SENSE AND NO-SENSE OF **PRETREATMENT FOR INCREASING BIOGAS YIELDS**





HINRICH UELLENDAHL

SECTION FOR SUSTAINABLE BIOTECHNOLOGY

AALBORG UNIVERSITY COPENHAGEN

A.C. MEYERS VÆNGE 15, 2450 COPENHAGEN

HU@BIO.AAU.DK, PH +45 99 40 25 85

AALBORG UNIVERSITY
DENMARK




Pretreatment for increasing biogas production

Overview

- Lignocellulosic biomass resources for biogas production
  - where pretreatment may be relevant to increase biogas production
- Effects of biomass pretreatment
- Costs vs. benefits of pretreatment
- Different pretreatment methods
- Implementation of pretreatment
  - in combination with solid-liquid separation
  - before and after the biogas reactor
- Conclusions

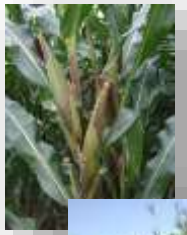
Lignocellulosic biomass for biogas

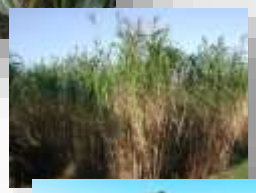
Waste Biomass

- Manure
- Manure fibers
- Agricultural residues
- Organic fraction of municipal solid waste
- …

Digestate

Energy crops



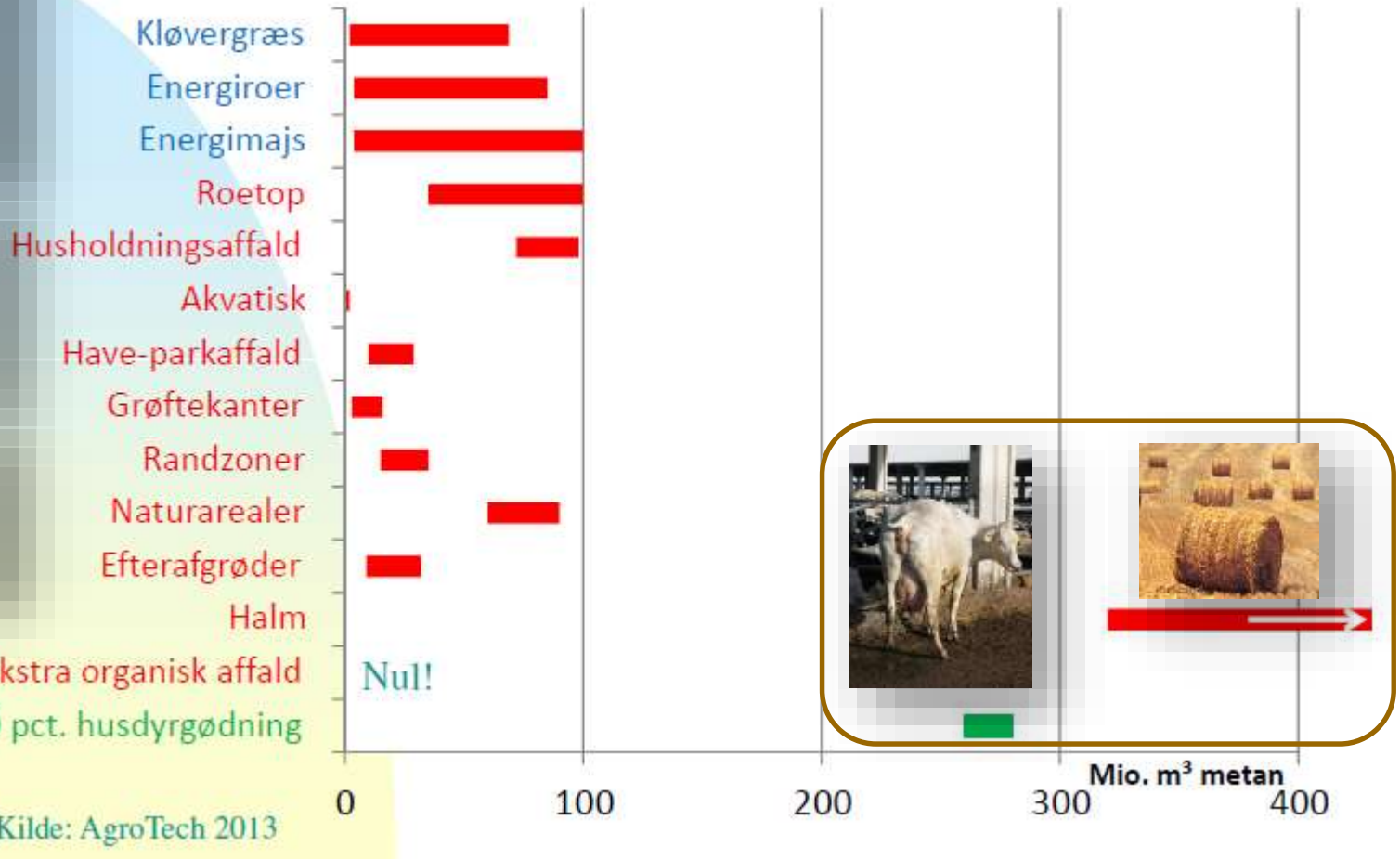


- Maize
- Miscanthus
- Catch crops
- …

Biogas from straw – focus in DK

Seminar on straw for biogas 2 weeks ago:

Lignocellulosic biomass for biogas – potential in DK



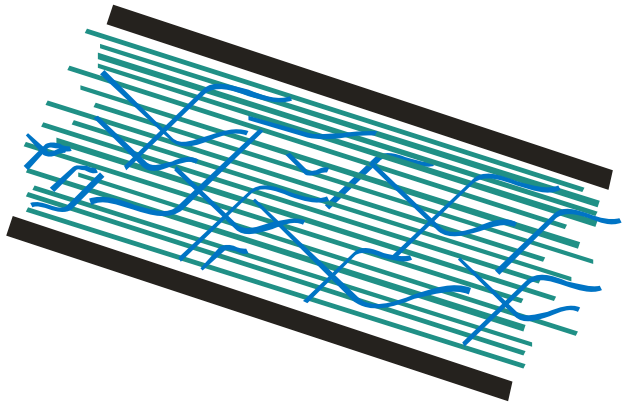
Pretreatment for increasing the biogas yield

Effects:

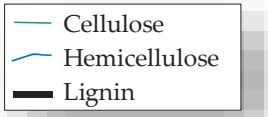
1) **Biomass is easier to handle**
   -> smaller particle size, lower viscosity

2) Increasing the biodegradability by addition of cellulolytic activity
   -> **Higher conversion rate**

3) Increasing the release of cellulose and hemicellulose from lignin
   -> **Higher final methane yield**



