Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

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Grass and grass-legume biomass as biogas substrate

Environmental and economic sustainability at different cultivation intensities

Thomas Prade

IBBA workshop, Esbjerg, Denmark, 25 August 2016

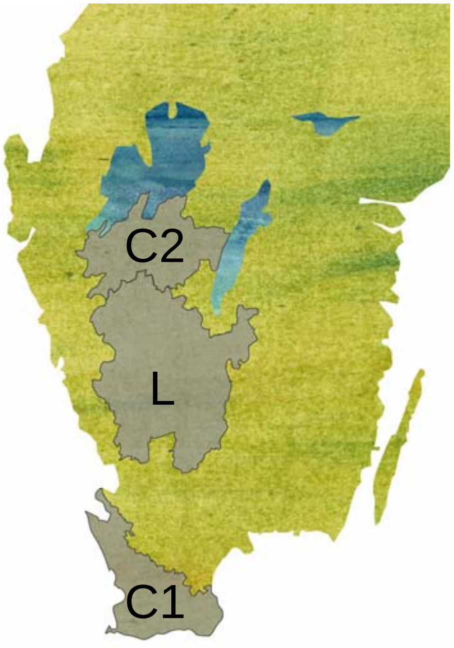
Grass in crop rotations

- Binds carbon in the soil…
- … which leads to improved cultivating properties (yield level, nitrogen efficiency, soil structure)
- Pre-crop effect

What are the environmental and economic effects of <u>intensive</u> grass cultivation?

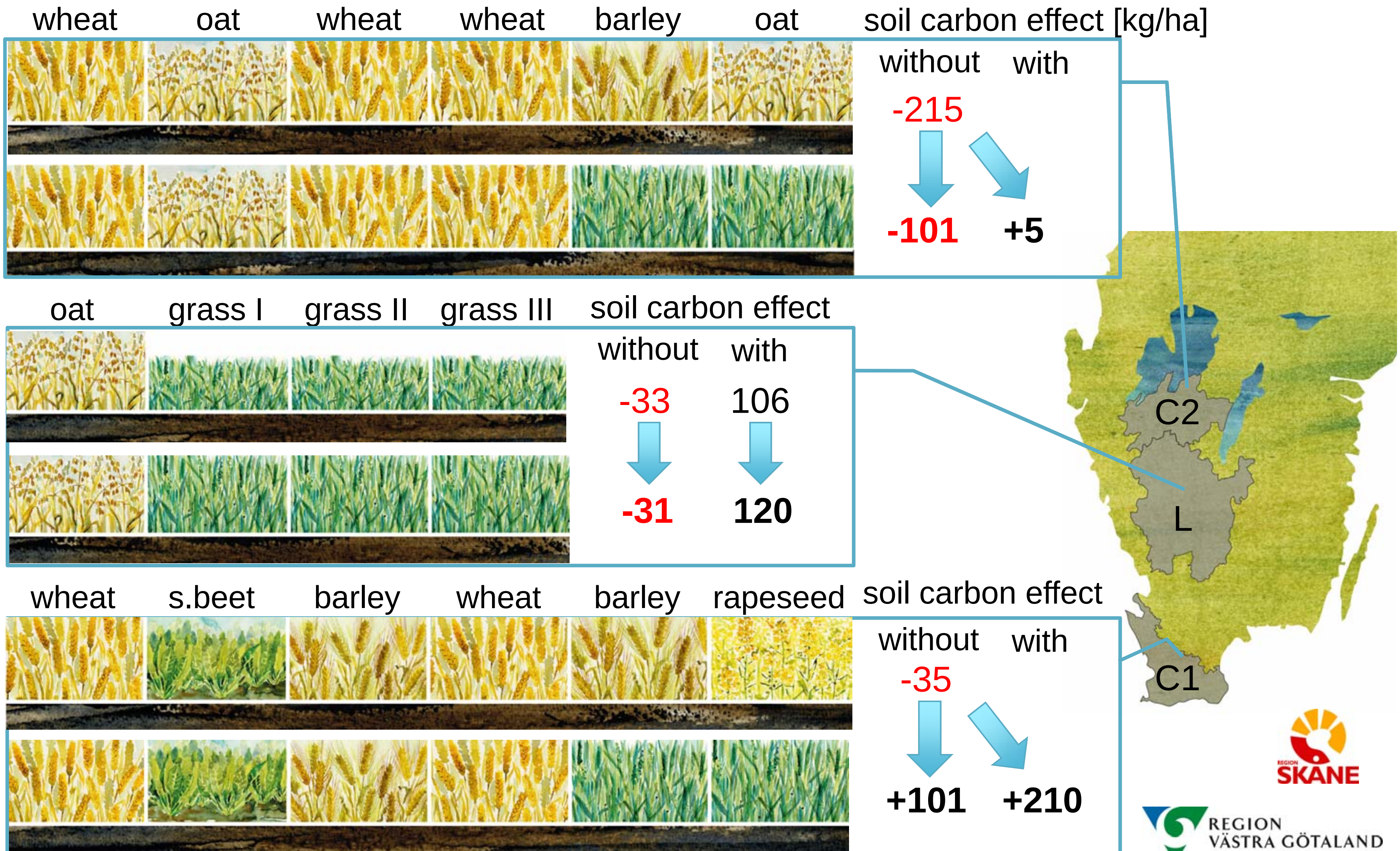
Regions

Focus	Cereal share	Grass share
Cereal production	High	Low
Livestock production	Low	High



Björnsson, L., Prade, T., and Lantz, M., 2016. *Grass for biogas - Arable land as carbon sink. An environmental and economic assessment of carbon sequestration in arable land through introduction of grass for biogas production*, Energiforsk, Stockholm, Sweden. Illustrationer: Anna Persson.

How much can grass contribute?



