Is it possible by using Biogas to make organic agriculture CO_2 neutral – and will it have influence on the content of humus in the soil

Dr. Kurt Möller

Institute of Crop Science

Plant Nutrition

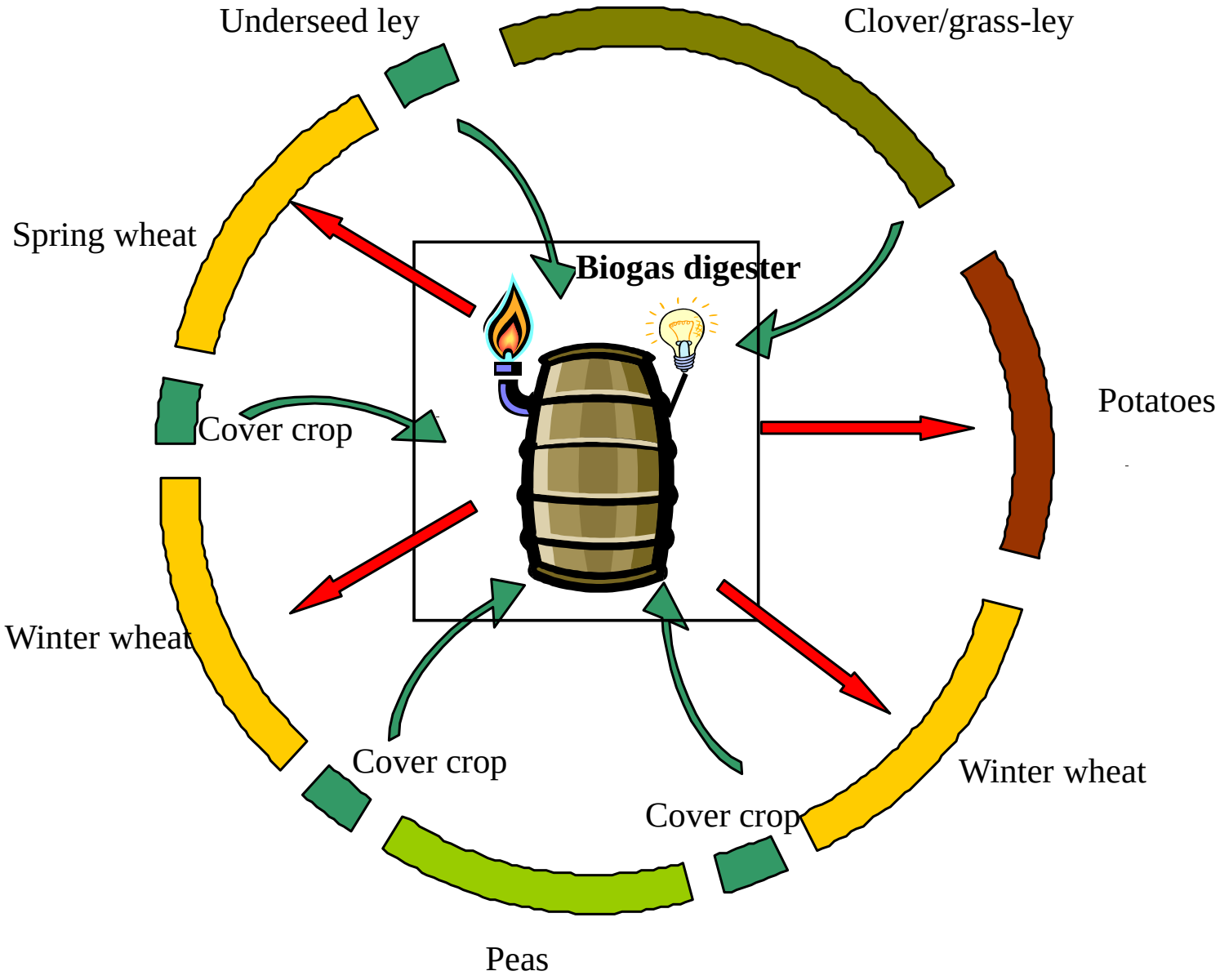
Universität Hohenheim

UNIVERSITÄT HOHENHEIM

Outline

- Introduction
- Influence on nutrient cycles and productivity
- Consequences for the humus budgets and soil biological activity
- Energy- and clima balance
- Conclusions

Stockless System with anaerobic digestion of residues



Effects on the organic matter and nutrient supply

	wL	wL-FR	wL-FER
organic DM (t ha^{-1})	6.47	2.53	3.08
C supply (t ha^{-1})	3.20	1.40	1.70
Total N supply (kg N ha^{-1})	128	126	154
Mobile N (kg N ha^{-1})	0	104	132
N supplied to non-legume crops	150	180	223
N supplied to legumes	83	10	10
C/N ratio organic manures	25,2	11,0	11,1
Ammonia-N (kg N ha^{-1})	0	43,2	54,5

