IBBA
INTER BALTIC BIOGAS ARENA

Malmö,
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für Agrartechnik
& Bioenergie

Experiences with mechanical pre-treatment of horse-dung on a biogas plant (190 kW)

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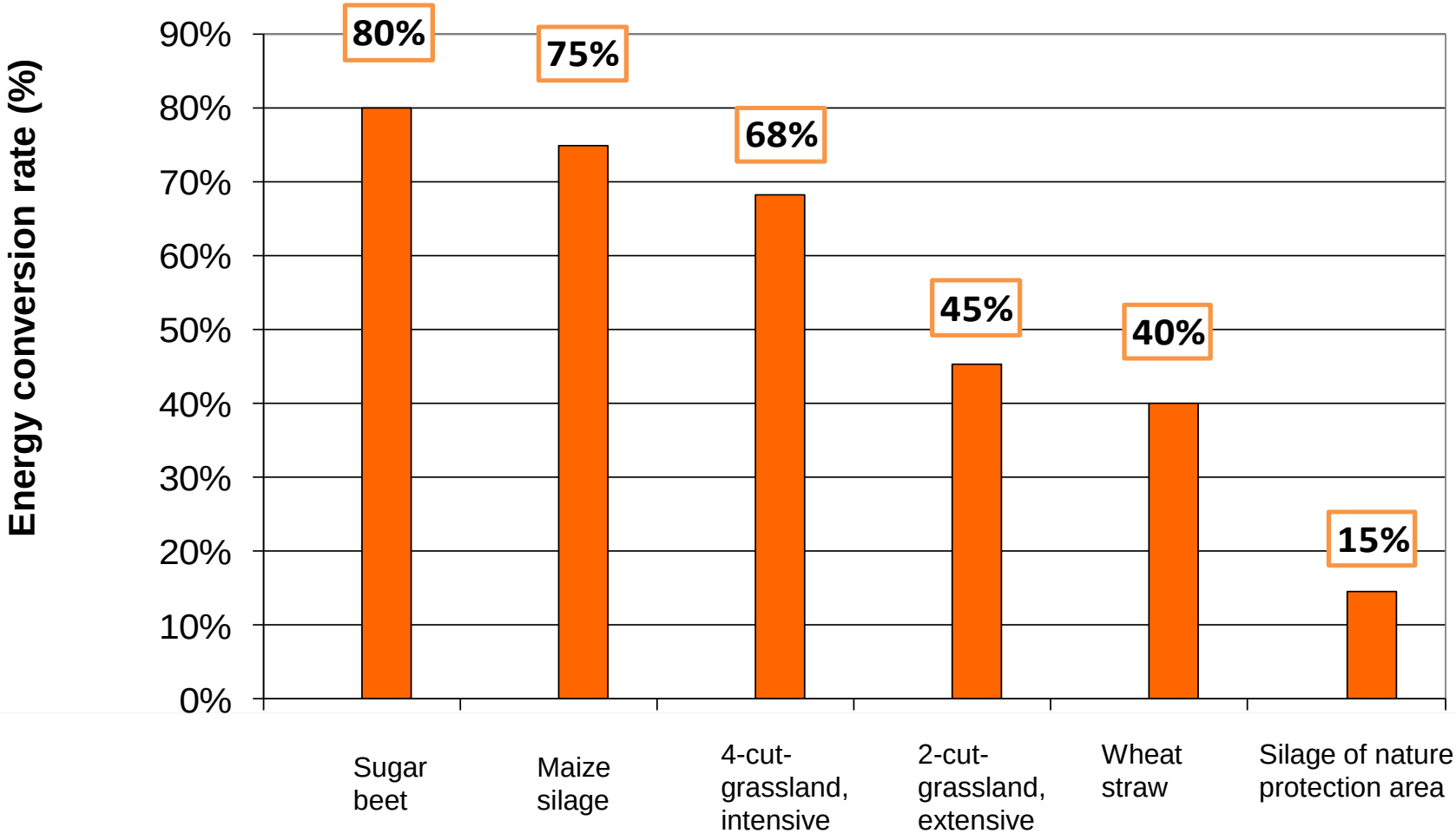
Biological energy conversion efficiency of different substrates



- Around 8000 Full scale biogas plants in Germany
- Substrate use about 115 Mio. t FM per year, >50 % energy crops, costs
- Alternative substrates?

Research project with horse manure, funded by the Federal Ministry of Environment

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Aims of the project:

- To determine of digestibility of this fibrous substrate
- To increase the degradability and efficiency
- To optimize the managability in the digester
- To increase the methane yield
- To use the horse manure as energy source

Horse manure as feed stuff for biogas plants?

- More than 1 Million horses in Germany
- Manure production: 17 - 20 t per horse and year
  - 50 – 70 % straw fraction (fluctuating)
  - Lack of space at the farms for storage and disposal problems
  - Problems in the surroundig of towns
  - High costs of disposal

→ Energetic use in biogas plants will be a chance

Häußermann et al., 2002; Beck, 2005; Winter, 2014

High fiber content causes process engineering problems

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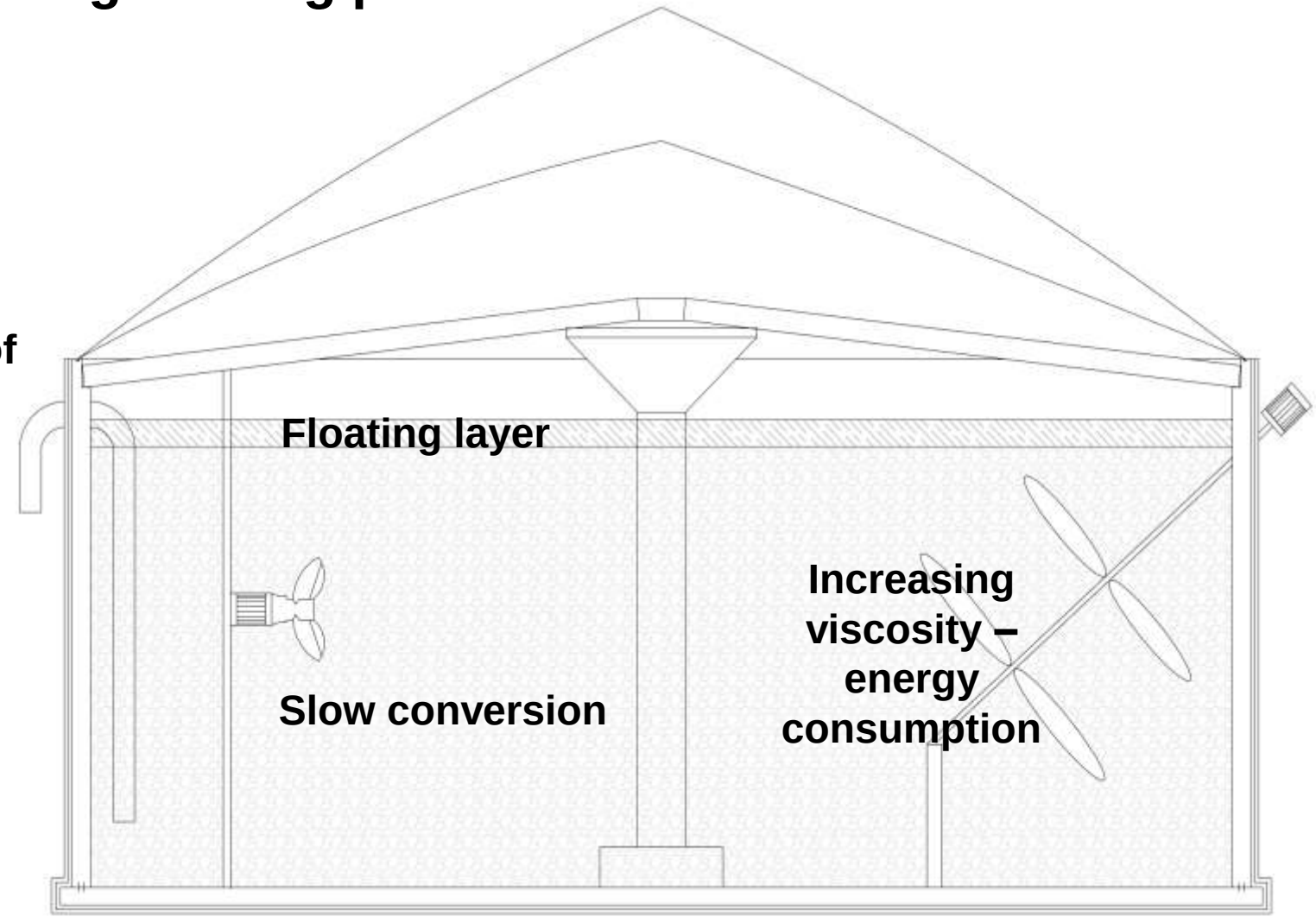
Blockage of leakage possible



