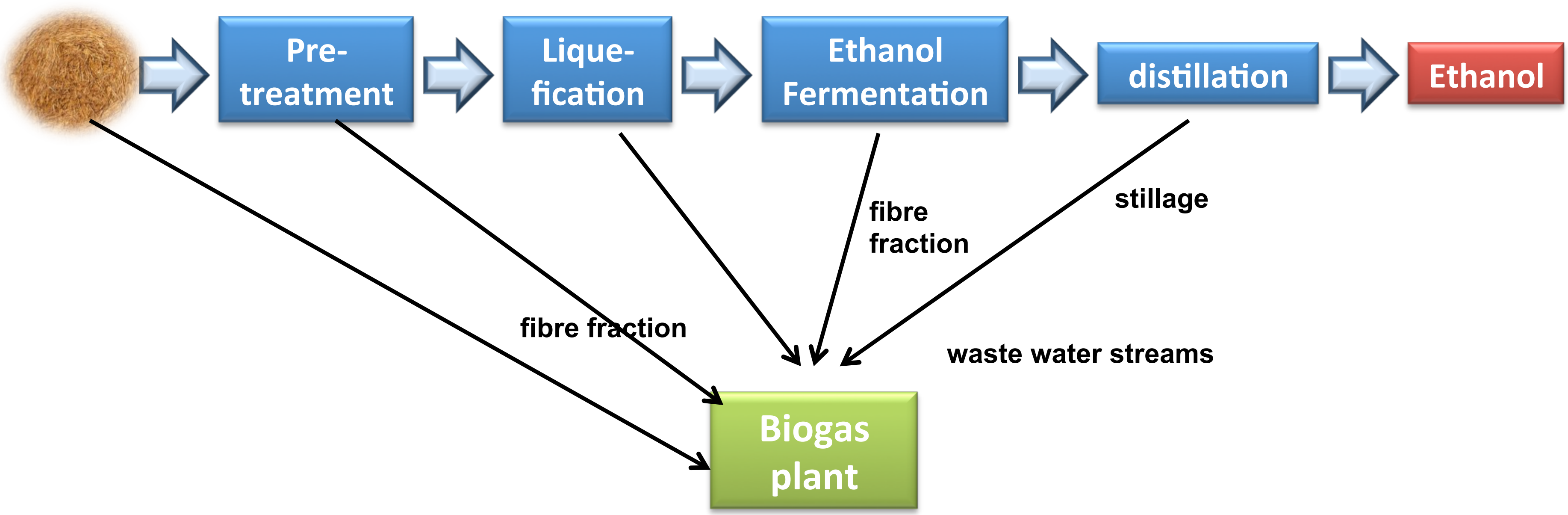
Lignocellulosic Biogas Production

pre-treatment

biorefinery

Lignocellulosic biorefinery

Streams examined for biogas production



Energy-content wheat straw

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carbohydrate composition

Compound	[kg/t] wheat straw]
Glucose	40.7
Xylose	24.9
arabinose	2.4

own laboratory analysis

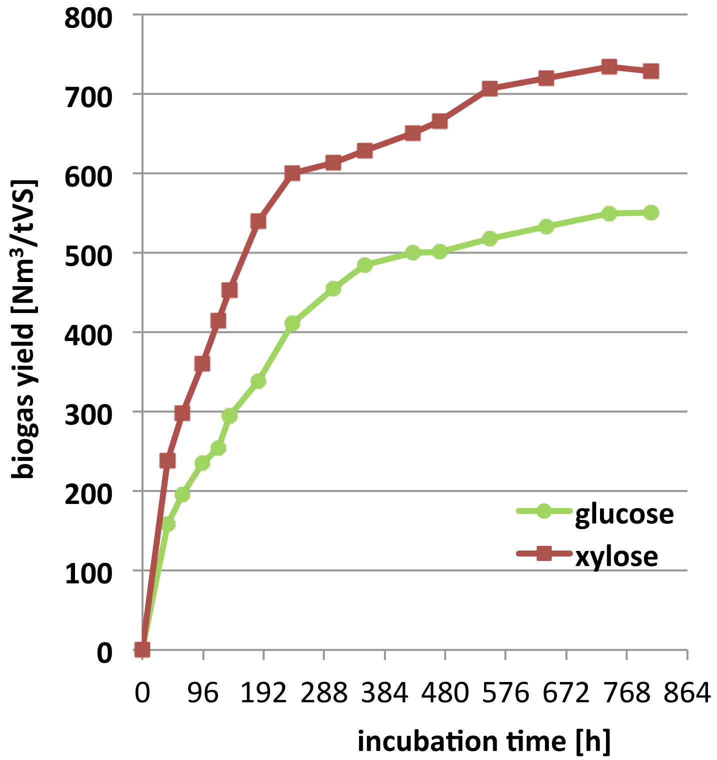
Compound	theoretical energy yield (ethanol)
Glucose	153.6 kWh
Xylose	93.9 kWh