Lignocellulose



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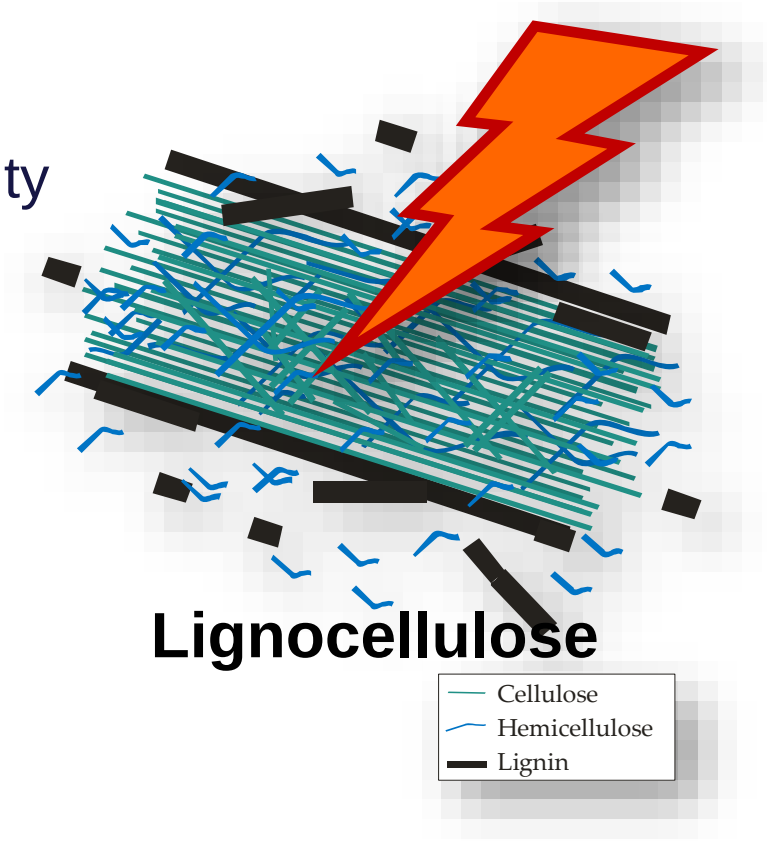

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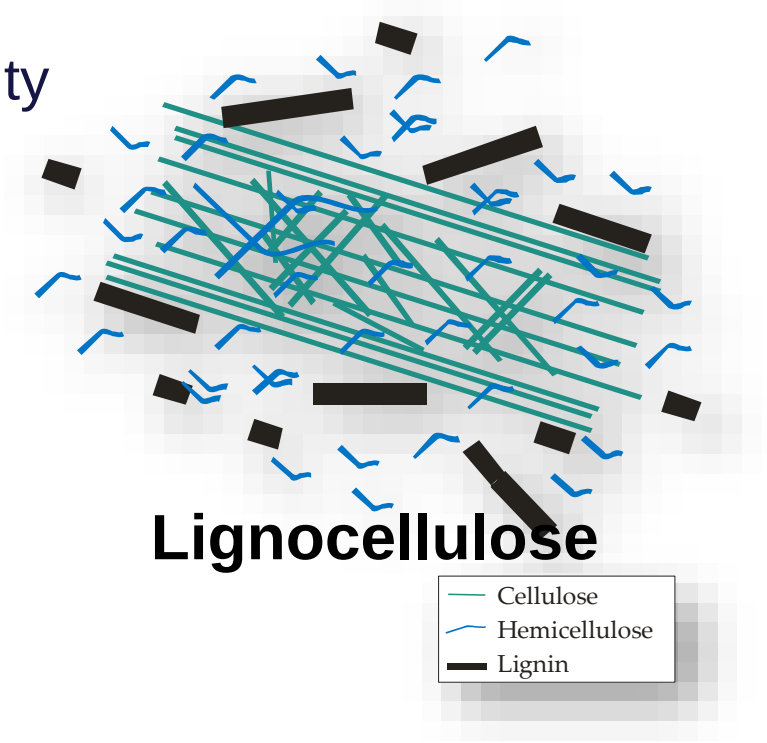
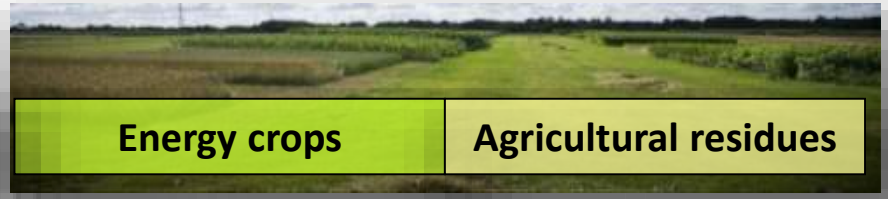


Pretreatment for increasing the biogas yield – depending on biomass and desired product

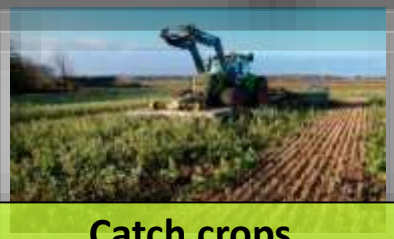
Manure

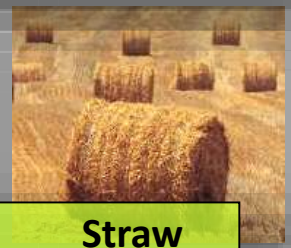


Energy crops | Agricultural residues

Manure separation

Fiber fraction





Maize | Catch crops | Straw

Depending on the biomass

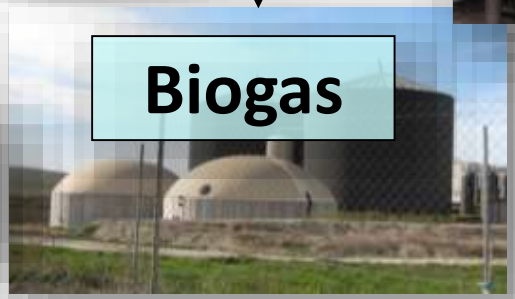
Depending on the desired product(s)