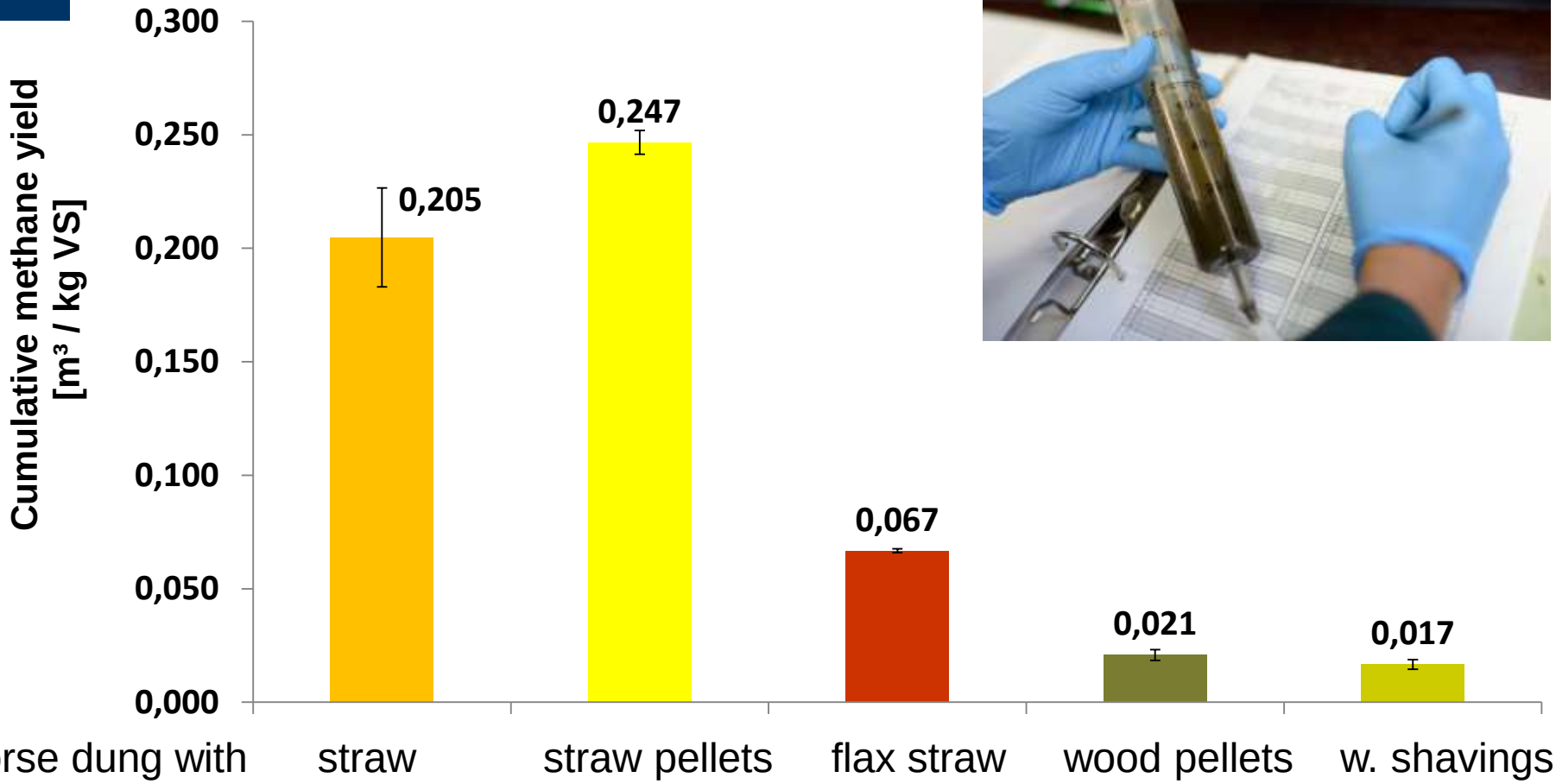
Digestibility of horse manure

Material and methods

- **Substrate from 10 farms:**
  - Used litter (straw, straw pellets, flax straw, wood shavings and wood pellets)
  - Horse dung
  - Horse dung mixed with different litter materials
  - Fresh and stored manure
- **Analysis of composition**
  - Weender and van Soest analysis
  - Concentration of trace elements
- **Analysis of biogas- and methane yields**
  - Hohenheim Biogas Yield Test (HBT)
  - VDI-regulars 4630 (35 days)

Digestibility of horse manure

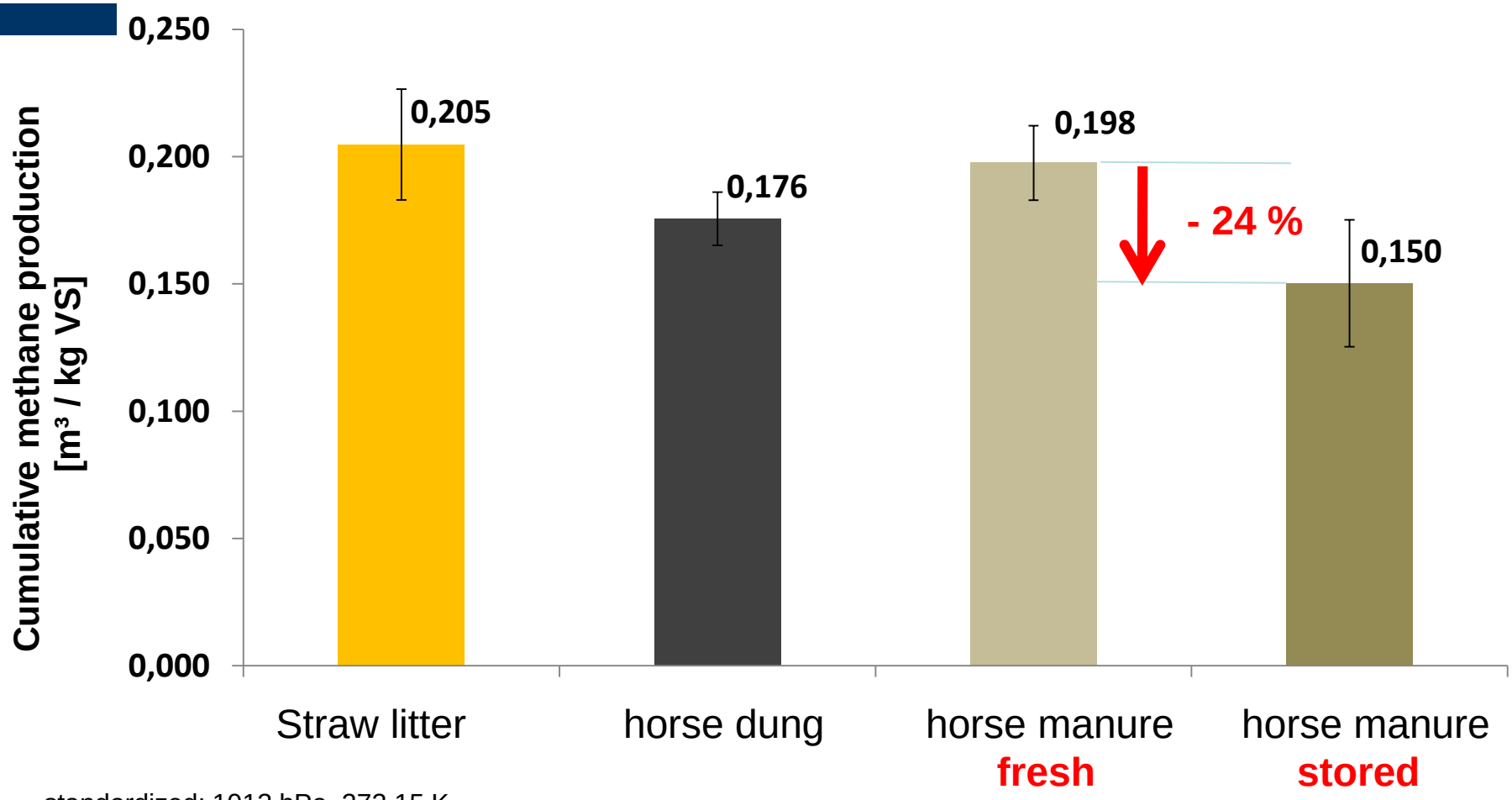
Specific methane yield of different litter materials



