An overview on biogas feedstock and characteristics

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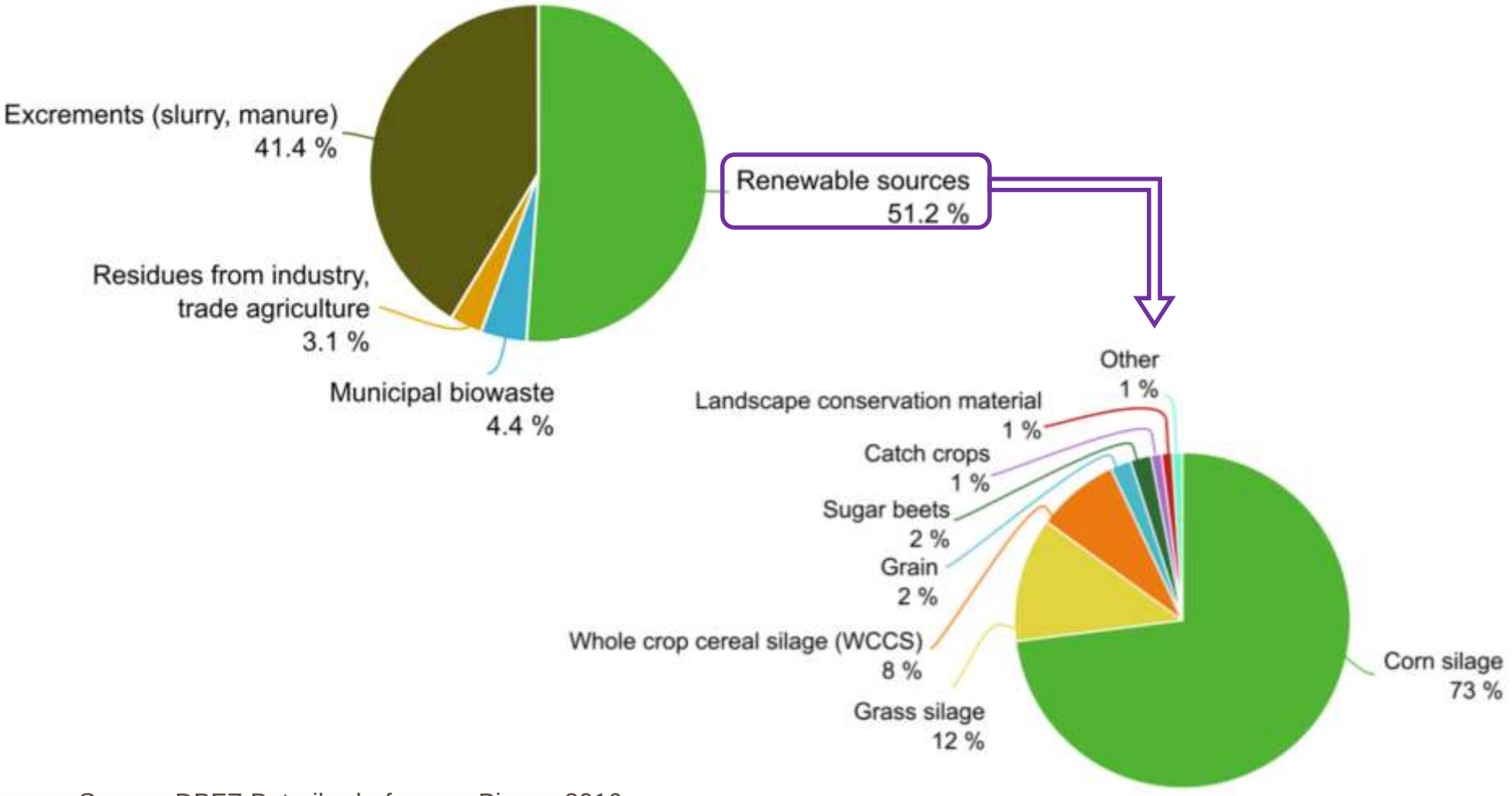
Content:

- Feedstock quality and quantity
- Different gas yields from substrates
- Dealing with difficult to digest substrates
- Need for testing

Feedstock for biogas production in Germany

9 009 biogas plants with a total installed electric capacity of 4 166 MWel



Source: DBFZ Betreiberbefragung Biogas 2016

How to know, if there is enough feedstock?

