Are catch crops sustainable for biogas production?

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Partners

Project title: Life-cycle assessment of catch crop cultivation for biogas production

- Partners & Collaborators
  - Agroscope Reckenholz-Tänikon (ART)
    - D. Scharfy, F. Hayer, G. Gaillard, V. Anspach
  - SFU
    - H. Hänni, A. Cropt
  - Ernst Basler + Partner (EBP)
    - R. Steiner
  - AGFF
    - Daniel Sutter

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Why catch crops?

- catch crops do not directly compete with human nutrition
- catch crops are not cultivated in the main cropping season
- catch crops could add to energy production from biomass while maintaining their main ecological function of nitrate capture
- since catch crops also serve as animal feed the usage as energy substrate indirectly competes human nutrition, but catch crops could replace fallows.

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Questions and Aims

- Hypothesis:
  - Due to the mentioned advantages catch crops can be used as a sustainable biogas substrate
- Aim:
  - recommendations for catch crop cultivation for biogas production
  - LCIs for the ecoinvent database
- Methodology:
  - LCA of the most common cultivated catch crops in different variants under Swiss conditions

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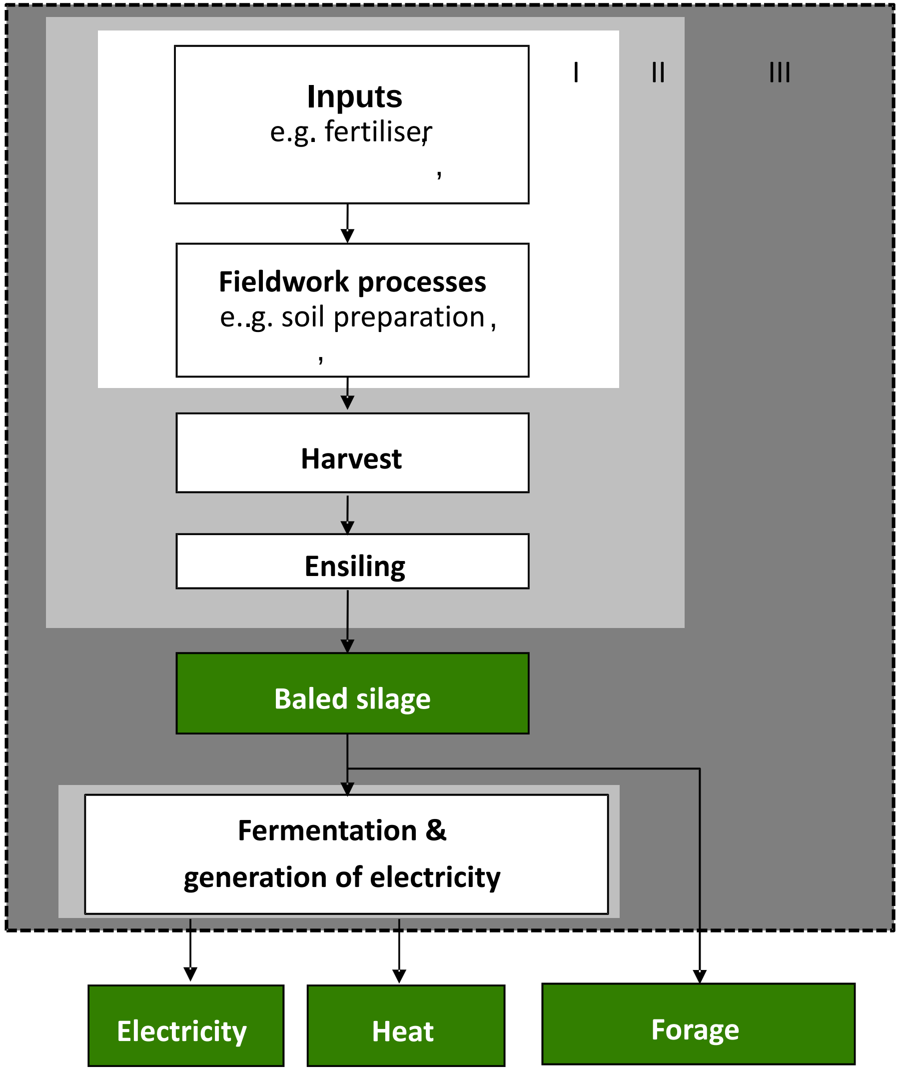
System boundary