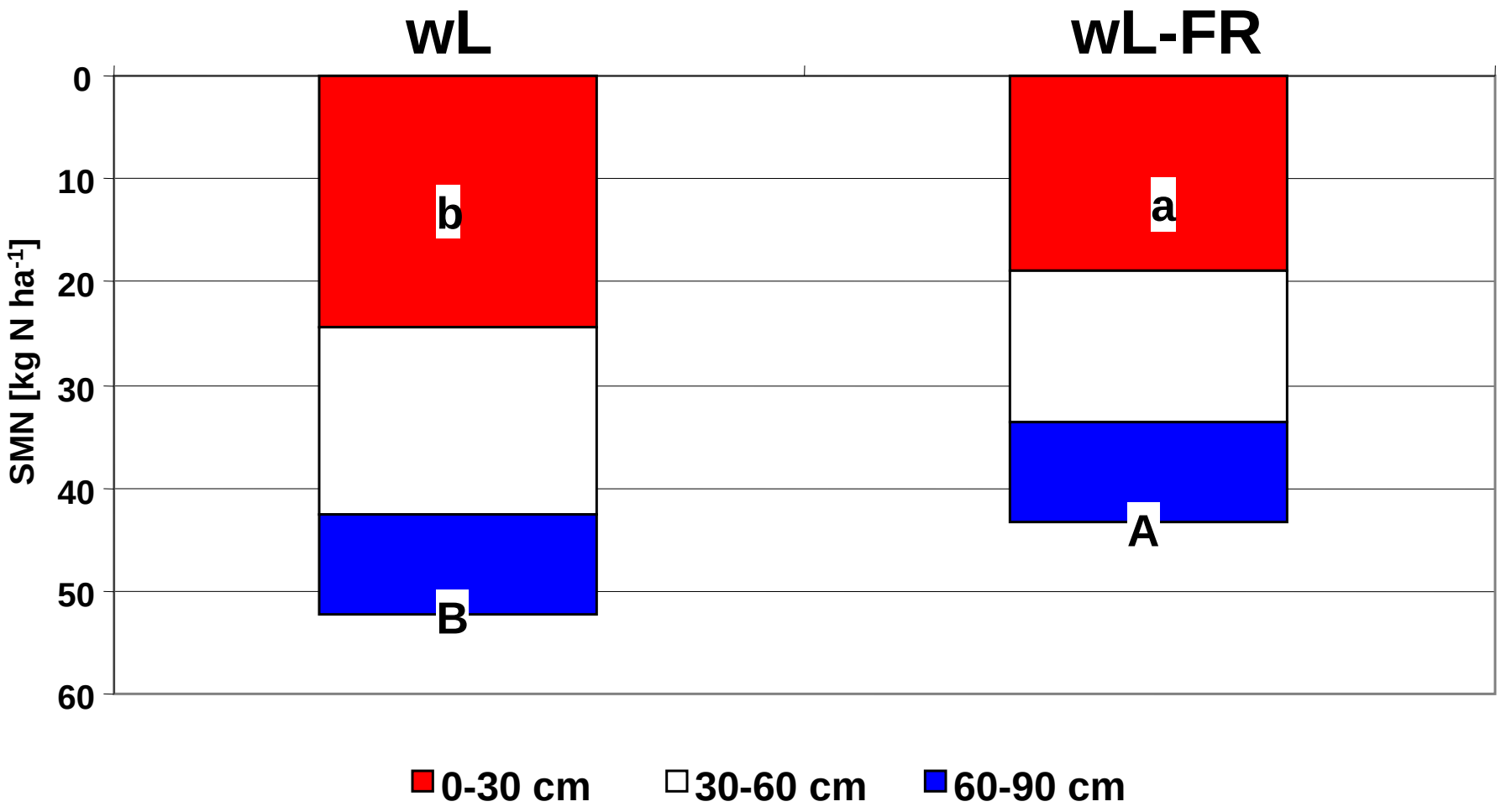
Möller 2009: Nutr. Cycl. Agroecosyst. 84, 179-202

Relative impact on crop N uptake (%)

	wL	wL-FR
CG	100	100
Potatoes	100	100
WW 3	100	117
Peas	100	100
WW 5	100	130
SW	100	117
Sum NL	100	116
Sum cereals	100	122

Stinner et al. 2008
Eur. J. Agron. 29, 125-134

Soil mineral N content in autumn at the beginning of the leaching period (Mean value crop rotation)



Möller and Stinner 2009
Eur. J. Agron. 30,1-16

Sum of soilborne N_2O-emissions of the crop rotation ($g\ N_2O\text{-}N\ ha^{-1}\ yr^{-1}$)

	wL	wL-FR
Clover Grass-ley	6,808	844
Potatoes	2,963	2,217
Winter wheat 3	761	1,748
Spring peas	1,399	944
Winter wheat 5	4,378	3,355
Spring wheat	1,175	1,800
∑ crop rotation	17,484	10,908
Mean crop rotation	2,914	1,818
Relative values (%)	100	62,4

Möller und Stinner 2009
Eur. J. Agron. 30,1-16

Conclusions: Biogas in a stockless System

- **Anaerobic digestion is a tool to get mobile manures, leading to:**
  - Significant increase of yields (+16%) and N uptake (+19%) of non-legumes
  - Significant increase of the cereal protein content (+0,6% absolute)

  <u>and simultaneously to a</u>
  - Reduction of the nitrate leaching risk (ca. 20%)
  - Reduction of soilborne N_2O-Emissions (ca. 40%)