Agriculture

- Manure (cattle, pig, poultry)
- Energy crops
- Algal biomass
- Harvest remains

Communities

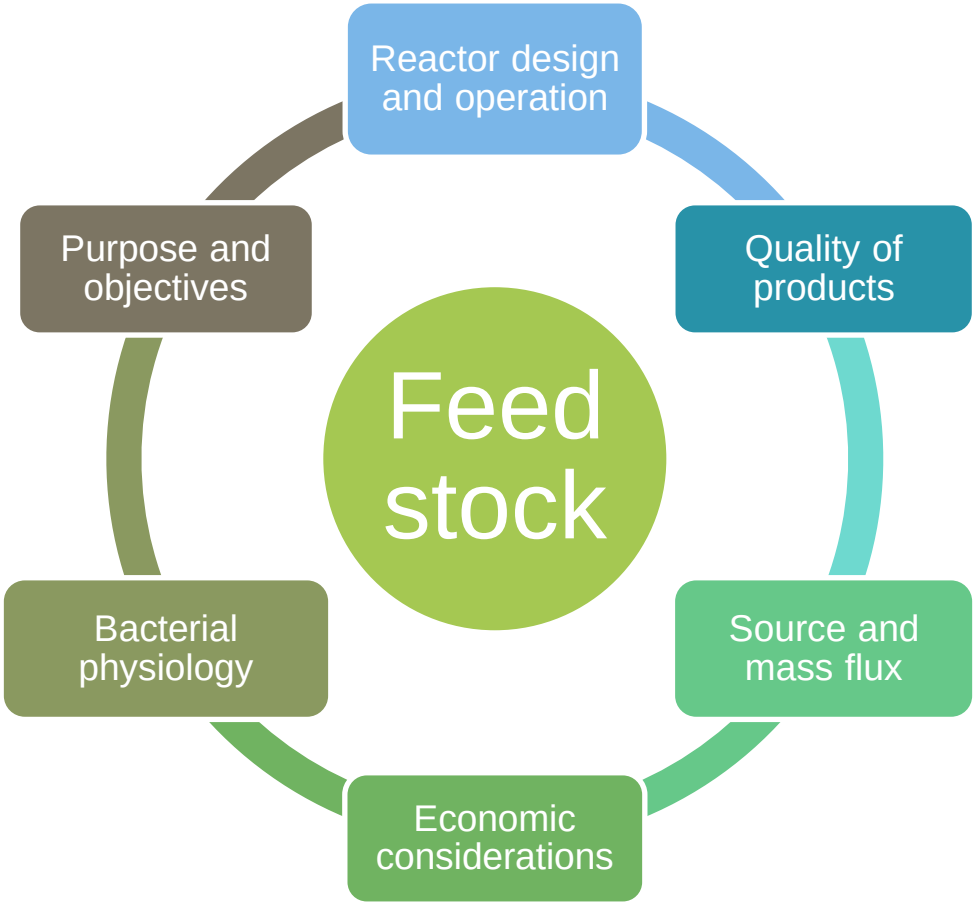
- OFMSW
- MSW
- Sewage sludge
- Grass clippings/garden waste
- Food remains
- Etc..

Industry

- Food/beverage processing
- Dairy
- Starch industry
- Sugar industry
- Pharmaceutical industry
- Cosmetic industry
- Biochemical industry
- Pulp and paper
- Slaughterhouse/ rendering plant
- Etc..