standardized: 1013 hPa, 273,15 K

Digestibility of horse manure

Specific methane yield - age of manure



standardized: 1013 hPa, 273,15 K

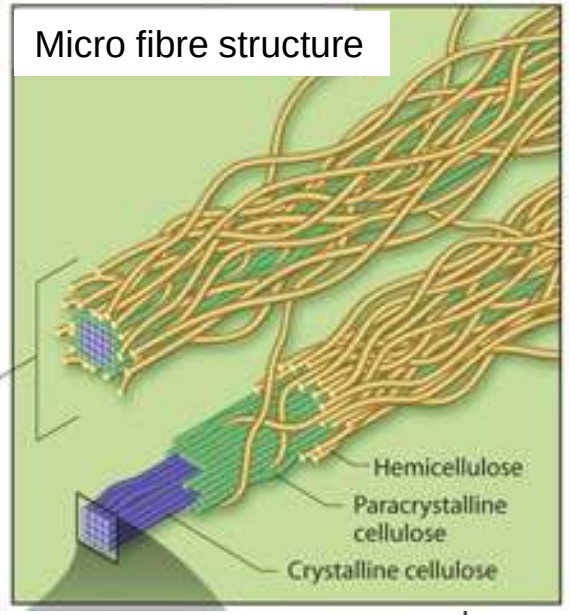
Digestibility of horse manure

Results

- Good digestibility of horse manure with straw as litter
  - VS: Horse manure 198 m³ CH_4 / t
    - (Maize 330 – 350 m³ CH_4 / t)
  - FM: Horse manure 80 m³ CH_4 / t
    - (Maize 100 – 120 m³ CH_4 / t)
- Insufficient decomposition with alternative litter materials
- Storage causes a considerable loss of organic components and loss of methane yield (24 % less)
- Content of trace elements comparable with grass silage

Conditioning of substrate

- Plants or parts of plants with high fiber fraction
- Lignocellulose – hindering for digestion
- **Will it be possible, to enhance anaerobic digestion by conditioning**



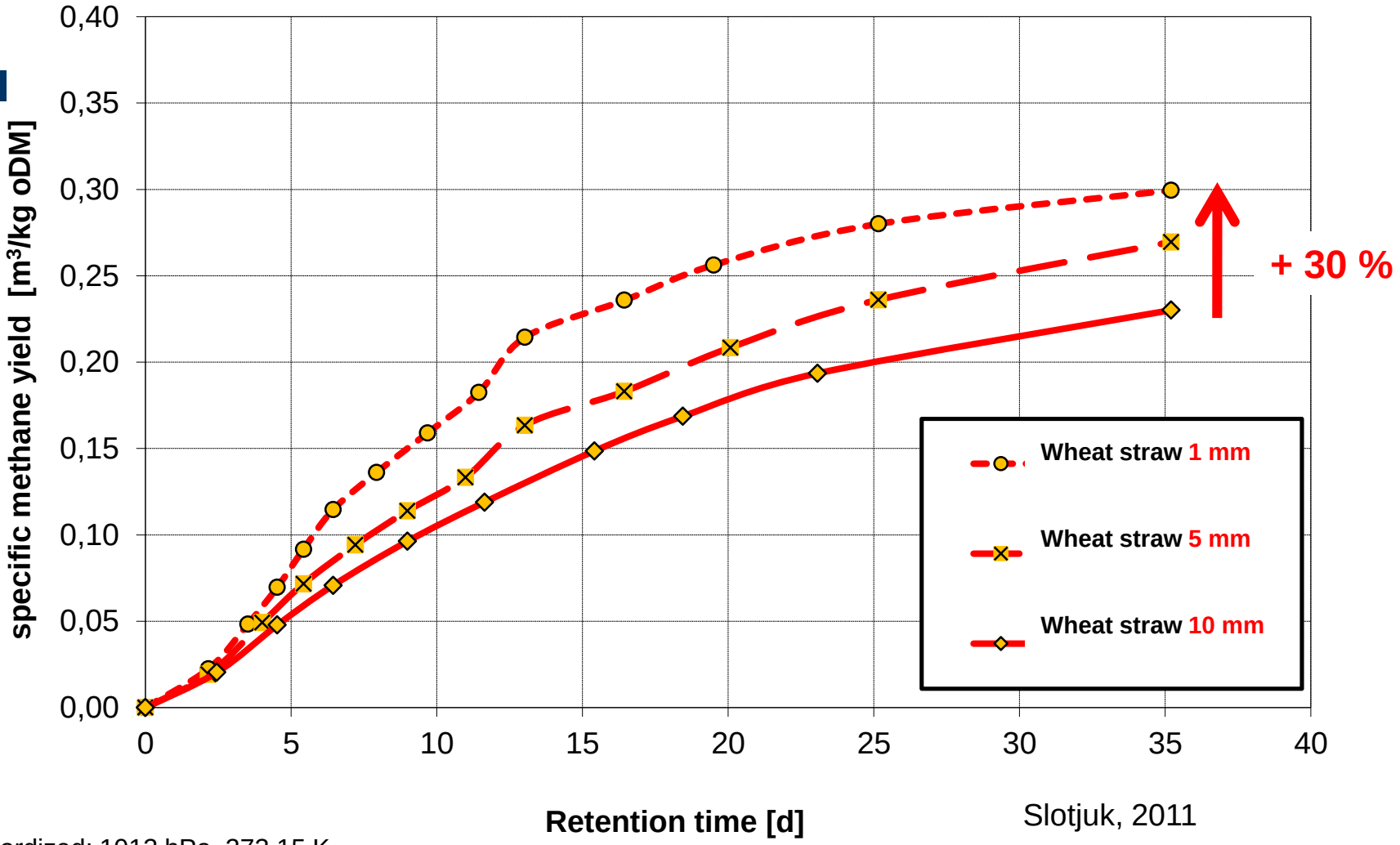
physical

mechanical	thermic	chemical	biological
- shearing strain - pressure	- hot water - steam - thermo-pressure-hydrolysis	- acid - base - oxidant	- enzymes

