CONBIOT int. Conference

„Combustion & Gasification of Biomass and Wastes“

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Organic residues for cofiring in a coal fired CHP-plant

A case study on markets and energetical potentials in Baden-Württemberg, Germany

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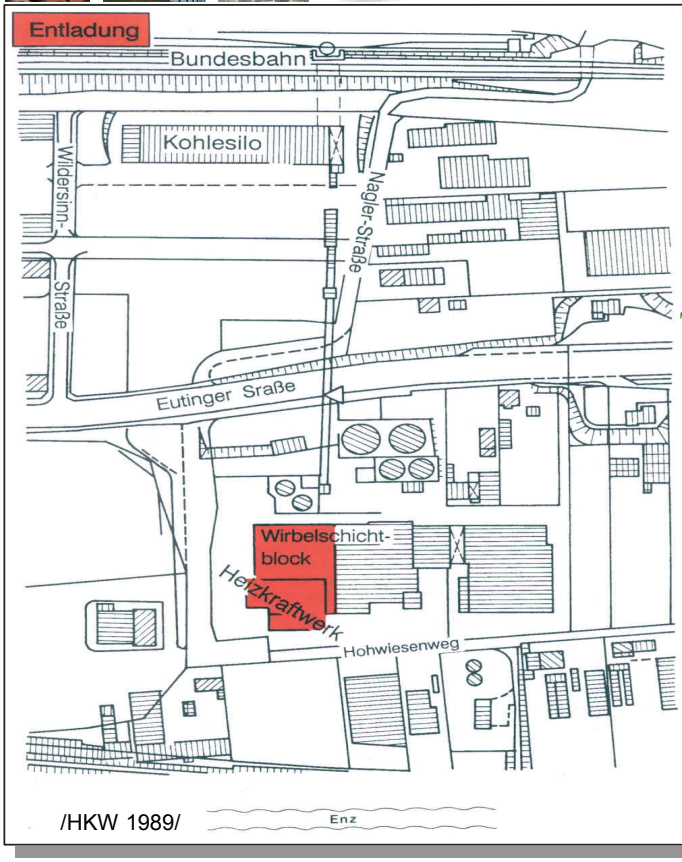
Presentation overview

- Subject of the study, frame conditions
- State of the art: former study results
- Data acquisition
- Energy use situation in Baden-Württemberg
- Results
- Critical discussion
- Conclusions and future prospects

The subject of study: CHP-plant Pforzheim

- General characterisation of the CHP-plant
  - Fuel: hard coal
  - Fuel demand: about 80 000 t/a
  - Firing technology: CAFBC - circulating atmospheric fluidized bed combustion block

- Recommendations from the CHP-plant operators
  - Substitution of up to 20.000 t hard coal/a (25%) by biomass residues
  - Price neutrality compared to hard coal (6,5 €/MWh lhv fuel costs)
  - Fuel handling requirements:
    - on-site transport and storage
    - fuel feeding



/HKW 1989/

Technical and logistical details of the CHP-plant Pforzheim

Technical details:

- Firing technology: CAFBC
- Firing therm. capacity: 78,7 MW_{th}
- Fresh steam: 90 t/h
  - Pressure: 143 bar
  - Temperature: 540°C
- Max. gross el. output (cond.):
  - 29,67 MW_{el} / 4,5 MW_{th}
- Max. th. output (heat exchanger):
  - 26,03 MW_{el} / 41,84 MW_{th}
- el. subsistence: 2,4 MW_{el}

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State of the art: Available assessments of biomass potentials in Baden-Württemberg

- Studies on RE's in the regions of Baden-Württemberg
- Studies specificly on energy wood
  - Diploma thesis „Meinhardt" / „Holzenergiefibel"
  - Study „Locations of the wood industry"
  - Study „raw wood potentials for energy use"
- „Standard" biomasses usually covered by studies on potentials
  - Energy wood
  - Residues from animal production (manure/liquid manure)
  - Straw
  - Wood from landscape conservation
  - Specificly cultivated energy plants
- Miscellaneous biomasses only scarcely covered
  - Grape cakes and fruit pomace

Investigated industries in BW

- Breweries and Malthouses
- Viniculture
- Fruit- and vegetable juice producing industry / Pektin manufacturers
- Sugar industry
- Food processing industry / Convenience food producers
- Oil mills