Feedstocks for Anaerobic Digestion: Steffen, R. et al., University of Agricultural Sciences Vienna, 1998-09-30

Feedstock and its involvement in various aspects of anaerobic digestion



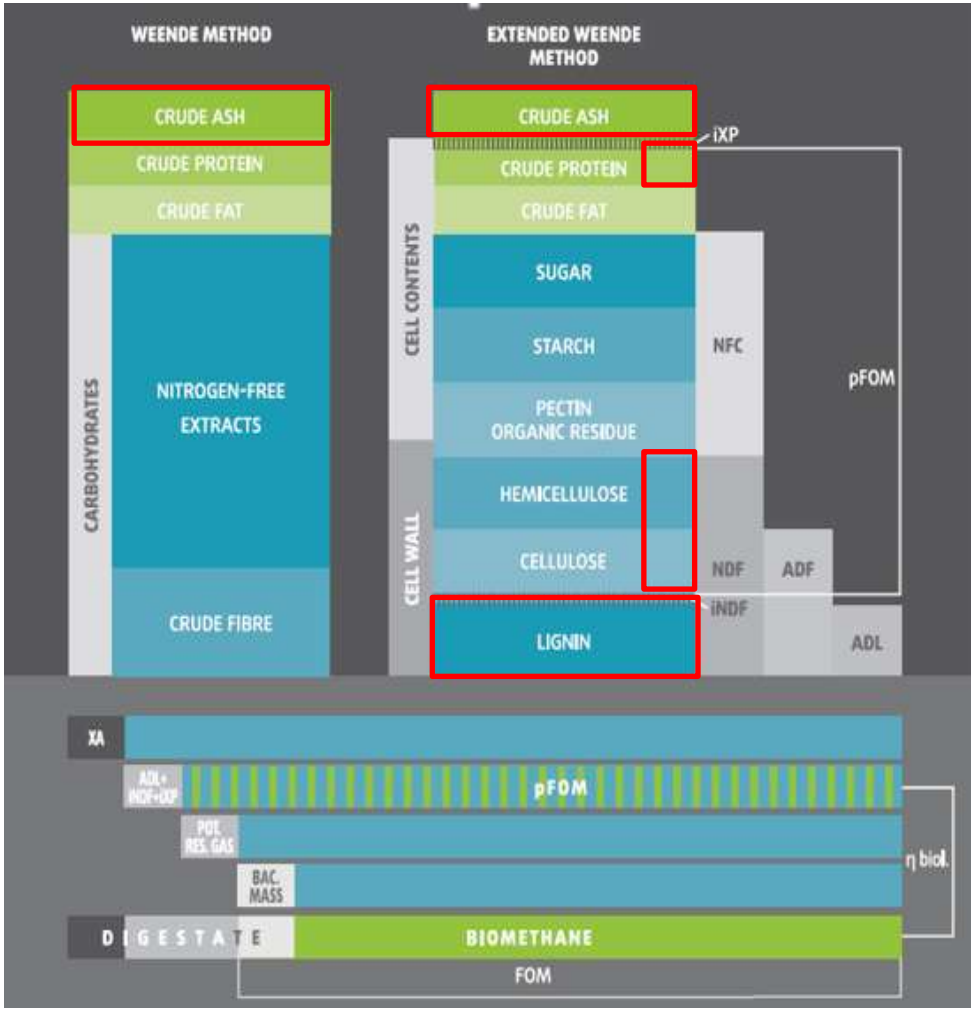
Feedstocks for Anaerobic Digestion: Steffen, R. et al., University of Agricultural Sciences Vienna, 1998-09-30

Simple feedstock assessment

- Communal residues available in the near vicinity
- Residues from food processing and agro-industries available in the near vicinity

Substrates	Amount [t/a]	Total solids	Total volatile solids	Gate Fee […./t]	Substrates

What kind of analysis?



