



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs DEA
Agroscope Reckenholz-Tänikon Research Station ART

LCA of energy crops from the perspective of a multifunctional agriculture

R. Freiermuth Knuchel, T. Kägi, G. Gaillard, Agroscope ART
Th. Hölscher, K. Müller-Sämman, Agentur ANNA
S. Deimling, PE International



PE INTERNATIONAL
EXPERTS IN SUSTAINABILITY

Life Cycle Management Conference 2007
28/08/2007



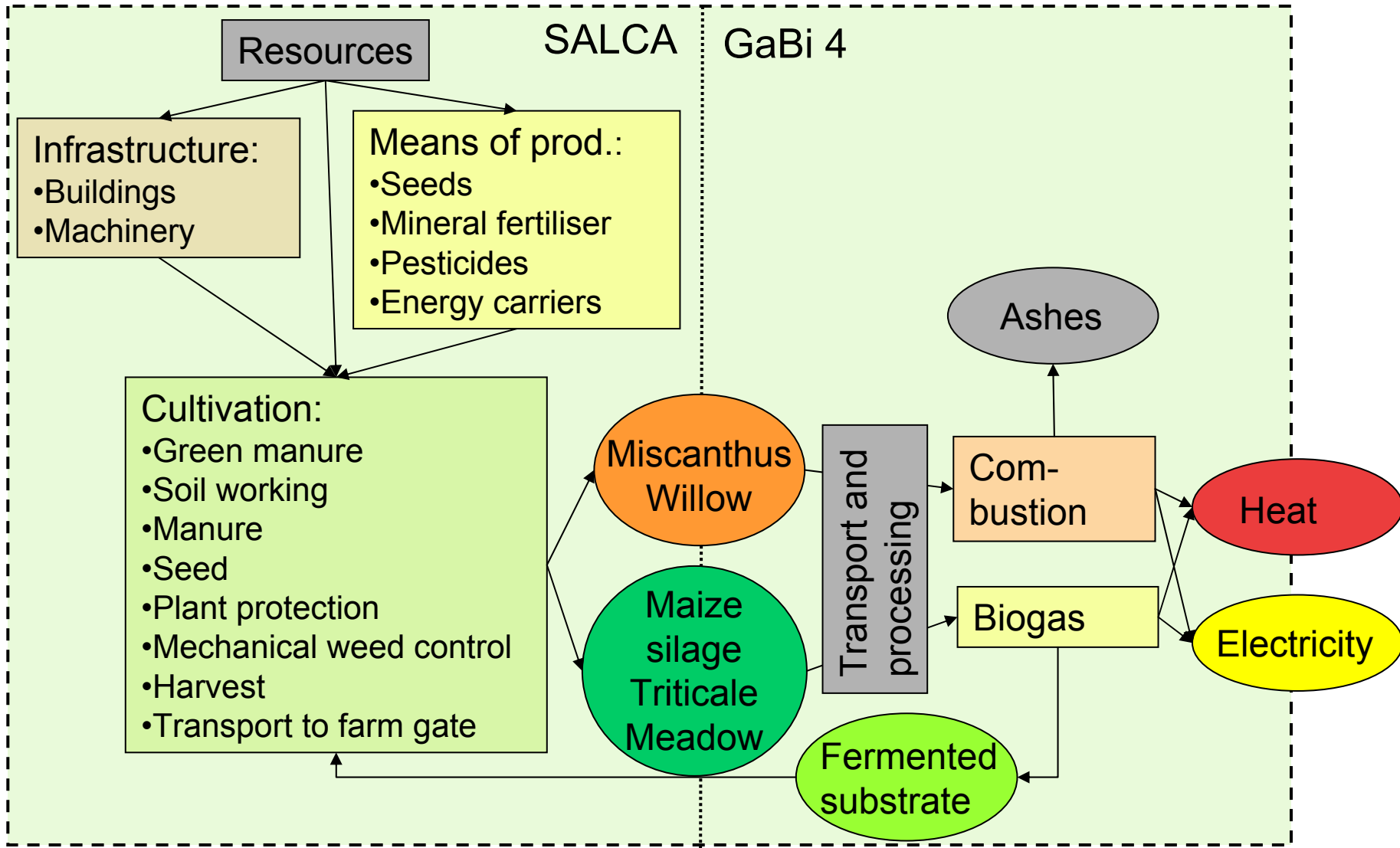
ART

Background & Aim of the Project

- **Partners:** Agentur ANNA (D), PE International GmbH (D) and Agroscope Reckenholz-Tänikon ART (CH)
- **Funding:** Innovation fund of badenova AG & Co. KG
 - Energy and water supplier in Southern Germany
 - Supports regional research projects for a sustainable water and energy use
- **Aim:**
 - Elaboration of a funded decision basis for the choice of ecologically and economically favourable bioenergy carriers
 - Evaluation of the impact on the environment when substituting food with energy crops. Focus on nitrate leaching
 - Site specific (German upper Rhine Valley)



