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Greenhouse gas savings of maize-based biogas systems: Comparison of calculated and measured emissions

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Background

Greenhouse gas (GHG) savings of maize-based biogas systems are usually calculated using the methodology out-lined in the EU Renewable Energy Directive. Generic emission factors provided by IPCC are used for calculating direct and indirect nitrous oxide emissions without taking regional- specific effects into account (Fig. 1). Residues from biogas production (digestate) are usually returned to the field in order to recycle nutrients. Whether the soil carbon stock increases or decreases after digestate application is controversially discussed; likewise are regional N-emissions after digestate application.

This research project aims to investigate the regional variability concerning GHG relevant emissions. Nitrous oxide and ammonia are measured (Fig. 2) at five test sites located in different regions of Germany (Fig. 3). Measured and calculated emissions are shown in Tab.1 and life cycle GHG-emissions are calculated and compared to a reference case.

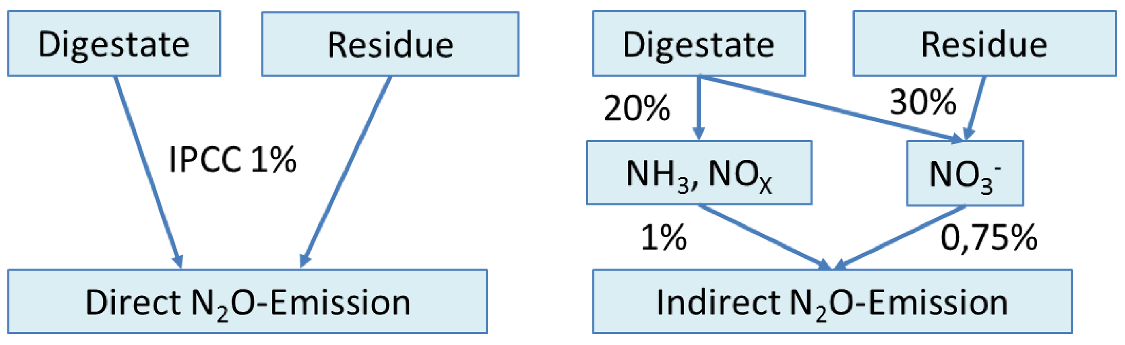

Fig. 1*: IPCC calculation approach for N-emissions*

Fig. 2*: Field measurements*

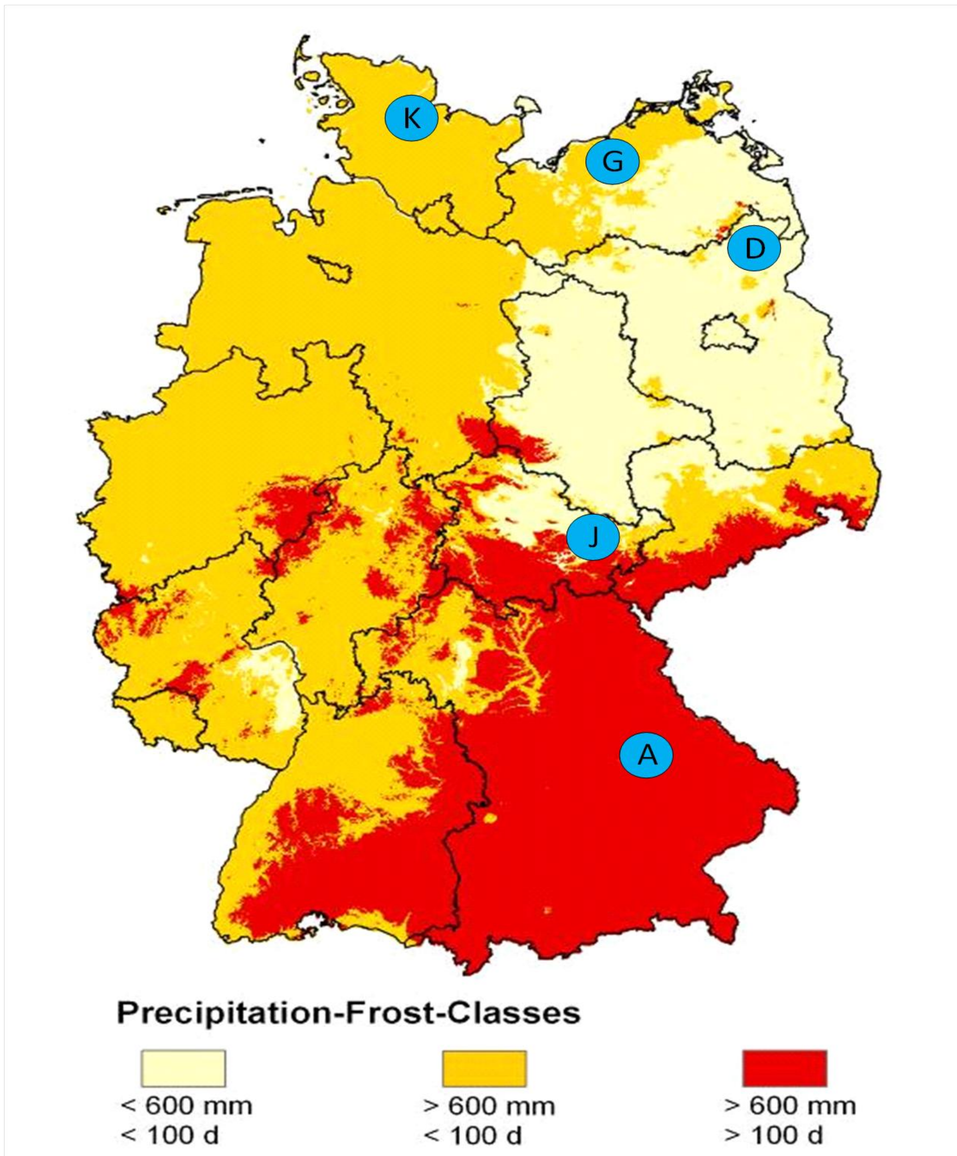

Fig. 3*: Test sites*
***A**scha (Bavaria), **J**ena (Thuringia), **D**edelow (Brandenburg), **G**ülzow (Mecklenburg- Western Pomerania) and **H**ohenschulen (Schleswig- Holstein).*