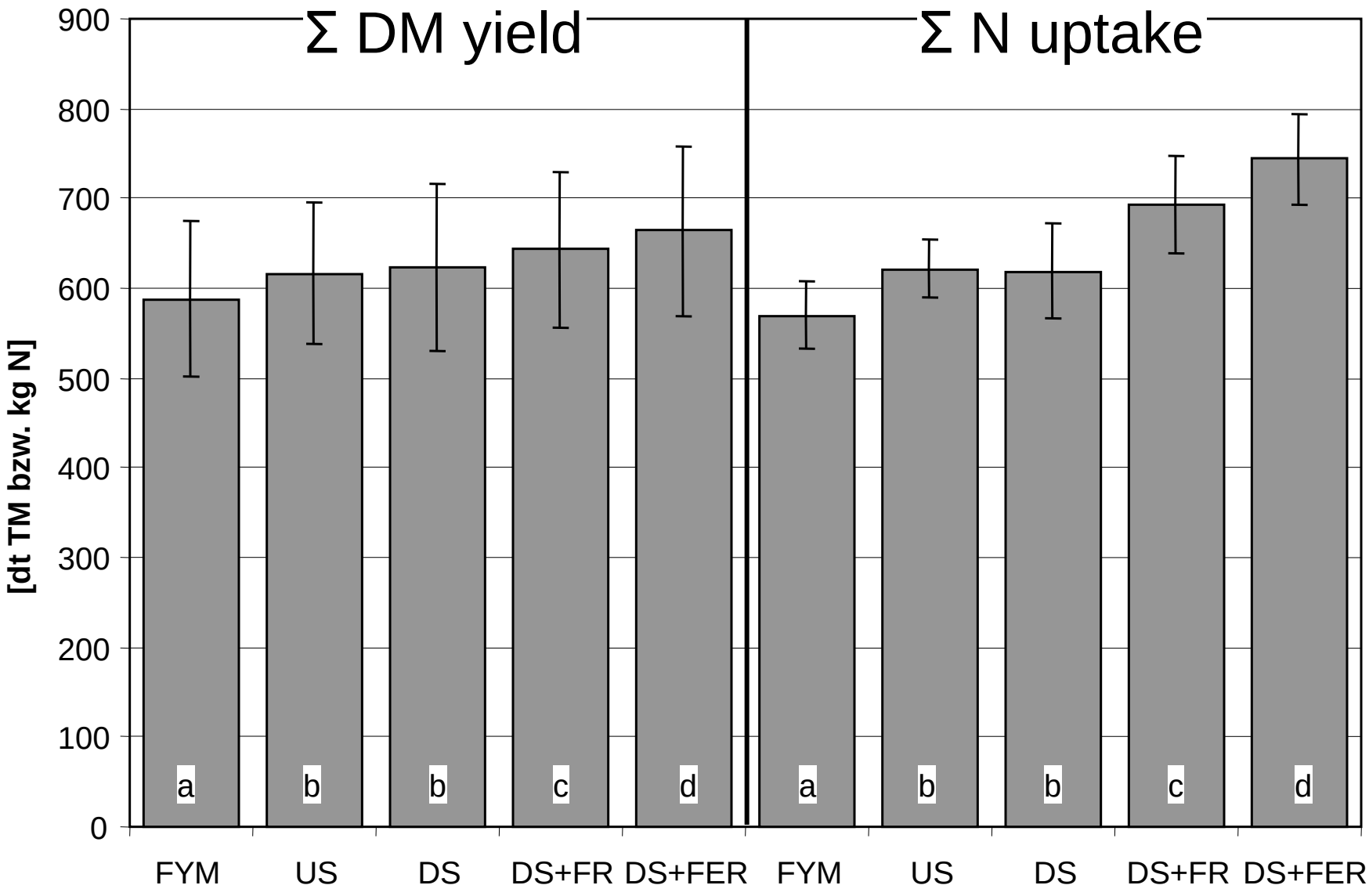
- **<u>Driving forces:</u>**
  - enhanced N-Inputs via BNF
  - Better allocation of nutrients in space and time
    - Allocation of nutrients in spring when crop N demand arises
    - Higher allocation of available manure-N towards non-legume crops, at the cost of legumes → N allocation more focused
  - Higher NUE of digested residues compared to the undigested substrates
  - lower N losses due to “safe” storage of N during the winter period

Effects of AD of animal wastes, etc. on organic matter and nutrient supply

	FYM [1)]	US	DS	DS+FR	DS+FER
Soil ODM supply (t ha^{-1})	4.9	6.2	6.0	3.7	5.0
N supplied (kg N ha^{-1})	157	172	169	173	216
Mobile N (kg N ha^{-1})	84	90	87	151	193
Non-Leg.-Manure-N (kg N ha^{-1})	225	241	239	264	336
Legume-Manure-N (kg N ha^{-1})	45	55	54	14	14
Ammonia-N (kg N ha^{-1})	18	40	44	76	85
C/N manures	15.7	18.4	17.8	11.8	13.0

[1)] including dung water (3% of P)

DM yields and N uptake by non-legume crops



Möller et al 2008: Nutr. Cycl. Agroecosyst. 82, 209-232.