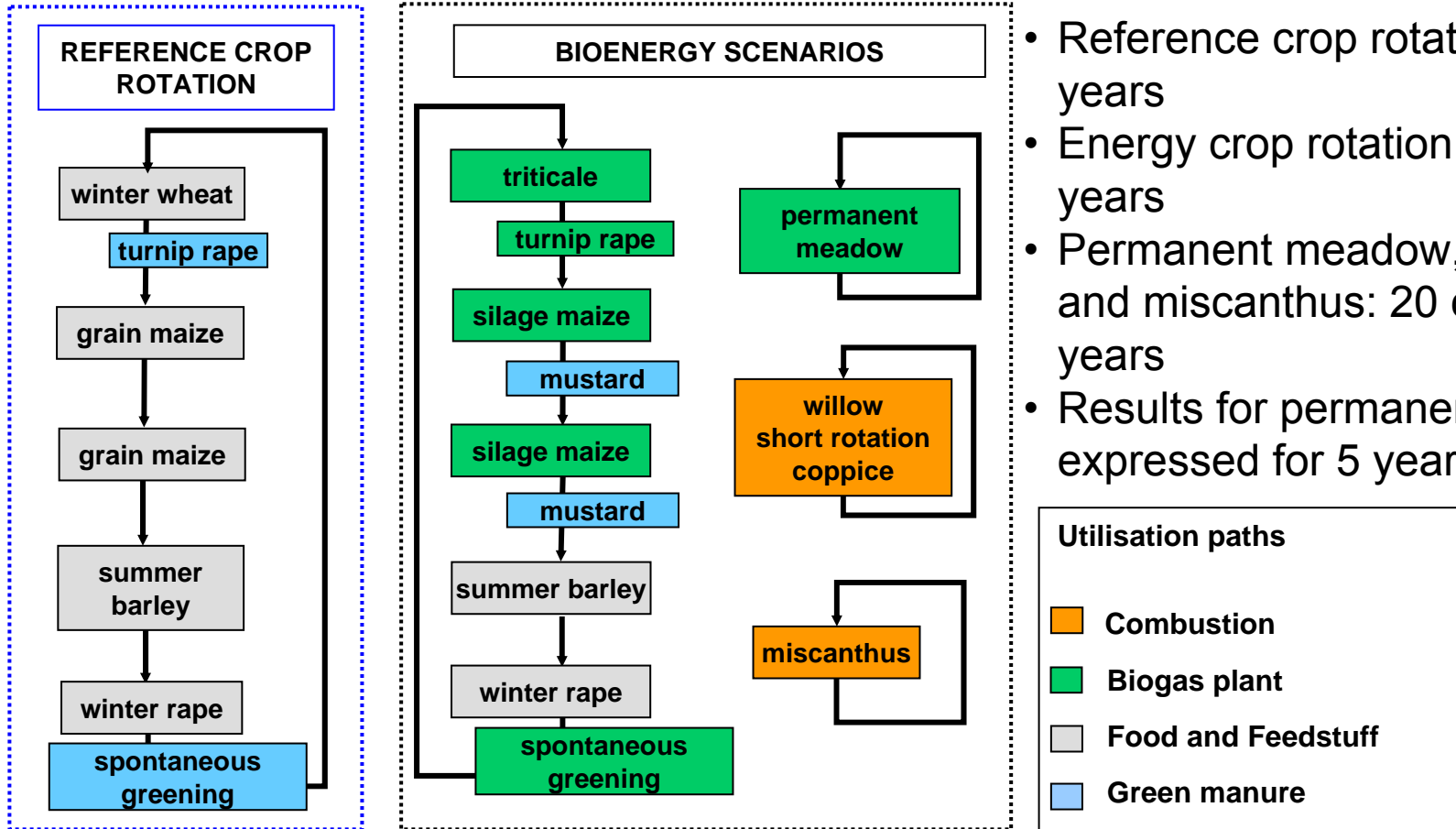
Materials & Methods: System boundary





Materials & Methods: System description

ART



- Reference crop rotation over 5 years
- Energy crop rotation over 5 years
- Permanent meadow, willow and miscanthus: 20 cultivation years
- Results for permanent cultures expressed for 5 years



Materials & Methods: LCA

- Life cycle inventory
 - Site specific management data
 - Inventory: ecoinvent-database Version 1.2 (Frischknecht et al. 2004), SALCA-database (Nemecek et al. 2004; Nemecek & Erzinger 2005) and GaBi-database (PE International)
- Impact categories (Midpoint)
 - Global warming potential (IPCC) → Terrestrial ecotoxicity (EDIP97)
 - Ozone formation (EDIP97) → Aquatic ecotoxicity (EDIP97)
 - Acidification (EDIP97) → Human toxicity (CML 01)
 - Eutrophication (EDIP97)
 - Non renewable energy demand (ecoinvent)
 - Renewable energy demand (CML 01)
- Calculation:
 - Agriculture: SALCA (Swiss Agricultural Life Cycle Assessment), based on software TEAM
 - Energetic conversion: GaBi 4 (Product Sustainability software)



