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Environmental effects of a novel pre-treatment technology for maize stover as a biogas substrate

Case study of a 500-kW Austrian biogas facility

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6th CASEE conference

"Latest Trends in Bioeconomy in Danube Region"

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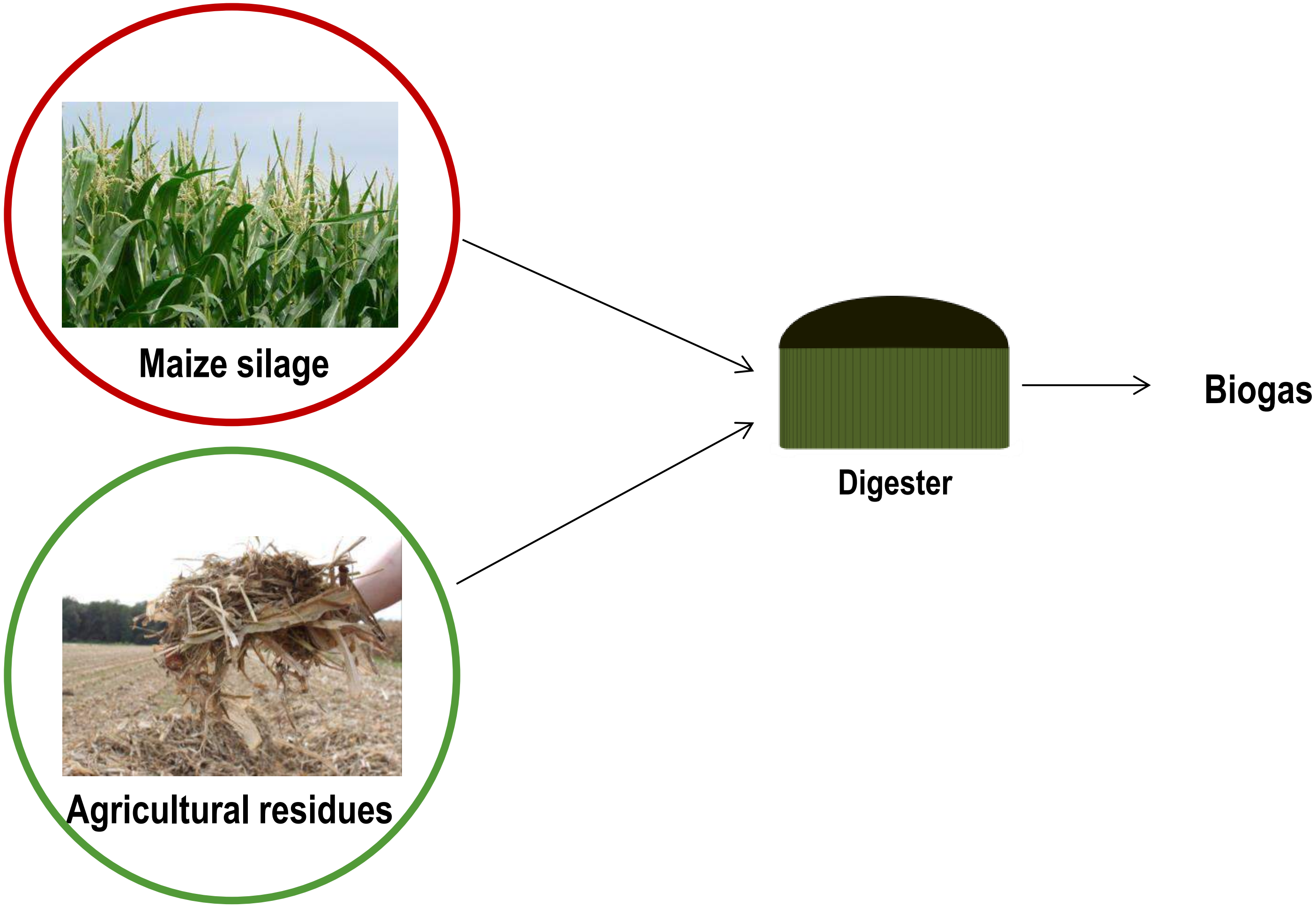
Slovak University of Agriculture in Nitra, Slovak Republic