Schwarz et al., 2009

Wheat straw – different particle size

Effect of grinding



Slotjuk, 2011

standardized: 1013 hPa, 273,15 K

Mechanical pretreatment

Requirements

Avoiding process engineering problems

Low investment costs and low operating costs

Increasing of particle surface and force up of conversion rate

Prevention of inhibiting effects

Optimizing of viscosity

Reducing the loss of organic components

Taherzadeh und Karimi, 2008; Agbor et al., 2011

Systems used in full scale biogas plants for mechanical treatment of substrate

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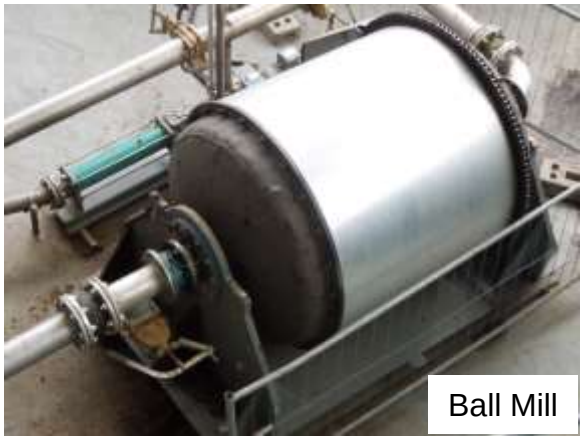
FREY, 2014



FREY, 2014

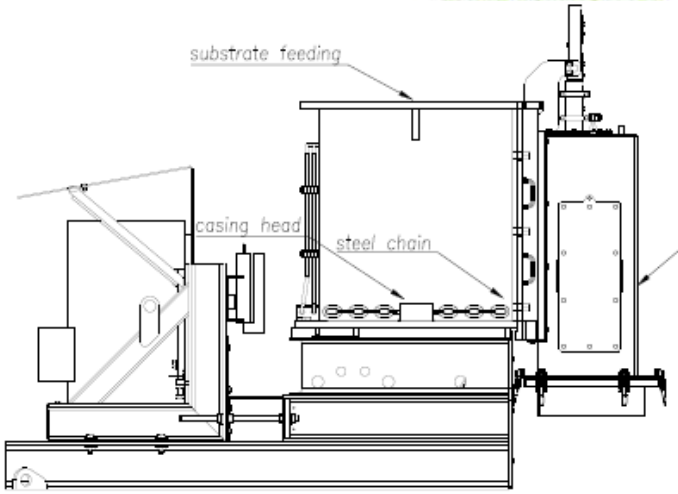
MÖNCH-TEGEDER, 2014

JENZ GMBH, 2014

BTS BIOGAS GMBH, 2014

BTS BIOGAS GMBH, 2014

Mechanical pretreatment as possible solution – cross flow grinder



- primarily recycling industrie
- working chamber diameter: 0.9 to 2.5 m
- connection power 55 to 315 kW
- number of rotation: 1200 /min
- working in batch or continuously