Conclusions: mixed farming system

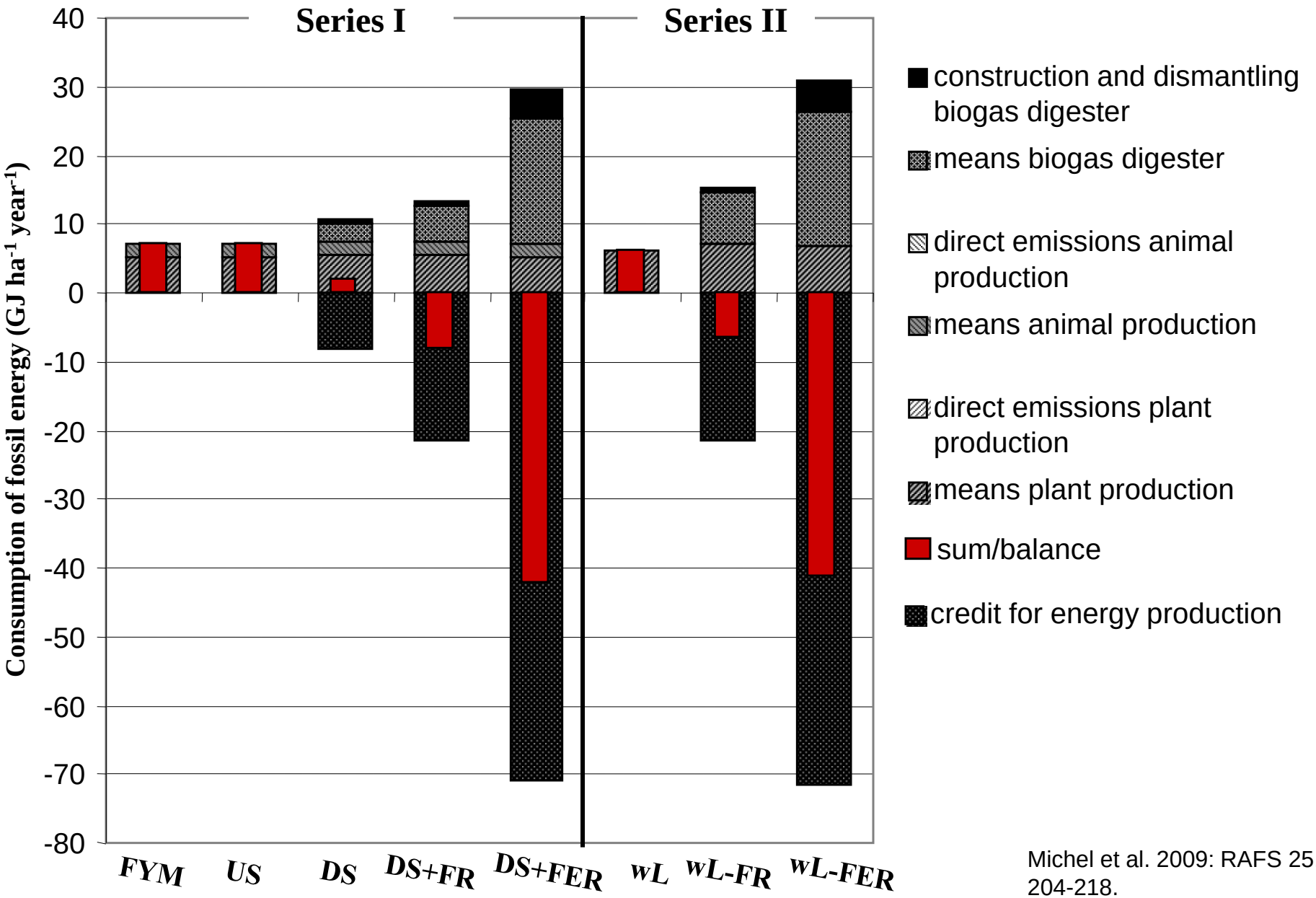
- Solid farmyard manure vs. undigested liquid slurry:
  - DM yields: -5%; N uptake: -8%
  - Nitrate leaching risk: +6%, gaseous N losses: +19%

- Digestion of liquid slurry (exclusively)
  - No effects on DM yields after surface banding
  - Significant effects only after incorporation immediately after spreading
  - No effects on overall nitrate leaching risk, tendency to lower SMN contents there where no cover crops were sown
  - Higher ammonia volatilization after surface banding

- Digestion of liquid slurry and crop residues:
  - higher mobile manure-N-pool (+54%),
  - Lower nitrate leaching risk (-8%)
  - Higher NUE by non-legumes (+12%)

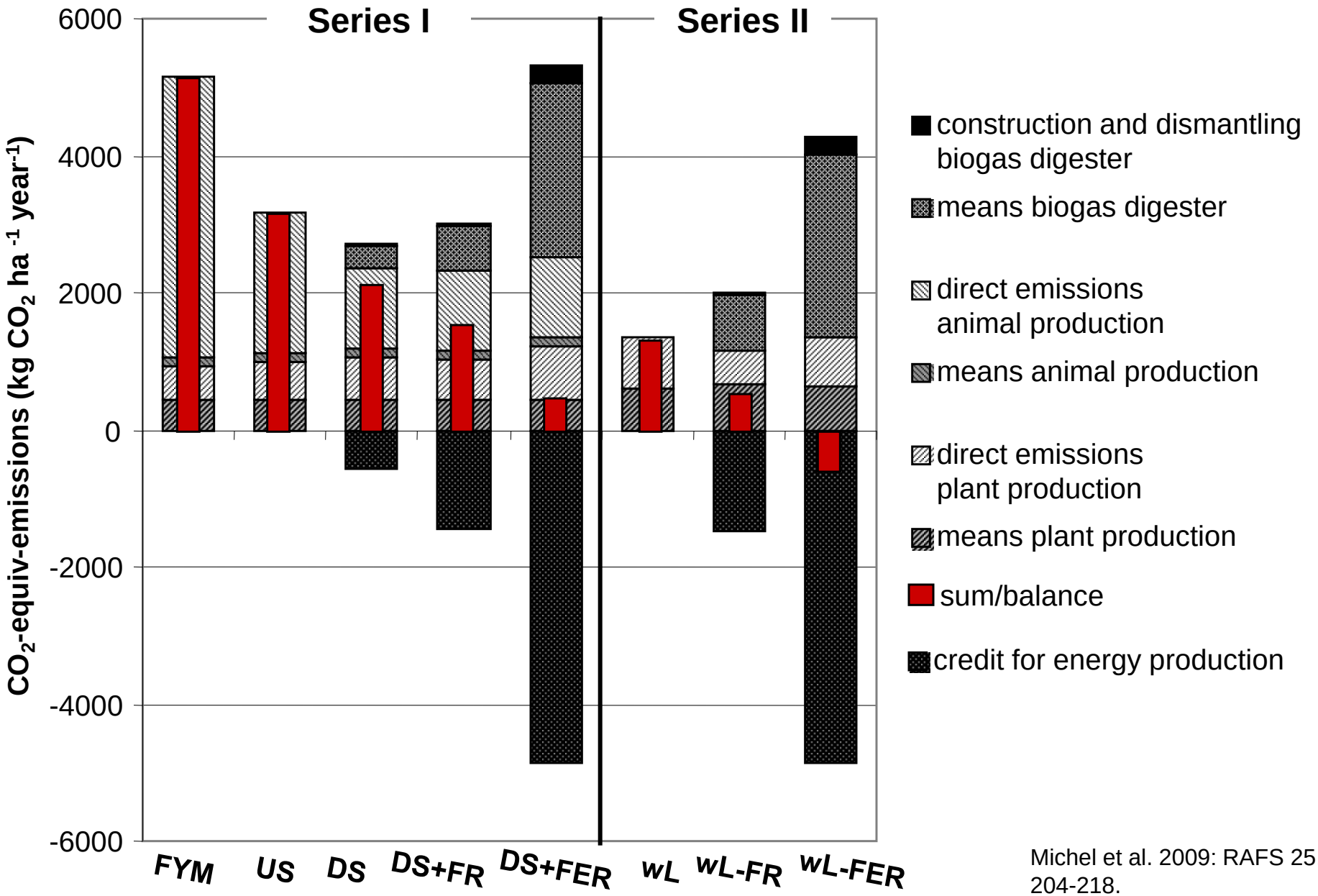
Inventory of fossil fuel consumption and greenhouse gas emissions