Motivation



Input substrates in biogas production

- Maize Silage Scenario
- Maize Stover Scenario

Including pretreatment

Seilnacht, 2014

Uidl, 2013

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Steam Explosion

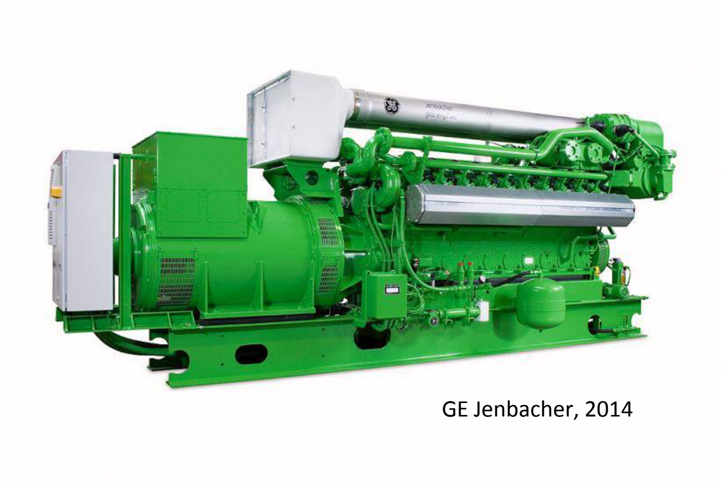
Pretreatment of biomass

- high temperature, saturated steam (140 -240 °C) for 5 – 20 min
- rapid pressure drop

→ easily digestible input material for anaerobic digestion

Biogas plant and CHP settings

- Main components: concrete, asphalt, crushed rocks, steel, iron
- Rated power of the CHP unit: 500 kW_{el}
- Electrical efficiency: 38%
- 50% off-heat usage



GE Jenbacher, 2014

Bioferm, 2014

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LCA model

- Functional unit: 1 kWh electrical energy at the CHP unit
- Modelling software: Open LCA v.1.4
- Data: Primary data from CHP manufacturer; Secondary data from Ecoinvent 2.2 database and literature
- Uncertainty analysis: Monte Carlo simulations
- Impact assesment methods
    - ReCiPe midpoint and CED
    - 6 different impact categories

System diagram

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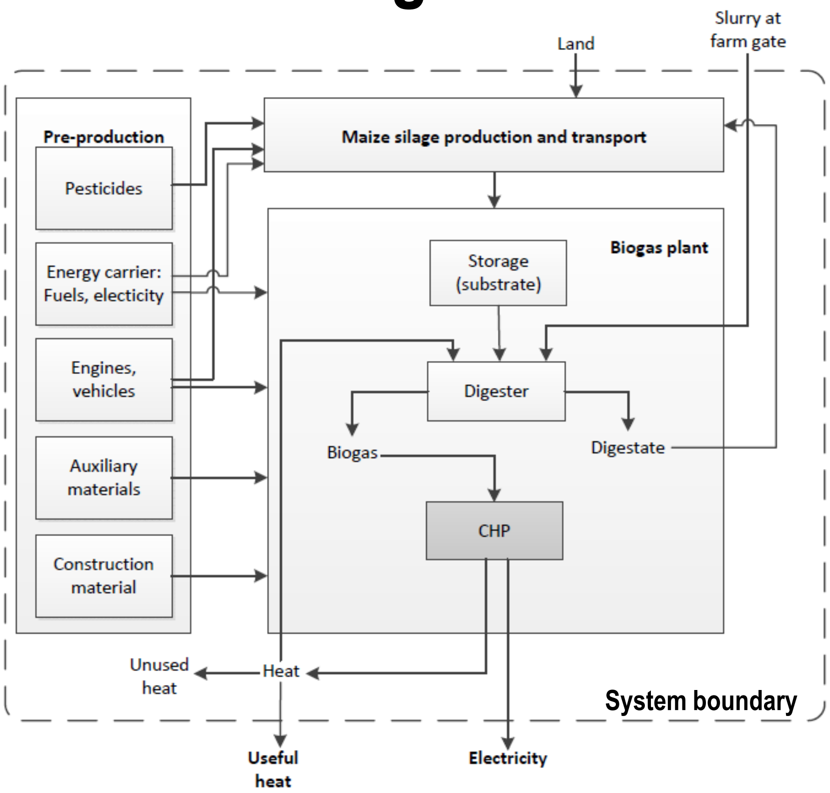
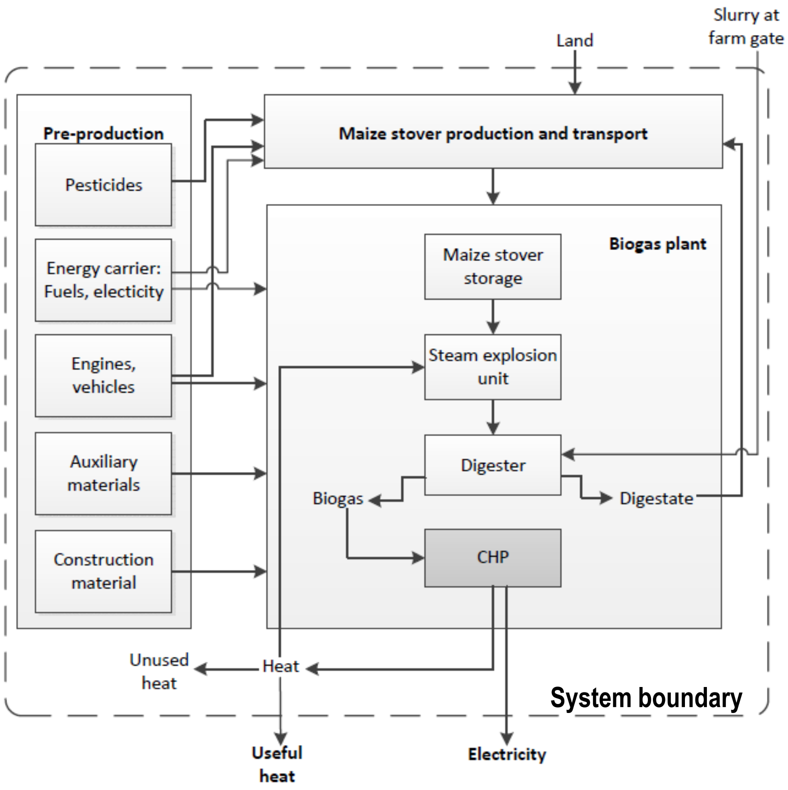
Maize silage scenario



