Wuppertal Institute for Climate, Environment and Energy

GHG mititgation potential revised?

New bottom-up LCA results on the N_2O emissions of biogas and suggestions for improvement

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Karin Arnold
Research Group
Future Energy and
Mobility Structures

Structure of presentation

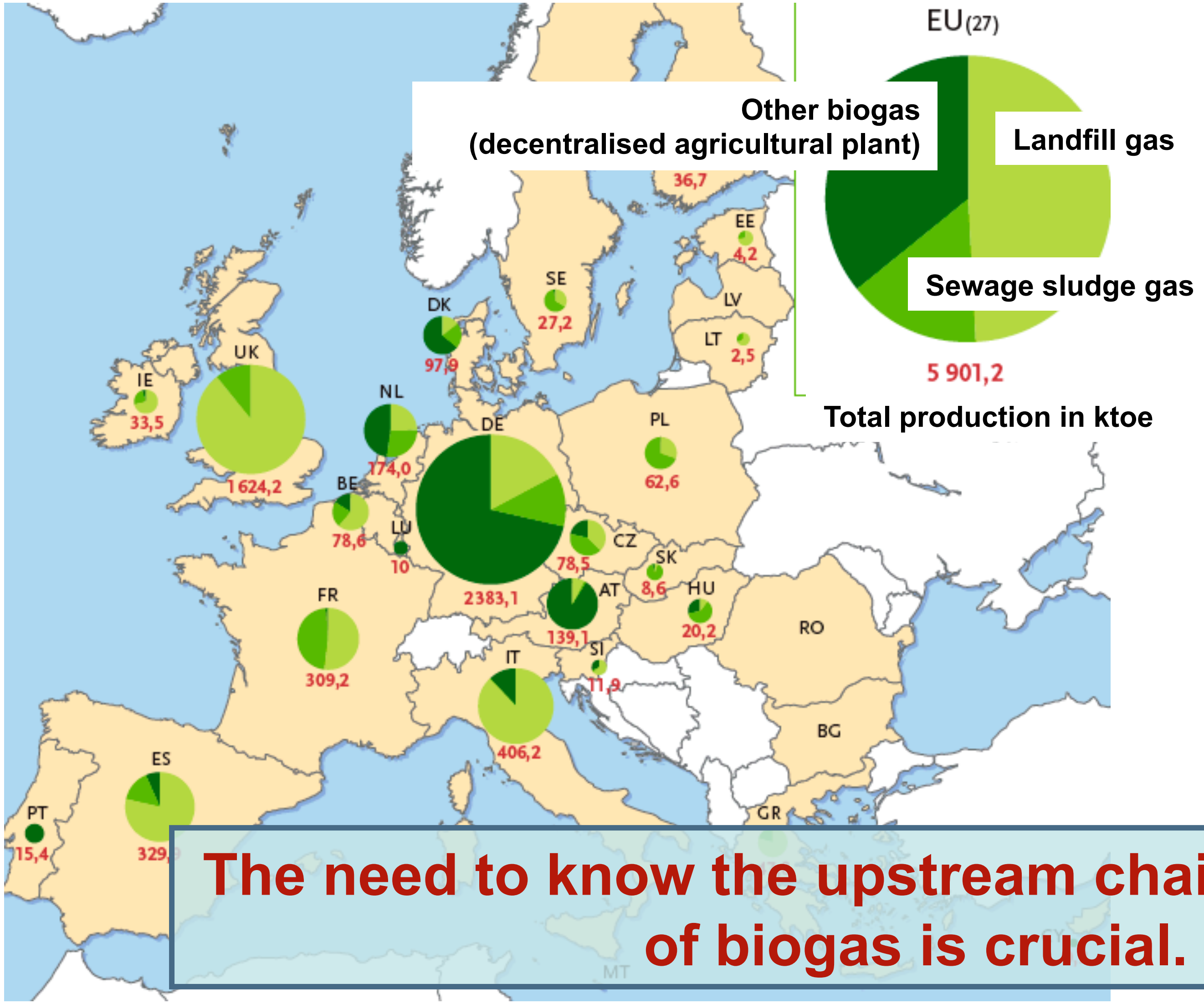
- **Introduction and Background**
- **LCA of bio methane:**
  - State of the art
  - Optimised technology
- **GHG from the process**
- **Effects of N_2O**
- **Conclusions**

Introduction and background

- **Biogas** (raw gas from the process, used on-site) **and bio methane** (upgraded biogas for injection into the natural gas grid) are renewable energy carriers, that can be produced from various feedstock. The focus of the research and presentation is on **industrialised** bio methane production.
- The combustion of biogas and bio methane can be calculated as "climate neutral", but during the production and supply, **considerable GHG emissions** can occur, **dependent of the feedstock.**
- In Europe and only few years ago, "biogas" mostly meant gas from landfills, sewage gas, etc. While using these residues, there is not to worry about upstream chain emissions of feedstock.
- Starting in 2004 and boosted by the Renewable Energy Law, energy crops from dedicated farming were used for biogas production in Germany. Biogas production was **increased by factor 7** (capacity installed).