Anaerob digestion

Pretreatment

Enzymatic hydrolysis

Fermentation



Biogas

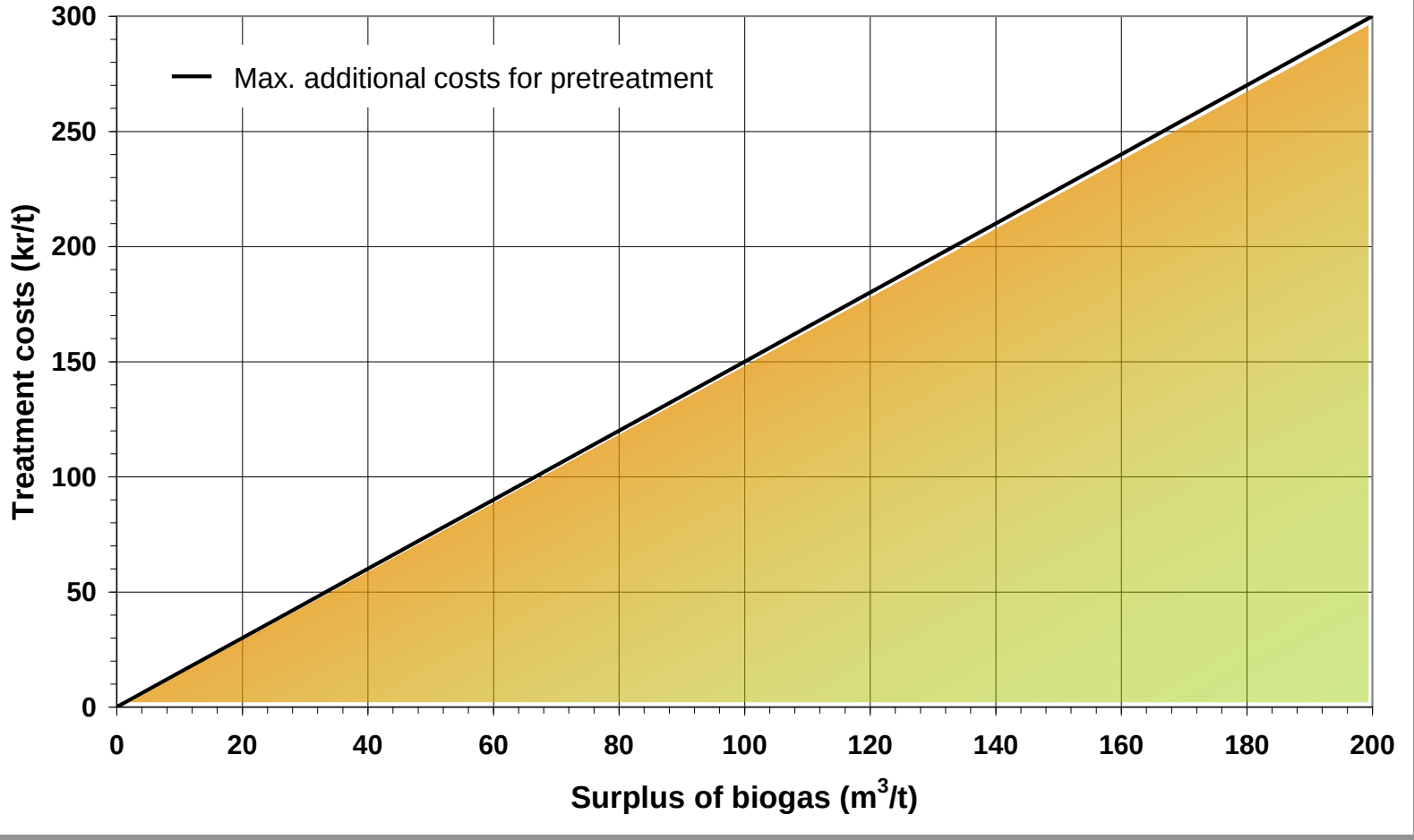
Downstream processing

BioChemicals

Bioethanol

Costs vs. benefit of pretreatment

Limit of treatment costs depends on revenue from biogas production

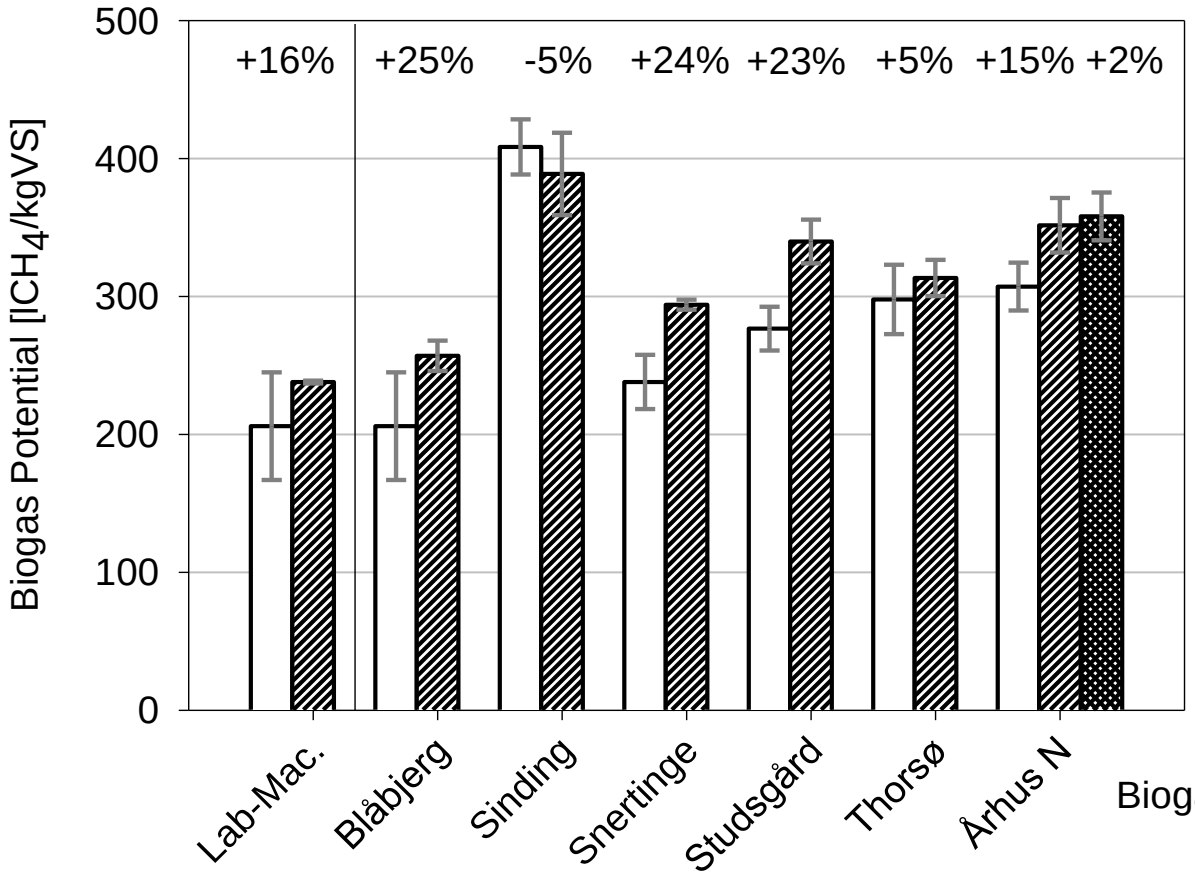


Pretreatment methods for lignocellulosic biomass

• Physical/mechanical	• Grinding, milling, maceration, ultrasound etc.
• Thermal	• Steam explosion, Wet oxidation @ 150-180ºC, +/- O_2
• Chemical	• Addition of acid, base etc.
• Biological	• Fungi, hydrolytic bacteria and their enzymes