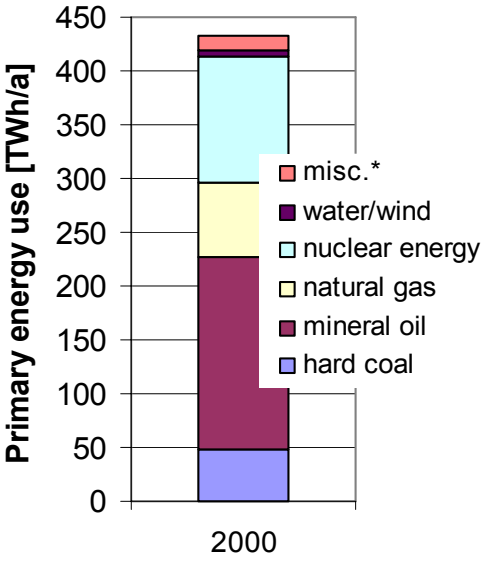
- Flour mills
- Agriculture and forestry
- Wood-working and wood processing industry
- Used wood industry
- carcass disposal plants

Results of investigations: recorded annual amounts of biomass residues in Baden-Württemberg

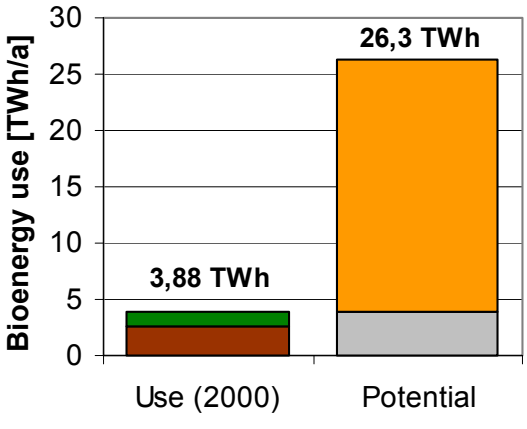
draff	**28 592 t/a FM**
sugar beet chips	**41 126 t/a FM**
cacao peelings	**7 200 t/a FM**
animal manure	**1 747 154 LU**
meat and bone meal	**43 200 t/a FM**
animal fat	**18 000 t/a FM**
malt rootlet	**4 560 t/a FM**
grain residues	**2 800 t/a FM**
soy bean seed-cake	**410 000 t/a FM**
sunflower seed-cake	**104 000 t/a FM**
rape seed-cake	**174 000 t/a FM**
apple pomace	**109 000 t/a FM**
grape cake	**86 707 t/a FM**
energy wood	**1 957 000 t/a DM**
bio waste	**421 500 t/a FM**
sewage sludge	**330 000 t/a FM**

FM = fresh matter
DM = dry matter
LU = livestock unit

The energy situation in Baden-Württemberg today



*wood, wastes, sewage and town gas, lignite, net electricity imports



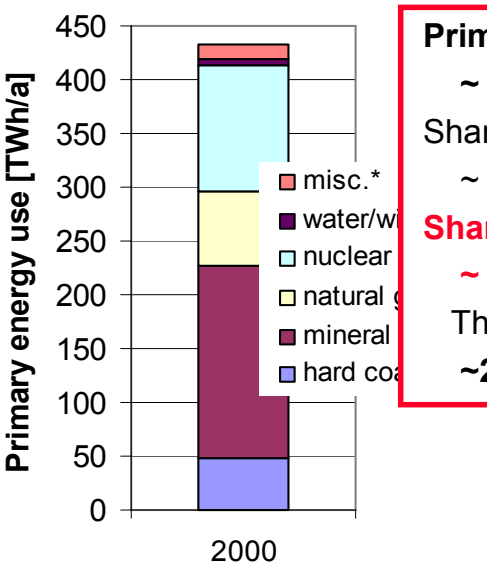
wood
currently used
sewage- & biogas
free potential