Thus, a strong link between agriculture, energy supply and climate protection targets was built.

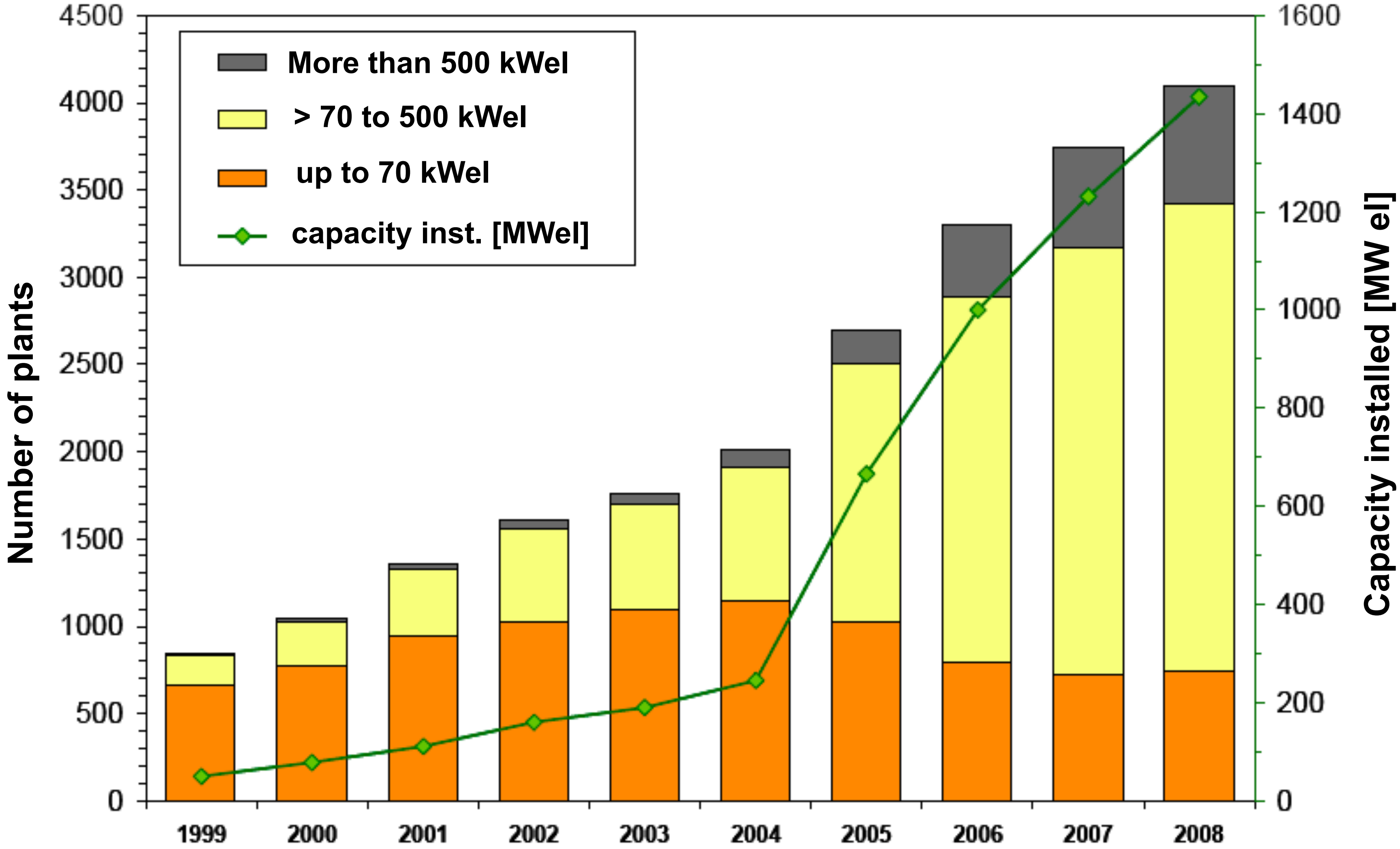
Introduction and background: Europe and the German case



- Germany produces the most biogas in Europe.
- The major part is based on energy crops from dedicated farming, while in other countries, residues are used.