+38 %

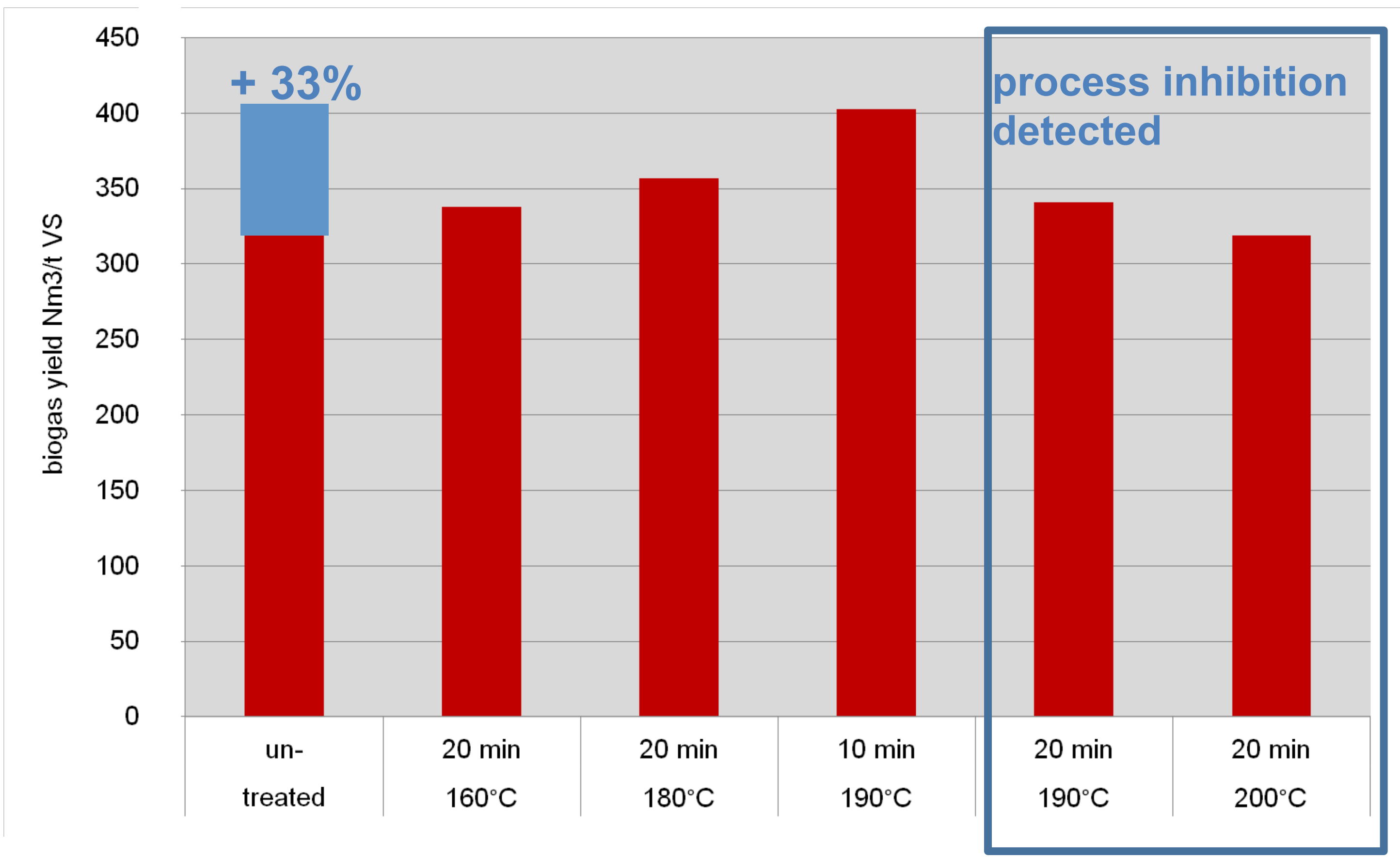
Lignocellulose biorefinery

conversion of pentoses

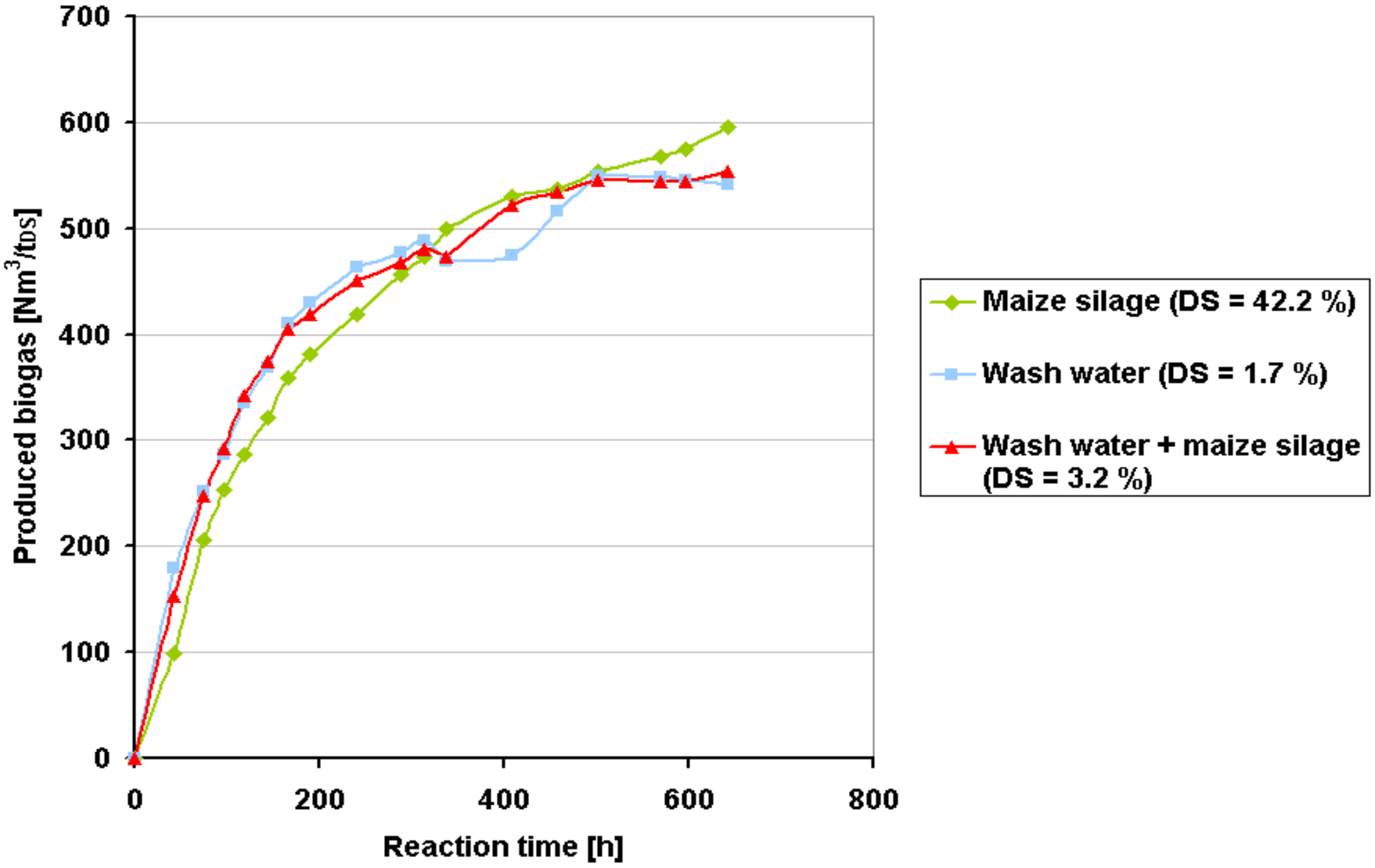
- **Biogas plant as simple C_5-converter**
  - no genetic modification
  - existing technology
  - no additional infrastructure