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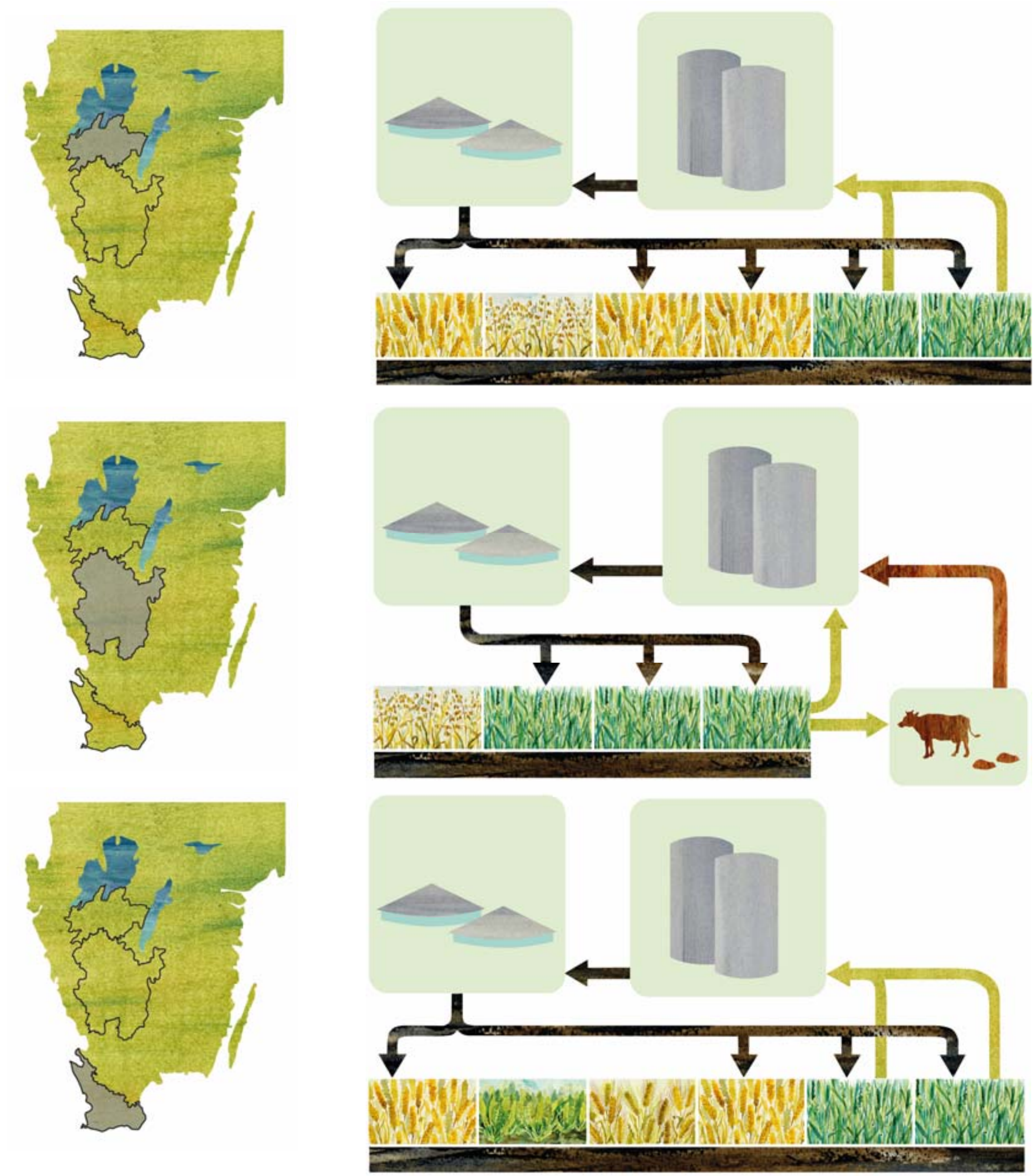
Grass as a biogas substrate



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Economic effects

- Soil organic carbon
  * higher N-efficiency
  * better soil structure
  * lower risk for soil compaction

Benefit for the farmer

- Reduction of greenhouse gas emissions

Climate benefit

- Revenues from sale as biogas substrate

Should cover the costs

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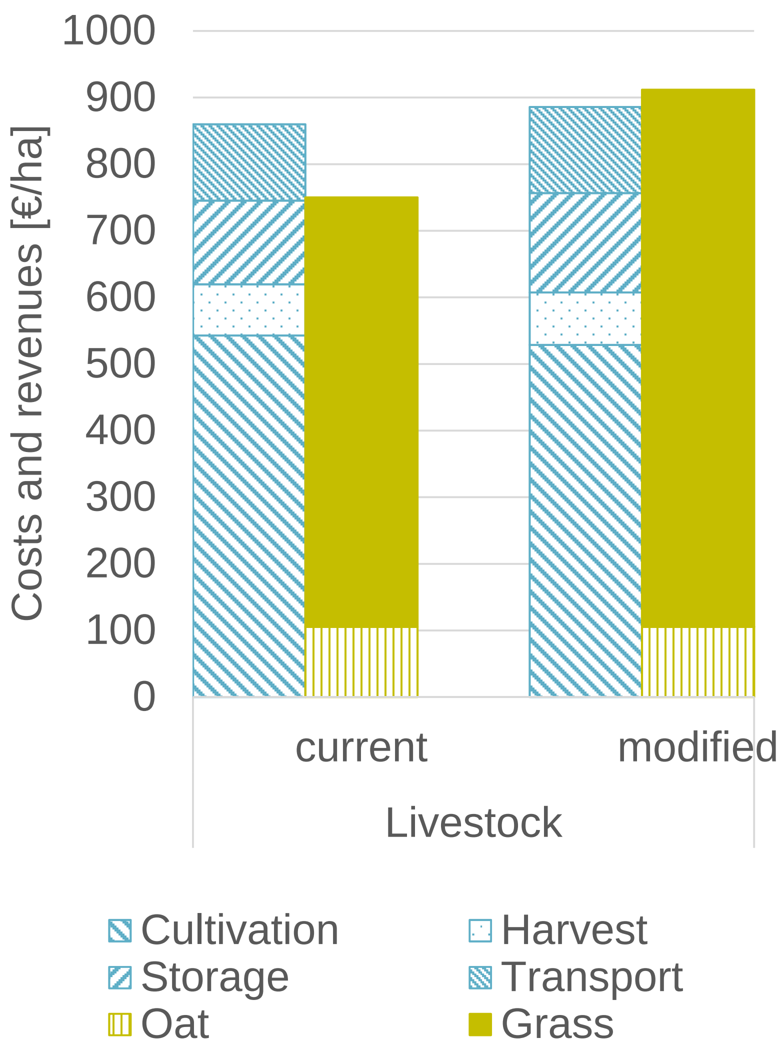
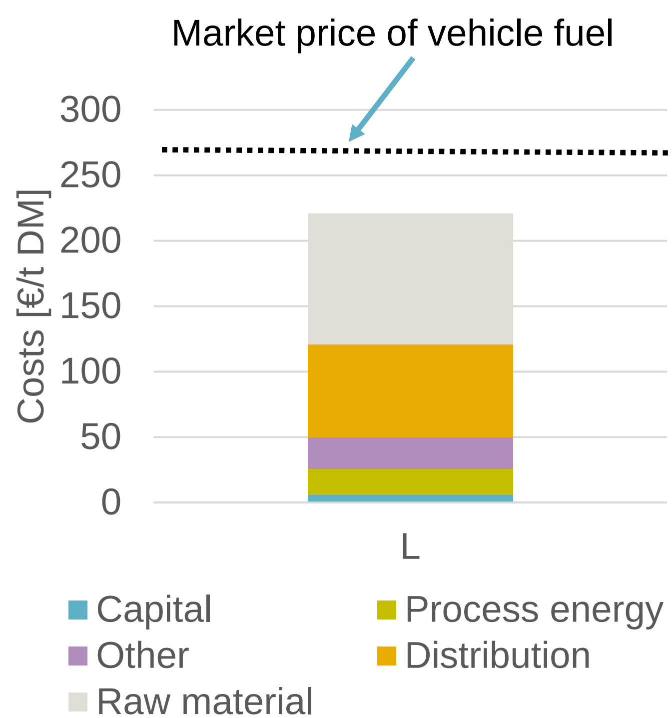
Economic result – L region