Maize stover scenario



Output: 3,735,000 kWh/a electricity and 1,994,490 kWh/a heat

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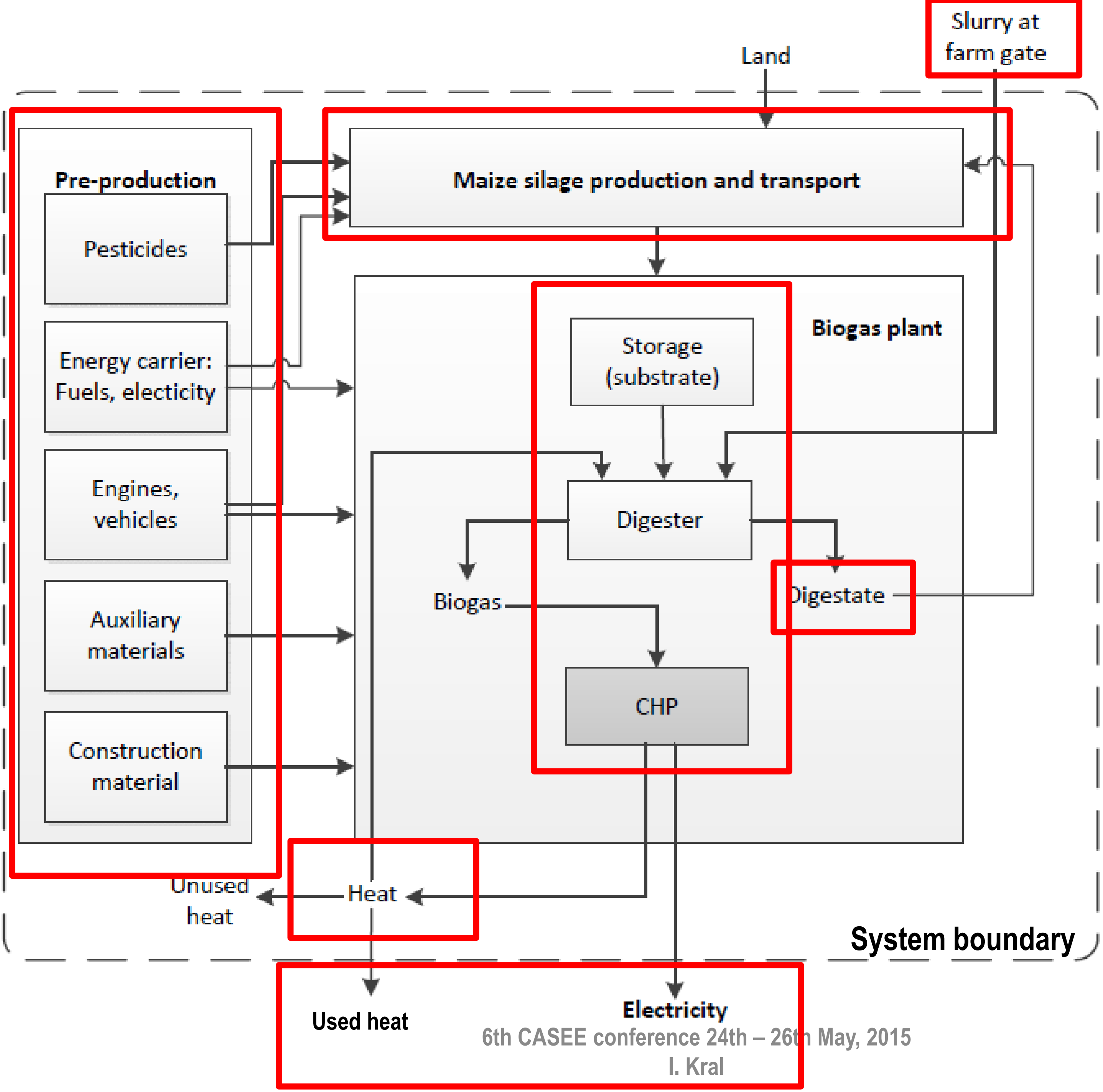