Mechanical pretreatment/maceration

for increasing the biogas potential of manure fibers

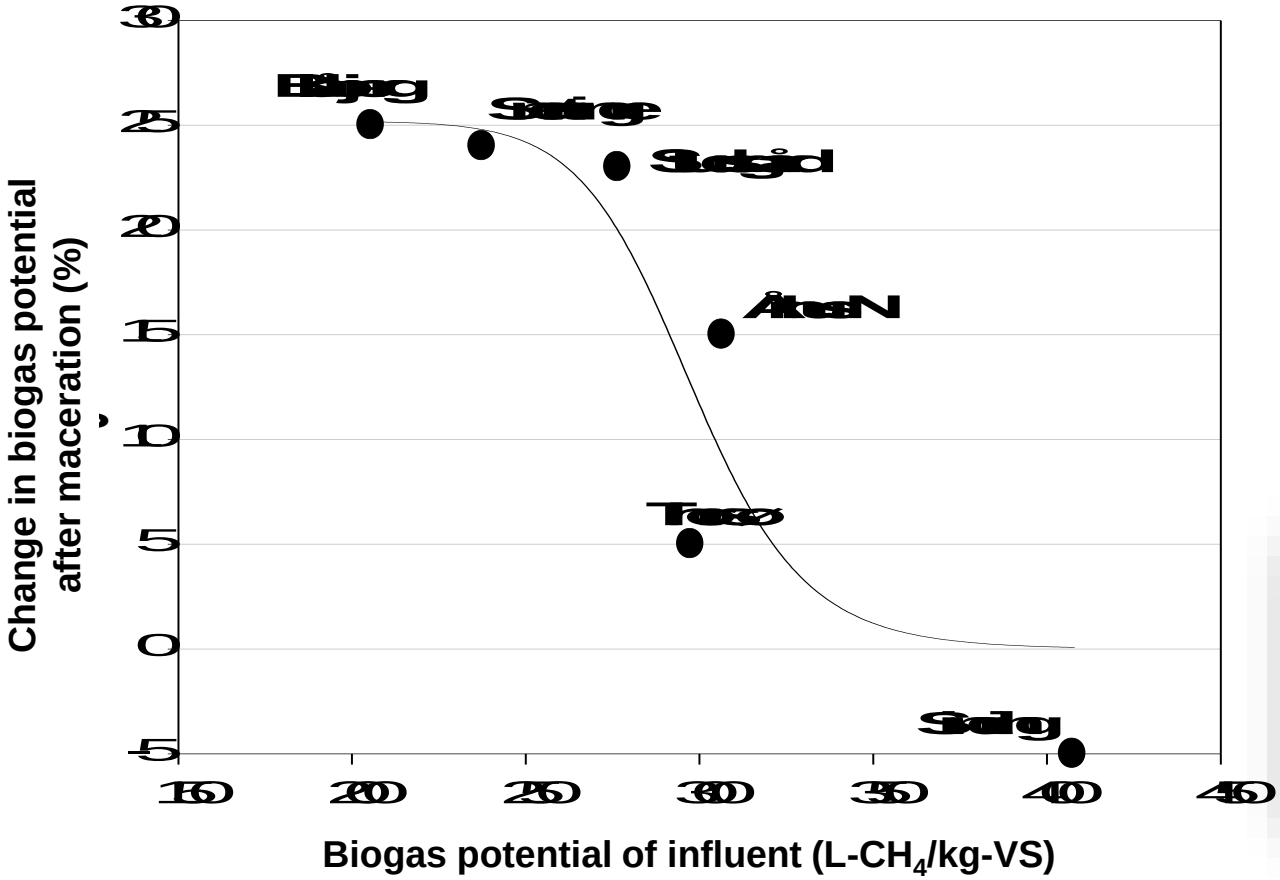


Change of
Biogas Potential

before mac.
after mac.
after 2nd mac.

Mechanical pretreatment/maceration

for increasing the biogas potential of manure fibers



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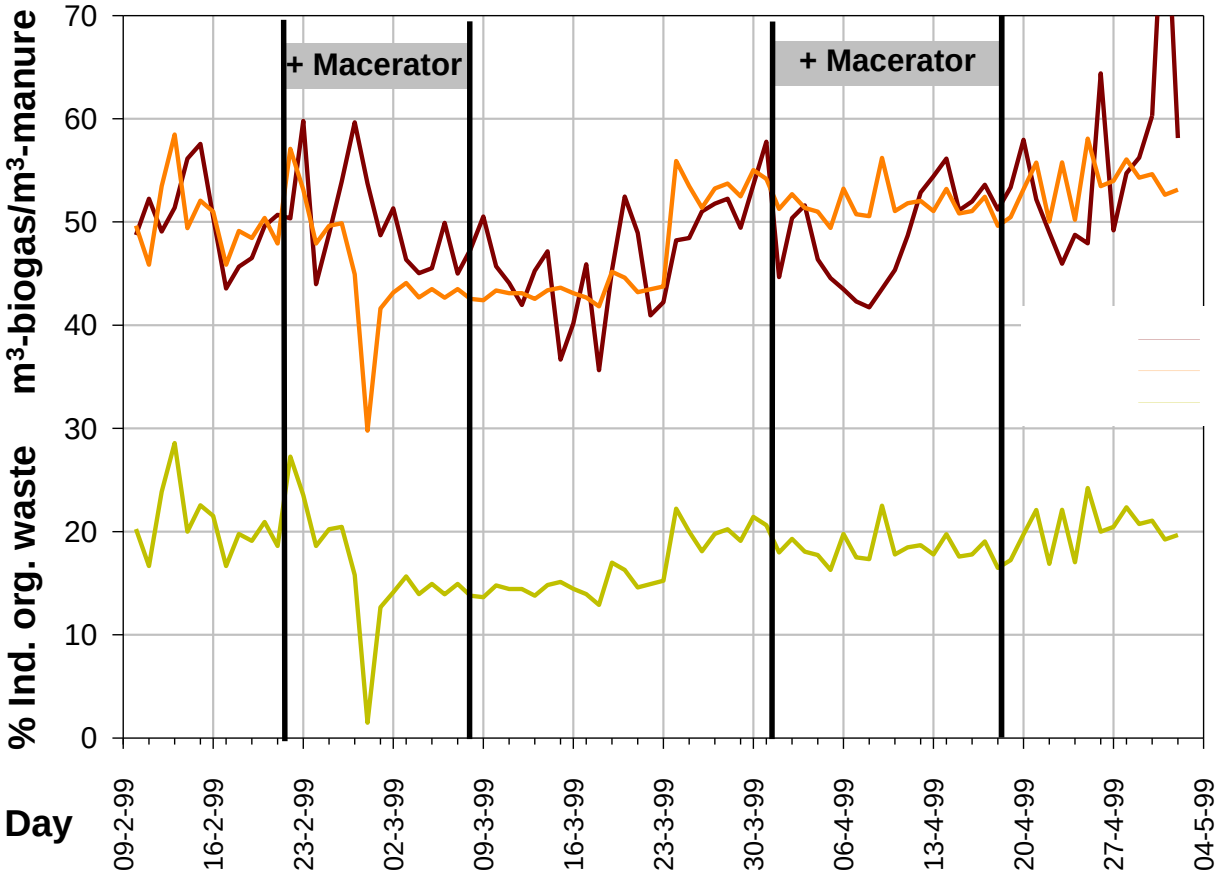