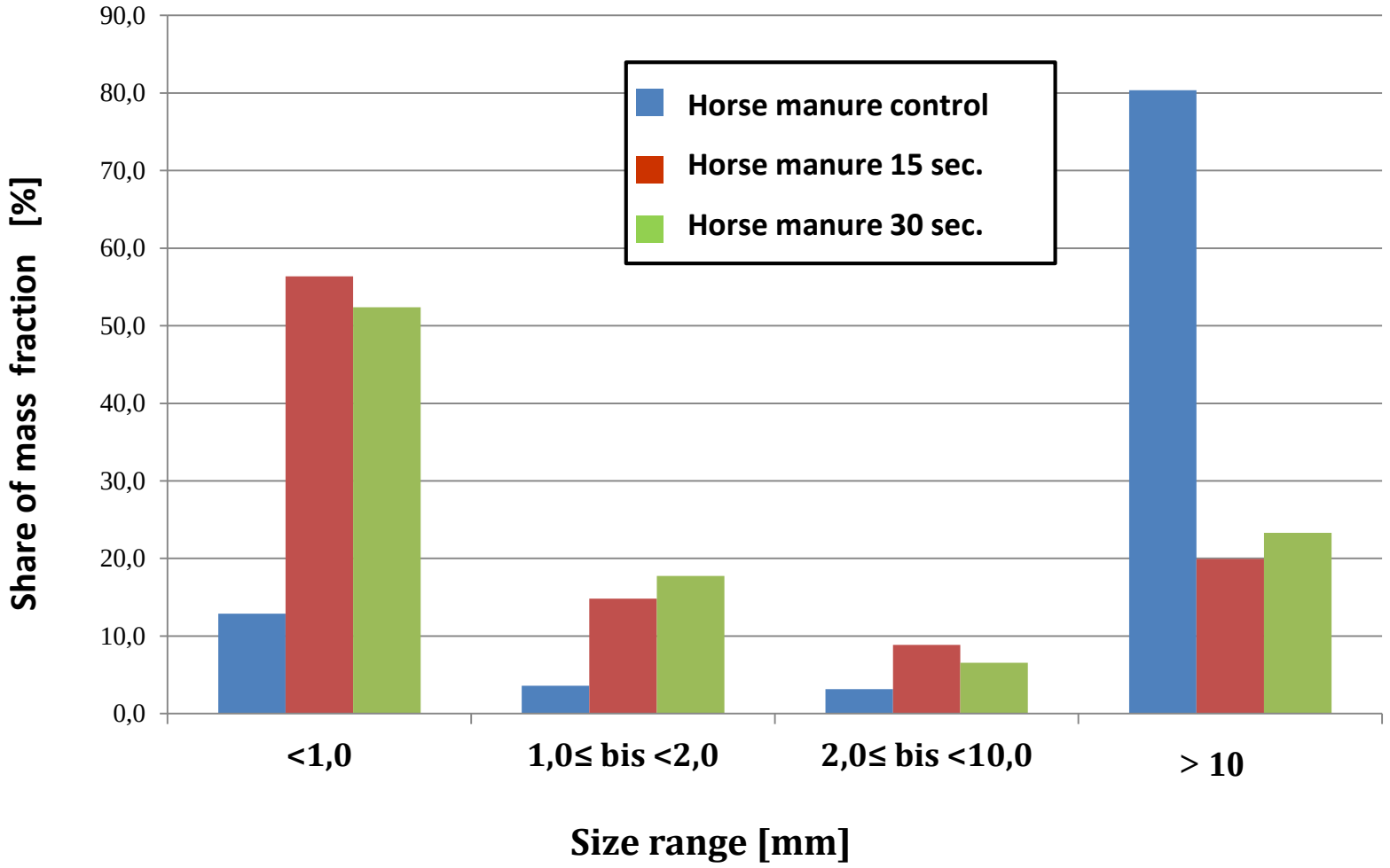
Mechanical desintegrated substrate

Maize silage 15 sec 30 sec

Horse manure 15 sec 30 sec

Wet sieving of the pretreated horse manure

- Variation of treatment time



Mechanical disintegration –
different substrates

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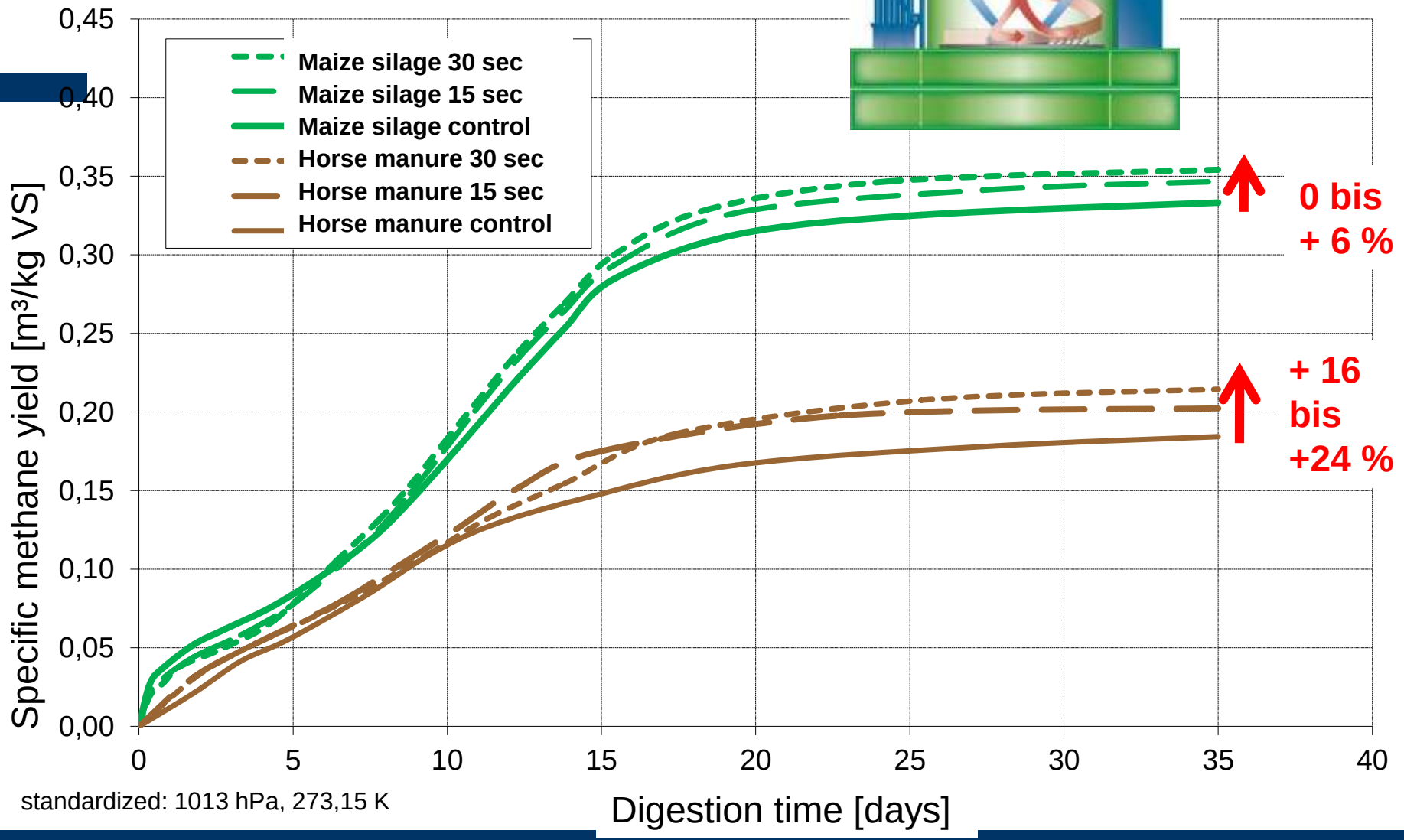

standardized: 1013 hPa, 273,15 K

Mechanical pretreatment

Optic effect

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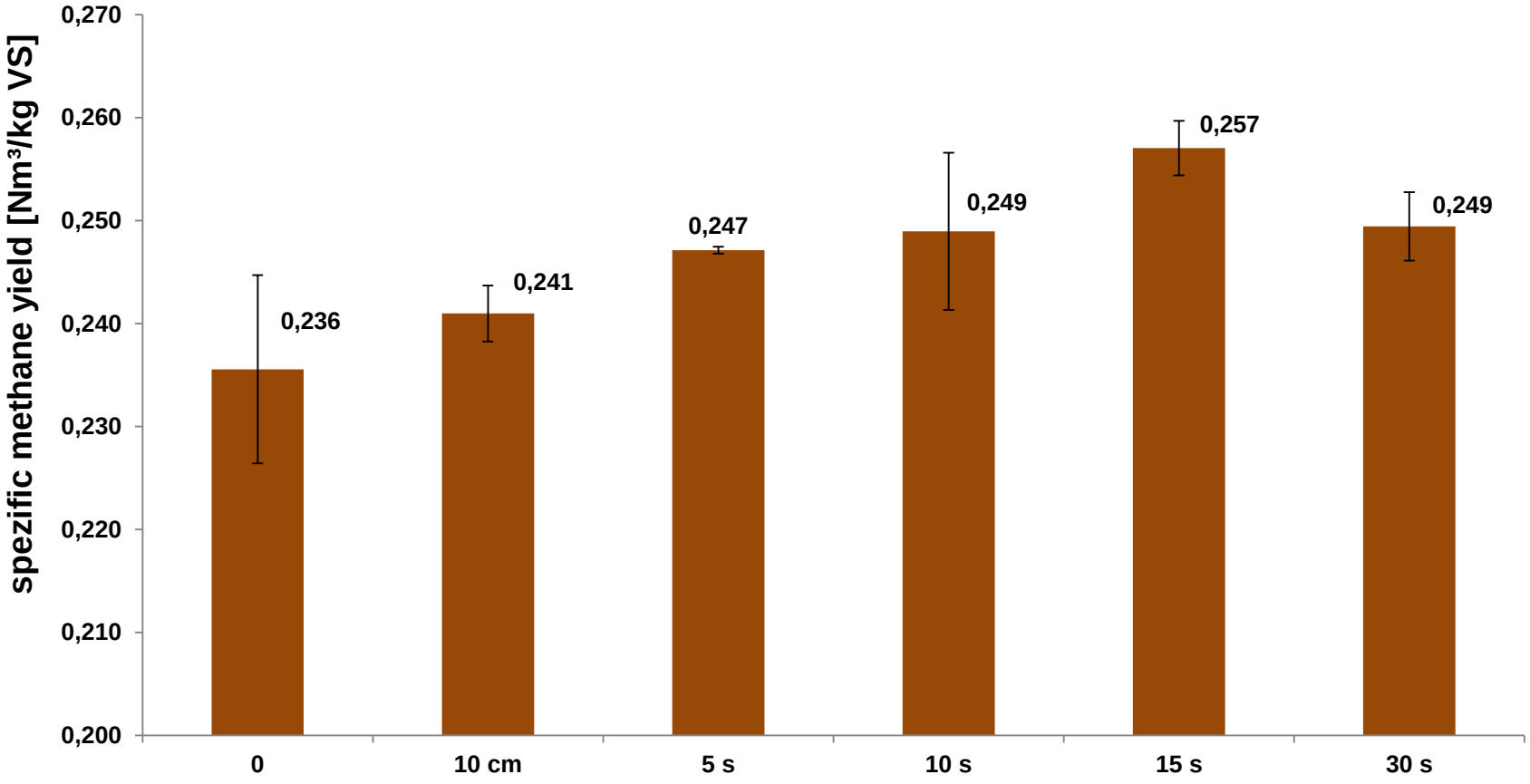
Mechanical pretreatment

