ATB

Leibniz-Institut für Agrartechnik und Bioökonomie

Greenhouse gas emissions from broiler manure treatment options

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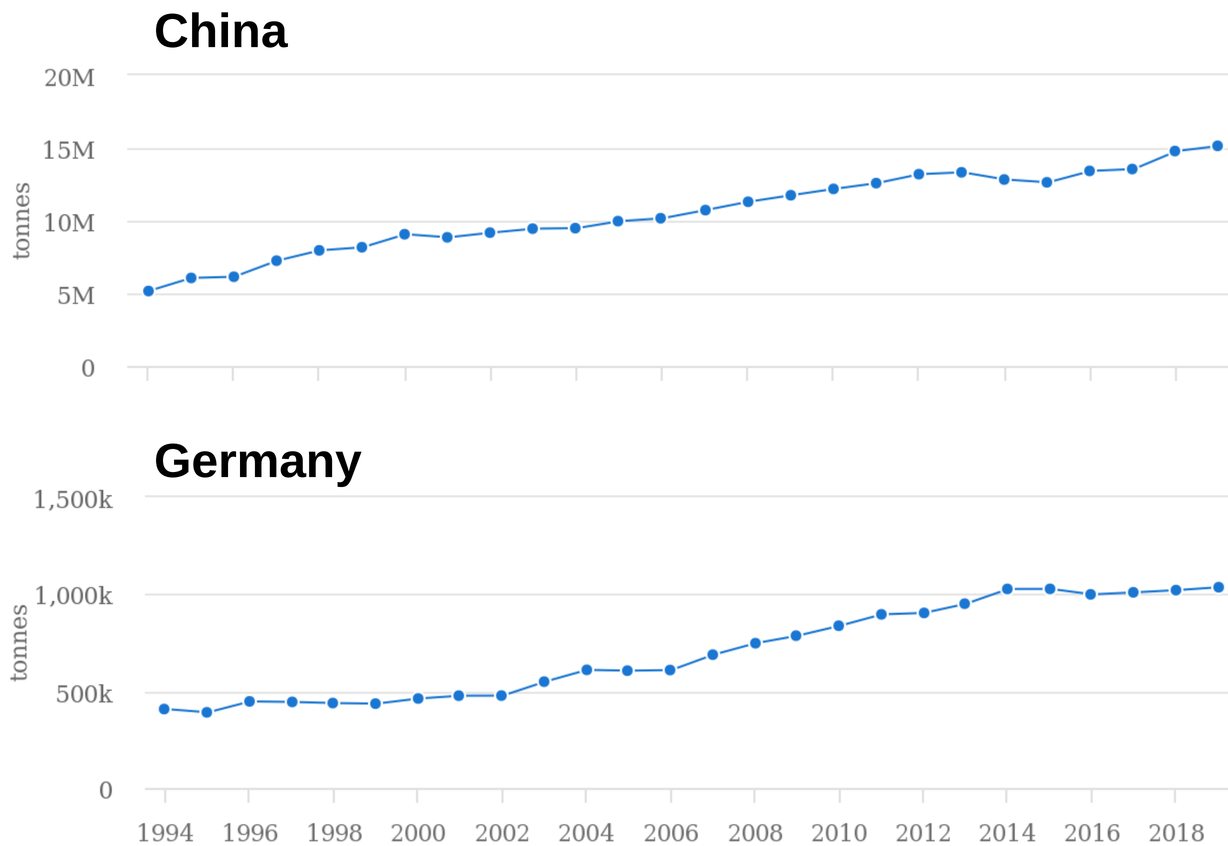
Background

Chicken meat production



Source: FAOSTAT

Poultry is expected to account for ~ 50% of the global growth in meat production over the coming decade