Non fermentable matter

pFOM potentially fermentable organic matter

Own consumption of the bacteria

Potential residue gas

FOM
fermented organic matter

Source: BTS-group

Requested parameters for lab based biomethane potential calculation

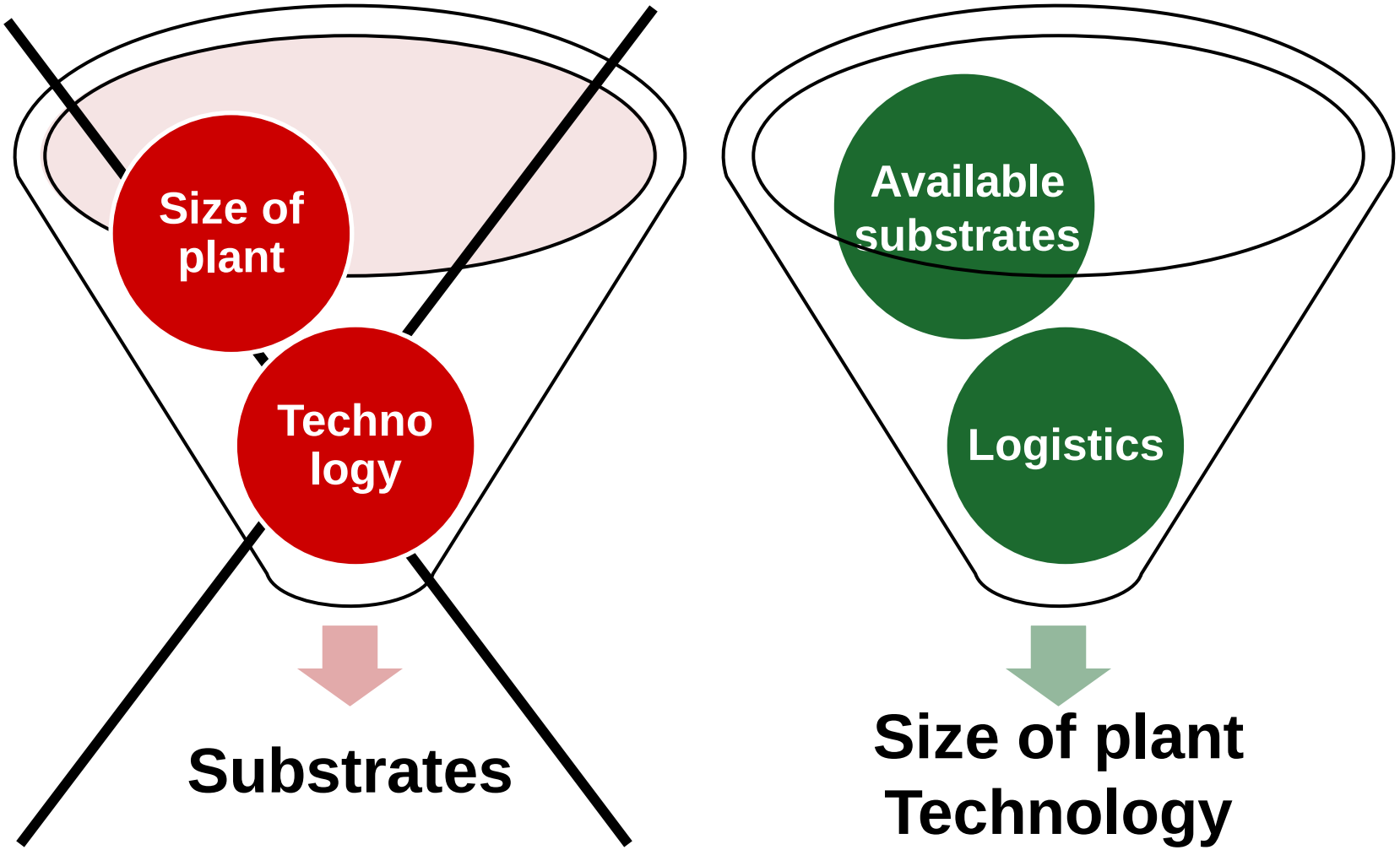
- %DM
- %oDM
- oDM/DM
- %TSS, %VSS
- TCOD g/L
- BOD/oDM
- pH
- Carbohydrates mg/L (glucose)
- TP, TN mg/L
- VFA, mg/L