Energetical use of straw not included

u.a. /Energiebericht BW 2001/

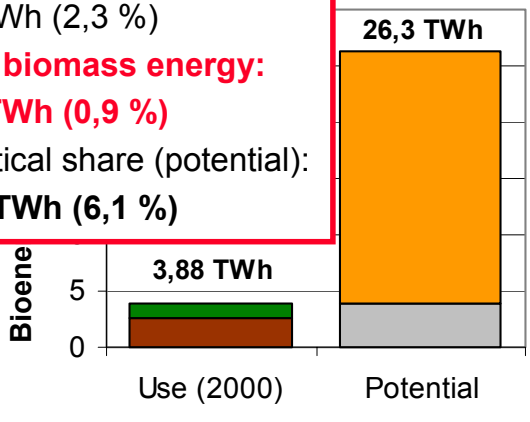
NET 2003
Universität Stuttgart
Institut für Energiewirtschaft und Rationelle Energieanwendung
IER

The energy situation in Baden-Württemberg today



Primary energy use:
~ 433 TWh (2000)
Share of RE:
~ 10 TWh (2,3 %)
Share of biomass energy:
~ 3,9 TWh (0,9 %)
Theoretical share (potential):
~26,3 TWh (6,1 %)

*wood, wastes, sewage and town gas, lignite, net electricity imports



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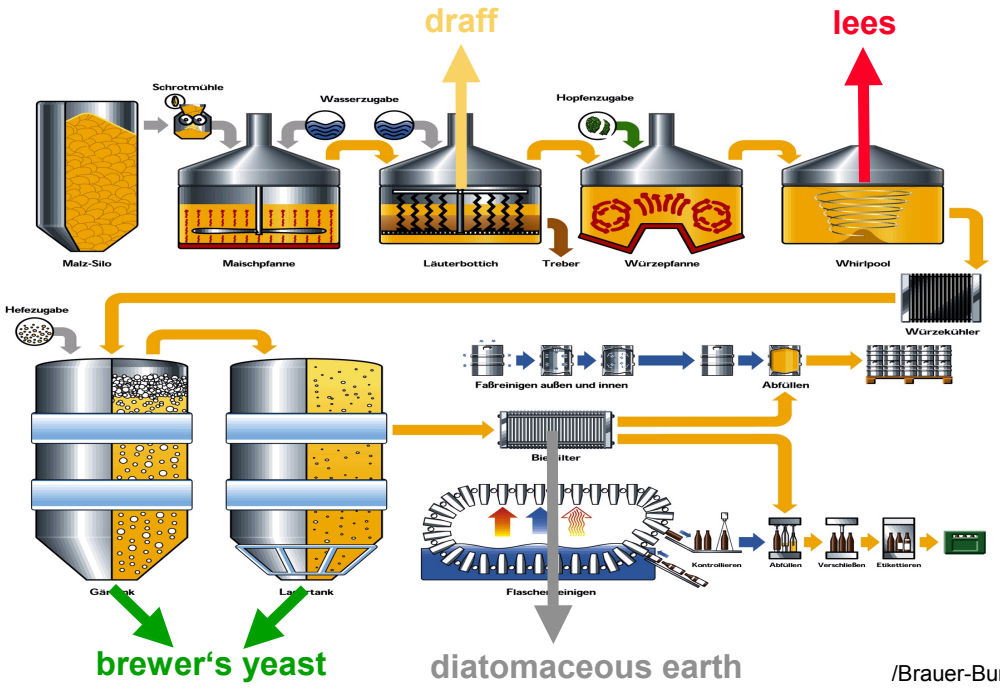
Data: Process chain analysis and emerging residues

- Example: beer production -



/Brauer-Bund 2002/

Example: Residues from beer production

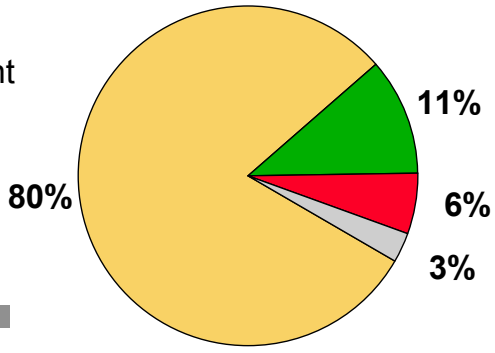
draff

18,7 kg FM/hl beer

20-25 % DM content

feeds: ~21 €/t FM

Share of fresh matter (FM):



brewer's yeast

2,6 kg FM/hl beer

10-15 % DM content

High protein content!

diatomaceous earth

0,62 kg FM/hl beer

30 % DM content

50 % mineral compounds in DM

Totals:

23,3 kg FM/hl = 4,3-5,5 kg DM/hl

draff: 3,7-4,7 kg DM/hl

lees

1,4 kg FM/hl beer

10-15 % DM content

High protein content

FM = fresh matter DM = dry matter

Draff: Element analysis of raw material and ashes

• Nitrogen	3,2 Mass.-% TS
• Sulfur	0,31 Mass.-% TS
• Oxigen	37,48 Mass.-% TS
• Carbon	49,18 Mass.-% TS
• Hydrogen	6,86 Mass.-% TS
• Chlorine	0,21 Mass.-% TS
• Ashes (A)	3,0 Mass.-% TS
– Calcium oxide	11,9 Mass.-% (A)
– Magnesium oxide	11,5 Mass.-% (A)
– K_2O	3,0 Mass.-% (A)
– Na_2O	0,5 Mass.-% (A)
– Silicium dioxide	25,3 Mass.-% (A)
– P_2O_5	40,5 Mass.-% (A)

/Scharf 1993/

Draff: fuel properties and emissions

- Energy content (lhv) 18,64 MJ/kg DM

- Emissions (/Keller-Reinspach 1989/, at 11 Vol.% O_2)
  - NO_X (as NO_2) 2500 mg/Nm³
  - SO_2 500 mg/Nm³

- Emissions (/Reisinger et al. 1997/, at 12,7 Vol.% O_2)
  - NO_X (as NO_2) 1184 mg/Nm³
  - SO_2 432 mg/Nm³
  - CO 763 mg/Nm³
  - HCL 9,2 mg/Nm³

Draff: Options for energetical use, data

- Direct combustion
  - Energy content = 18,64 MJ/kg DM content
  - Water content 75 - 80 %
  - Dewatering/drying required
  - Energy content after drying:
    16,5 MJ/kg substrate (at 9 % water content)

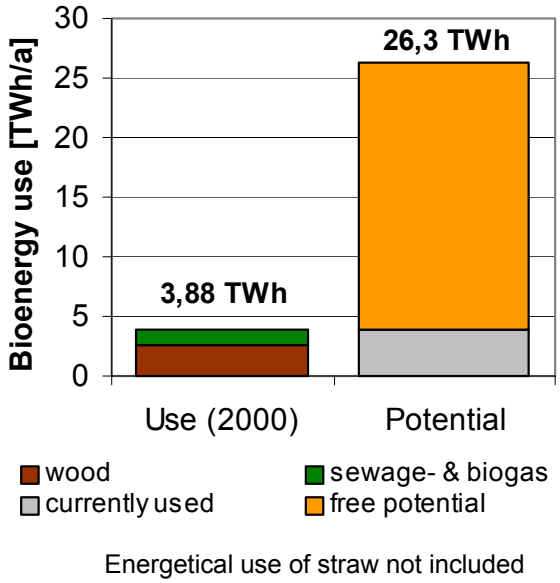
- Biogas production
  - biogas production: 148 m³ /t wet draff
  - Share of methane in biogas: ~ 60 %
  - Residues from fermentation: 25 - 30 %
  - Energy yield: 3,8 GJ/t wet draff

Draff: Energy potentials for Baden-Württemberg and minimum fuel prices

- Direct combustion
  - 142 961 t/a wet draff with 80 % water content (1,7 MJ/kg)
  - 31 392 t/a dried draff with 9 % water content (16,5 MJ/kg)
  - 144 GWh energy potential
  - Energy requirements for additional treatment not taken into account
  - Minimal fuel costs (actual markets for substrate):
    - Wet draff: 48,7 €/MWh lhv
    - Dried draff: 5 €/MWh lhv (costs for drying not taken into account)

- Biogas production
  - 88,8 m³ methane gas per ton substrate (9,94 kWh/m³ methane)
  - 126,2 GWh/a energy potential
  - 1133 kg fresh matter per MWh lhv
  - Minimal fuel costs (actual markets for substrate): 26 €/MWh lhv