Inventory consumption fossil fuel energy



Michel et al. 2009: RAFS 25, 204-218.

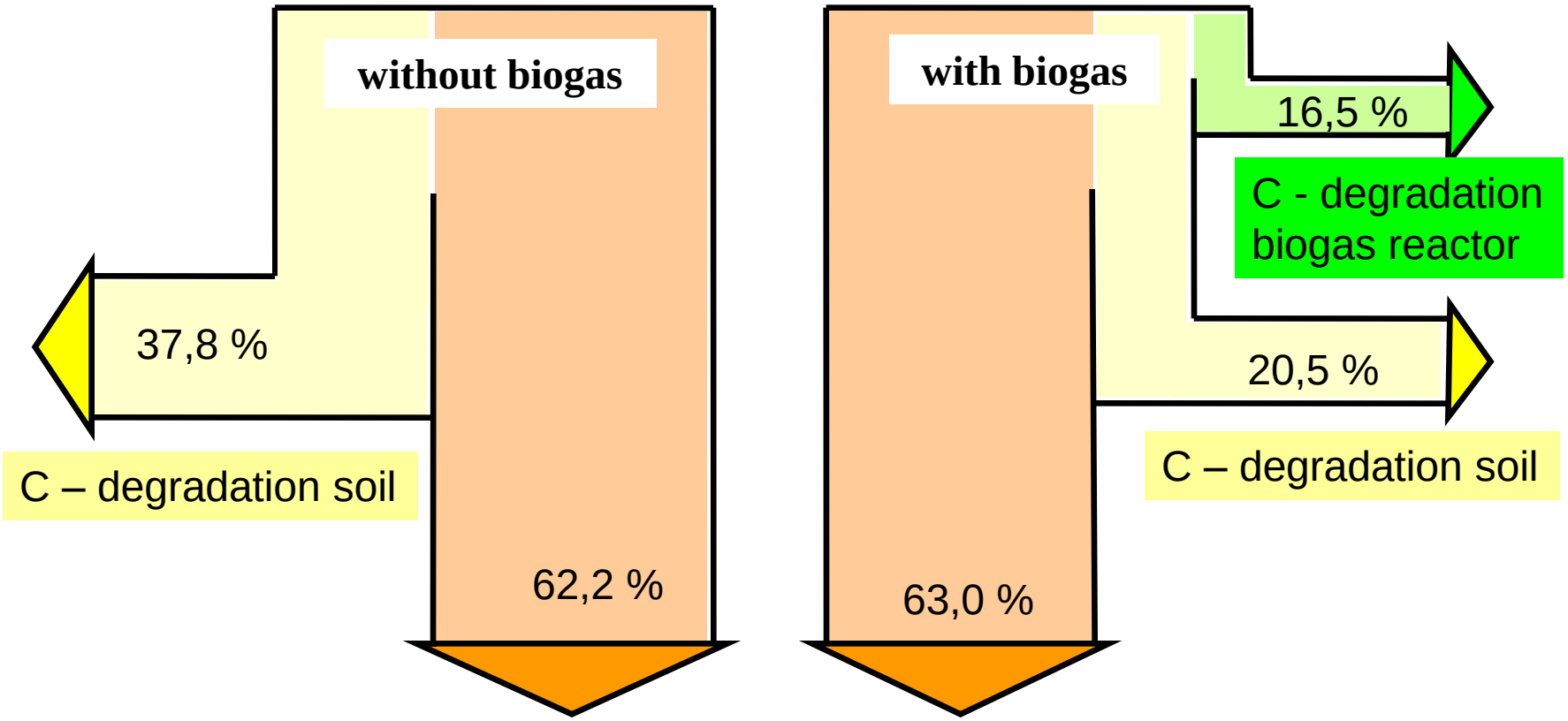
Inventory greenhouse gas emissions (Michel et al., 2009)



Michel et al. 2009: RAFS 25, 204-218.