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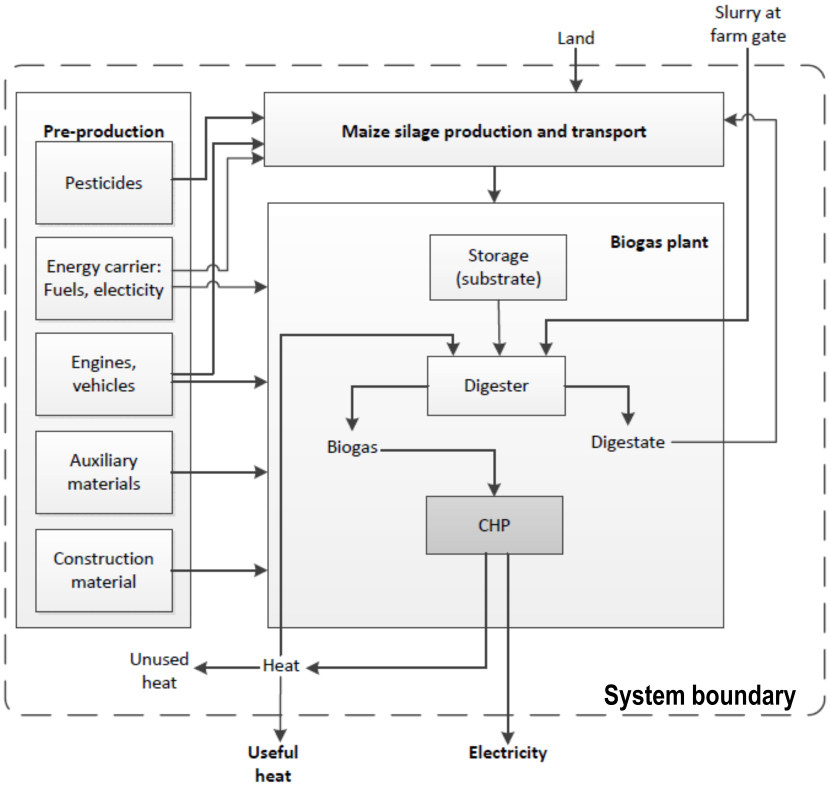