ART

Results 1: Agricultural cultivation

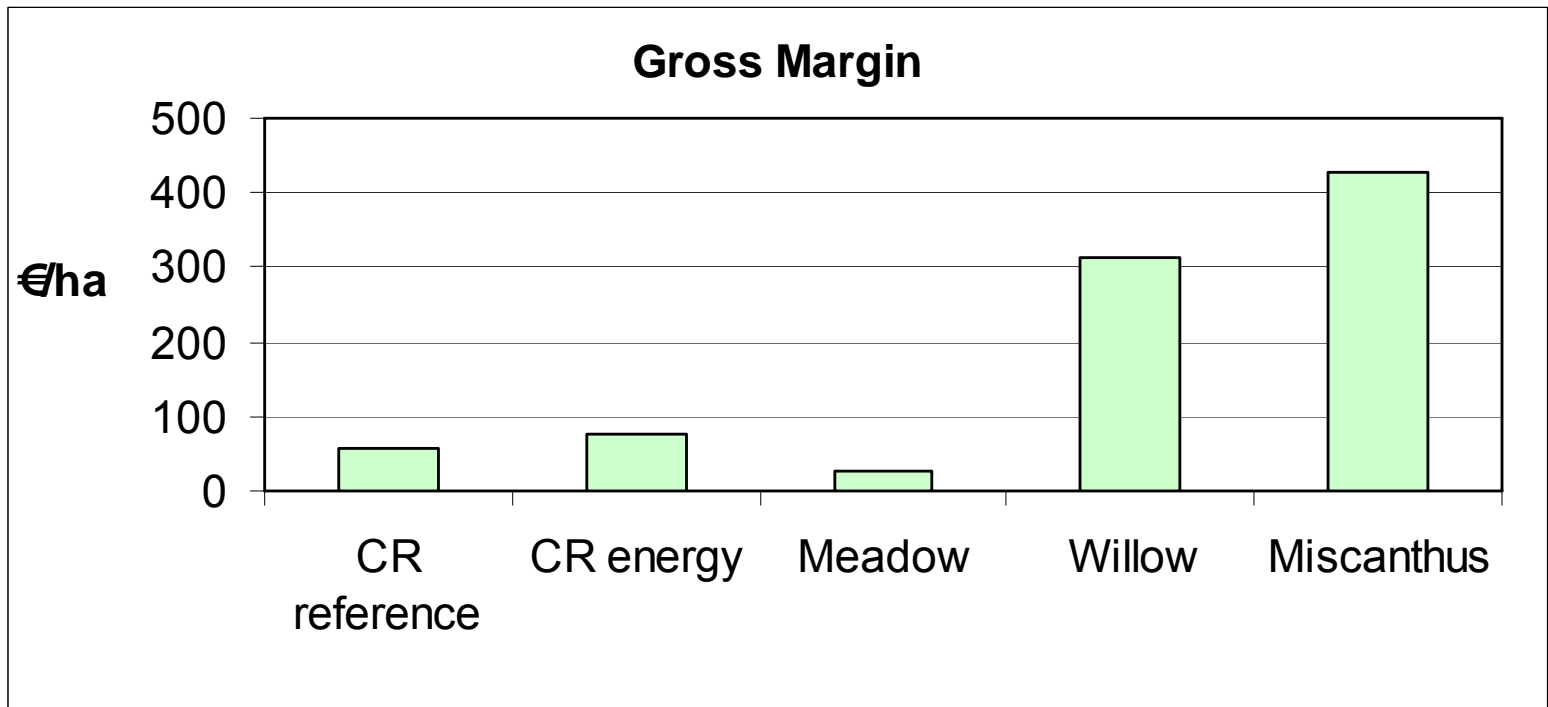
Functional Unit: kg oDM*5yr.		CR reference	CR energy	Meadow	Miscan- thus	Willow
Impact category	unit	absolute	% of Reference			
non ren. energy demand	MJ-eq.	3.188	60	36	21	16
Global warming pot. (100 y.)	kg CO2-eq.	0.556	53	28	16	11
Ozone formation	kg Ethylene-eq.	0.000	70	45	23	22
Acidification	kg SO2-eq.	0.003	261	435	20	12
Eutrophication	kg N-eq.	0.011	89	62	19	18
Terrestrial ecotoxicity	Tox. points	0.056	44	7	21	16
Aquatic ecotoxicity	Tox. points	0.425	54	11	4	4
Human toxicity	Tox. points	0.009	57	39	21	18
Direct nitrate leaching	kg N	0.007	69	0	18	16
Yield	kg oDM/ha	32542	178	116	232	164

Legend: similar better much better worse

- Lowest impact for miscanthus and willow, comparable for CR energy thanks to high yield
- CR energy and meadow: High impact for acidification due to ammonia emissions from fermented substrate
- For functional unit ha: CR energy higher nitrate leaching and higher impact for ozone formation, acidification and eutrophication than CR reference