Source: OECD-FAO Agricultural Outlook 2021–2030

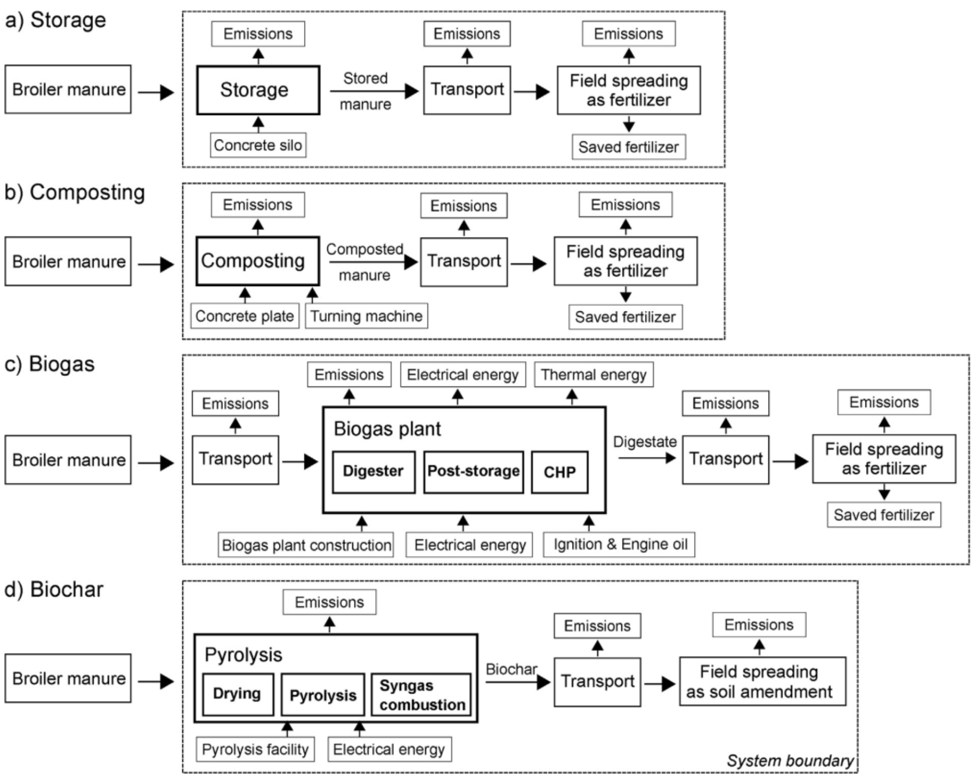
Research question

- How can we reduce greenhouse gas emissions from broiler manure handling?
- Which treatment option leads to lowest emissions?

- Four options assessed:
    a) Storage
    b) Composting
    c) Biogas
    d) Biochar

Overall approach

- Life Cycle Assessment & Modelling
  - Emissions from all major processes
  - and pre-chains (e.g. for machinery construction)
- No new measurements



Storage scenario

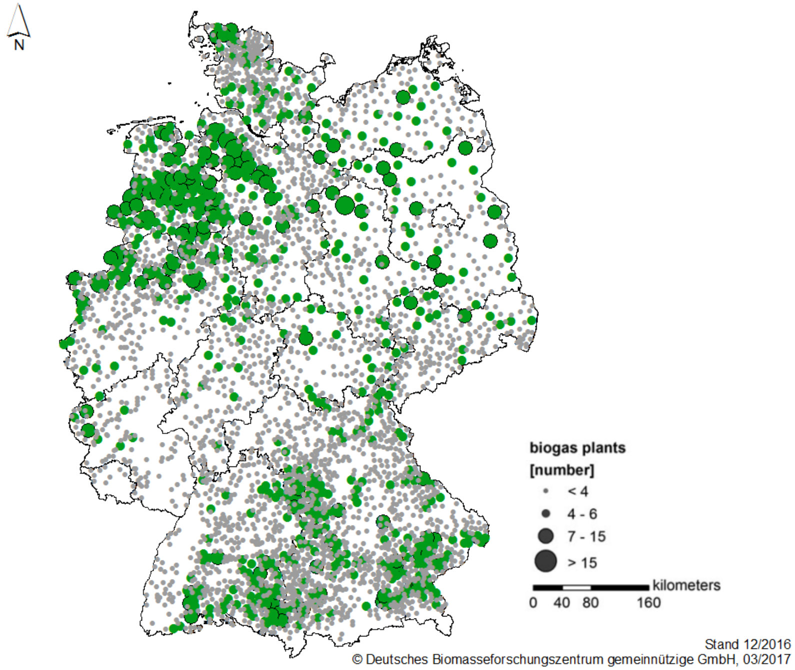
- Storage of manure in a concrete silo after cleaning of stable
- Calculation of CH_4, CO_2, N_2O, NH_3 emissions based mainly on methods established for European and German emission reporting
- After storage period spreading of the manure as a fertilizer