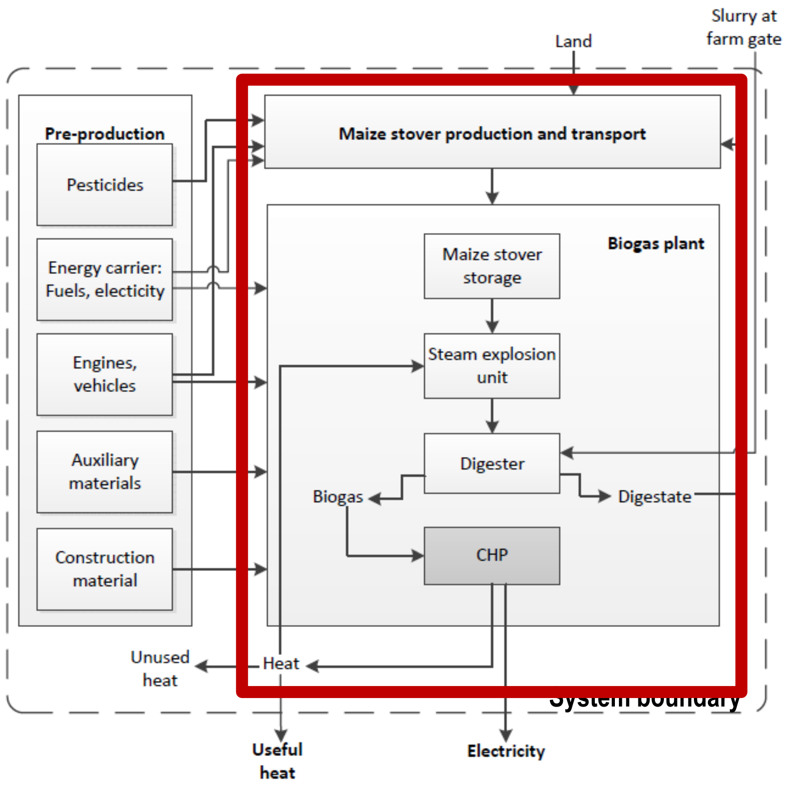
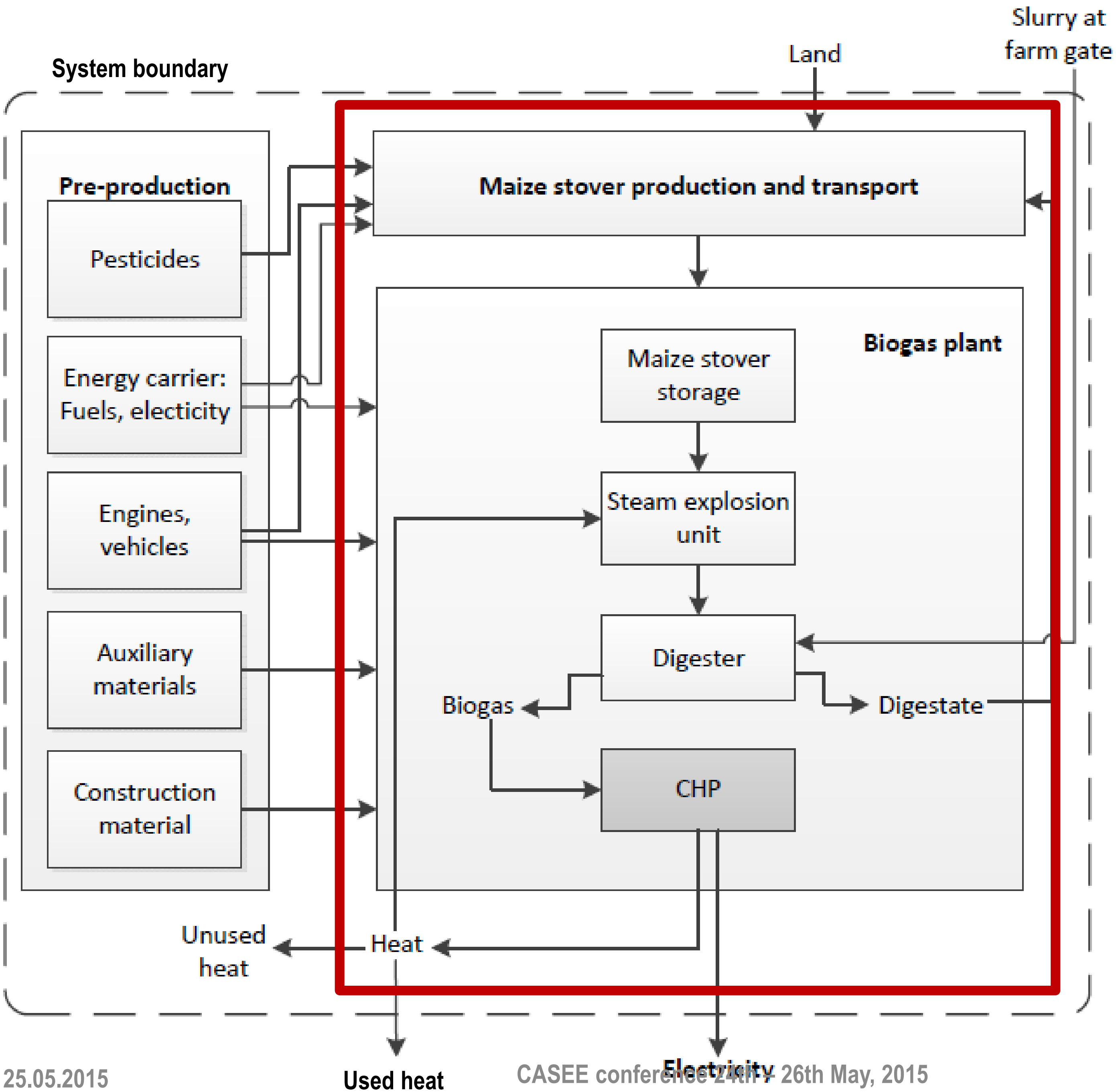
Maize silage scenario