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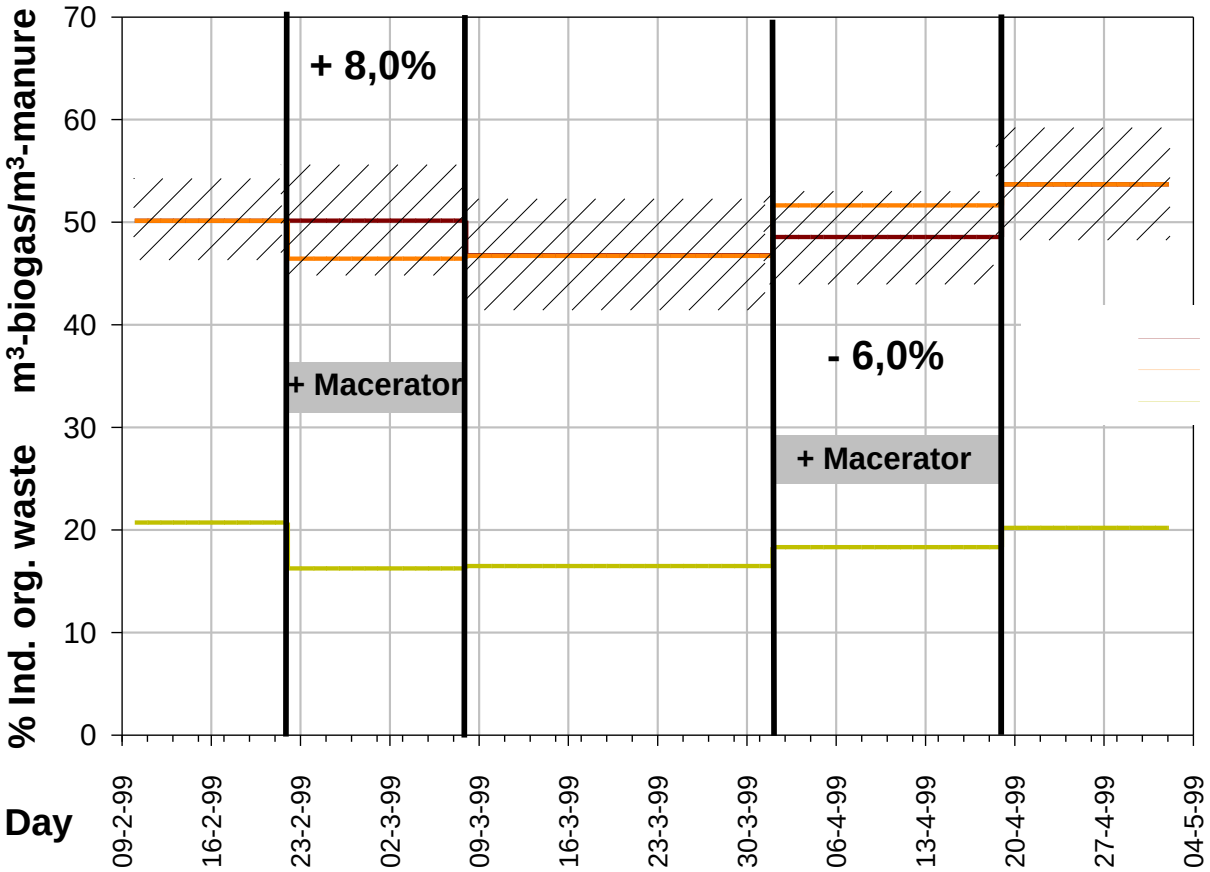
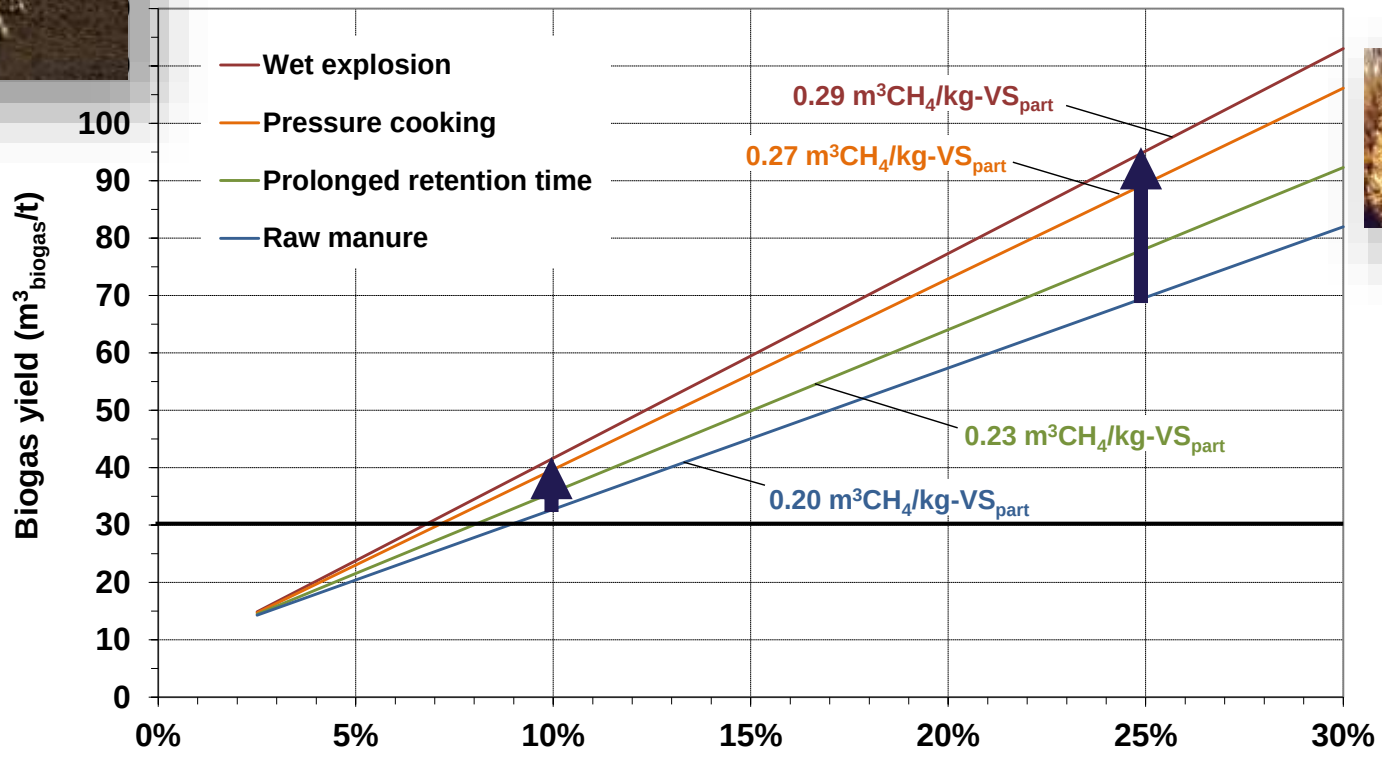