- Internal feed costs assumed unchanged
- A reasonable price for biogas substrate is 1 kr/kg (~110 €/t)

➔ The economic result was improved!



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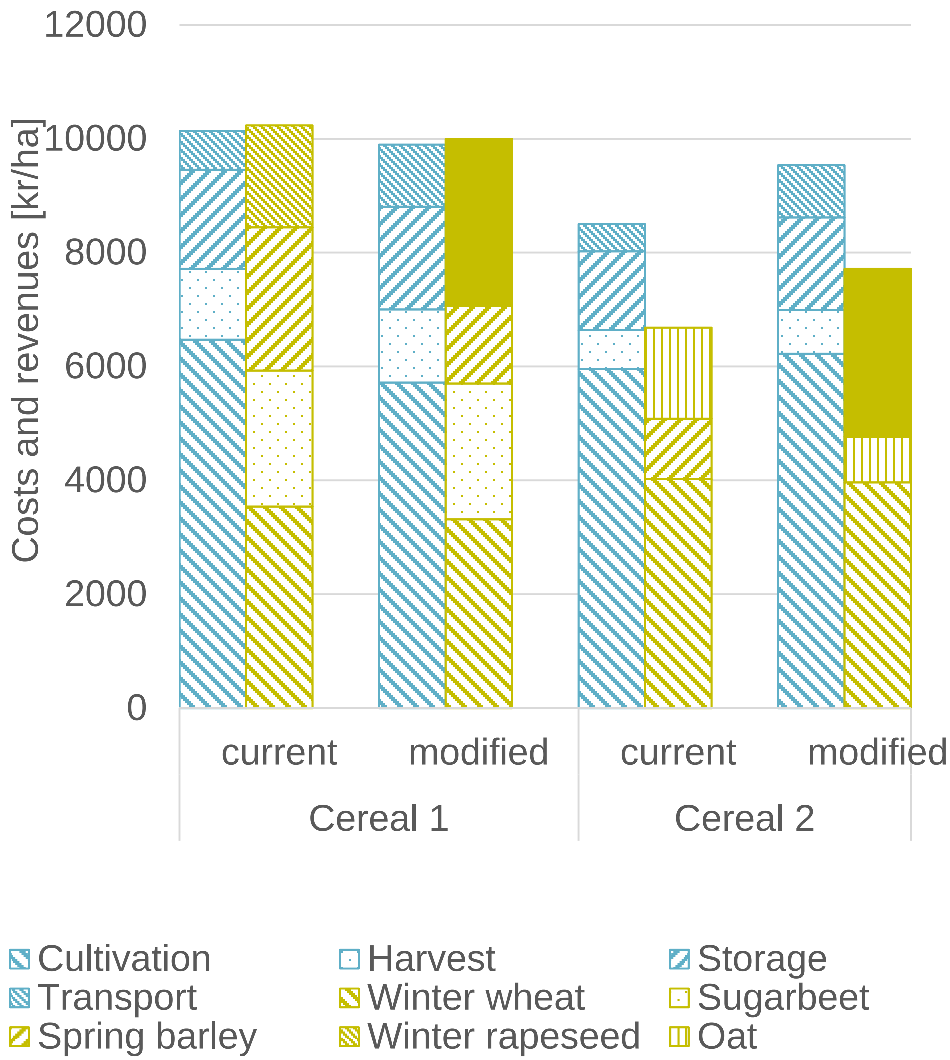
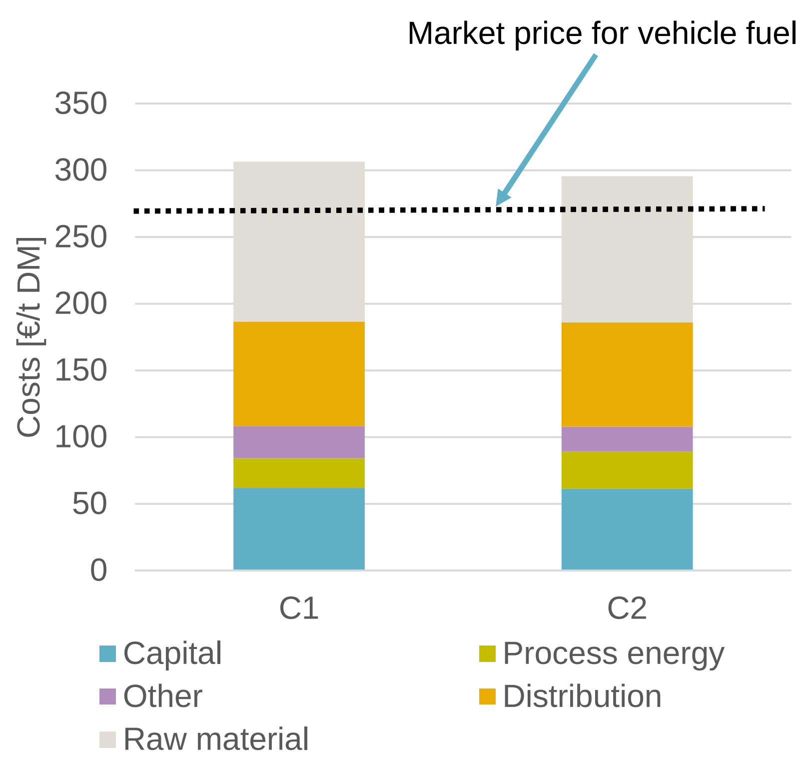
Economic result C regions