Production measures were inventoried according to Swiss production conditions for 1 ha

Field emissions were calculated with SALCA-Models

Fermentation & generation of electricity
•electricity, at cogen with biogas engine, agricultural, alloc. exergy/CH“
•electricity, at cogen with biogas engine, agricultural covered, alloc. exergy/CH

The studied catch crops:

Green manure:

mustard (*Sinapis alba*)
phacelia (P*hacelia tanacetifolia)*

Autumnal catch crops

mustard, phacelia

sunflower

SM101: oat-vetches-mixture

SM 106: grass-clover-mixture

Overwintering catch crops

SM 200, SM 210: grass-clover-mixtures

Italian Ryegrass

Variants and analysis

Yield variability for each crop according to sowing date, fertilisation intensity and harvest frequency, but no yield differences were assumed between different fertiliser types

- Fertilisation variants: (0), 20-80 kg N
- Fertiliser type: mineral fertiliser, cattle slurry
- Harvest: 1-3 times (grass-clover-mixtures)

Including rotational and catch crop effects by system expansion

$$I_{S(W)CC} = I_{S(W)CC+SM} - I_{GM+SM}$$

I	= Impact
CC	= Catch Crop
GM	= Green manure
S(W)CC+SM	= Silage maize with CC
GM+SM	= Silage maize with green manure

Impact assessment

- Impact categories:
  - Non-renewable energy (NRE) — ecoinvent 2007
  - Global warming potential (GWP) — IPCC 2007
  - Eutrophication, acidification — EDIP 2003
  - Human toxicity, ecotoxicity — CML2001, extended