Gennemsnit+/-
Standardafvigelse

Dry matter concentration and pretreatment effect

Increase of biogas yield by pretreatment in combination with TS increase



Pretreatment of raw manure and manure fibers

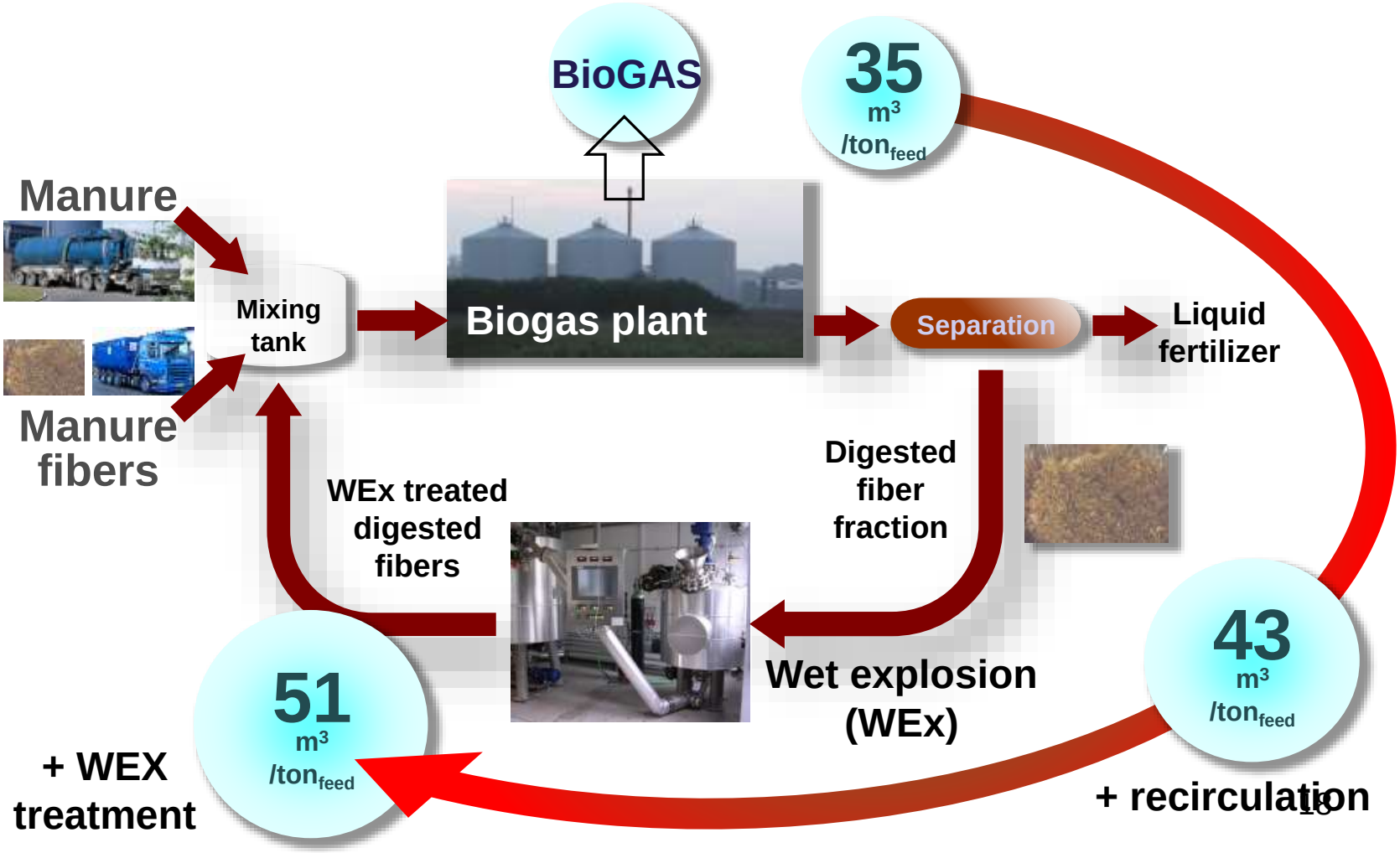
- Increasing the biogas yield by wet explosion

	Raw manure		Separated Manure fibers	
	cow	pig	pig	after digestion
Methane yield ($L\text{-}CH_4/kg\text{-}VS$)				
before	287	587	286	125
after	362	426	256	177
	+26%	**-26%**	**-10%**	**+42%**

Wet explosion

Most efficient concept

- Pretreatment of the digested fiber fraction

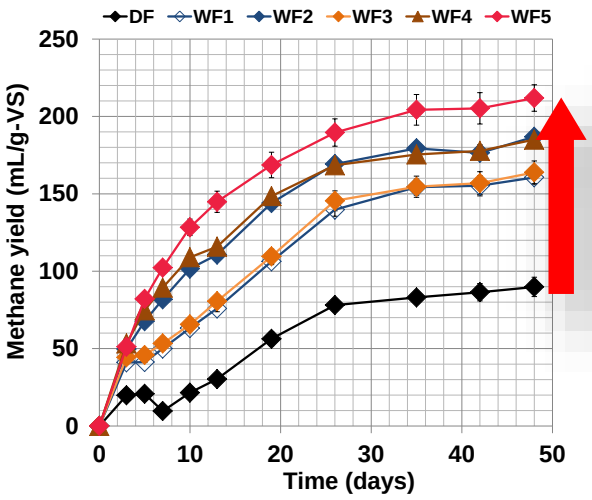


Increasing the biogas production from manure

Pretreatment of the digested fiber fraction

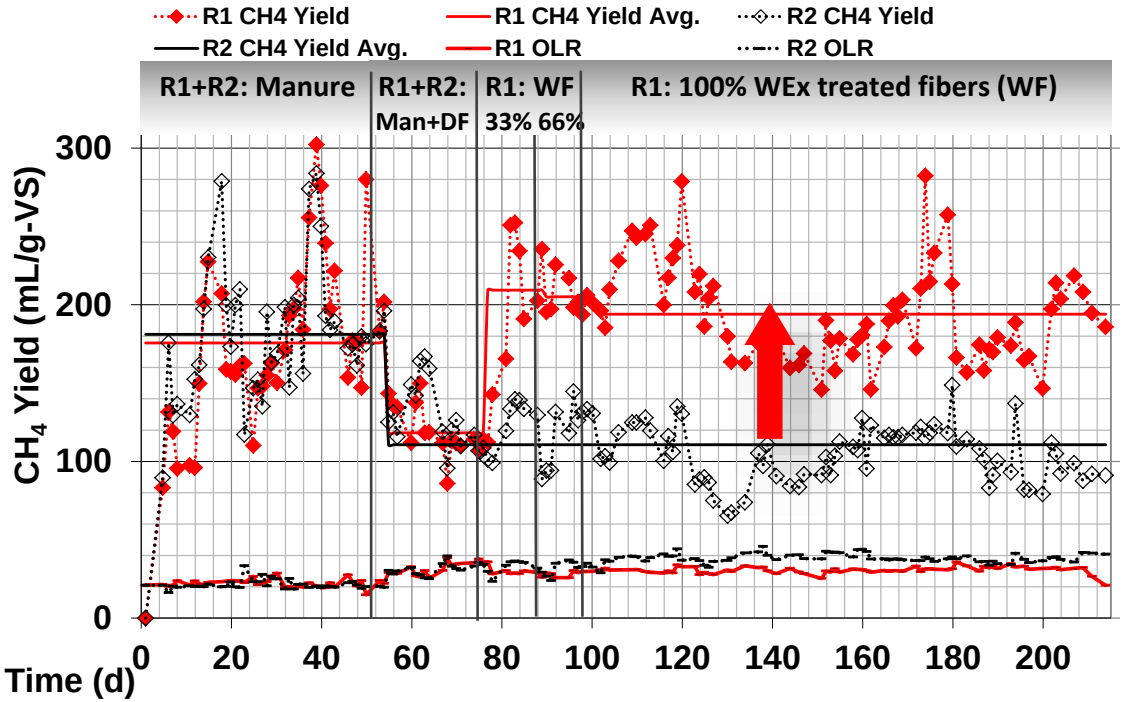
- Wet explosion (WEX) @ 150-180ºC, +/- O_2