- An unchanged economic result was assumed
- The minimum price for grass as biogas substrate was calculated



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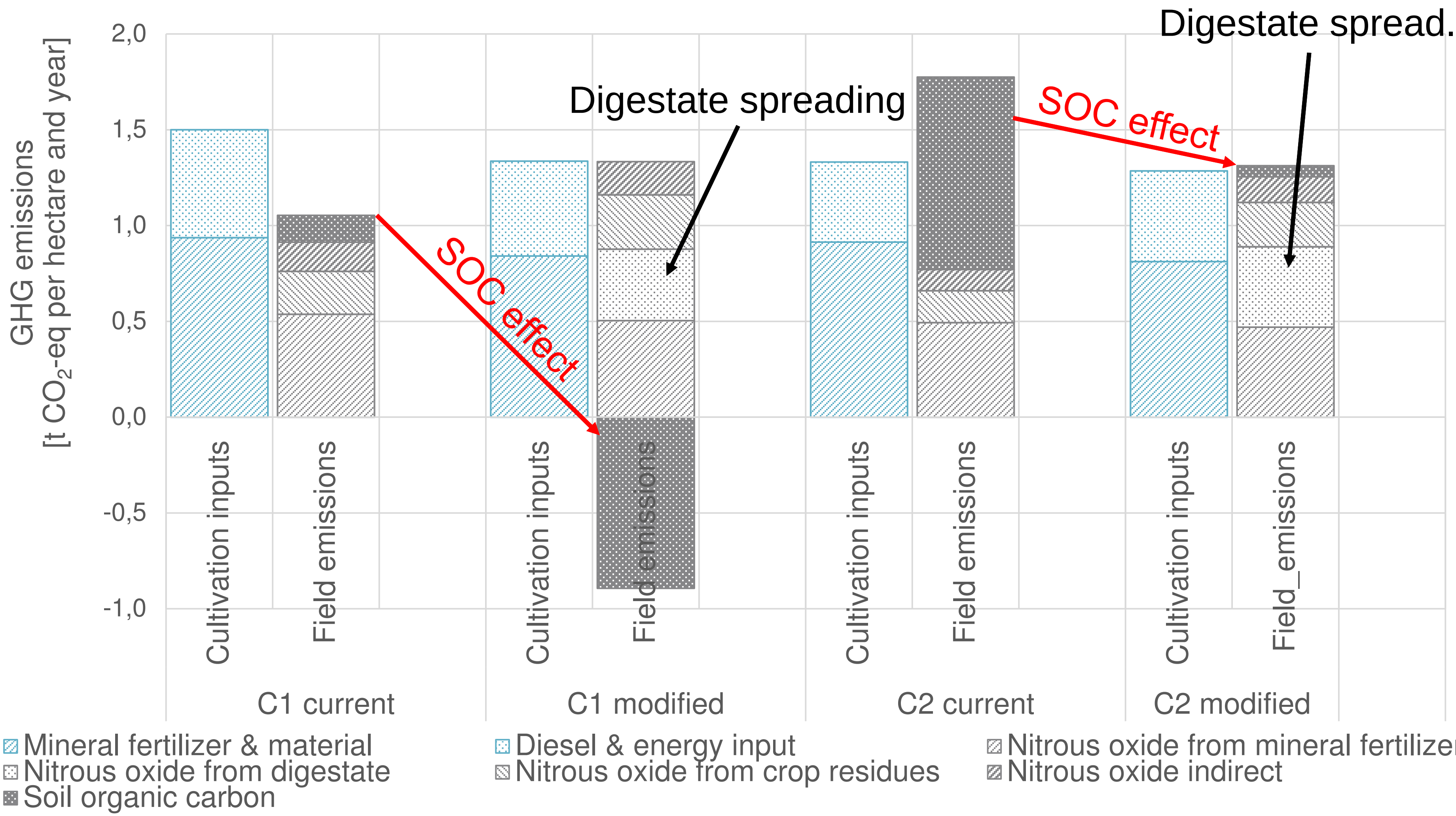
GHG emissions ISO-LCA



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GHG emissions – field-to-fuel