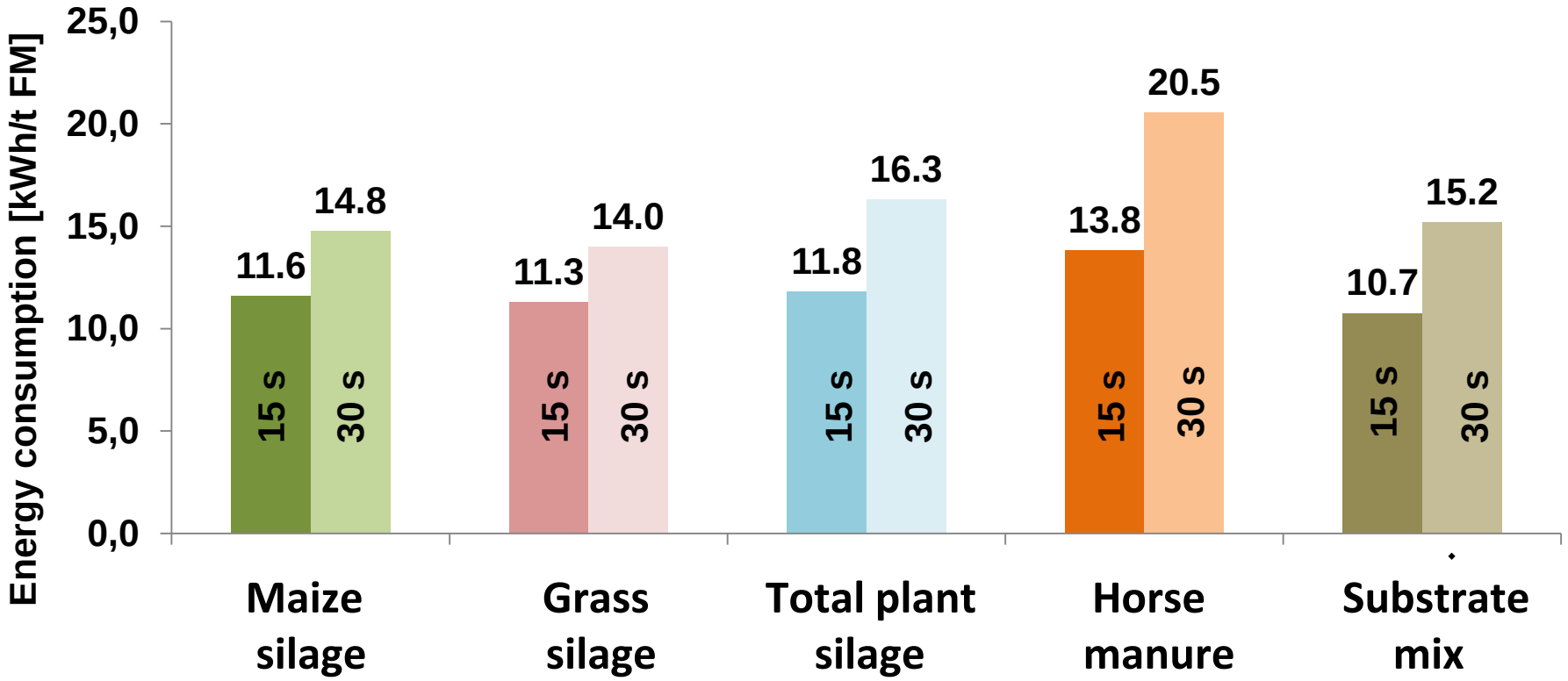
Specific methane yield – horse manure

Variation of treatment intensity



Mechanical pretreatment

Energy consumption of cross flow grinder



DM-content has an influence on energy consumption

Mechanical pretreatment
Cognition

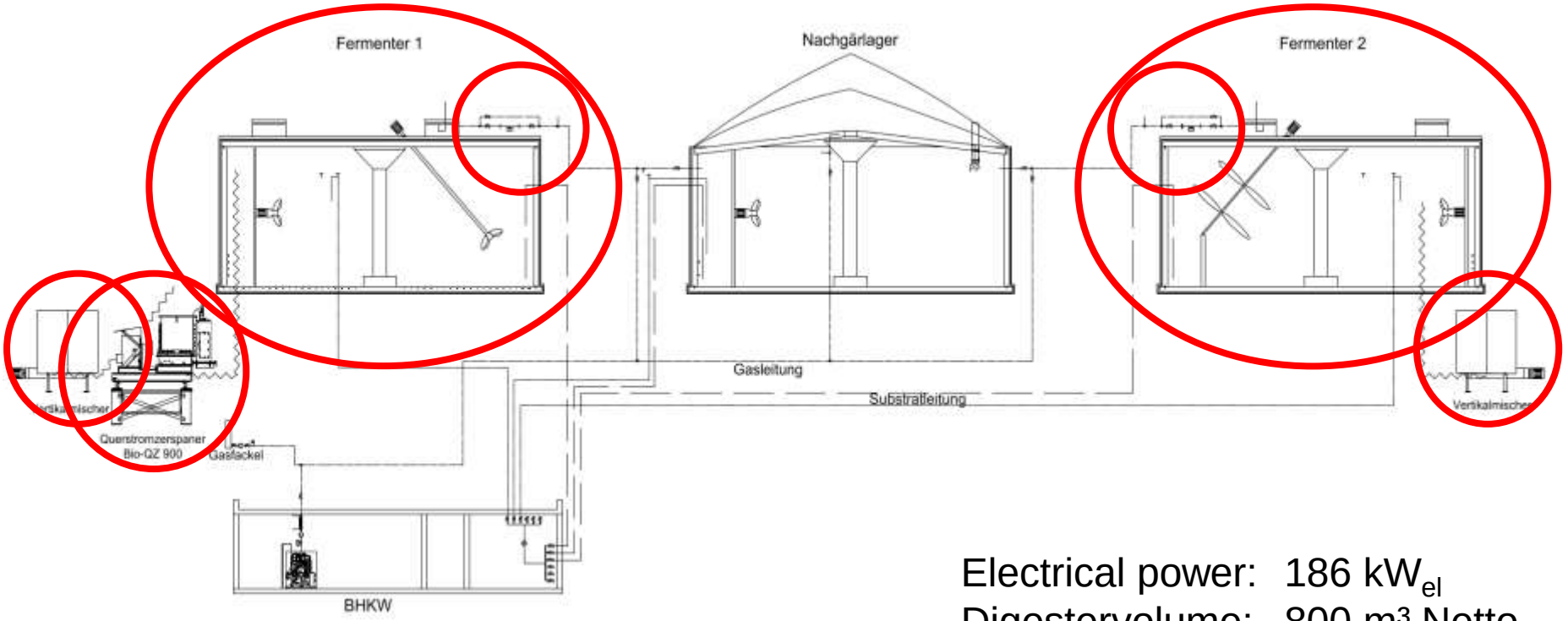
- Significant influence on particle structure and - size
- No significant effect on methane yield of green plant silage
- Clearly significant effect for horse manure
  - Increasing of methane yield
  - Degradation kinetics
- Optimal grinding effect at 15 s pretreatment
- Energy consumption is depending on substrate type and DM-content (10 - 20 kWh / t FM)
- Mechanical desintegration only relevant for lignocellulosic material

Examinations in practical scale

- Too little experience with lignocellulosic materials in practical plants:
  - Effects on process biology
  - Influence on substrate utilisation
  - Demand on process engineering
  - Necessity of pretreatment

Usability of horse manure in practical scale

Research biogas plant „Unterer Lindenhof“



Electrical power: 186 kW_{el}
Digestervolume: 800 m³ Netto
Temperature: 40.0 °C

Usability of horse manure in practical scale
Research biogas plant „Unterer Lindenhof“

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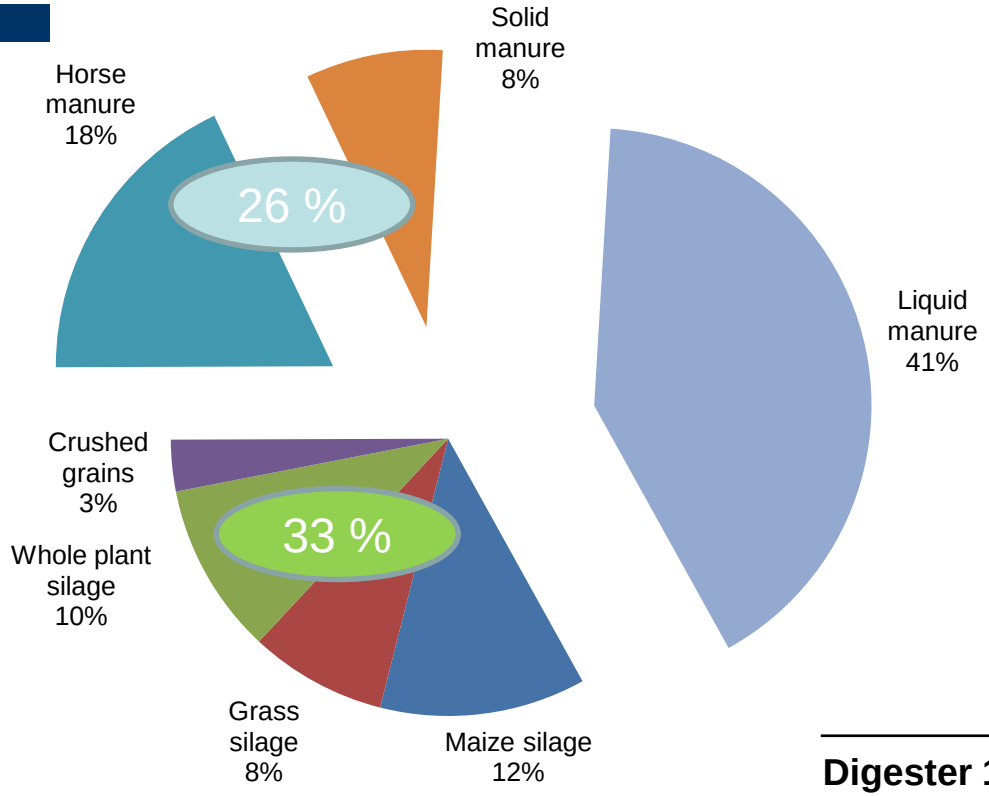
- Period of investigation: 160 days
- Use of Cross Flow Grinder MeWa Bio-QZ 900 at digester 1
- Identical mass and ratio of feed in both digesters
- Analyse of biological parameters
- Continuously investigation of gasvolume and gas composition
- Calculation of degradation efficiency
  - Methane yield of digestate with HBT
  - Calculation of methane yield by using of substrate input