Maize stover scenario

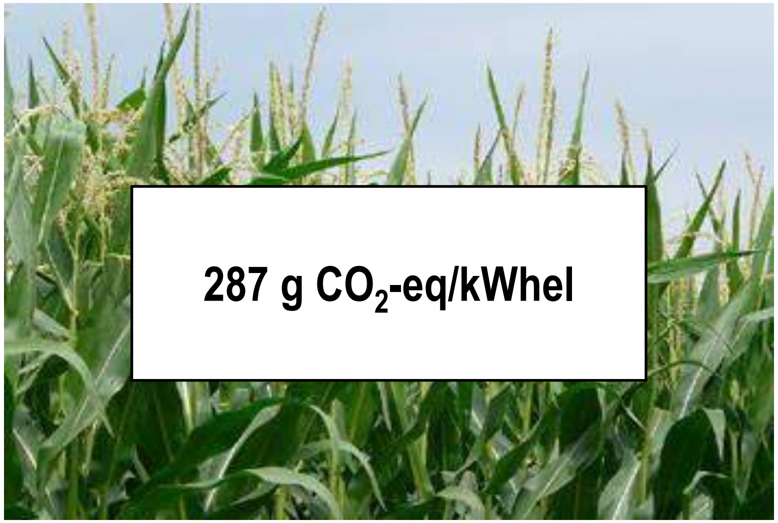



System boundary
Land
Slurry at farm gate
Pre-production
Pesticides
Energy carrier: Fuels, electicity
Engines, vehicles
Auxiliary materials
Construction material
Maize stover production and transport
Biogas plant
Maize stover storage
Steam explosion unit
Digester
Biogas
Digestate
CHP
Unused heat
Heat
Used heat
Electricity

Results

Global warming potential – 100yr time horizon

Maize silage scenario



Seilnacht, 2014

Maize stover scenario

Uidl, 2013

GWP of contributing processes
(both scenarios)

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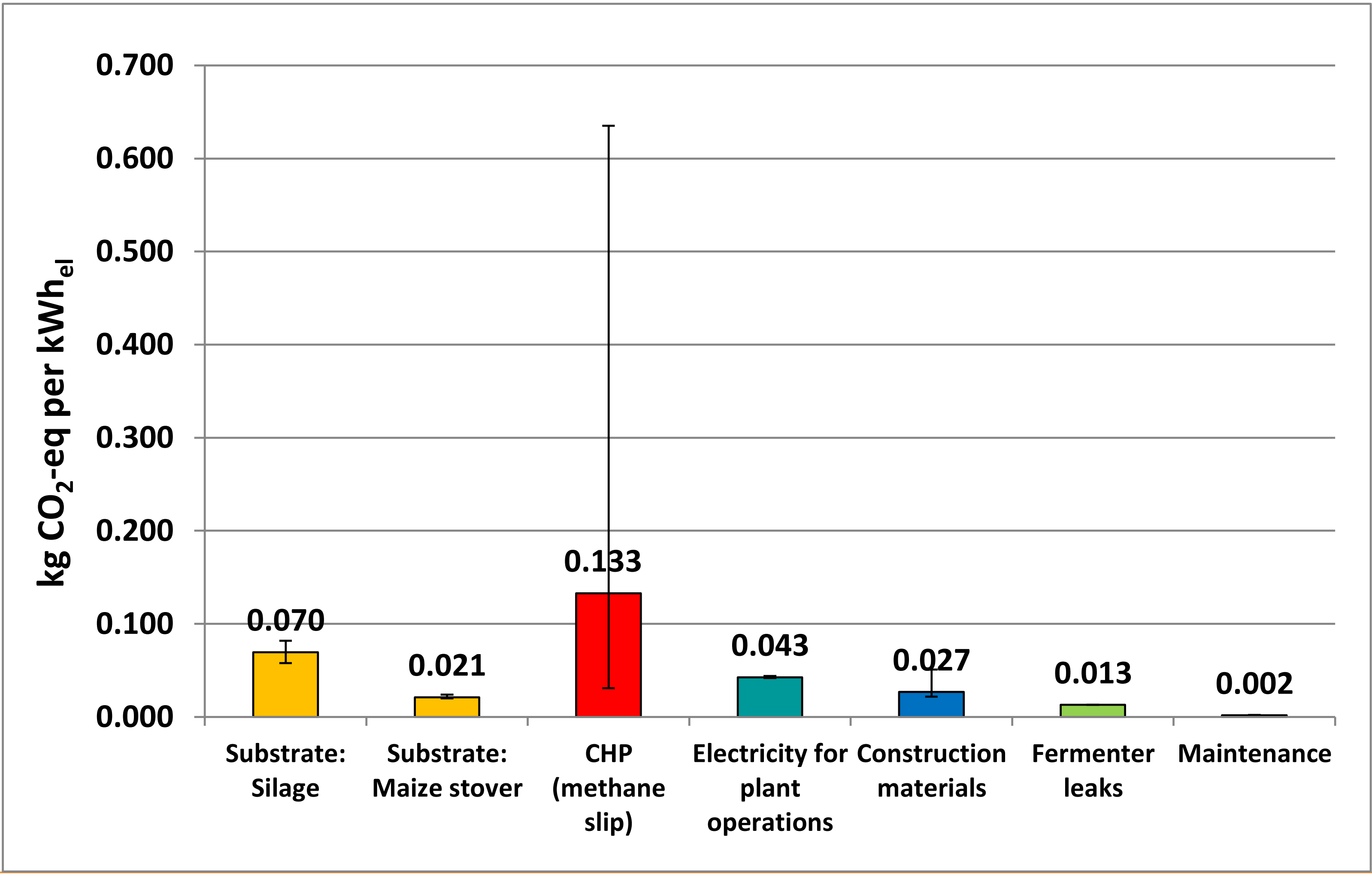