Biogas from pretreated straw



Biogas from washwater (200°C/20min)



Evaluation of 3 Scenarios

		scenario 1	scenario 2	scenario 4
		energy [kWh]	energy [kWh]	energy [kWh]
190°C	10 min		**2333**	1940
180°C	10 min		2027	2179
160°C	20 min		1655	**2360**
untreated		**1504**		

- (1) untreated straw → biogas
- (2) pretreated straw → biogas
- (4) pretreated + hydrolysed straw → biogas + bioethanol

Conclusions + Outlook

- **Different optimal pretreatment conditions could have been determined for bioethanol and biogas production**
  - **pretreatment conditions for combined bioethanol and biogas plant (180°C/10min) differ from single bioethanol production (200°C/20min)**

- **biogas production increased when enzymatically hydrolysed**
  - **process energy needs to be implemented**

- **energy content of by products need to be integrated**

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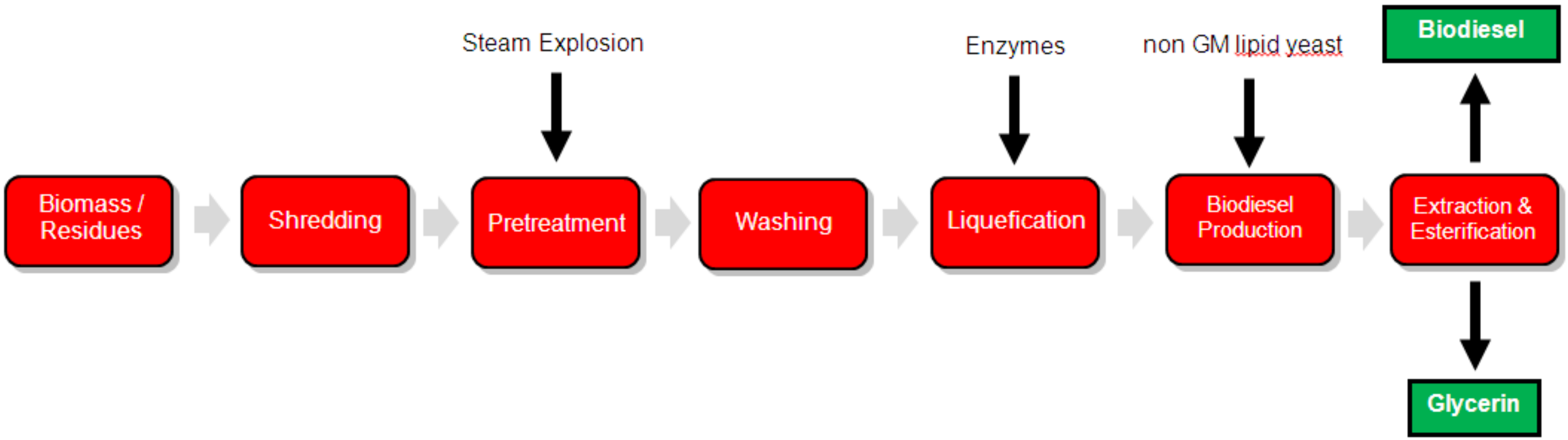
Biodiesel production