Usability of horse manure in practical scale

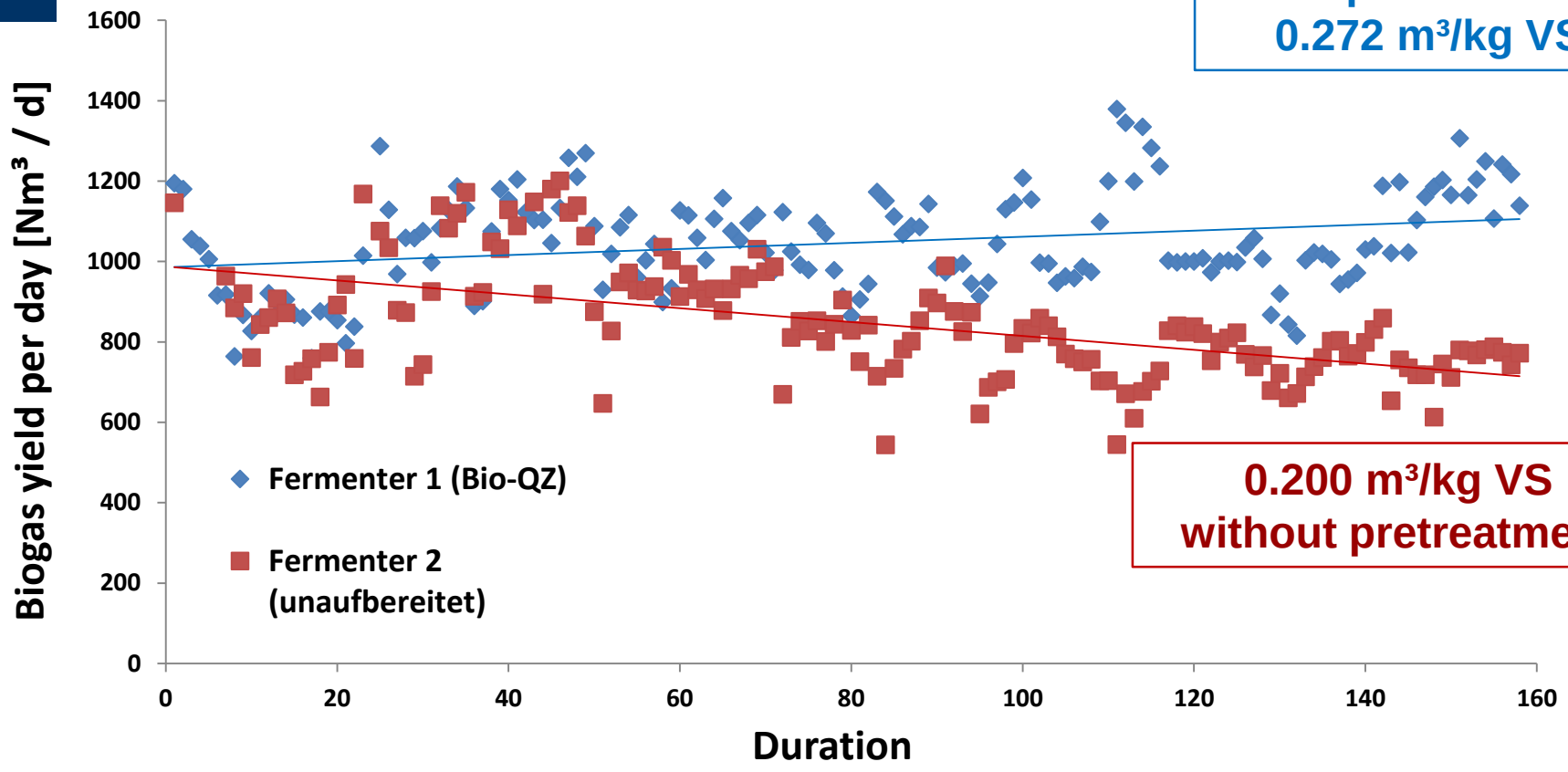
Ration of feed



	Feed amount [t/d]	HRT [d]	OLR [kg/m³ d]
Digester 1 pretreated	**10.5 ± 2.0**	**78.8 ± 14.1**	**2.9 ± 0.5**
Digester 2 control	**10.4 ± 2.3**	**79.5 ± 15.6**	**2.8 ± 0.6**

Horse manure in practical plant

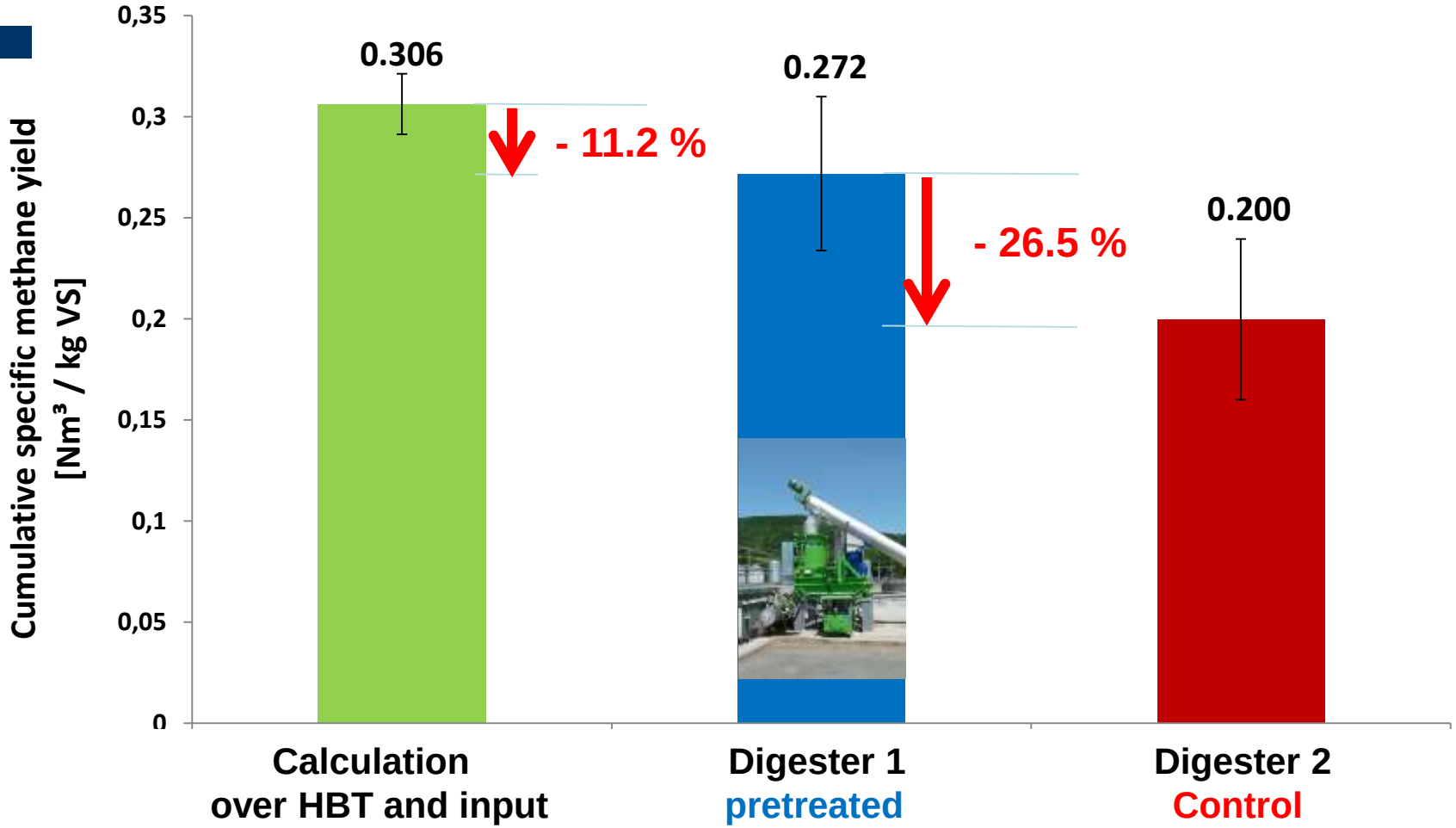
With and without mechanical pretreatment