Composting scenario

- Windrow composting on
  a concrete baseplate
- Regular turning for ventilation
- Field spreading of the compost

Biogas scenario

- Co-digestion of broiler manure with feedstock with lower dry matter and nitrogen content (e.g. liquid cow manure)
- Biogas converted in combined heat and power (CHP) unit
- Electricity replaces current German energy mix
- Heat used to 40% to replace heating by natural gas



In Germany > 8000 agricultural biogas plants

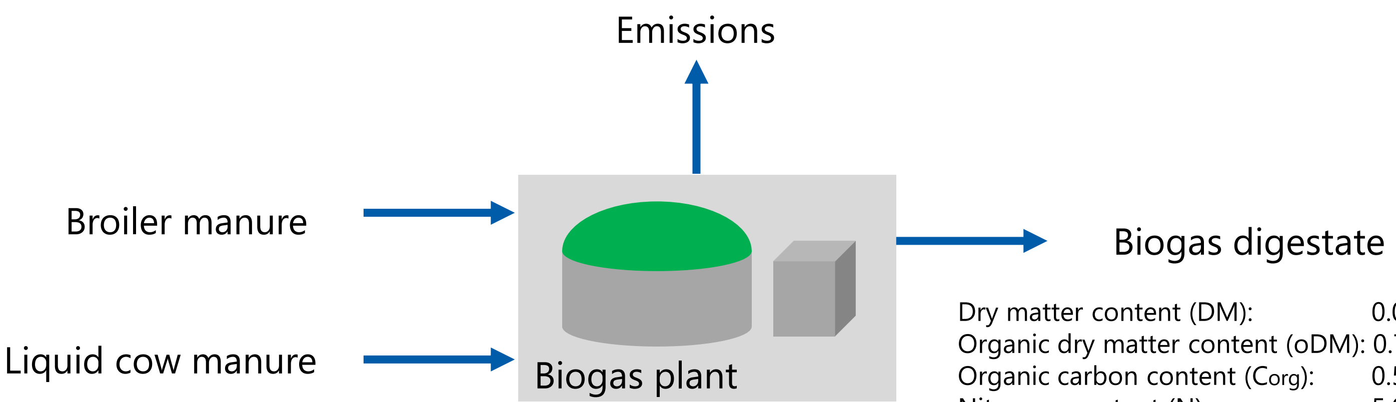
Biochar scenario

- Dry pyrolysis of the broiler manure
- Biochar is distributed on fields
  with the aim to sequester carbon

- Considered CO_2 emissions for carbon that is sequestered for less than 100 years
- Higher pyrolysis temperature
  - Lower biochar yield
  - But higher stability

Biological Resource Utilization Impacts Model (BIORIM)

- Developed at working group at ATB
- Full accounting for carbon and nitrogen flows
  - Biogenic CO_2 emissions also calculated
  - Influence of process parameters on product properties