Biomass energy use and calculated potential in Baden-Württemberg

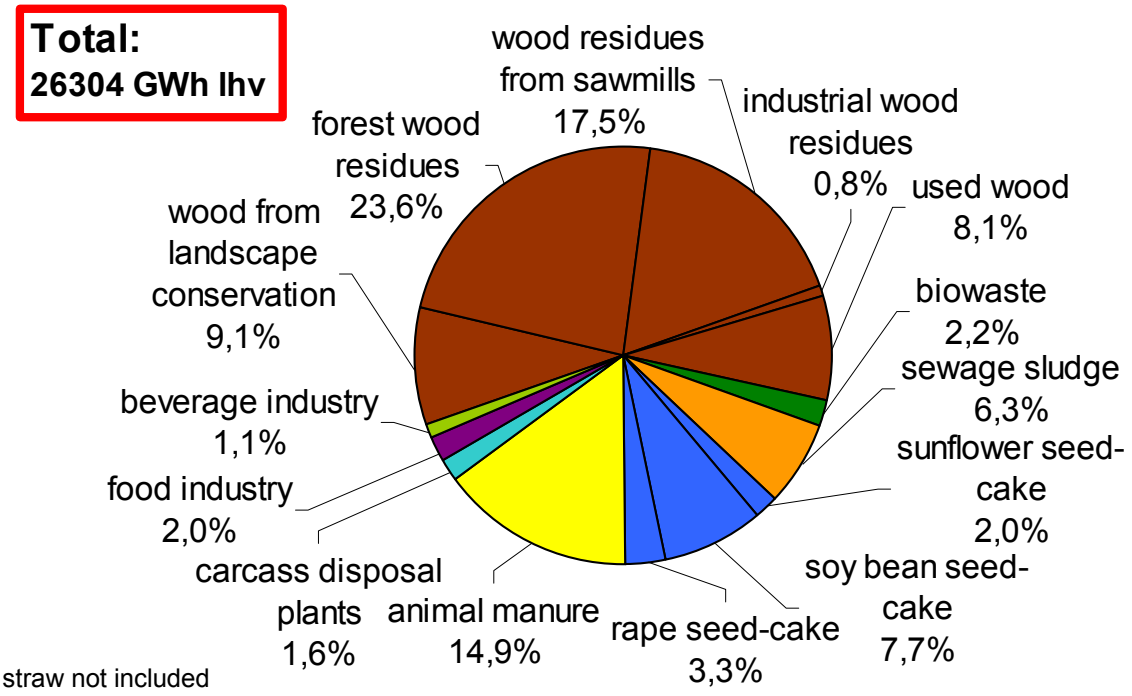


Energetical use of straw not included

/Energiebericht BW 2001/

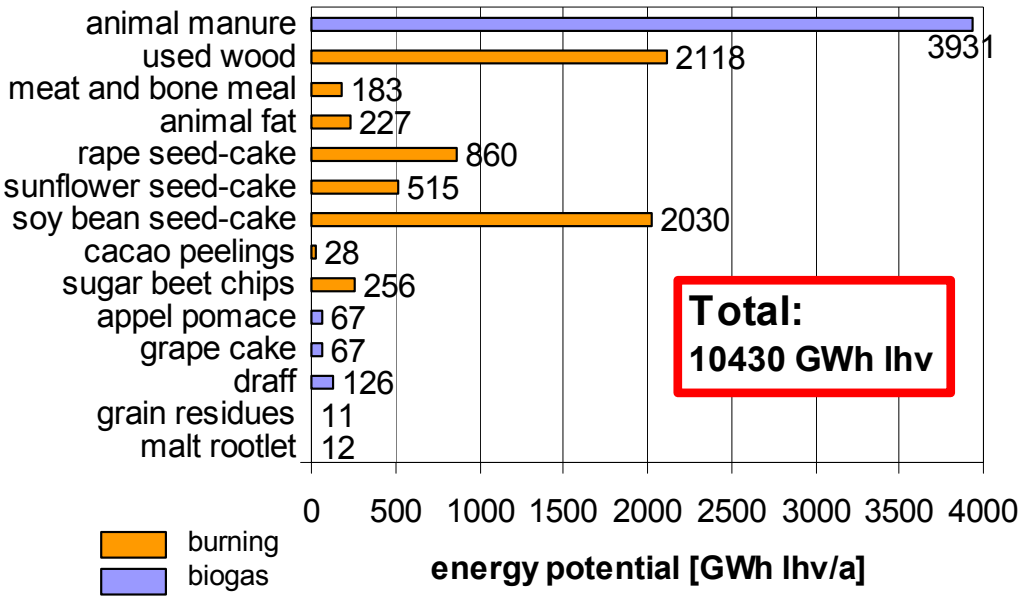
Theoretical biomass energy potentials from residues in Baden-Württemberg (literature/own data)