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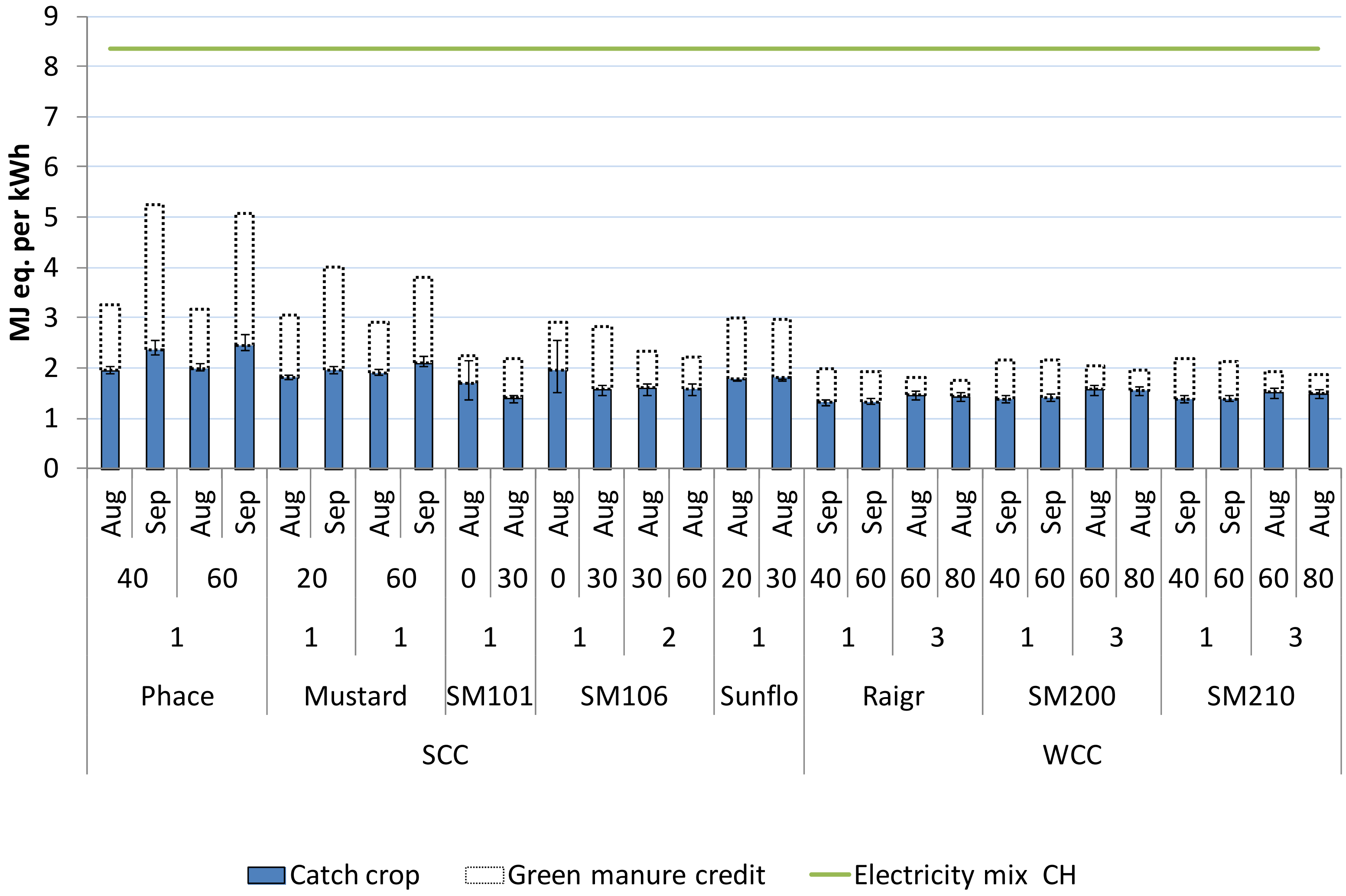