Fermentation test

Batch-tests in different magnitudes

Continuous experiment

Substrates


Size of plant
Techno logy
Substrates
Available substrates
Logistics
Size of plant
Technology

Storage characteristics

Agricultural substrates – silage

- Dry matter
- Buffer capacity
- “Clean” harvesting
- Compression

Source: Herfter/Biogas Service

Organic Waste

- No long-term storage
- Continuous delivery
- Flexibility in input materials
- Liquid material - tanks

Source: Fitec

Food waste

- Food processing waste from food industry provides relatively high biogas yields
- Separated from municipal solid waste stream and therefore with low levels of contaminants;
- Organic fraction of the municipal solid waste stream,
- In large parts so-called post-consumer food waste (cooked, mixed, rotten …)

Contraries

In food waste (depending on origin)

- Dry substance matter (DM): 20-30%
- Contaminations up to 25% of DM
- Bones, seashells
- Packages, plastic bags
- Cutlery, dishes
- Stones, glass, etc.

Restaurant waste

Source: Fitec

Contraries

Mixed organic grocery store waste:

- Dry (DM): 20-35%
- Contaminations up to 35% of DM
  - Plastic
  - Card board
  - Egg- and seashells
  - Glass, tins, etc.

Expired food from supermarket

Source: Fitec

Contraries

Source separated organics (green bin, households):

Dry matter (DM): 35-42%

Impurities up to 35% of DM

- Wood
- Plastic
- Metals
- Sand, etc.

Household biowaste

Source: Fitec

Characteristics of raw POME

- Dark-brownish
- Low pH
- High COD&BOD
- High SS
- High O&G
- High Temperature

Pulp and paper mill effluent – Black Liquor

- In 2011 Indonesia was on rank 10 of the world's biggest producers of paper
- Producing more than 10 million tons of paper
- High water usage results in large amounts of wastewater generation
- Approximately 95 % of the total pollution load is drained as so called *black liquor*
- A dark brownish effluent of various inorganic components and organic polymeric substances
- Has a high biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solids and organic carbon

Livestock manures

- Well-known feedstock
- Potentially available in significant quantities
- Good for co-digestion with other feedstock such as food waste
- Economically feasible only if biogas digester is located at the place of manure production:

  → transportation of manure is costly

  → manure has relatively low-biogas yields.

Gas yield from liquid manure depending on the dry matter content

Dry matter content	Pigs	Dairy cattle	Beef steer
4 %	15 m^3 (60 %)	-	-
6 %	23 m^3	20 m^3 (55 %)	-
8 %	30 m^3	26 m^3	30 m^3
10 %	-	33 m^3	37 m^3

Source: Biogas Journal 1/09

Crop residues and silages (energy crops)