Results

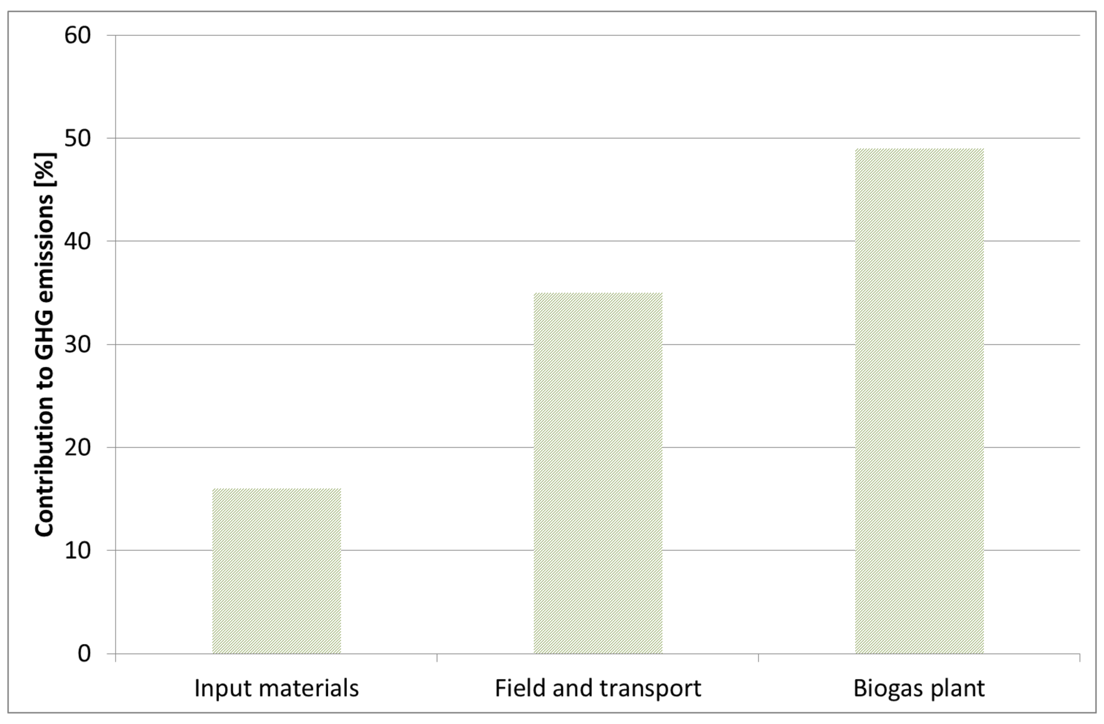

Fig. 4: Reference case according to the JRC-report on „Solid and gaseous bioenergy pathways“

Tab. 1: Yield as well as measured and calculated N-emissions of maize cultivation systems

	Unit	High field emission		Reference case (JRC)	Low field emission	
		Measu.	IPCC	IPCC	Measu.	IPCC
N_2O, direct	[kg N_2O-N/ha]	11	2.3	2.8	0.64	2.0