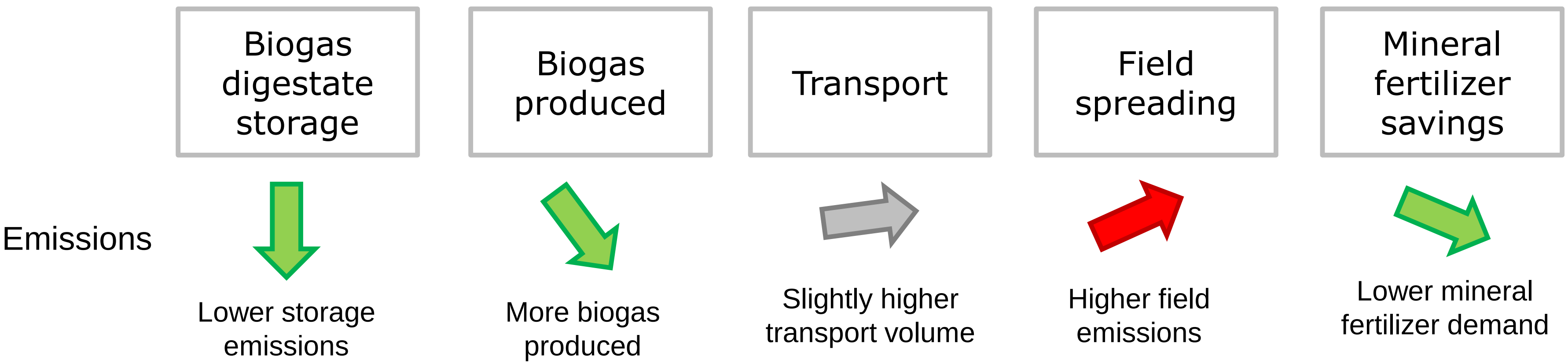


Dry matter content (DM):	0.091 kg DM/ kg FM
Organic dry matter content (oDM):	0.761 kg oDM / kg DM
Organic carbon content (C_{org}):	0.527 kg C_{org} / kg oDM
Nitrogen content (N):	5.05 kg N / ton FM
Ammonium content (NH_4-N):	3.41 kg NH_4-N / ton FM
Potassium content (K) :	4.34 kg K / ton FM
Humus equivalent (HEQ):	0.283 HEQ / t C_{org}
Nitrogen fertilization efficacy:	0.6 kg N / kg N