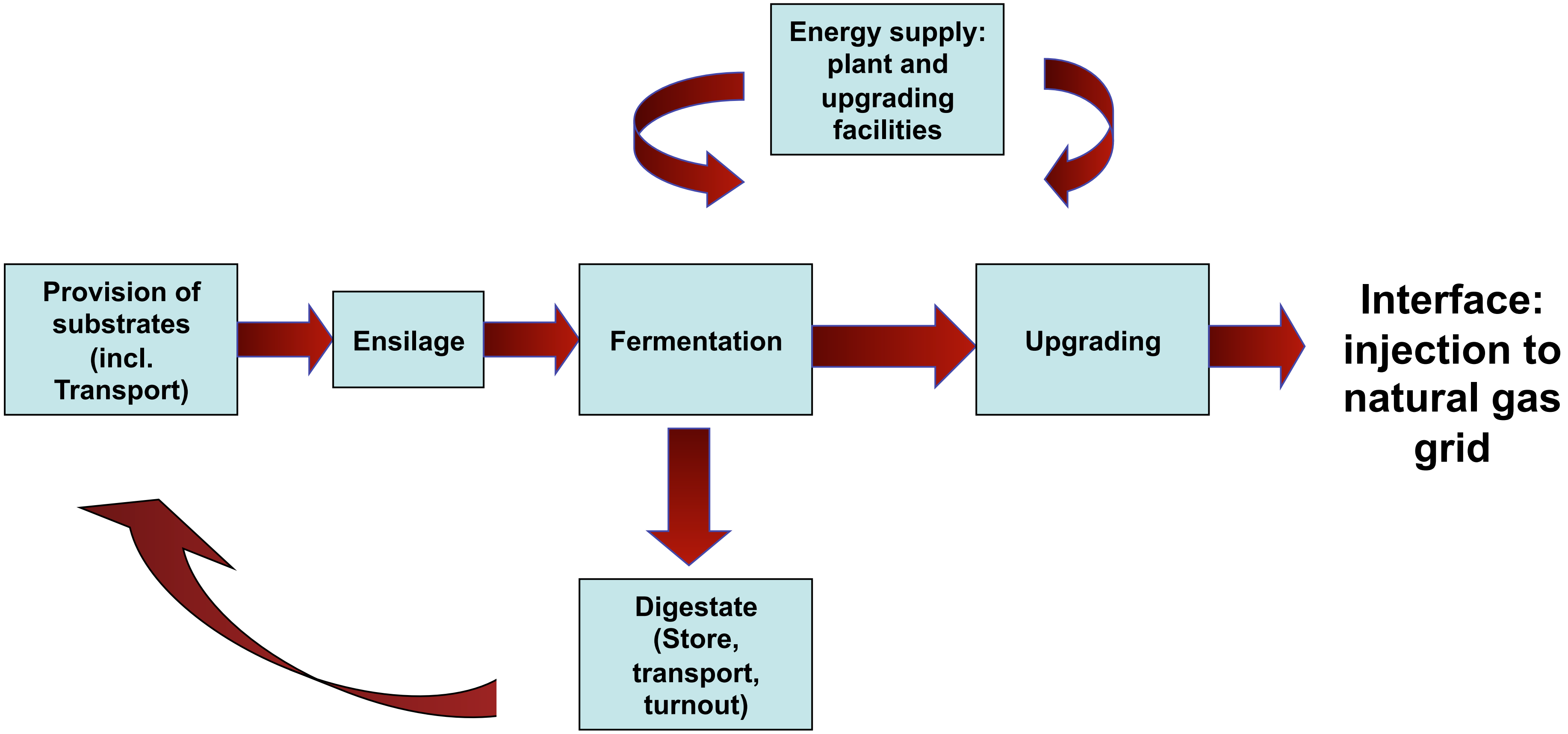
The need to know the upstream chain emissions of biogas is crucial.