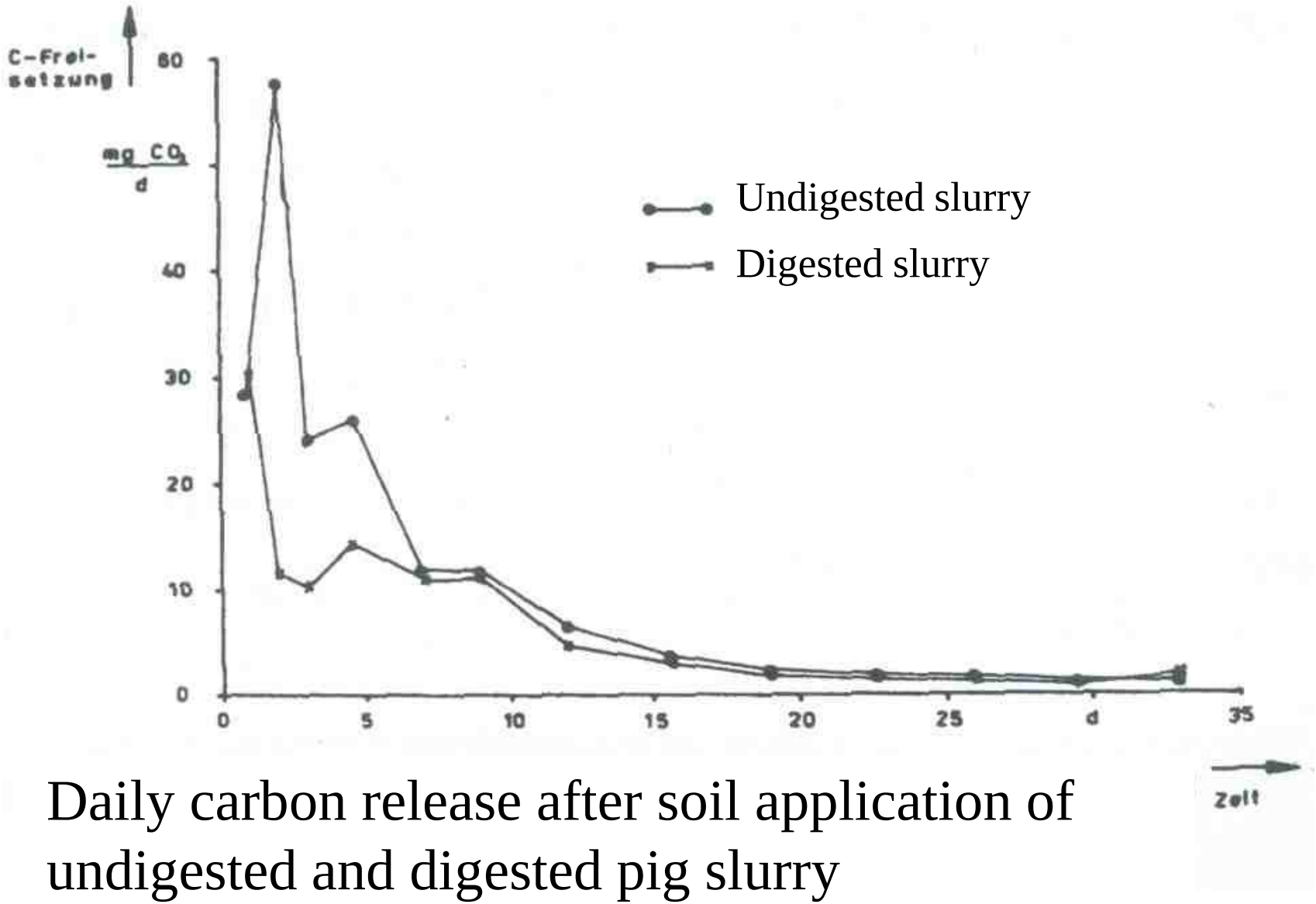
Effects on soil organic matter inputs, humus balance and soil biological activity

C-balance of Biogas (Reinhold et al., 1991)