Results 2: Agric. cultivation / Economy

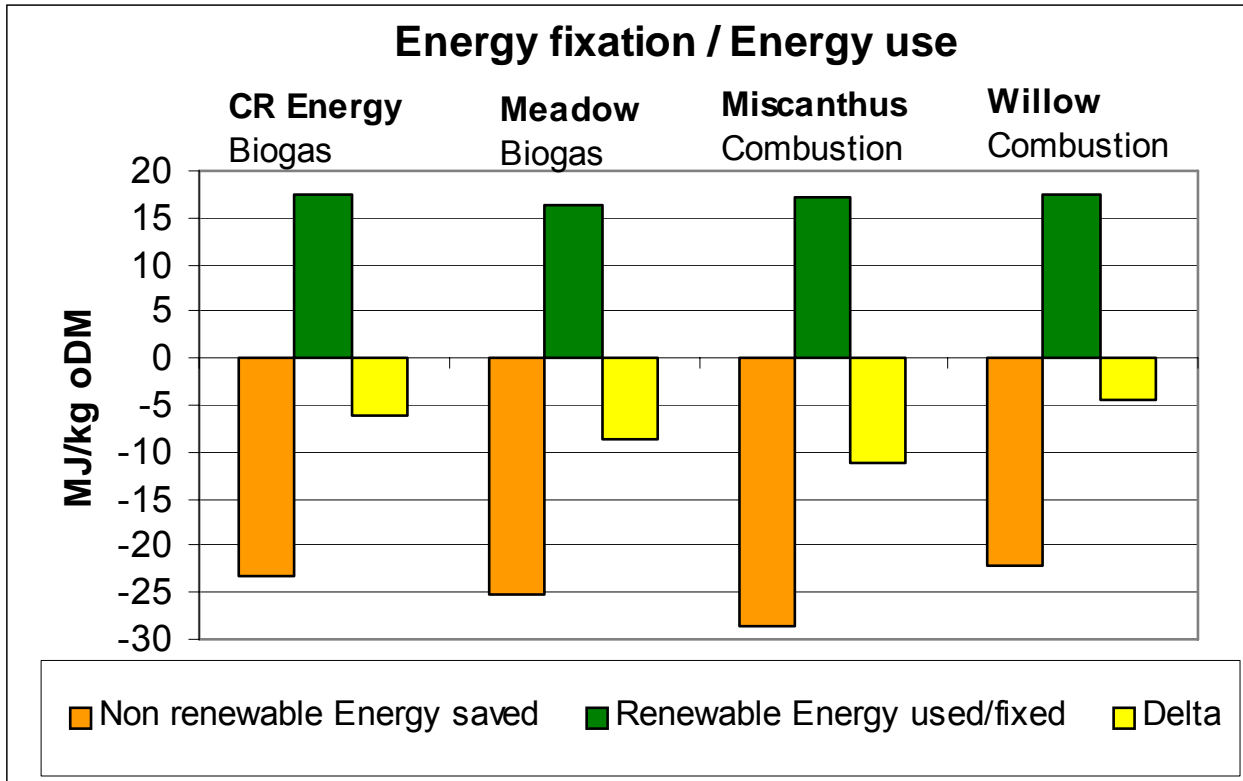


Comparison of full costs shows:

- Miscanthus is the cheapest biomass
- Willow needs to be dried which leads to higher costs
- Permanent meadow has a very low productivity and therefore the highest full costs.