Biodiesel production from xylose parts of lignocelluloses

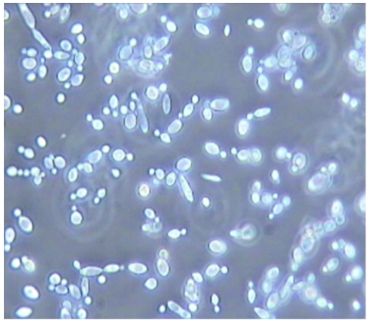
Yeasts

Substrates:

1) Xylose within washing water and from 2nd Generation Bioethanol

2) Glycerol

3) Corn Cobs



Extraction of lipids like

Oleic acid

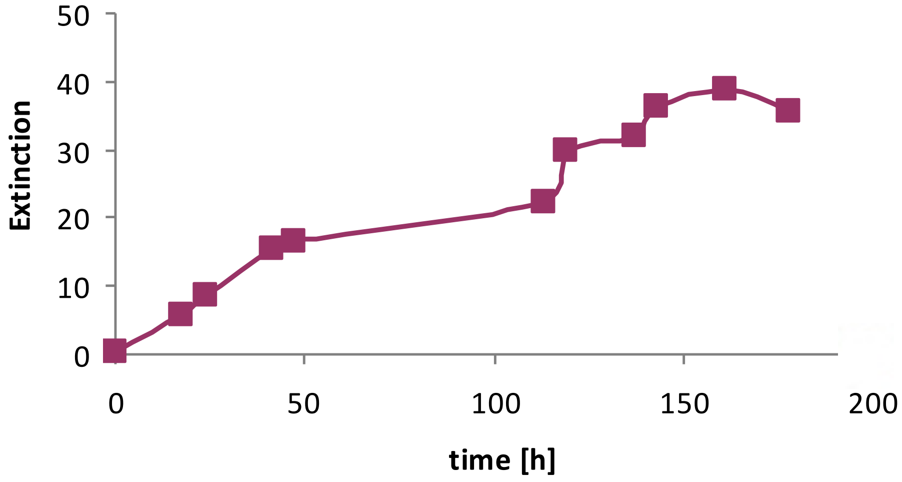
Stearic acid

Palmitic acid

Transesterification

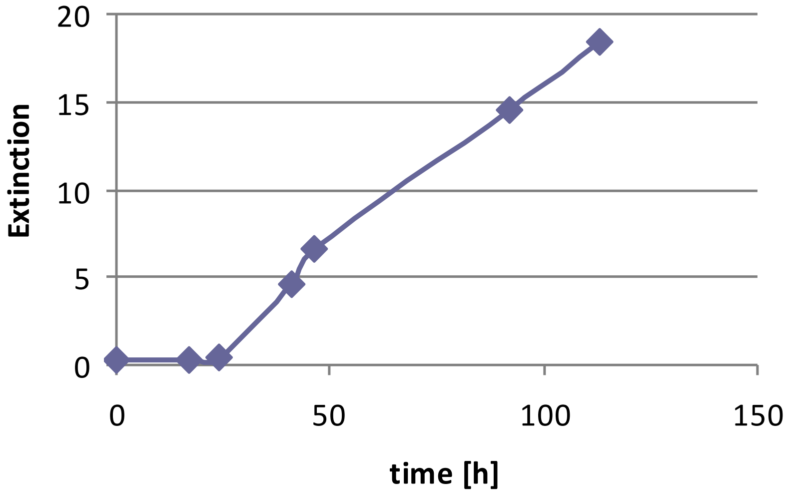
Biodiesel

Stream 1: Washing water



Fedbatch of xylose and nitrogen after consumption of xylose and nitrogen

Stream 2: Wheat straw hydrolysate after fermentation



Delay: 24 hours, growth

No growth in hydrolysate at dry matter concs. higher - 20 %.