Introduction and background: Development of biogas technology in Germany



Quelle: DBFZ, 2009: Stromerzeugung aus Biomasse

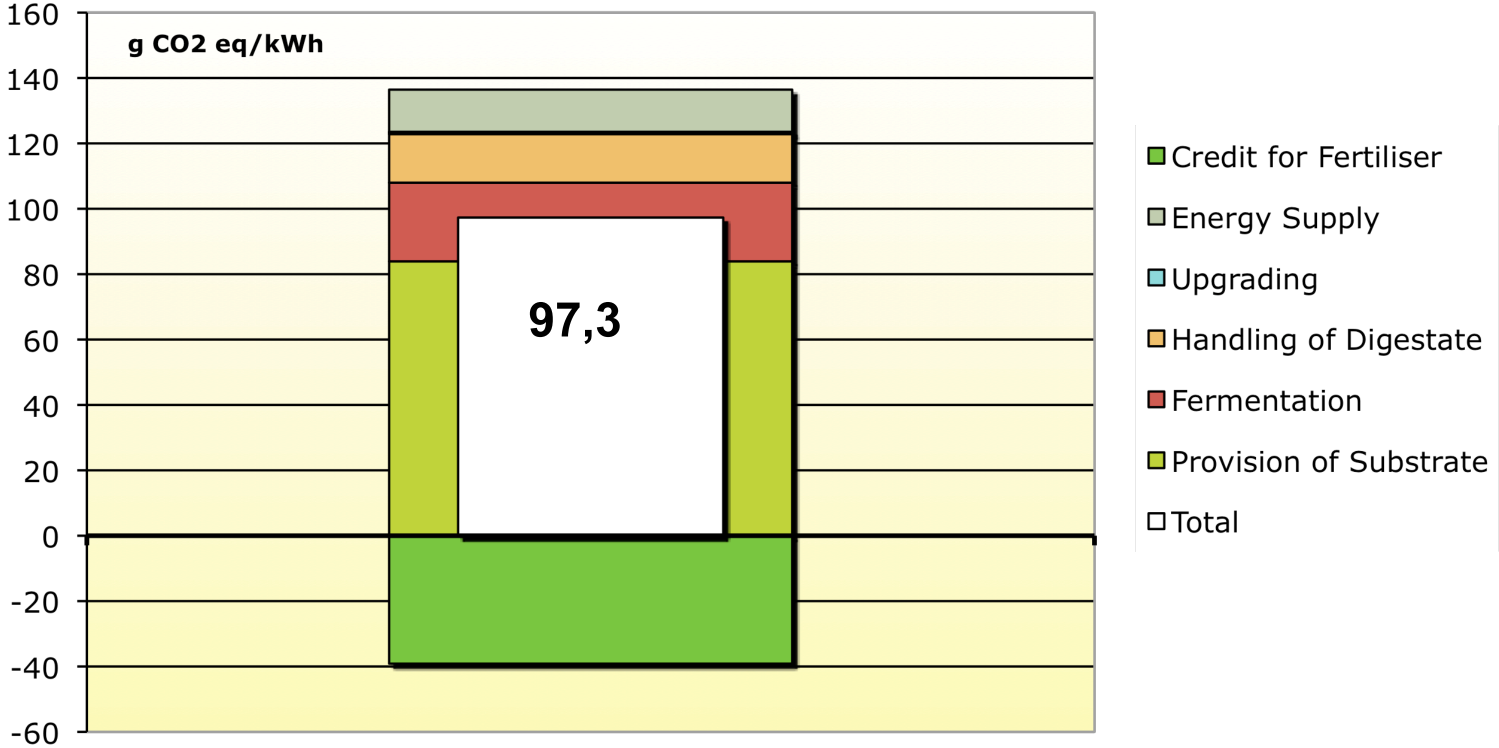
Bio methane production: technical process chain



In all steps, direct or indirect GHG emissions can evolve.

LCA Result: State of the Art

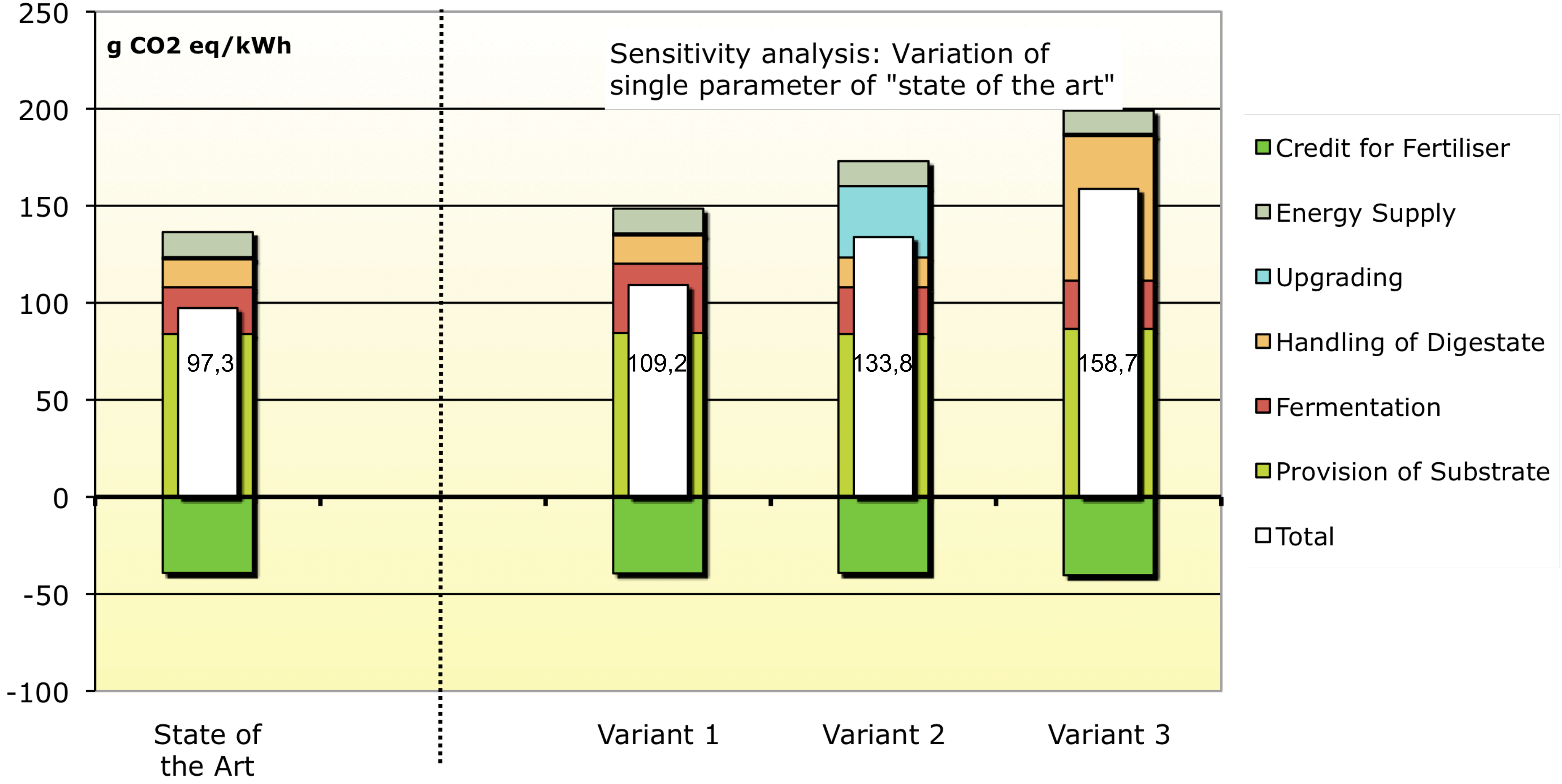
- The focus is on **industrial plants for biogas upgrading and injection** into the grid. The results **do not hold** in every case for small-scale, agricultural biogas plants for on-site electricity production.
- Paramters include provision of substrate (various energy crops from regional adjusted crop rotation systems), fermentation, handling of digestate, upgrading unit and energy supply.