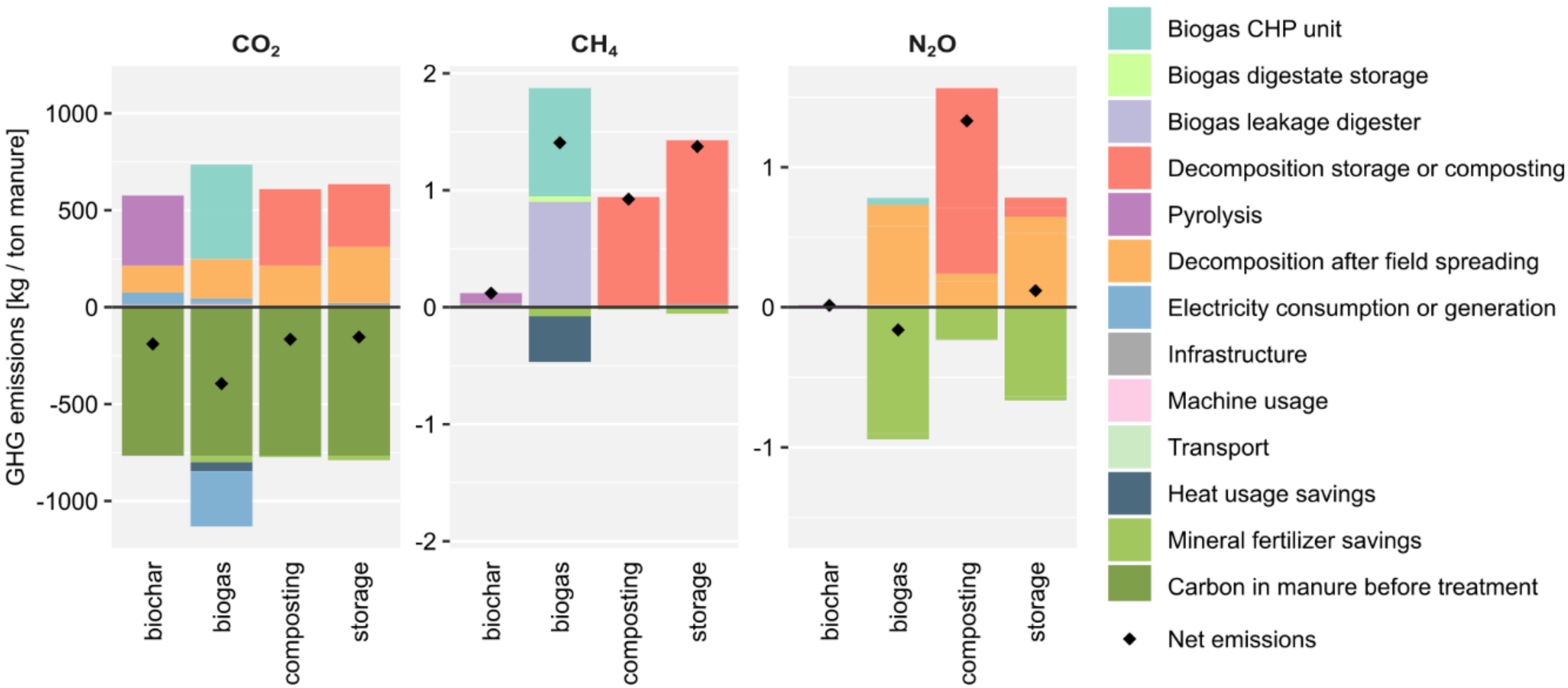
Biological Resource Utilization Impacts Model (BIORIM)

- Products properties are passed between processes
- Allows for accounting for interlinkages

Example: Effect of gas-tight biogas digestate storage (after leaving the fermenter)