- Batch tests:



⇒ **Increase by factor 2.36**

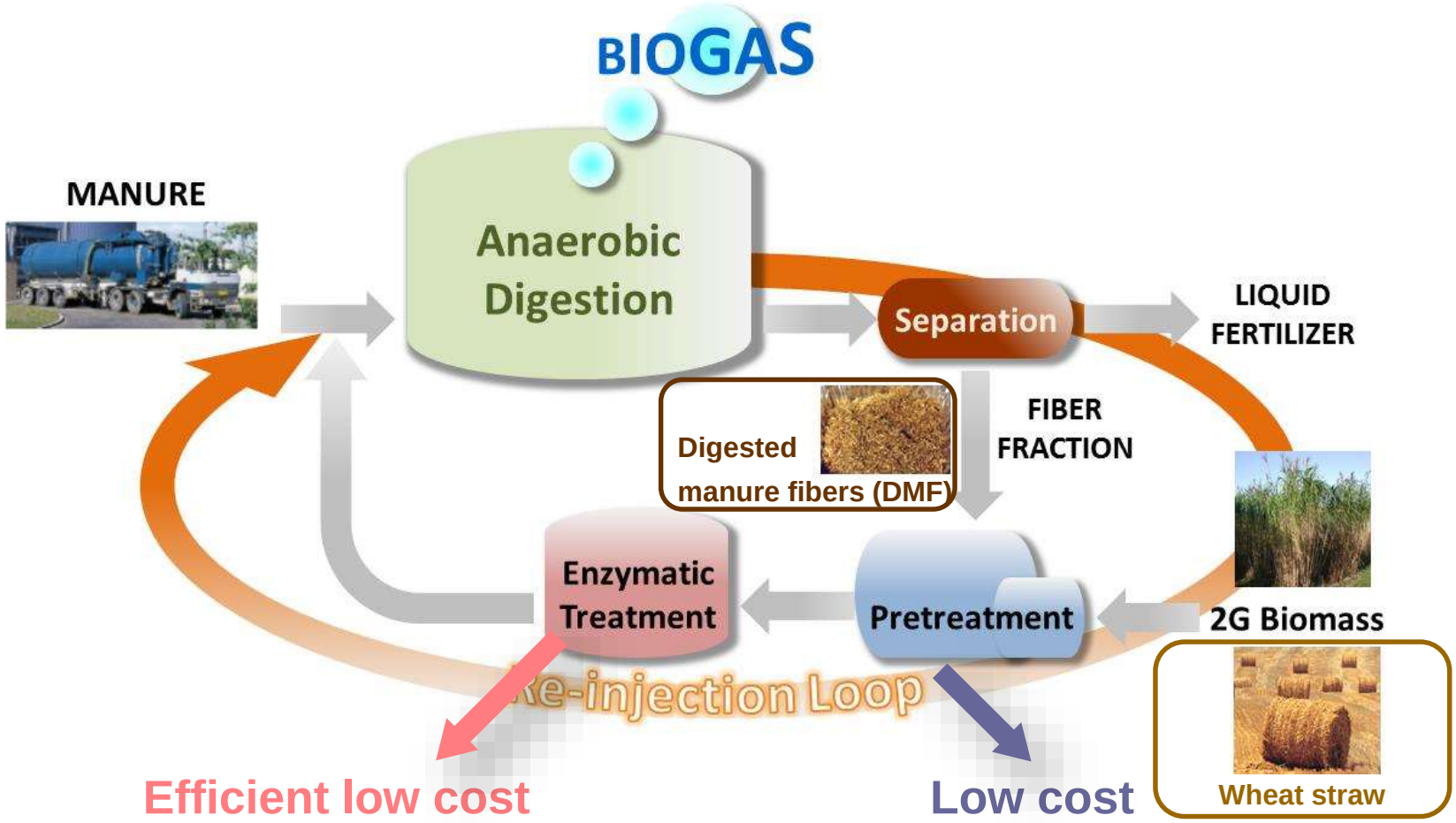
- Reactor experiments:



⇒ **Increase by factor 1.72**

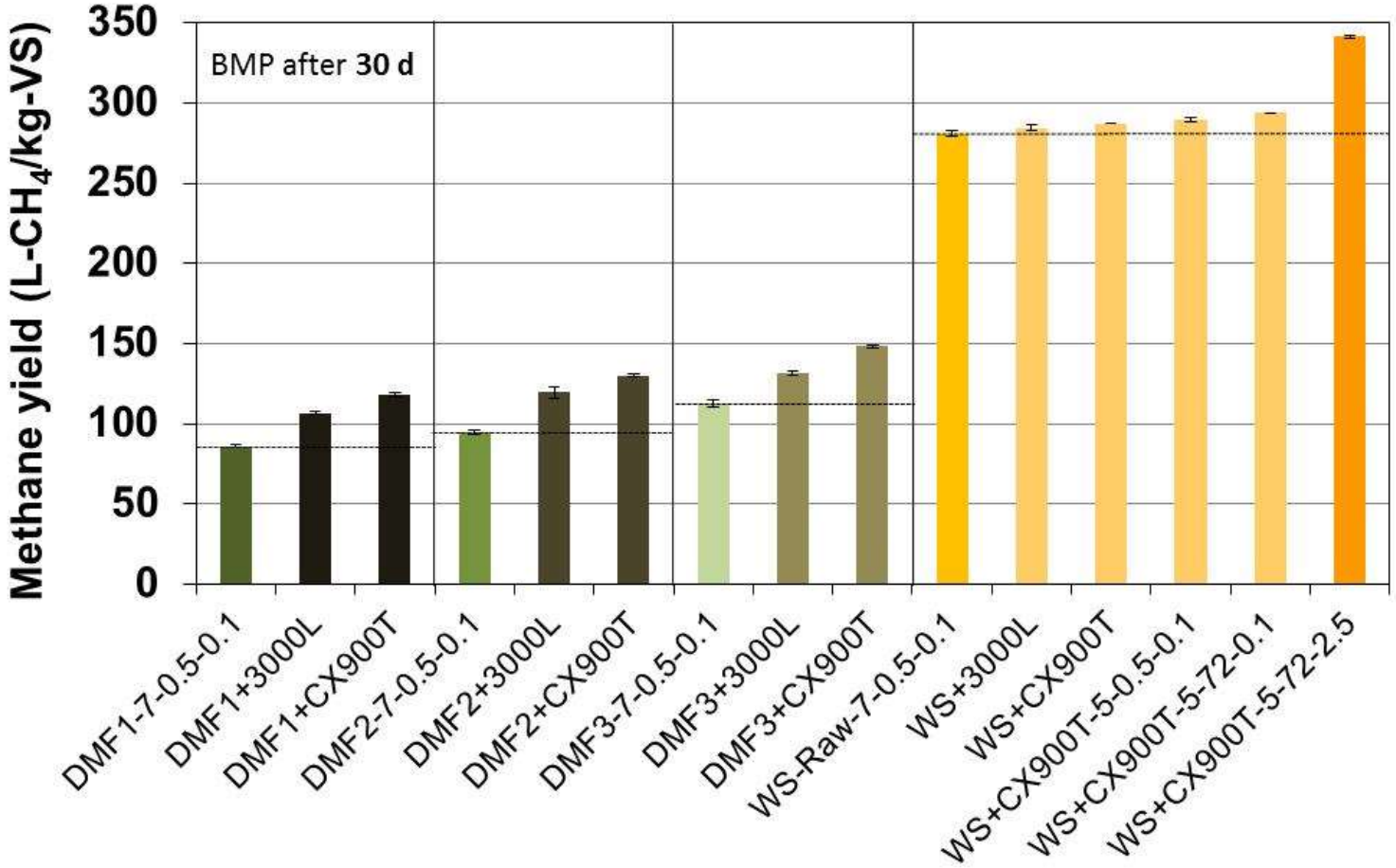
Further optimization of the concept

The Re-injection loop (EU project BIOMAN)



Effect of enzyme addition on biogas yield

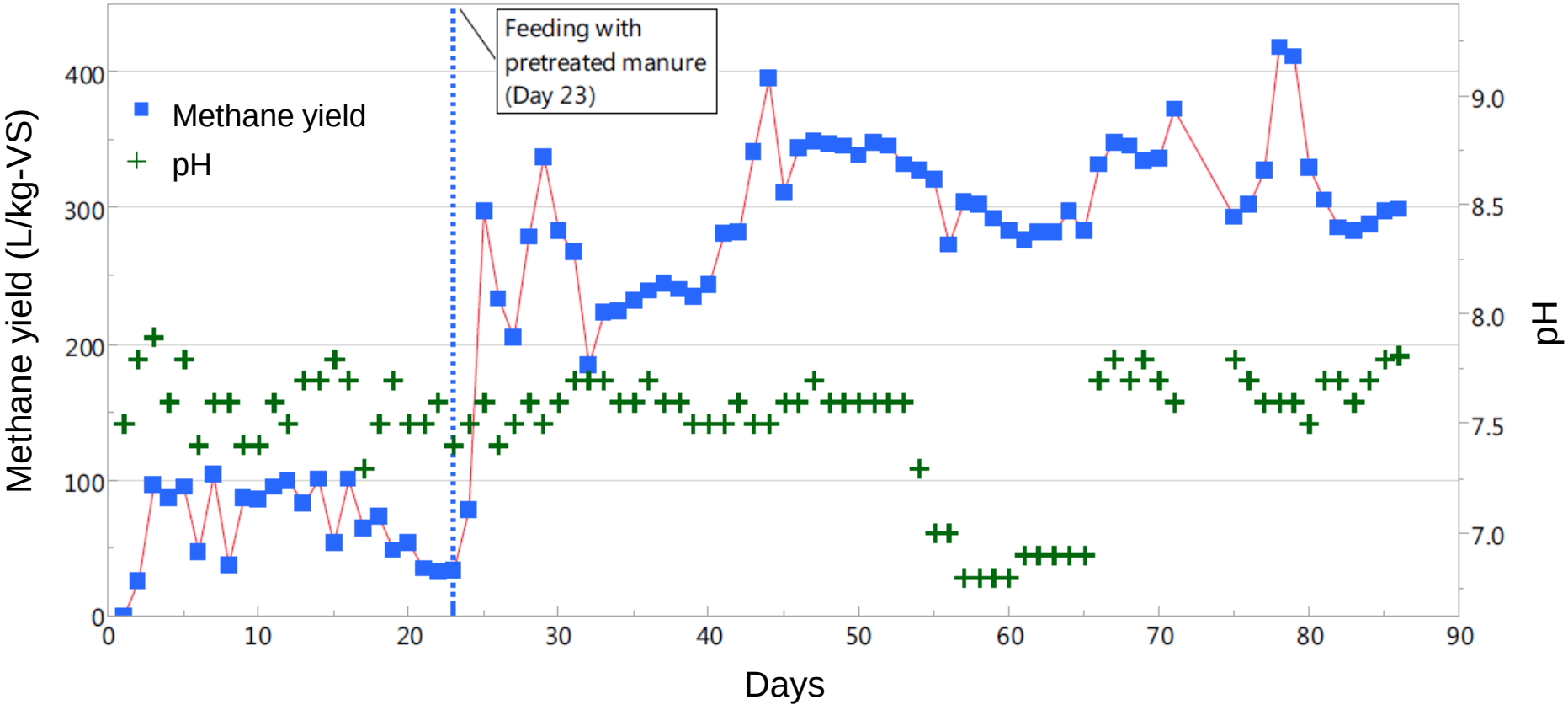
BMP of digested manure fibers (DMF) and of wheat straw (WS) with addition of enzymes



Increasing the biogas production from manure

Pretreatment of feedlot manure

- Wet explosion (WEX) @ 170ºC, 4 bar O_2, 25 min.



Conclusions (1)

The choice of the most suitable pretreatment for a viable concept depends on several factors:

- The **ADDITIONAL biogas yield** (or other benefits) have to be higher than CAPEC and OPEC of the pretreatment
  -> The increase in biogas yield by the pretreatment should be significantly higher than the variation in biogas yield of the biomass.
- It has to be distinguished if the pretreatment should just **increase the CONVERSION RATE or the FINAL YIELD** of the biogas production
  -> In the 1st case a larger reactor volume or a shift to thermophilic process operation may be just as effective

Conclusions (2)

The choice of the most suitable pretreatment for a viable concept depends on several factors:

- The **volume of the biomass to be pretreated should be reduced** as much as possible
  -> For example by combination with solid-liquid separation
- The **pretreatment should be specifically applied only to the biomass (fractions), which actually needs pretreatment**
  -> Specific pretreatment of biomass (fractions) with a high lignin content; treatment of the fiber fraction after the first digestion in a biogas plant
- **Economy of scale!** Pretreatment will be in most cases only feasible for large biogas plants