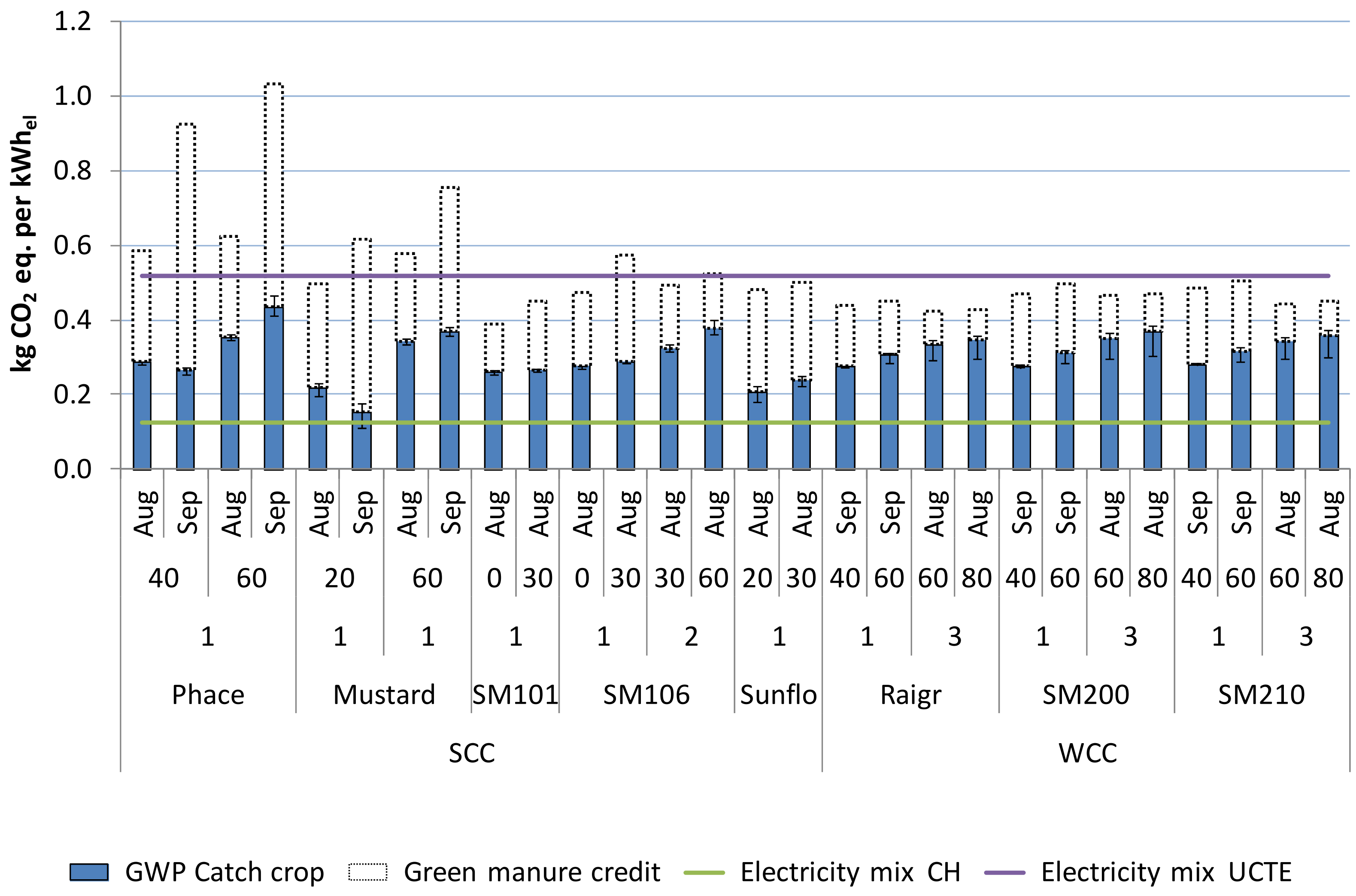
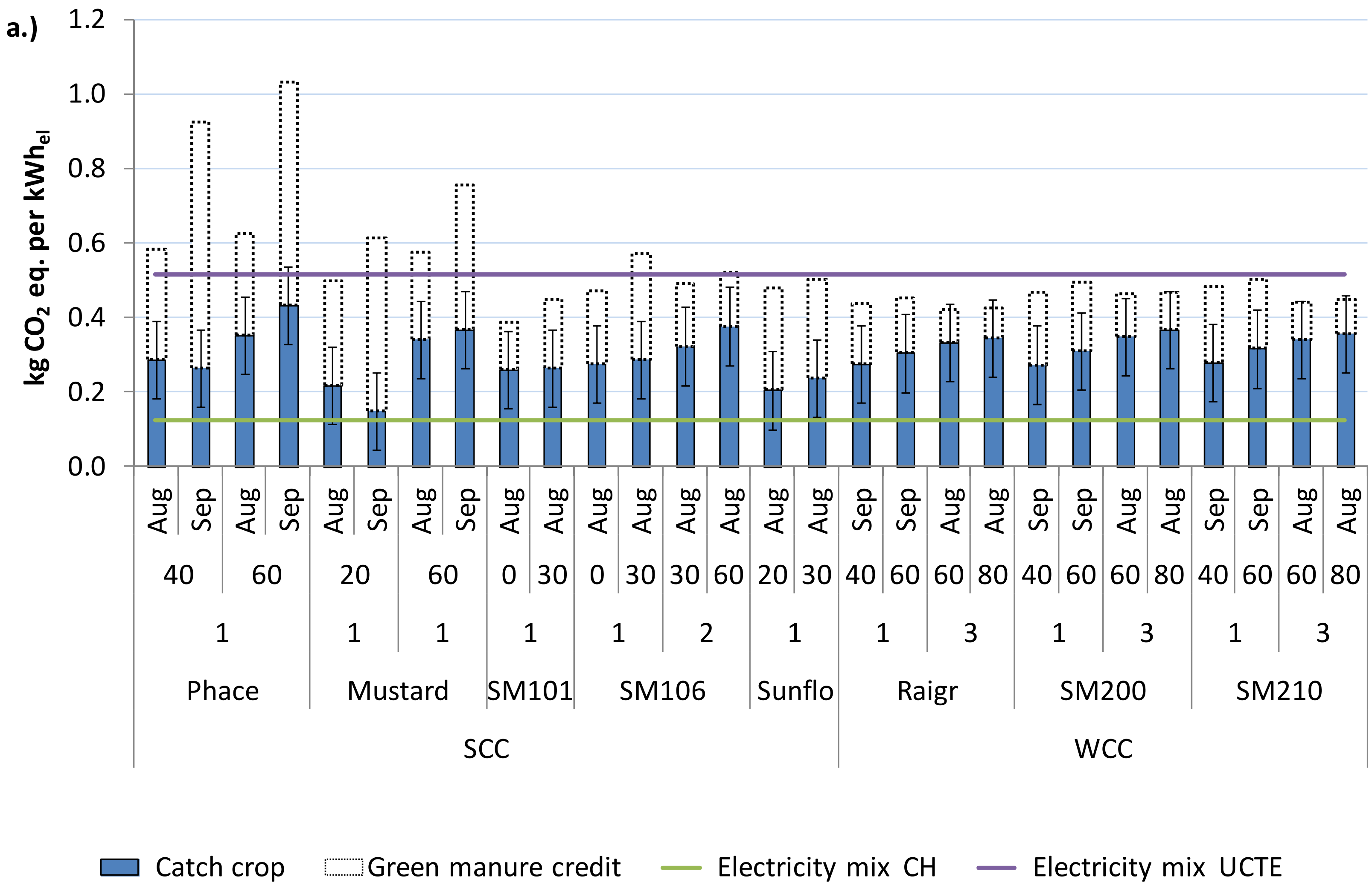
Non renewable energy demand