N_2O, indirect	[kg N_2O-N/ha]	0.48	0.90	0.70	0.09	0.80
NH_3	[kg N_2O-N/ha]	9.0	40	36	6.5	34
NO_3	[kg N_2O-N/ha]	52	70	60	3.1	61
Yield	[$t_{biomass}$/ha]	60		41	67	

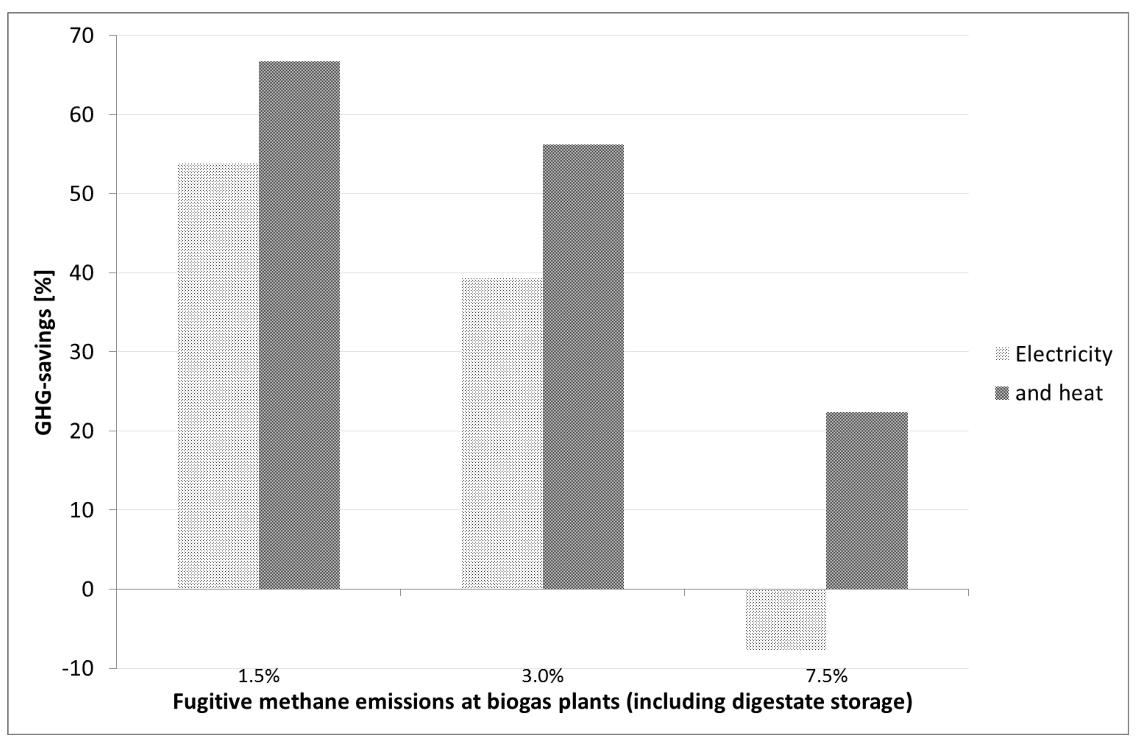

Fig. 5: GHG savings of maize-based biogas systems depending on fugitive methane emissions for systems that can either utilise electricity or electricity and heat