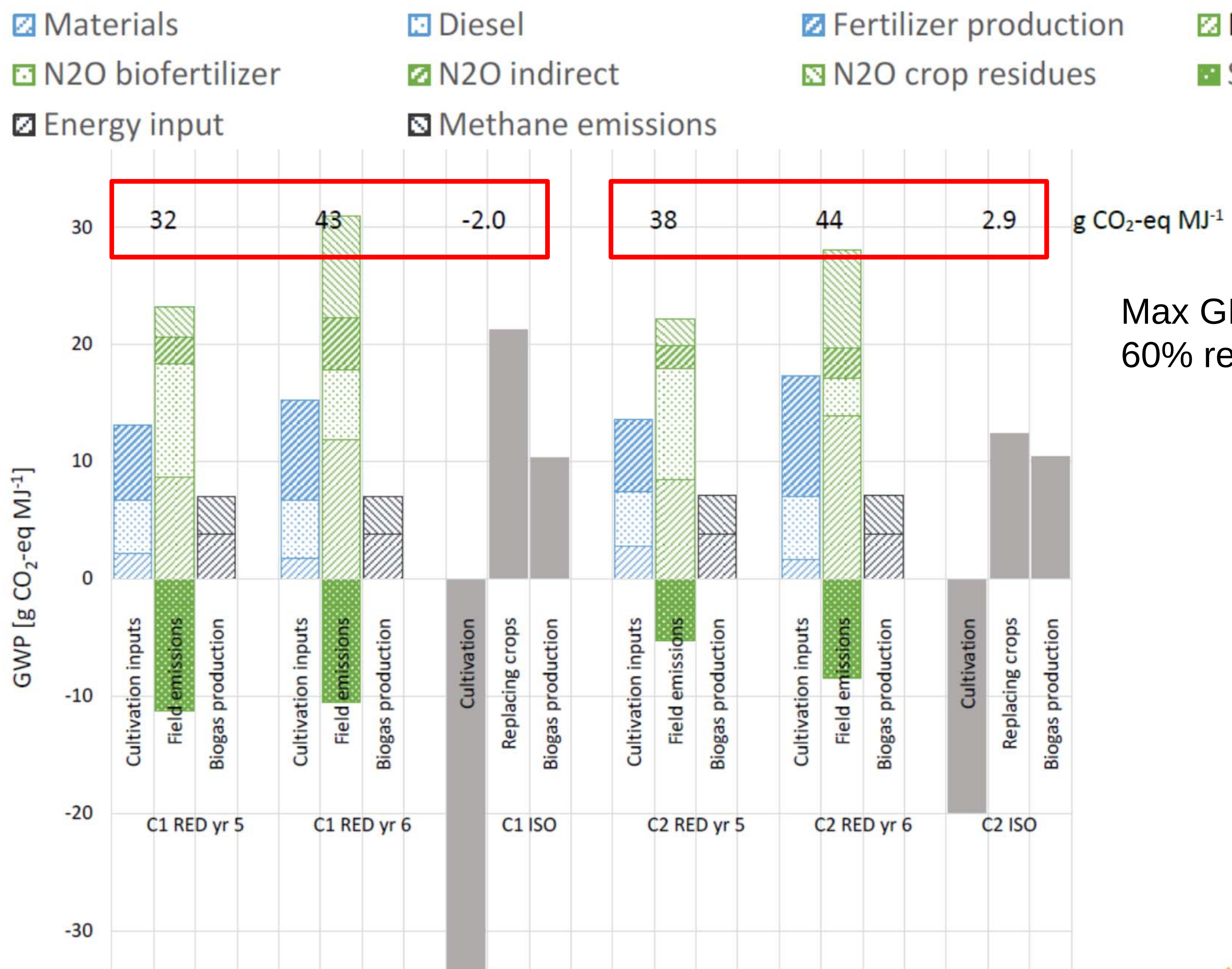
Field-to-fuel GHG emission reductions in the modified crop rotation compared to current crop rotation:

C1 1500 kg/ha/a CO_2-equivalents
C2 1600 kg/ha/a CO_2-equivalents

Carbon source/sink	ISO LCA	EU-RED
Electricity mix	Swedish (11 kg CO_2-eq/GJ)	Nordic (35 kg CO_2-eq/GJ)
Soil carbon		
- Land use change	✓	-
- Digestate use	✓	Residues are excluded
- Crop residues	✓	✓
N_2O emissions		
- Direct (crop residues, mineral N, bio NH_4-N, org-N)	✓	✓
- Indirect (N-leakage, NH_3-N)	✓	-

EC (2009) Directive on the promotion of the use of energy from renewable sources (2009/28/EC). Council of the European Union, Brussels, Belgium, 47 pp

GHG emissions – field-to-fuel



Max GHG emissions for 60% reduction: **33,6 g/MJ**

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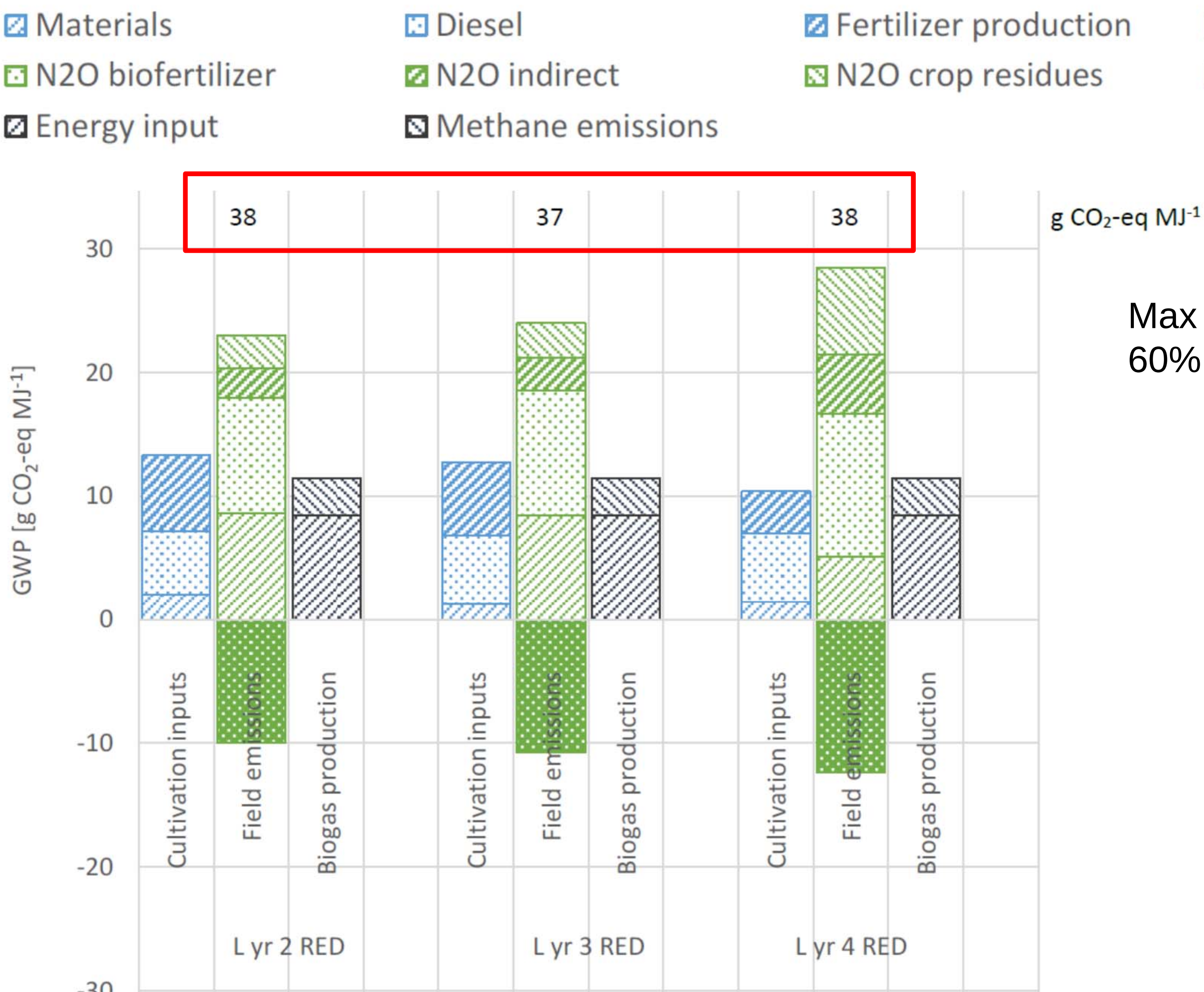
GHG emissions – field-to-fuel