Mönch-Tegeder, 2013

Use of horse manure in practical scale

Degradation efficiency



standardized: 1013 hPa, 273,15 K

Usability of horse manure in practical scale

Costs of pretreatment

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186 kW		30 % liquid manure; 30 % horse manure; 40 % maize silage	30 % liquid manure; 50 % horse manure; 20 % maize silage
Total input	**t / d**	**16.5**	**17.9**
Solid Input	**t / d**	**11.5**	**12.5**
Input horse manure	**t / a**	**1,825**	**3,285**
Amortisation	**€ / a**	**15,720**	**15,720**
Maintenance costs	**€ / a**	**2,000**	**2,000**
Electricity costs	**€ / a**	**9,235**	**10,038**
Pretreatment costs of horse manure	**€ / t**	**14.8**	**8.4**
Cost saving because of maize substitution	**€ / a**	**24,150**	**67,150**

Definition: investment 104,800 €; interest rate 5 %; machine life 8 a; electricity consumption 11 kWh / t FM; electricity costs 20 ct / kWh ; price of maize silage 40 € / t

Usability of horse manure in practical scale
Cognition

- **Process biology**
  - Stable operation (low concentration of VFA)
  - Increase of DM-content in digester (+3 %)
- **Substrate efficiency**
  - Quality of horse manure is essential
  - Nearly complete utilisation of energy content with pretreatment **(89 %)**
  - Insufficient degradation without pretreatment **(65 %)** (In reference to HBT-yields)
- **Process engineering**
  - Neither problems in digester 1 detected (with pretreatment)
  - Floating layer in digester 2 (without pretreatment)
  - Reduced demand of process heating (4.750 kWh_{th} / month)
  - Energy consumption of Bio-QZ: **11,3 ± 1,3 kWh_{el} / t FM,** to allow the use of a substrate, which yields > 300 kWh/t FM electric energy

Conclusions

- **Digestibility of horse manure**
  - Horse manure with straw as litter can be well used as cosubstrate in biogas plants
  - Quality of horse manure (composition and age) have a big influence on biogas yield
- **Mechanical pretreatment**
  - For the use of **green plant silages**, pretreatment has no positive effect on digestibility and gas yield
  - For the use of **fibrous substrates**, pretreatment has a crucial effect on gas yield and degradation kinetics
- **Usability of horse manure in practical biogas plants**
  - Use of horse manure is only feasible with pretreatment
  - Substitution of 7.8 Mio t maize could be possible in Germany, if 50 % of available horse manure is digested
  - 156,000 ha is equivalent to 13 % of momentan used crop area for biogas production
  - Extension of substrate spectrum possible

Thank you for Your attention!

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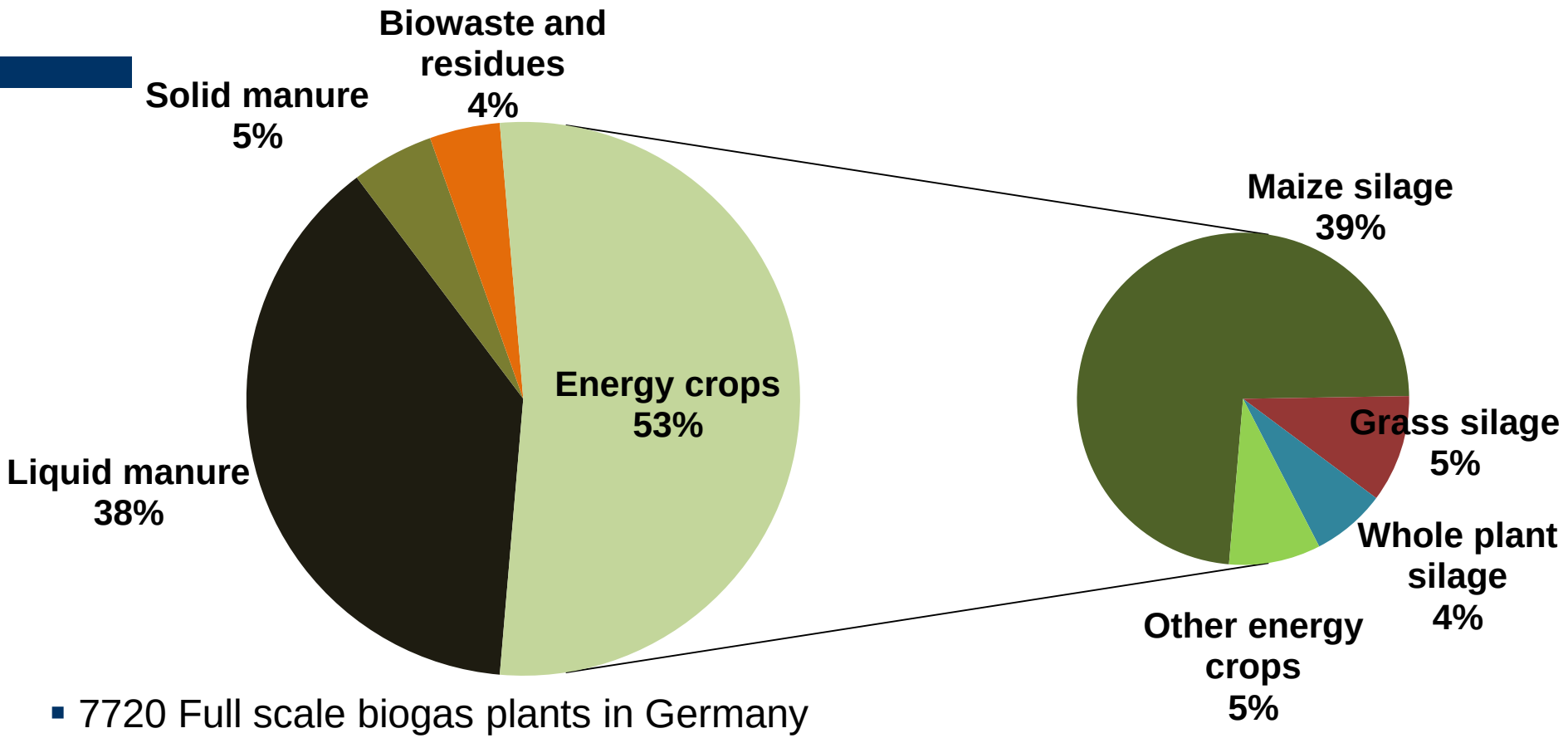
Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Use of substrates in Biogas plants



- 7720 Full scale biogas plants in Germany
- Substrate use about 115 Mio. t FM per year
- 10 % of arable land

Daniel-Gromke et. al, 2013; Fachverband Biogas e.V., 2013; Gömann, 2013