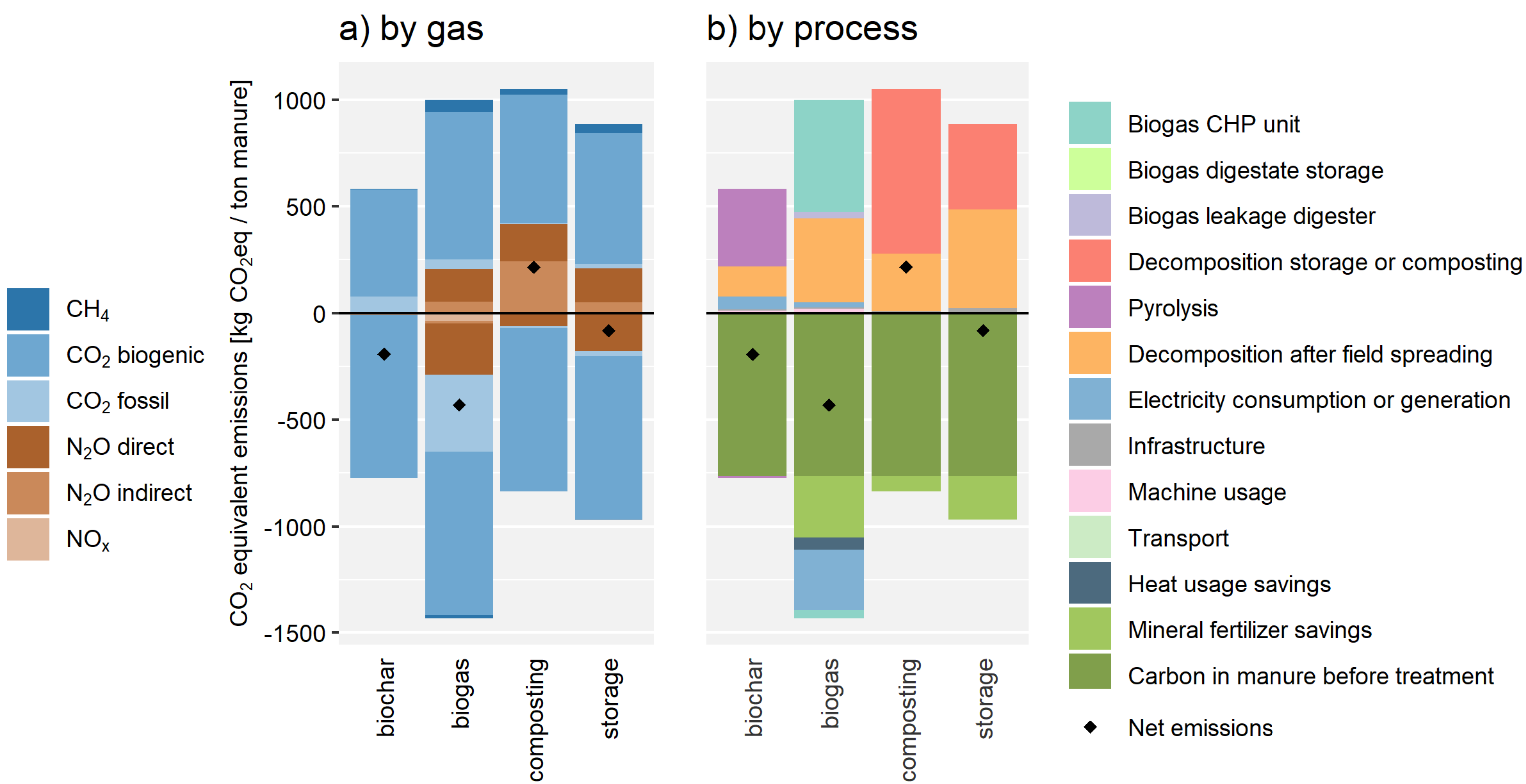


Results



- Biogas: highest CH_4 emissions
  - Leakage from the digester and the CHP unit
- Composting: high N_2O emissions
  - Mainly a result of NH_3 volatilisation

Results

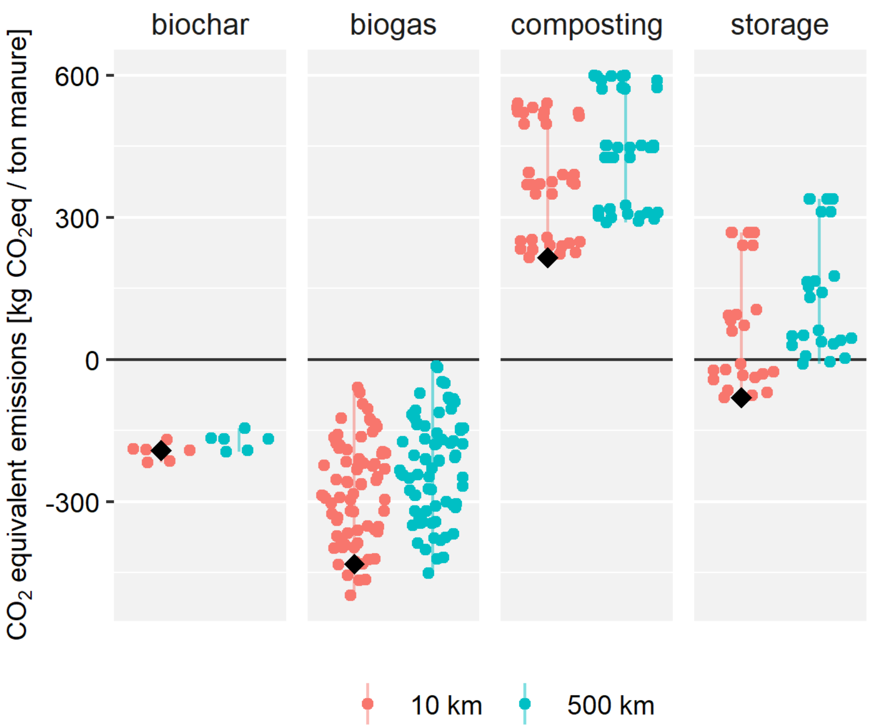


- Biogas scenario leads to lowest greenhouse gas emissions for default parameterization
  - Energy production
  - Low nitrogen losses -> high fertilizer value