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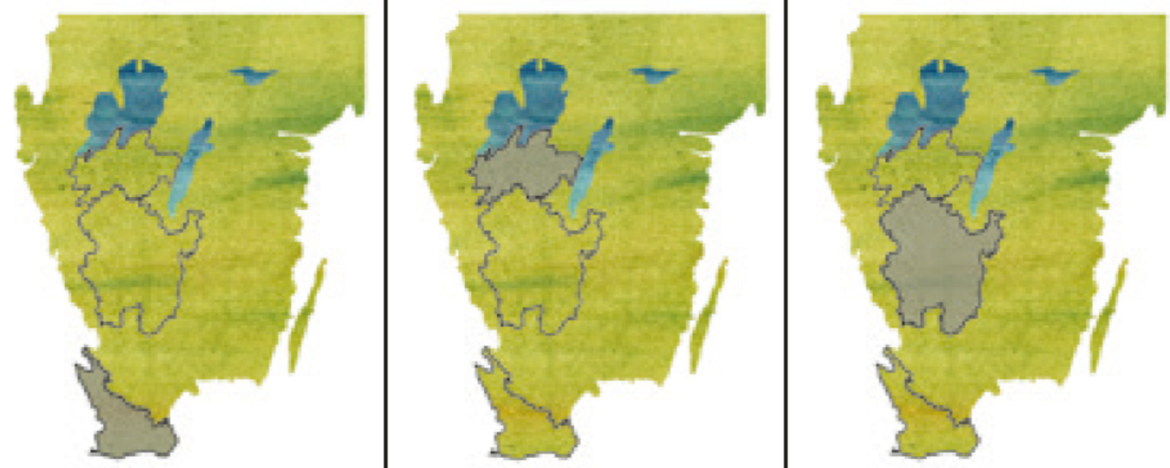
Region Skåne
Region Västra Götaland
Göteborg Energi

GHG emissions – field-to-fuel



	S1			S2			D		
	ISO	EU RED		ISO	EU RED		EU RED		
		År 5	År 6		År 5	År 6	År 2	År 3	År 4
t CO_2–ekv per hektar och år	-1,5			-1,6					
g CO_2-ekv per MJ	-2,0	32	43	2,9	38	44	38	37	38
% reduktion		-62%	-49%		-55%	-48%	-55%	-55%	-55%

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Summary

Intensive grass cultivation…

…contributes to SOC build-up…

…which can turn arable land from GHG source to carbon sink

…produces biomass for renewable fuels…

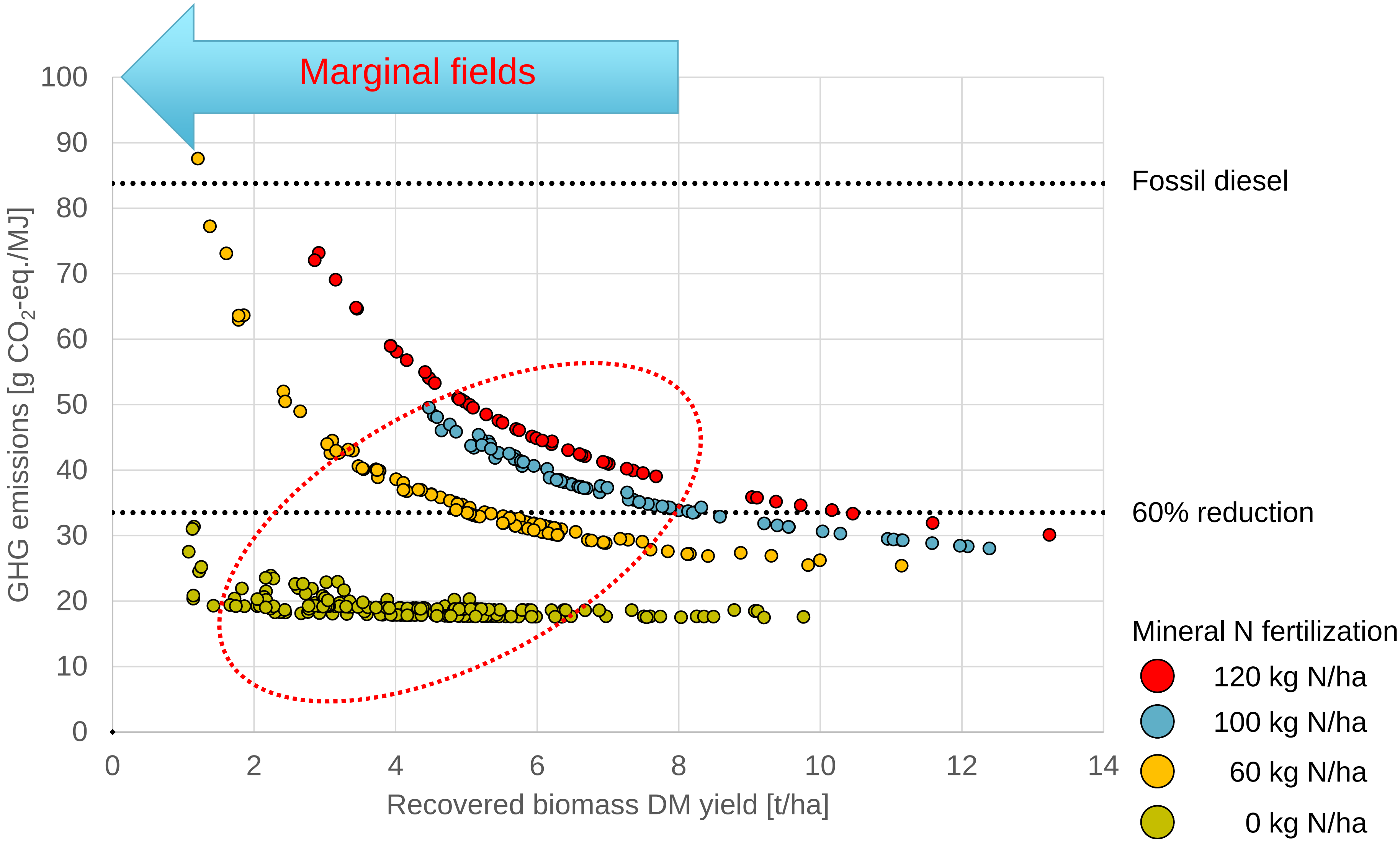
…which require some economic support.