Carbon available for the long term reproduction of the soil humus pool

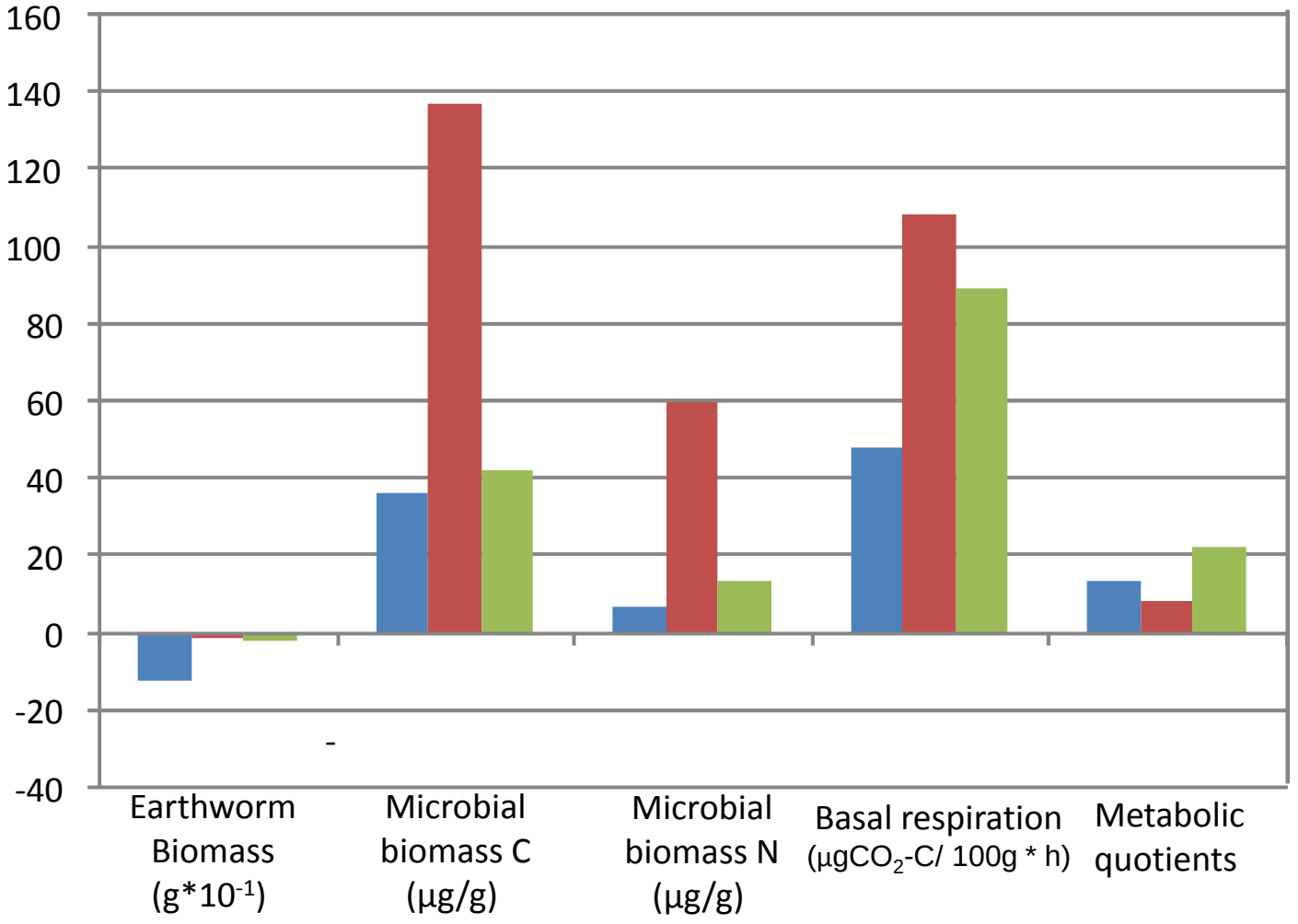
→ These results were confirmed by Sánchez et al. 2008 and Marcato et al. 2009!



Daily carbon release after soil application of undigested and digested pig slurry

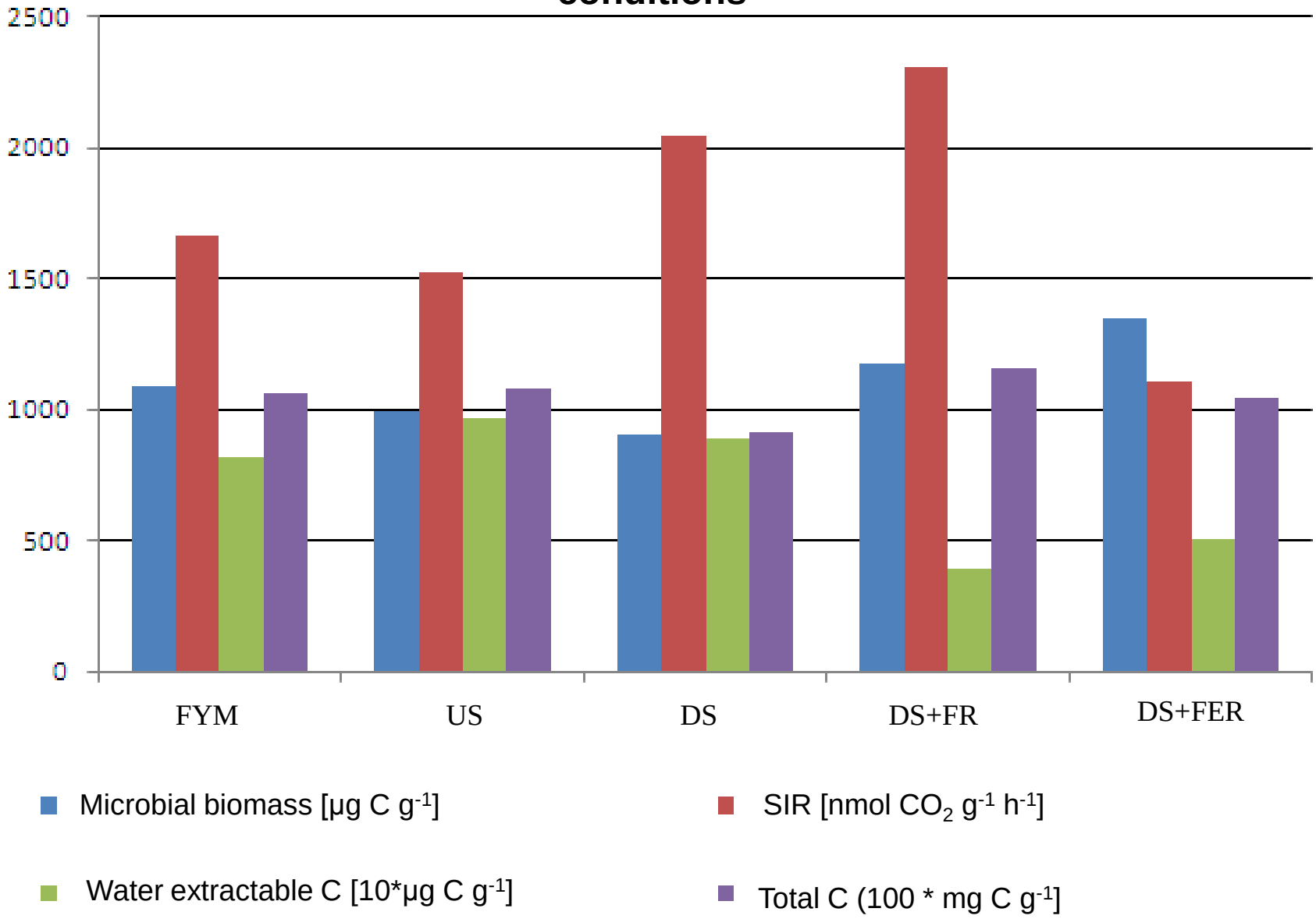
Reinhold et al 1991

Effects of undigested slurry and digestate application on soil biological activity (microcosm experiment without crop)