Parameter:
State of the Art and Sensitivity analysis

- GHG emissions can appear from **indirect effects** (energy supply, agricultural processes) and **direct leakage of methane**. Leakage occurs in the reactor itself and can occur in the store of digestate, if it is not properly covered, as well as in the upgrading unit.
- For **industrial plants** for bio methane injection, a **closed store and an aftertreatment** in the upgrading unit are mandatory under the new regulation. Discrepancies are not very likely to happen. As they have a **considerable influence on the climate protection potential**, they will be examined in the sensitivity analysis.
- **Sensitivity analysis** for state of the art:
  - Variant 1: increased methane leakage in reactor
  - (1,5% instead of 1%)
  - Variant 2: increased methane slip in PSA
  - (no after treatment; 2% instead of 0,01%)
  - Variant 3: digestate store not completely covered
  - (moderate emissions of 2,5% of gas stored)

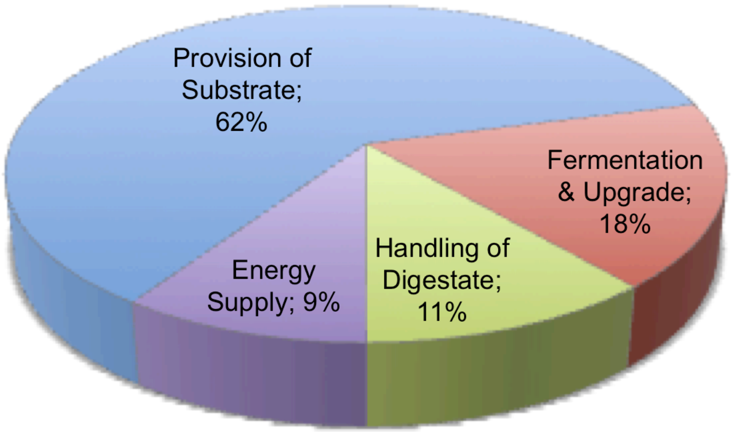
LCA Results: GHG from Biogas
State of the Art and Sensitivity analysis



All variants show increase in direct methane leakage.

LCA Results: which GHG from what parts of process chain?

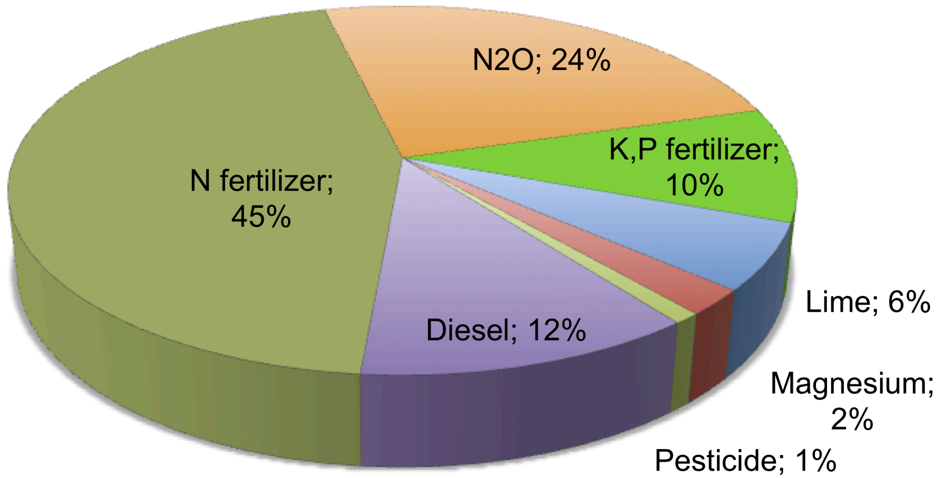
State of the art



- CO_2: ca. 62%
- CH_4: ca. 18%
- N_2O: ca. 20%

- **Not yet included: credit for digestate as fertilizer substitute**
  - N fertilizer: 60% substitution,
  - Other: 100% substitution