How much is SOC built-up/GHG mitigation worth?

Grass on marginal soils

Can we produce sustainable vehicle fuel from extensively managed marginal soils?

GHG emissions – field-to-fuel

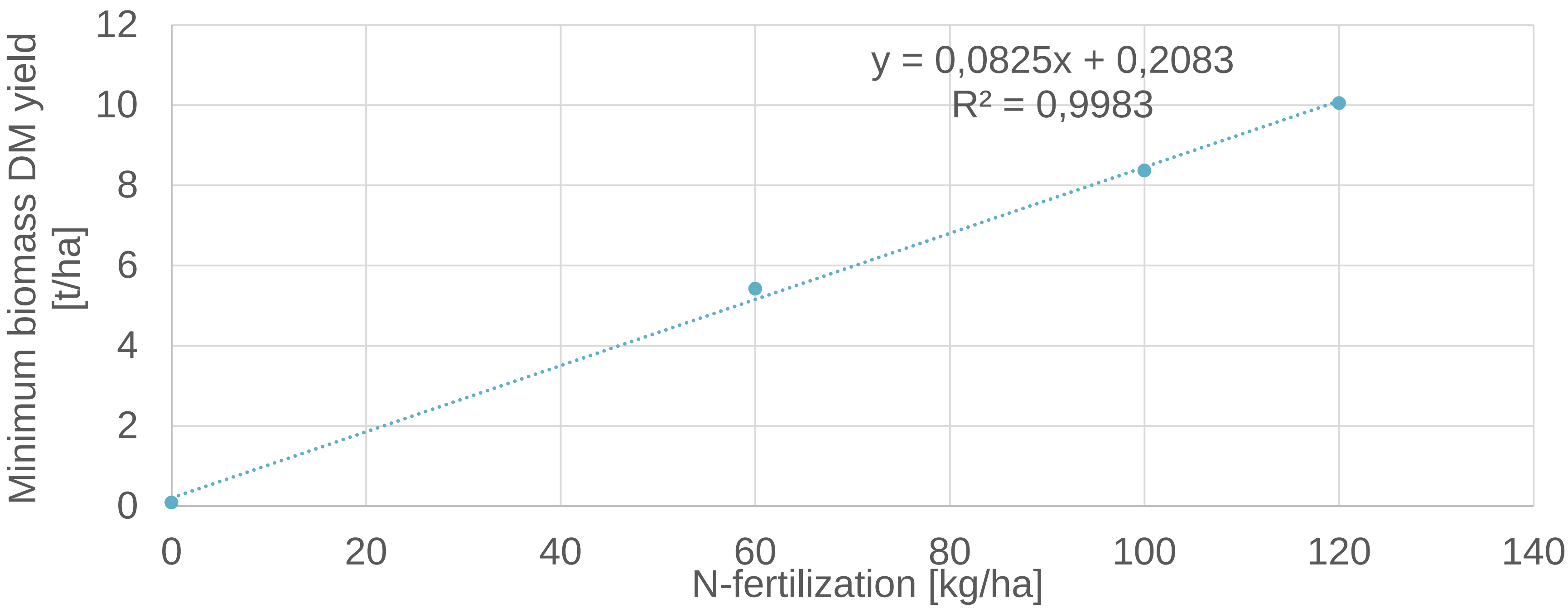


Carlsson, G., Mårtensson, L.-M., Prade, T., Svensson, S.-E., and Jensen, E.S. 2016. Perennial species mixtures for multifunctional production of biomass on marginal land. GCB Bioenergy.