Ernst et al. (2011): SBB 40, 1413-1420

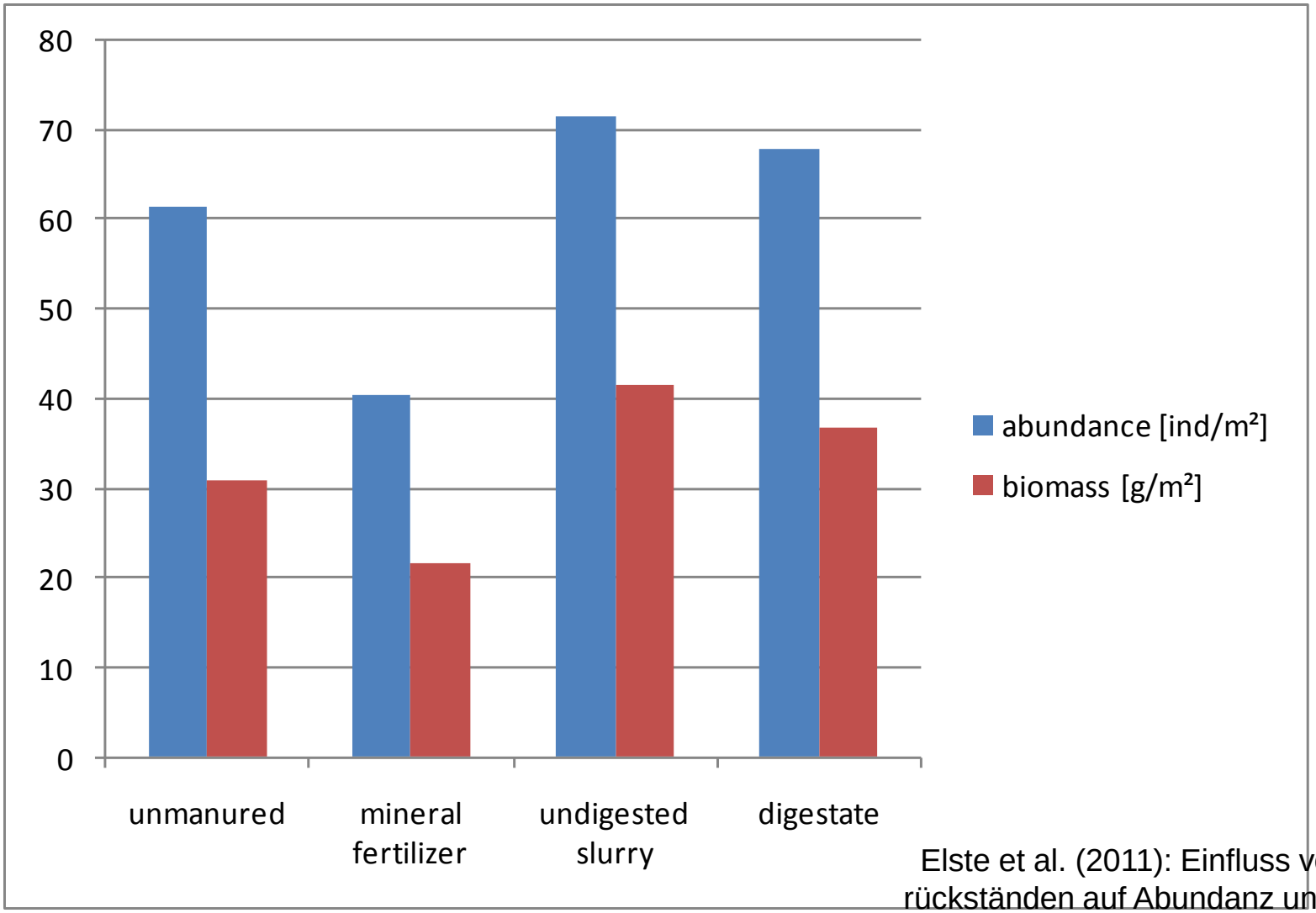
Effects of the manuring system on the microbial biomass, substrat-induced respiration, water extractable C and soil C content after 4 years under field conditions



Schauss et al 2006

Influence of manuring on earthworm abundance and biomass under field conditions

(mean of 2 experiments)



Elste et al. (2011): Einfluss von Biogas-rückständen auf Abundanz und Biomasse von Lumbriciden. Proc. Gülle 11, 213-217.

Conclusions: effects on soil humus and soil biological activity

- Digestion of animal wastes→ no effects on soil humus, effects on soil biological activity under field conditions seems to be irrelevant

- Digestion of crop residues and cover crops → unclear, humus balances still very positive due to very large org. matter inputs

- Higher recalcitrancy of organic matter in digestates

Conclusions

- **Anaerobic digestion is a very interesting tool to generate renewable energy from residues, however total energy potentials are rather low**
- **Enables strategic nutrient management and allocation**
- **It resulted in a win-win situation by enhancing yields, creating a new product and reducing the negative environmental impacts of farming activities**
- **Effects on the soil humus balance will depend on the performed/replaced cropping system**

Thank you for your attention