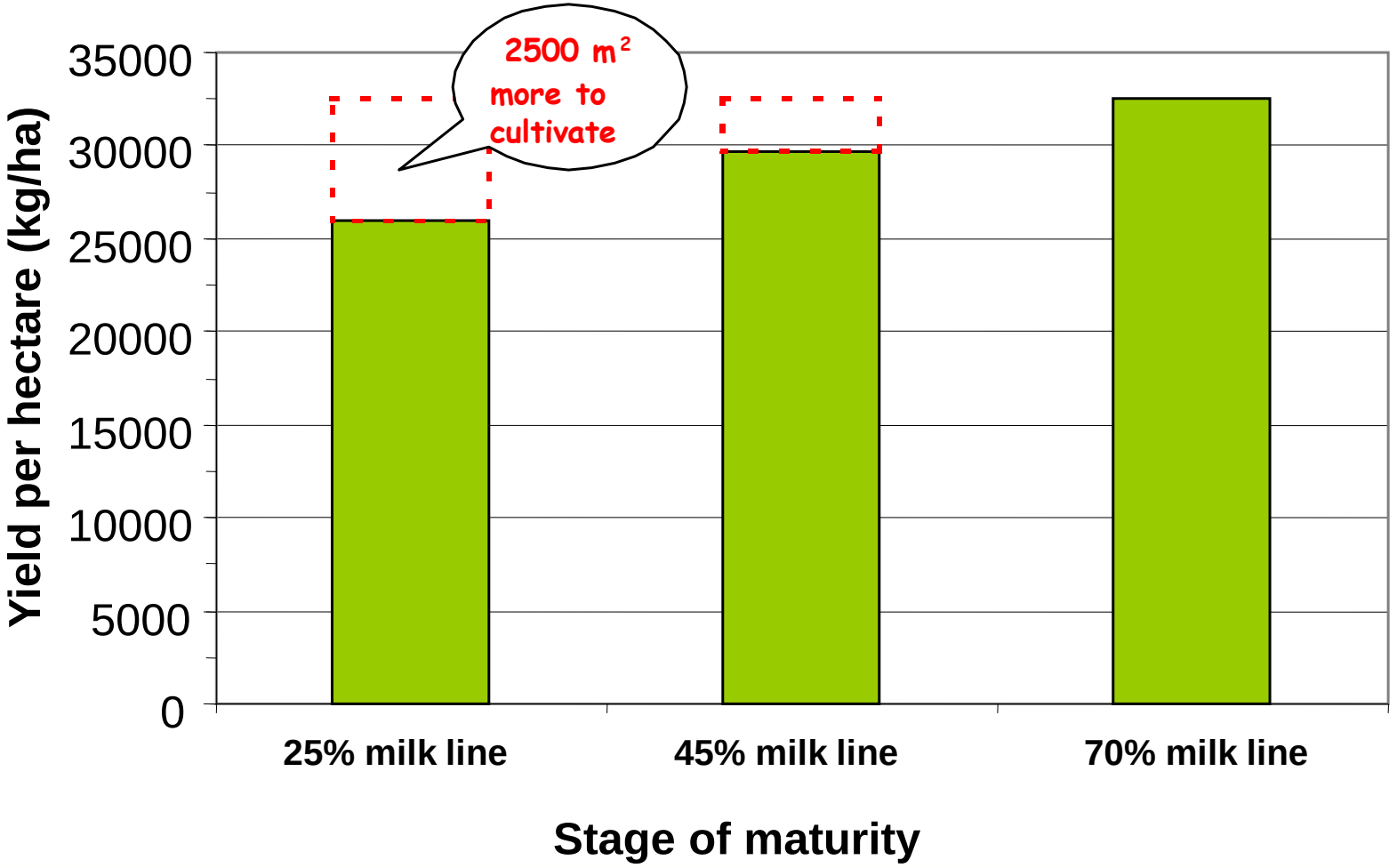
Crops or crop residues as co-feedstock:

- ✓ support to maintain an optimal pH for methane producing bacteria
- ✓ decrease free ammonia/ammonium inhibition, which may occur in AD of manure-only fed biogas digesters
- ✓ provide a better C/N in the feedstock

Milk line in different harvesting times

Source: BTS-group

Period of the harvest and the potential productivity



Source: BTS-group

Chopping - Important facts

- The surface is more important than the chop length
- The bigger the surface for the micro-organisms the better
- Mechanical disintegration of the crops through a corn cracker
- Length about 5 – 9 mm + crop disintegration