Results 3: Energetic conversion

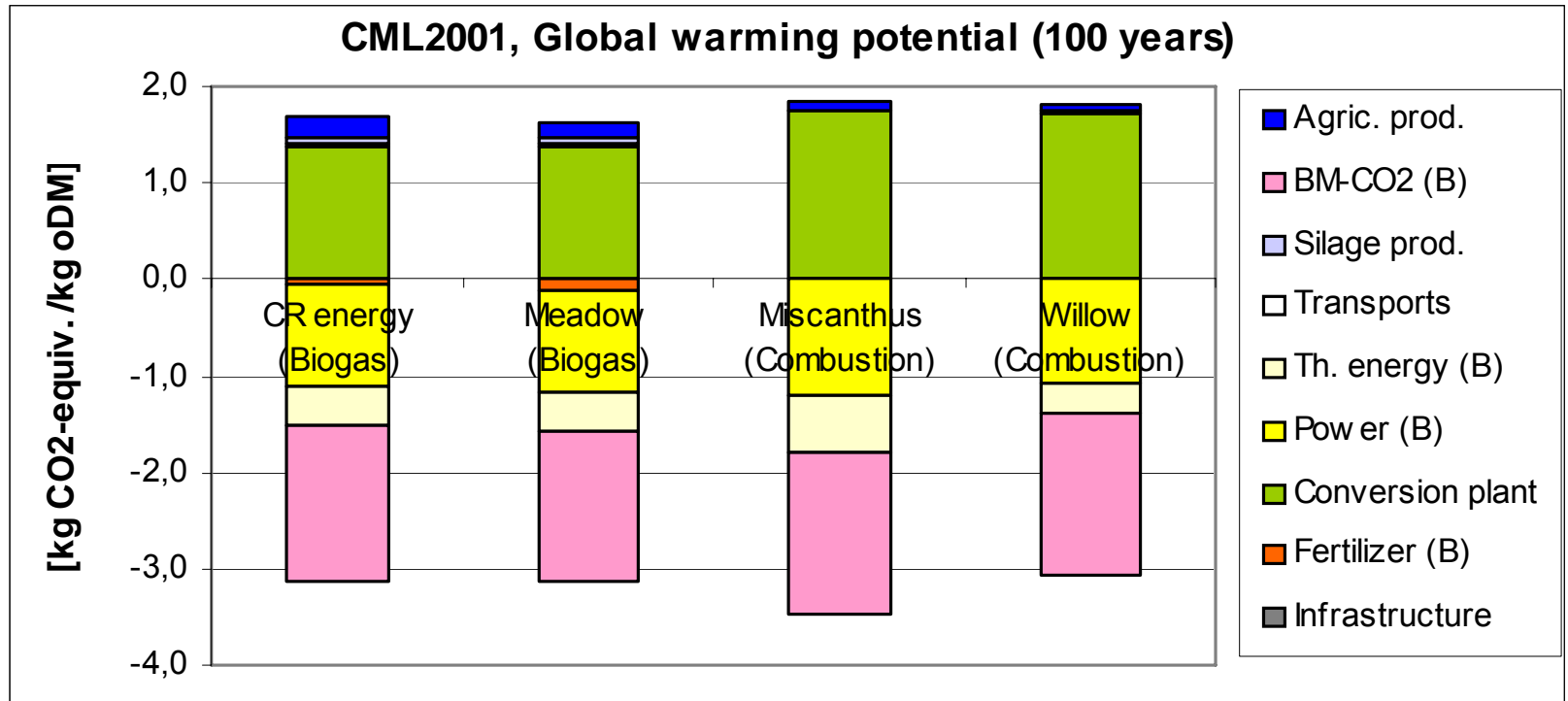


- All options show a saving potential, which is highest for miscanthus followed by meadow, CR energy and willow
- The saving potential is e.g. due to substitution of fertilisers with fermented substrate and the combination of electricity/heat production