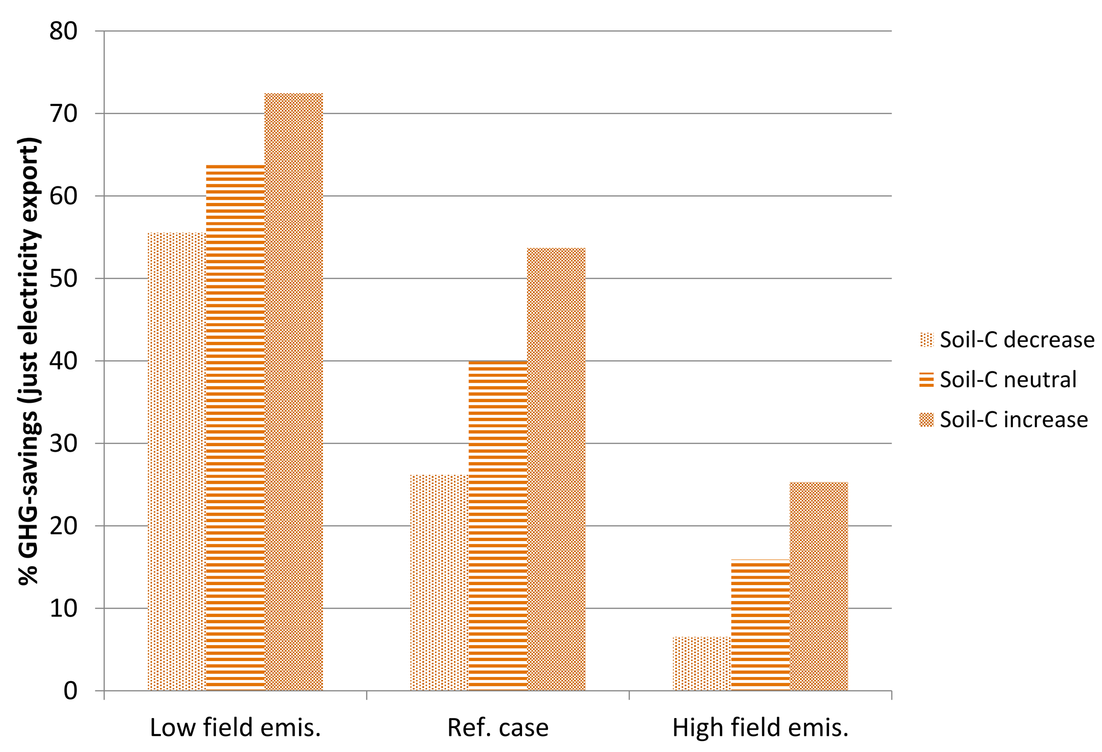

Fig. 6: GHG savings of maize-based biogas systems depending on soil-C change (± 300 kg per ha)

Summary

- Good management practise at biogas plants determines GHG-savings (Fig. 4)
- Good agricultural practise cannot compensate poor management practise at biogas plant (Fig. 5)
- N-emissions from maize cultivation can vary substantially (Tab .1)
- The IPCC approach overestimates particularly ammonia emissions and nitrate emissions (Tab. 1), hence indirect N_2O
- Digestate application can reduce or increase SOC (Fig. 6)

Conclusions

- It is a challenge to achieve 50% GHG-savings when maize is used as feedstock despite indirect N_2O-emissions are overestimated by the IPCC approach
- Soil-C change within crop rotations and regional-specific data are crucial for assessing the **real GHG-savings** of biogas sytems , but also bioenergy systems in general.

THÜNEN

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