Source: CLAAS KGaA mbH, 2007

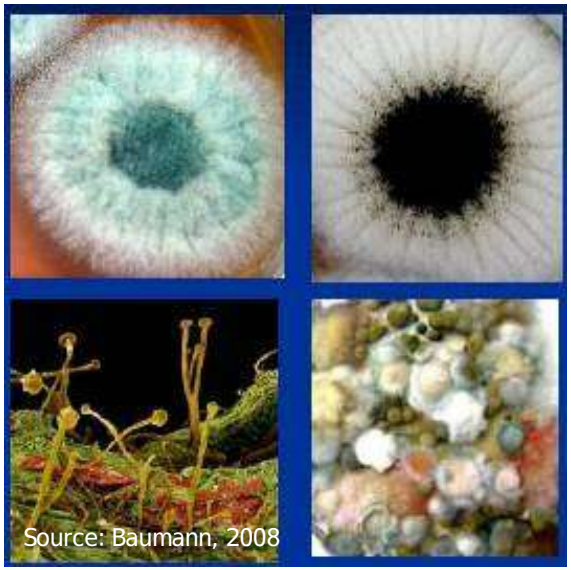
Ensiling of substrates and energy crops

Silage aims

- Economic conservation of the biomass
- Consistent substrate in time
- Preparation of the biomass for the digestion process
- Increase of the substrate digestibility

Silage problems (1/2)

1. Mold (due to air presence)



- Funghis and aerobes metabolize 30 - 80% of organic substance.
- They produce potent poisons, antibiotics, endotoxins and mycotoxins.
- They produce respirable pathogens, like spores and aspergillum.

2. Material too dry

3. Open area too big

Silage problems (2/2)

4. Not enough compaction

5. Uncovered silo

Silage logistics greatly affect digester's operating efficiency!

Conserving chicken manure and reducing the losses

- To avoid odours!
- To increase gas yield!

Source: BTS-group

Straw

- Lignocellulose-containing biomasses
- Not fermentable without special pretreatment:
  - ✓ **Thermal**
  - ✓ **Chemical**
  - ✓ **Mechanical**
- Energy efficient fermentation particularly of straw and leaves could make a substantial contribution to power supply