Sensitivity analysis

- Strong influence of emission factors on results
- Open vs. closed digestate storage

Sensitivity analysis



- Default scenarios settings for composting and storage were best case assumption
- Under worst conditions biogas not better than storage

Discussion

Neglected effects:

- Potential impacts on yields (positive and negative)
- Indirect effects of biochar spreading on emissions

Challenges:

- Limited data availability on biochar production
- Carbon sequestration in biochar and humus not perfectly comparable

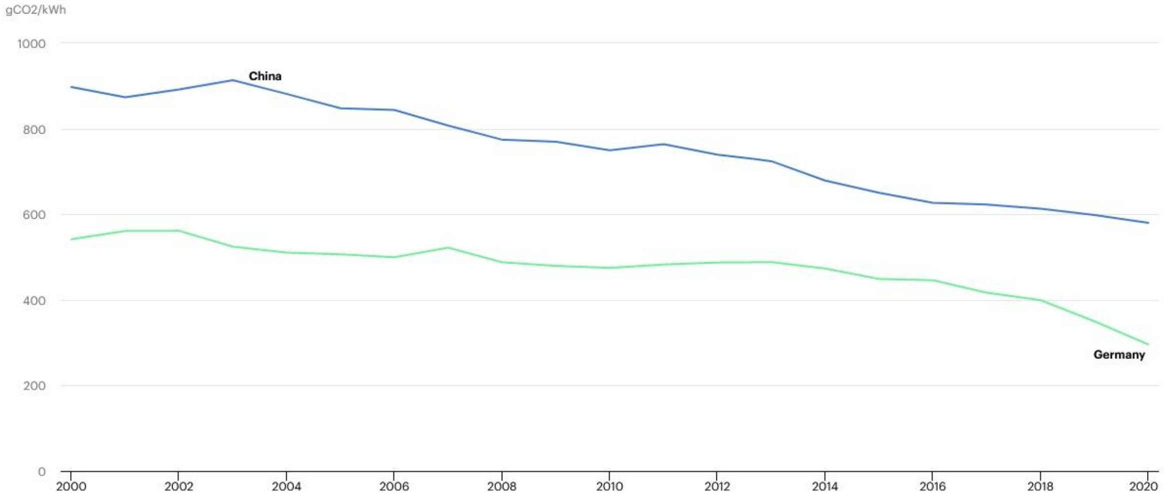
Other simplifications:

- Composting and storage in reality probably more similar

Transferability to Chinese conditions

- Emission factors used are specific for German conditions
- However, results should generally be valid for other locations

- Carbon intensity of electricity mix is relevant
  - Every kWh of electricity produced by biogas more 'valuable' the higher the current carbon intensity



China: 580 gCO_2/kWh

Germany: 296 gCO_2/kWh

Source: IEA

Conclusions

- Of the four assessed scenarios, biogas production from broiler manure leads to lowest greenhouse emissions

If:

- The digestate storage tank is gas-tight
- There are few leakages from the biogas plant
- The cogeneration unit is well adjusted (uncombusted methane avoided)
- The digestate replaces mineral fertilizers

For more information

The publication (Open Access):

Kreidenweis U, Breier J, Herrmann C, et al (2021) Greenhouse gas emissions from broiler manure treatment options are lowest in well-managed biogas production. Journal of Cleaner Production 280:124969.
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