Total:
26304 GWh Ihv

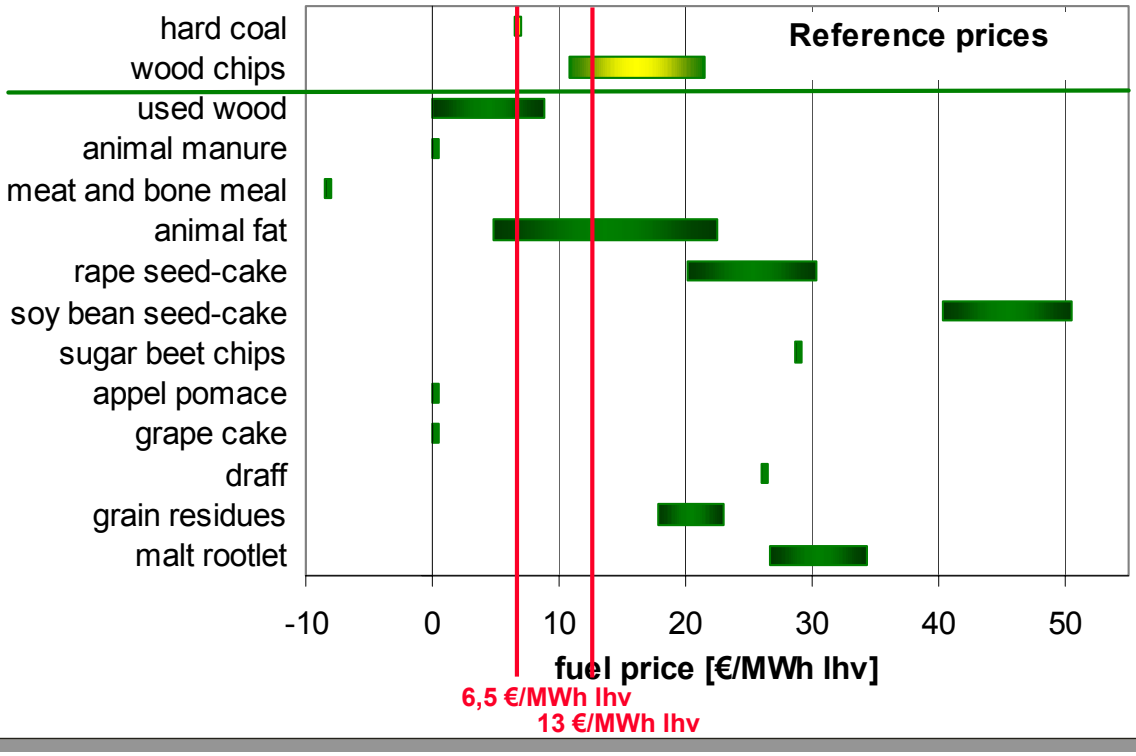


straw not included

Theoretical biomass energy potentials from residues in Baden-Württemberg, assessed in this study



Current market prices of investigated residues



Discussion

- Situation
  - Competition with animal food production
  - Pricing of raw materials for recycling chains
  - Too small amounts of residues
  - Seasonal accumulation
  - Limited suitability for direct combustion
- Consequences for HKW Pforzheim GmbH
  - No co-combustion of biomass residues in Pforzheim
  - Enhanced realisation of a new wood-fired biomass plant instead

➢ Many substrates studied are potentially suitable for agricultural biogas plants instead

Further perspectives in BW

- Wood: district heating / CHP plants:
  - about 140 plants supported by public grants (2002)
  - Baden-Württemberg still supports more installations of wood fired plants financially

  ➢ Still good energy potentials of untreated fuel wood in many regions
- Agricultural biogas plants:
  - ca. 325 (17 %) installations (2002, 1900 in Germany)
  - ca. 17,5 MW_{el} (7 %) installed capacity (2002, 250 MW_{el} in Germany)
  - Cosubtrates usually improve the economic performance of biogas production and use

  ➢ Further extension not at least strongly depends on economic frame conditions (EEG) and attractive markets for heat delivery