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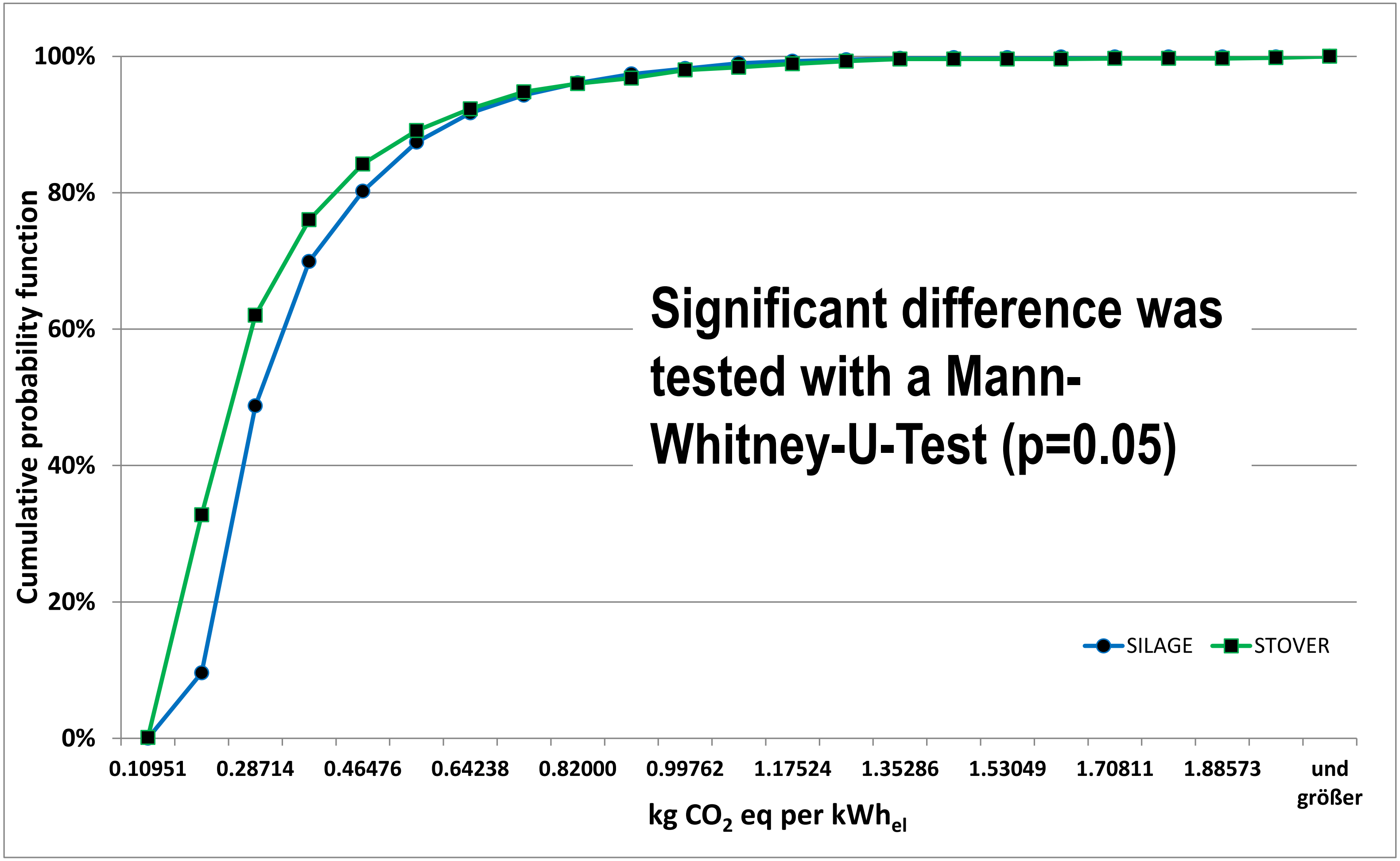
Monte Carlo simulations (n=10,000)