Provision of substrates

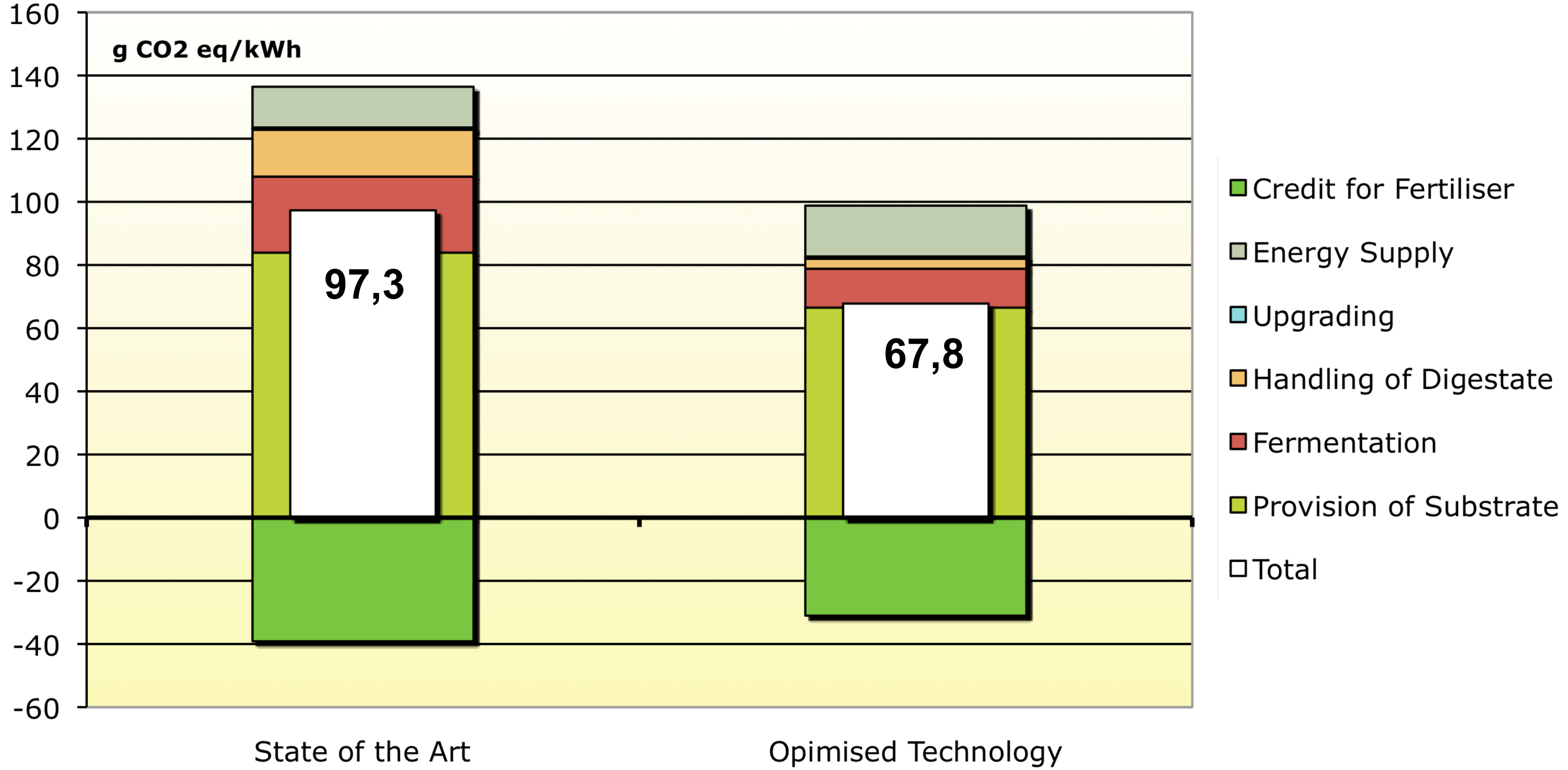


Optimisation potential:
State of the Art and Optimized Technology

- The focus of the presentation and the research is on **industrialised biogas plant** for bio methane provisions to the grid. Thus, the state of the art plant is already **a widely effective plant**.
- Small-scale biogas plants can be operated in a less effective way, possibly leading to much higher GHG emissions.
- A number of parameters were closely looked at for optimisation potential of the state of the art, leading to optimised technology.