ART

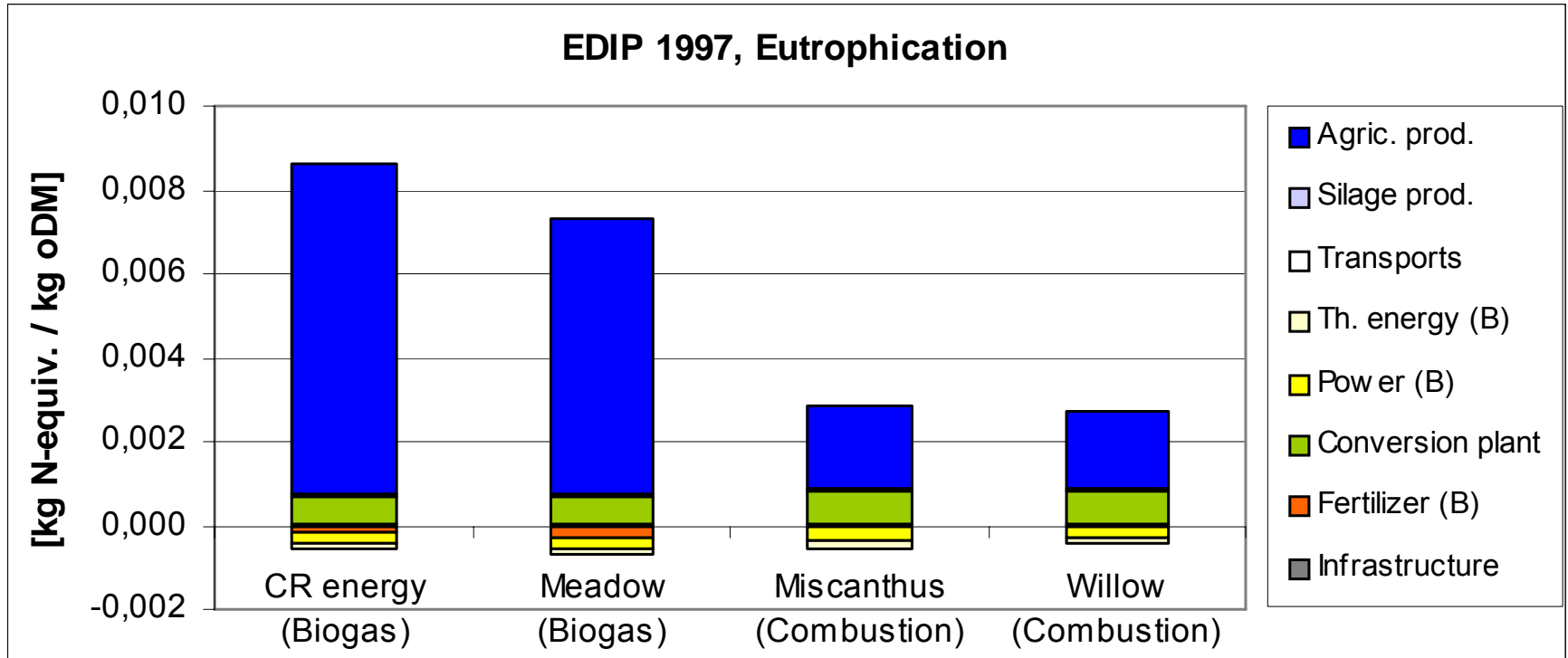
Results 4: Global warming potential



- Absolute CO₂ reduction potential ranges from -1.27 to -1.63 kg CO₂/kg oDM
- Dominant are emissions from conversion plant and the benefit (B) for substituting fossil energy carriers
- Transportation, silage production and infrastructure play a minor role for global warming potential

Results 5: Eutrophication

ART



- Eutrophication and acidification: the agricultural production plays a dominant role



Conclusions

- Double conflict:
 - Production of bioenergy vs. Nitrate leaching
 - Current practice vs. Nitrate leaching
- LCA results depend on the functional unit chosen showing the conflict of interests between the functions of agriculture (land use, productive and financial function).
- Miscanthus and willow allow a resource and groundwater protecting production of bioenergy. Permanent meadow has the same effect but the yield is lower.
- Looking at the whole system, Miscanthus allows the biggest reduction of CO₂-emissions compared to the use of fossil energy carriers and is from the economic point of view most favourable.



ART

Thanks

- To Thomas Hölscher (Agentur ANNA) for leading the project
- To the partners Sabine Deimling (PE International GmbH), Karl Müller-Sämman (Agentur ANNA), Thomas Kägi, Gérard Gaillard and Thomas Nemecek (ART)



PE INTERNATIONAL
EXPERTS IN SUSTAINABILITY

- To badenova AG & Co. KG for funding the project

... and for your attention!