Other impact categories

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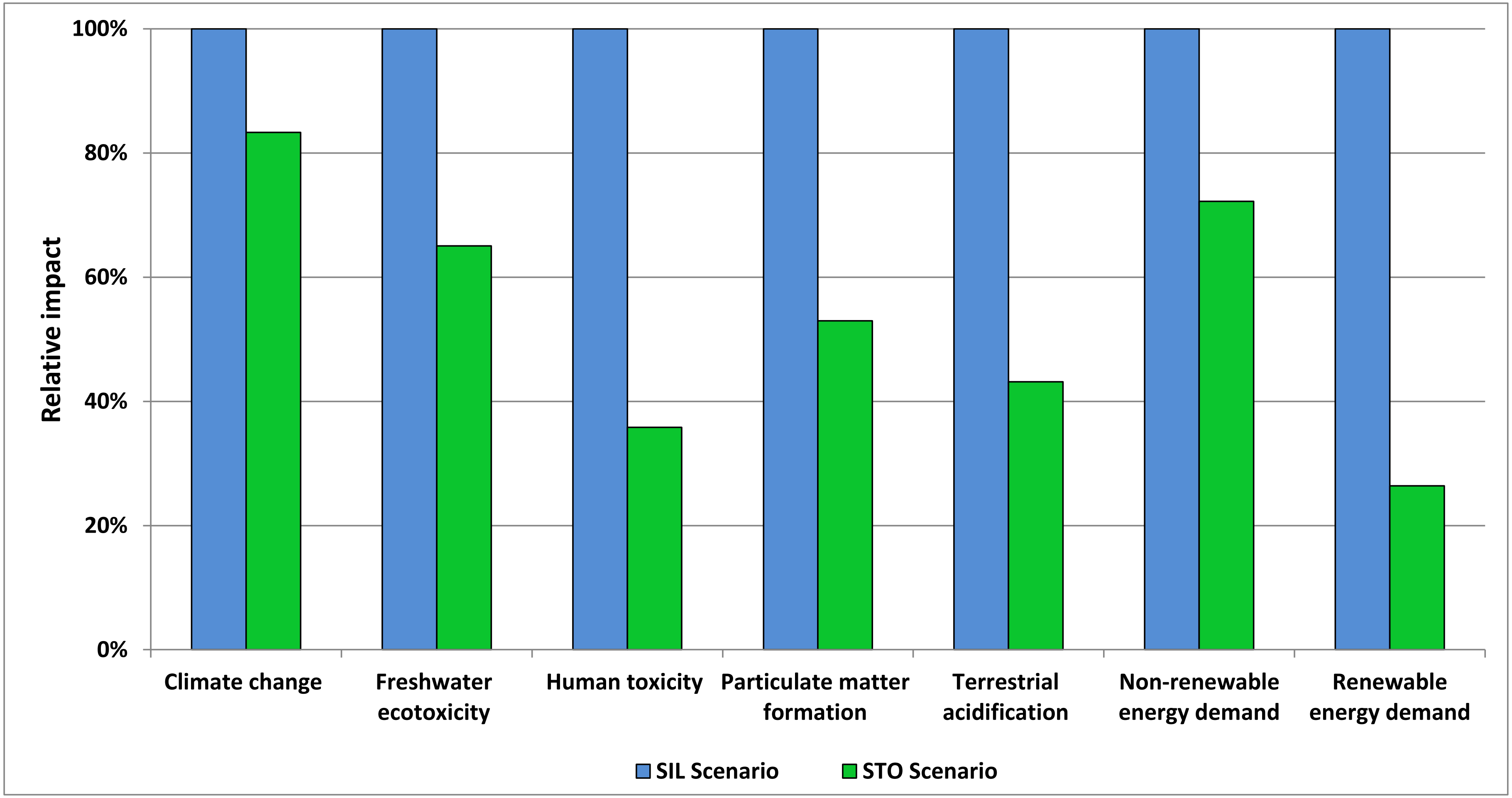

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Sensitivity analysis, selected cases

- **Alternative electricity mix** (green electricity): 244 g CO_2-eq/kWh_{el} (SIL); 196 g CO_2-eq/kWh_{el}
- **ILCD Method**: STO scenario hast less impact throughout all categories

- **Best case version STO**: Reduced mixing power due to a lower substrate viscosity - 231 g CO_2-eq/kWh_{el}
- **Worst case version STO**: assumes that the heating requirement for the SE unit is not covered by “free” off-heat from the CHP-unit - 266 g CO_2-eq/kWh_{el}

Original results:	287 g CO_2-eq/kWh_{el} (SIL)
	239 g CO_2-eq/kWh_{el} (STO)

Conclusions

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- Maize stover as a biogas substrate compares favorably to conventional maize silage for all of the studied environmental impacts

- The main contribution to GWP is methane in the CHP exhaust (“methane slip”), followed by substrate production (maize silage) and grid electricity for plant operations

BOKU alp-S
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Thank you for your attention

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