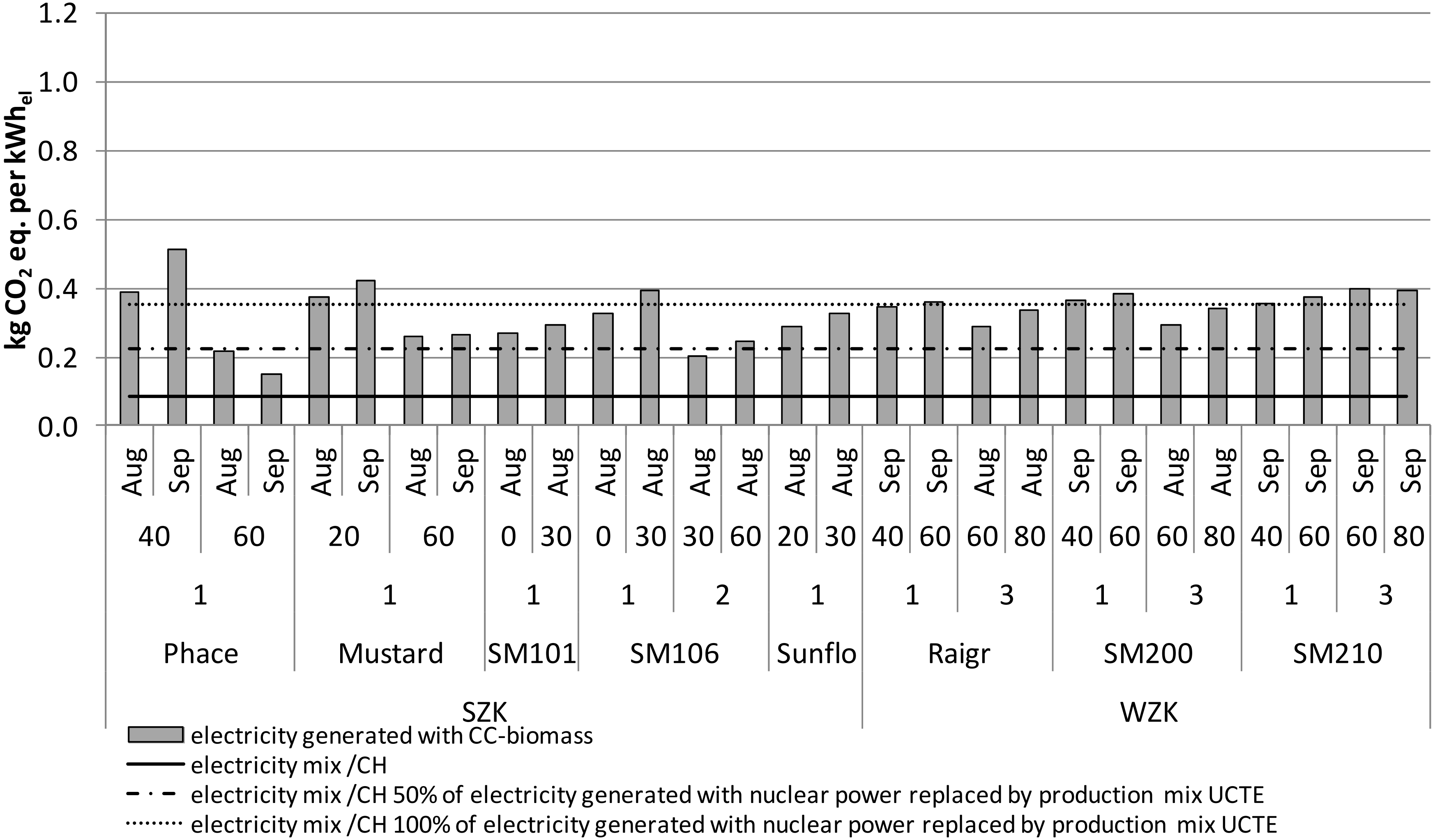
GWP: Sensitivity to yield



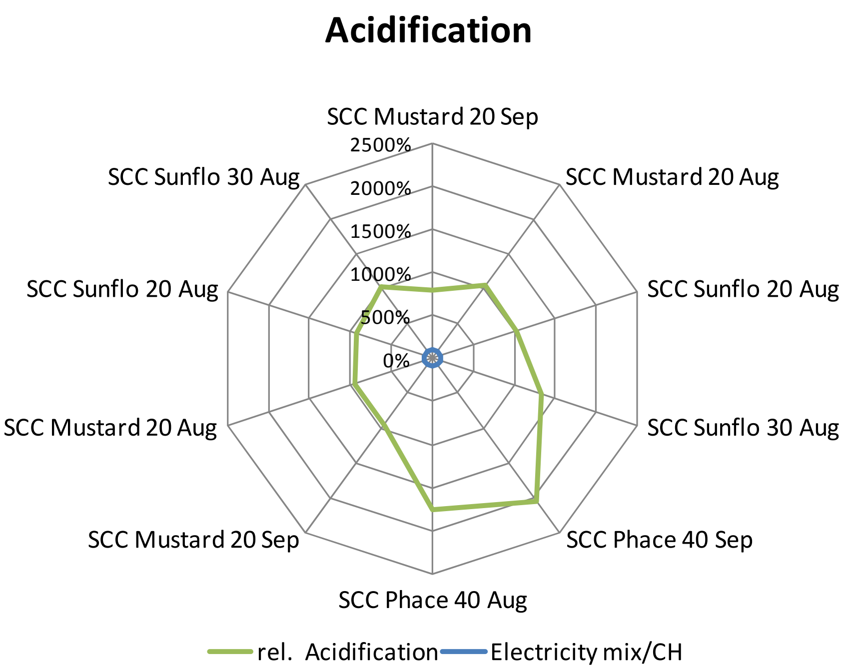
GWP: covered vs. uncovered production