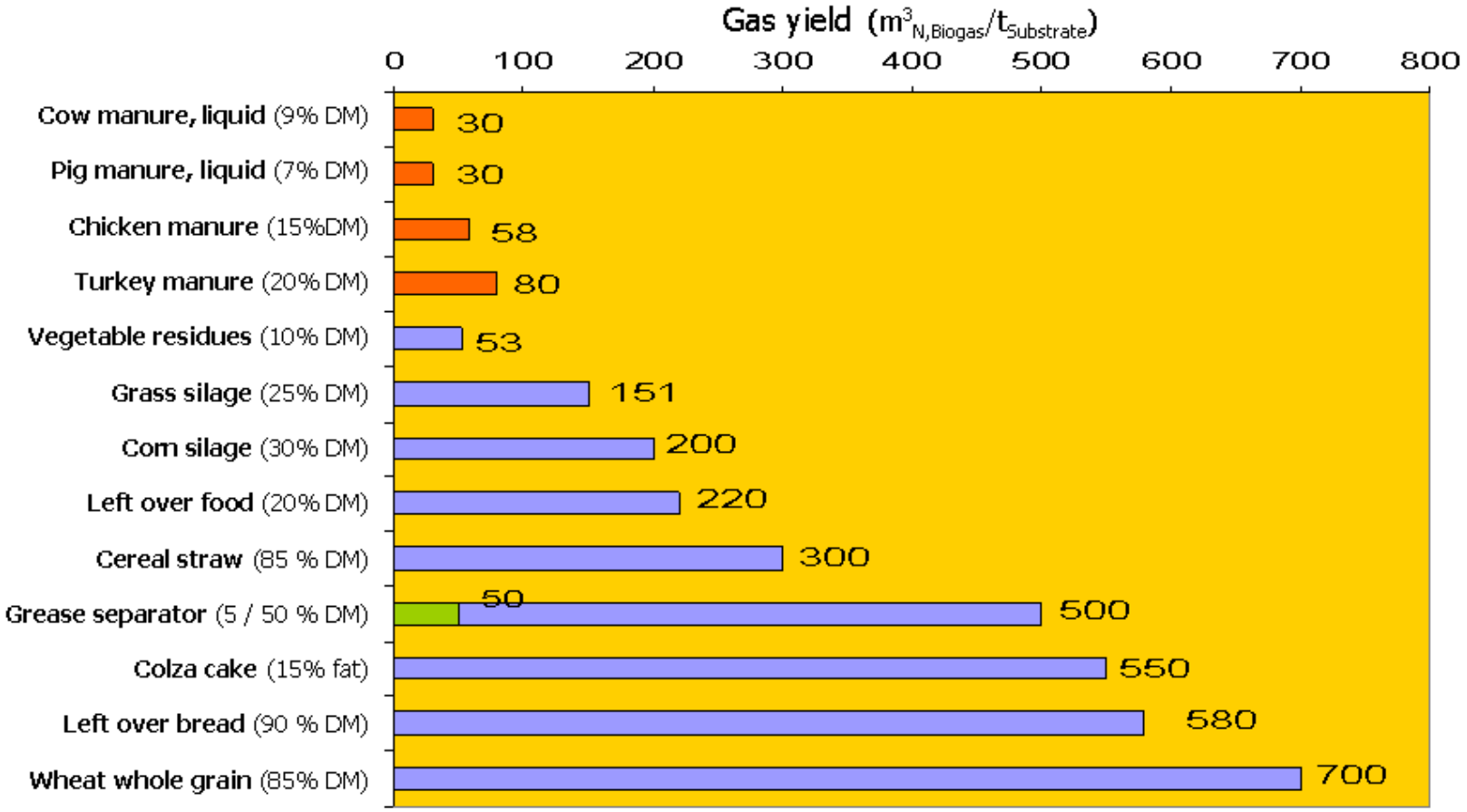
Fecal sludge

- …. blackwater, content of septic tanks and holding tanks
- **EXAMPLE**:
  India: available human excreta compared to fertilizer need

Feces	250,000 tons/day
Urine	1,000,000 m^3/day

Dry org. matter (DS)	90 000 t/day
Nitrogen (N)	15 000 t/day
Phosphorus (P_2O_5)	5 000 t/day
Potassium (K_2O)	3 000 t/day
Carbon (C)	35 000 t/day
Calcium (CaO)	5 000 t/day
Potential biogas	**50 mil m^3 day**

Gas yield from different substrates



Source: LFL 2004

Specific yield of biogas

Substrat	TS		oTS		Biogas			
	%		%		m^3 CH_4/kg TS		m^3 CH_4/kg/oTS	
	between	to	between	to	between	to	between	to
Raw glycerine (RME man.)	>98		90	93	0,62	0,67	0,69	0,72
Potato tops	25		79		0,40	0,47	0,50	0,60
Beet (turnip) tops	15	18	78	80	0,19	0,40	0,24	0,50
Diverse cereals	85	90	85	89	0,26	0,53	0,30	0,60
Clover	20		80		0,32	0,40	0,40	0,50
Apple slop	2	15	90	95	0,30		0,33	
Apple pomace	25		86					
Spent grains from beer	20	22	87	90	0,22	0,63	0,25	0,70
Spent hops (dried)	97	97,5	90		0,45	0,50	0,50	0,55
Filtration silica gel (beer)	30		6,3		0,02	0,02	0,30	0,35
Vegetable waste	5	25	76	90	0,18		0,24	0,40
Old bread	90		96	98	0,67	0,74	0,70	0,75
Coco bean shells	95		91					
Potato slop	12	15	90		0,22	0,50	0,24	0,55
Cereal slop	6	15	87	90	0,52		0,60	
Foliage			82		0,33		0,40	
Melasse	80		95		0,29		0,30	
Whey	4	95	80	92			0,48	0,60
Fruit pomace	45		93		0,25	0,48	0,27	0,52
Oil seed residue (pressed)	92		97		0,56	0,60	0,58	0,62

Thank you for your attention!

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