- The **difference between state of the art and optimised technology** is mostly due to three parameters:
  - **Less material loss in ensilage**
  - **Better yield of raw gas**
  - **Less methane leakage in reactor**

LCA Results: GHG from Biogas
State of the Art and Optimized Technology

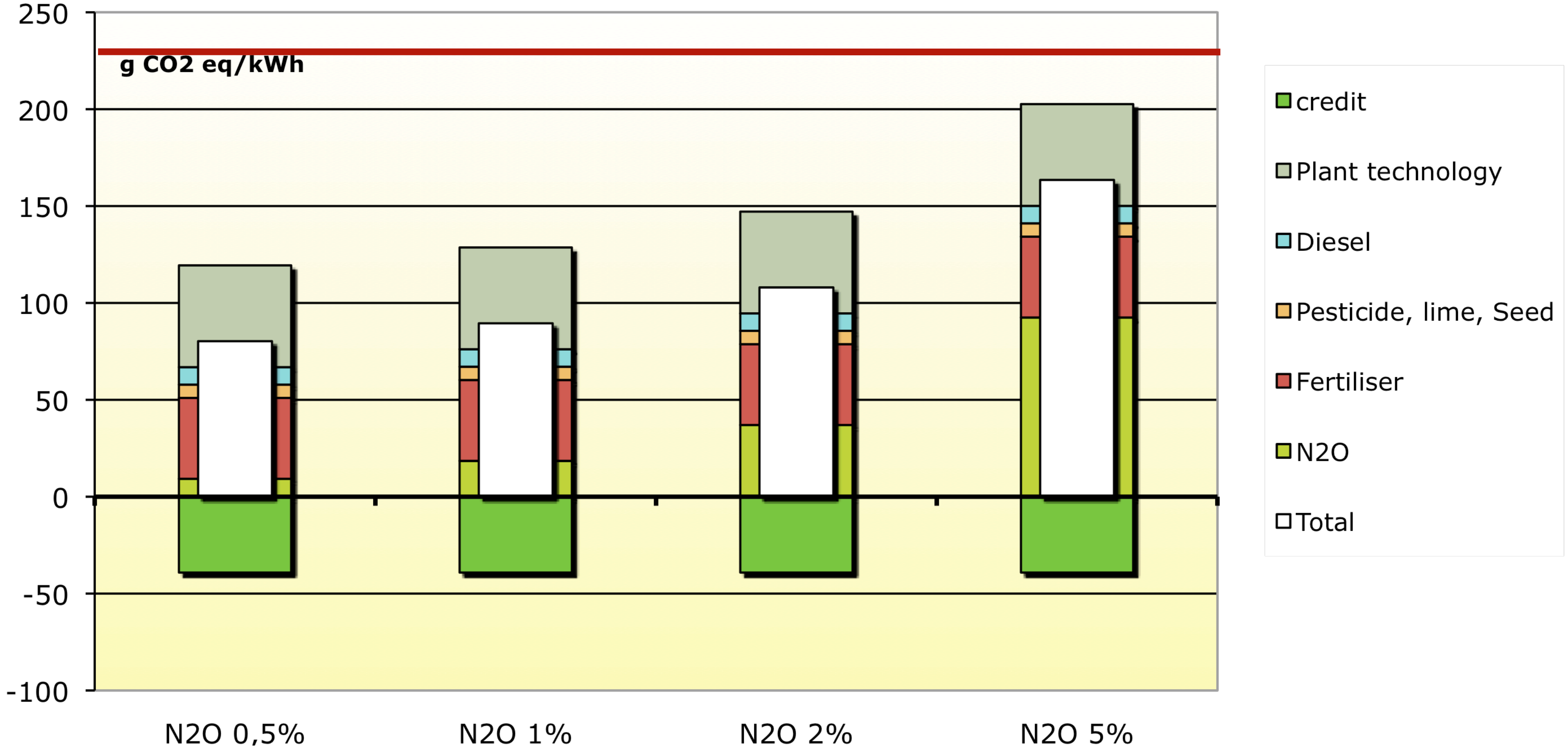


GHG emissions can be decreased by about 30% with optimized technology – available today.