GrassMargins

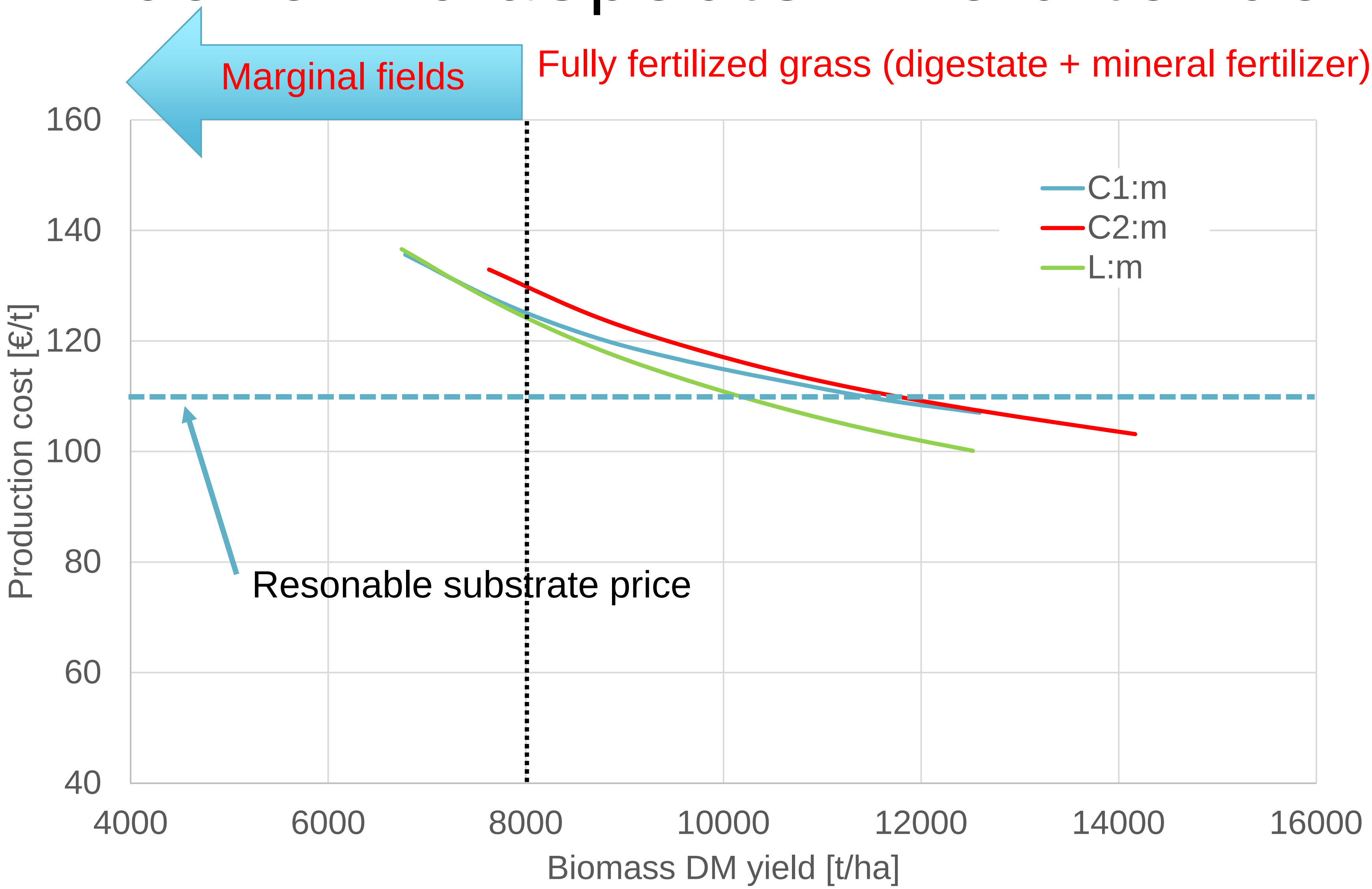
GHG emissions – field-to-fuel

Minimum biomass DM yield at 60% GHG emission reduction:



A return of ca 80 kg DM biomass per kg N added is required!
=> N content of 1,25%; grass typically 2,5 %!

Economic aspects – field-to-fuel



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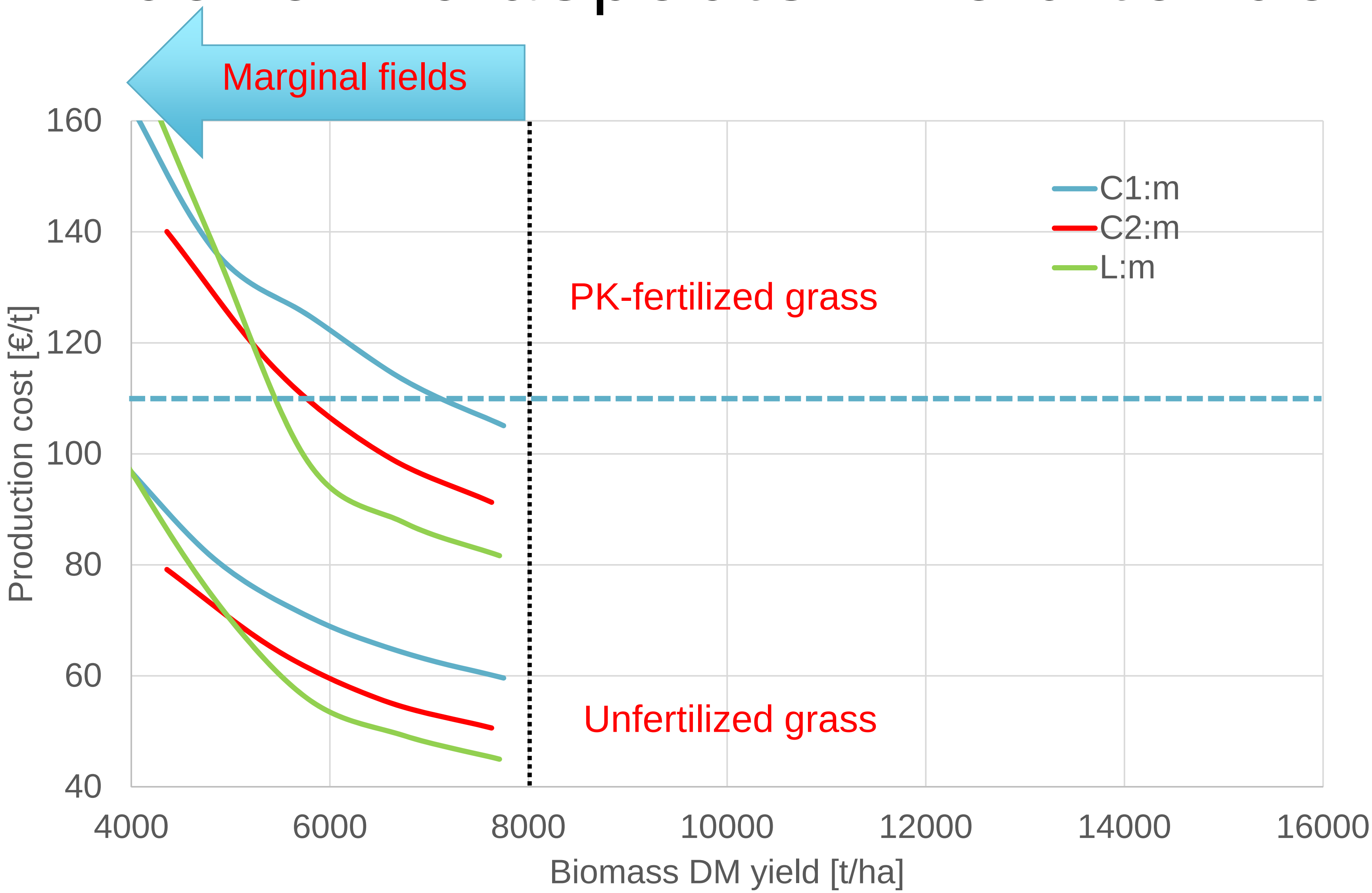
Economic aspects – field-to-fuel



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Summary

Extensive grass cultivation on marginal soils can deliver biogas substrate…

…that fulfills the 60% GHG reduction target for unfertilized grass crops and fertilized when yielding 80 kg/kg N

…with promising production costs at biomass yields
>~6-8 t DM/ha with PK-fertilization
>~4 t DM/ha unfertilized (e.g. with N-fixating plants)

Conclusions I

- Grass cultivation is an effective measure for turning the negative SOC trend
- Grass cultivation is currently not economically viable i cereal regions where it would give the greatest benefits
- Grass is an economically suitable substrate for co-digestion, where only small technical adaptations are needed

Conclusions II

- GHG mitigation target is barely missed, when excluding SOC effects according EU-RED
- It is reasonable to reach harvestable biomass yields 4-5 t DM/ha on marginal soils without fertilization, but K removal may reduce yields over time

Thank you!

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