Summary and outlook Biodiesel

2 streams for xylose are available:

Stream 1 = washing water (reduces inhibitors of bioethanol production)

Stream 2 = xylose after fermentation

First steps like cell growth on the substrate Xylose 2nd. Generation were tested

Stream 1 = washing water – works good

Stream 2 = good growth in hydrolysate from 10 % dry matter

no growth in hydrolysate from 20 % dry matter due to EtOH

Challenges: testing the conditions for lipid accumulation, determination of extraction method,…..

Summary and outlook

Integrated Biorefinery could increase economy and flexibility of lignocellulosic utilization

Data for LCAs to be completed

Bioethanol process ready for scale up

Biogas process large otimization potential

N.G. Bioediesel production still basic research

Political, public aceptance of renewable energy?

Working group „Bioethanolics“

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Thank you for attention

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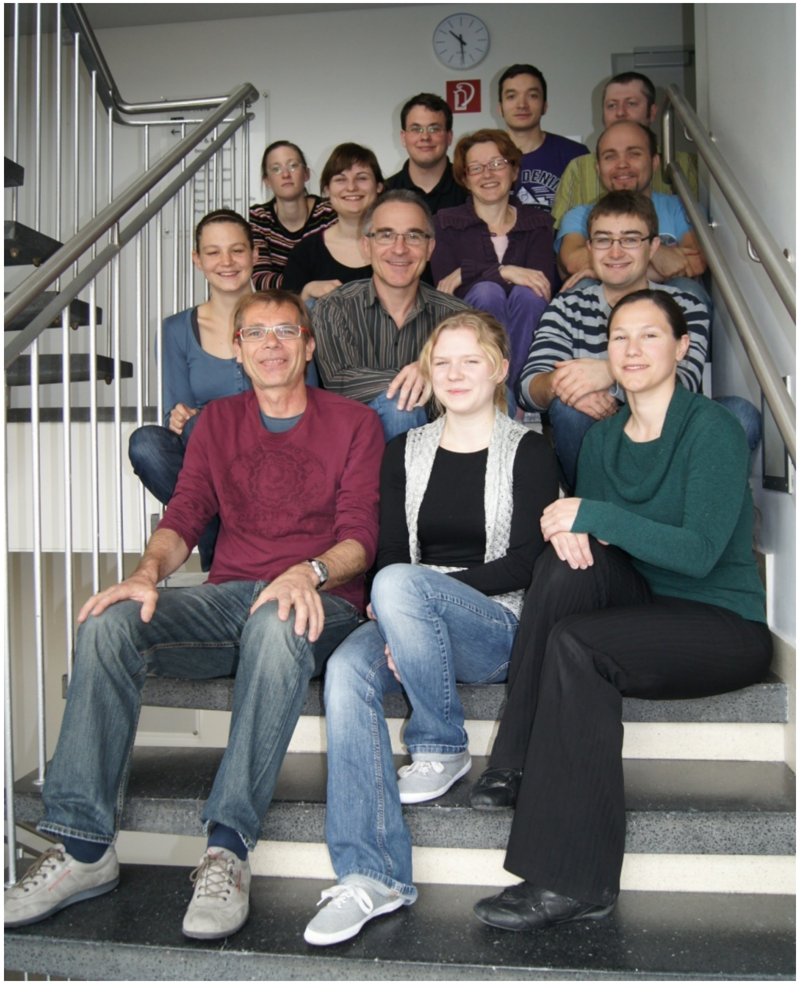

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