N_2O from organic processes

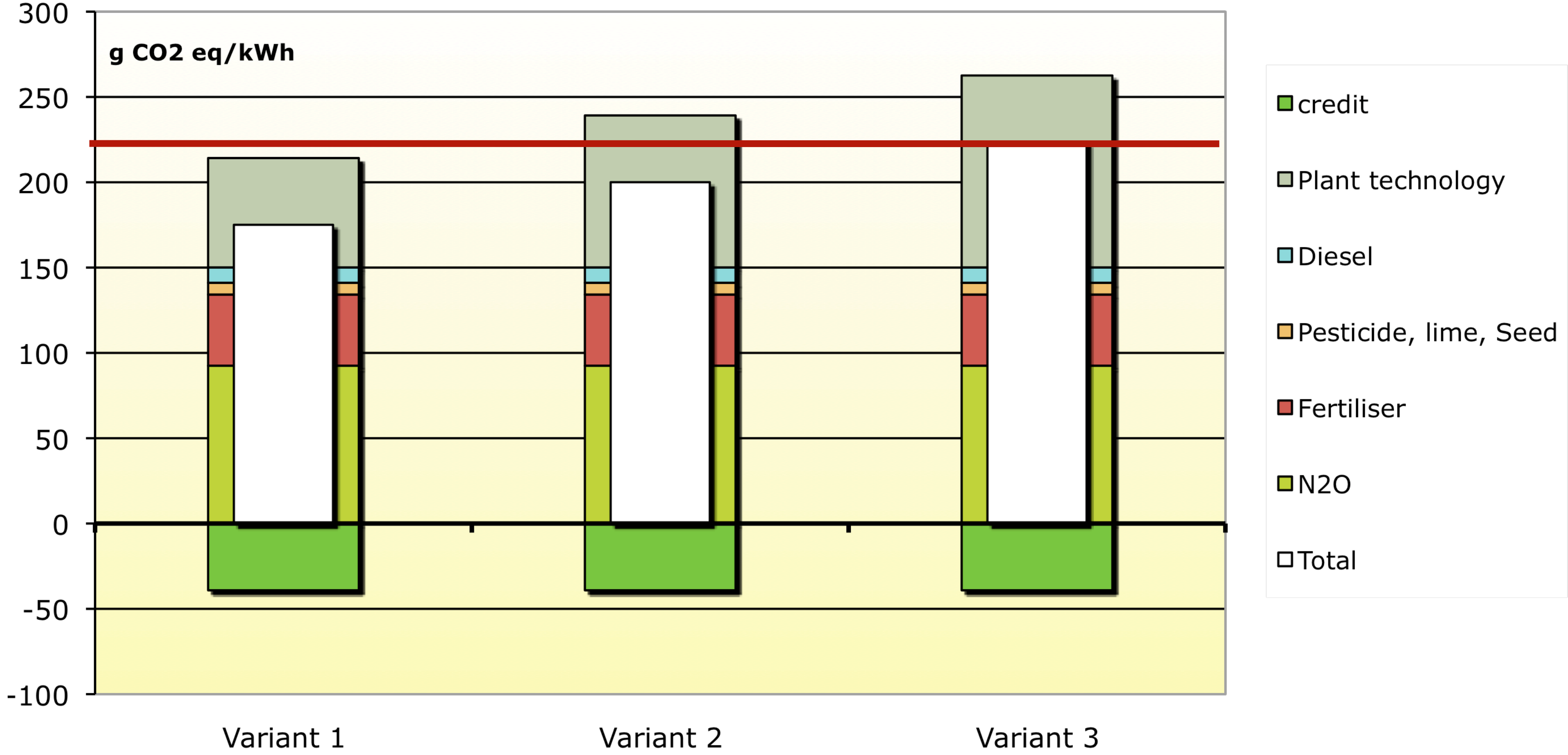
- Nitrous oxide is an extremely potent greenhouse gas, that is set free during **organic processes in the soil during farming of crops** – no matter, if they are used for feed & fodder or energy.
- The dicussion on the amout of N_2O emissions is partly controversial:
  - IPCC 2007: 1% of nitrogen fertilizer deployed
  - Crutzen et.al. 2008: for indirect effects multiply by factor 3-5
  - Wulf, 2002: not more than 0,5% of fertilizer deployed
  - Leick, 2003: positive effects to N_2O from nitrification inhibitors
  - Edwards 2008: specific location is more important than proportional approach
- While the author is not trained and fit to decide, which of the approachs is better than the others, nevertheless the **effects** of the different numbers to the **overall upstream chain of bio methane** can be shown and the **remaining climate protection potential** can be assessed.

LCA Results: Effects of N_2O emissions (State of the Art Technology)



The climate protection potential of bio methane is shrinking with increased N_2O emissions.

LCA Results: Effects of N_2O emissions of 5% (State of the Art Technology and Sensitivity)



If N_2O emissions were 5% of fertilizer deployed, there is not much margin for error in plant technology.

Conclusion

- In Germany, we see the **biggest potential for bio methane production via energy crops** from dedicated farming as substrate.
- This means, that we have to pay **special attention to the upstream chain emissions** of feedstock supply – farming of energy crops.
- When applying **optimized technology** to the fermentation and upgrading of biogas to bio methane, the **cultivation of substrates** contributes to the biggest amout of GHG emissions.
- CO_2 emissions are coming from the (fossil) energy supplied to the process (small optimisation potential); methane emissions are from leakage (with optimised technology nearly avoidable) and nitrous oxide from farming processes.
- In the “worst case” of N_2O emissions assumed here, there is **not much margin for error in biogas plant technology**. The gap to natural gas is shrinking, and so is the climate protection potential.

Bio methane is an energy carrier with a considerable climate protection potential – especially, if optimised technology is deployed, which is available today.

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for Climate, Environment
and Energy

Thank you for your attention !

Dipl.-Ing. Karin Arnold
Research Group I
„Future Energy and Mobility Structures“

Tel. 0202-2492-286 (-198 Fax)
Email: karin.arnold@wupperinst.org
http://www.wupperinst.org