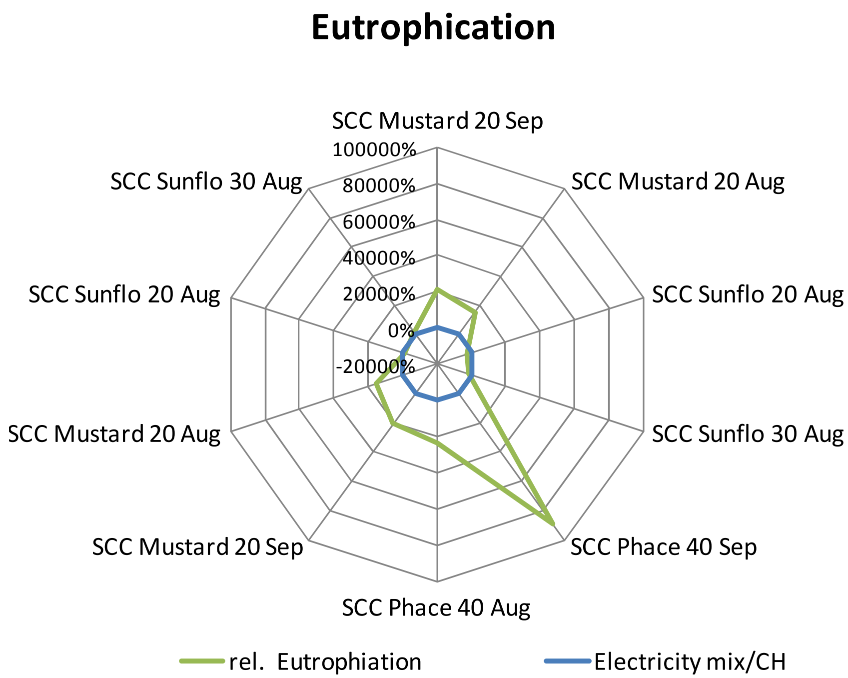


GWP: Comparison with different electricity mixes



Acidification & Eutrophication





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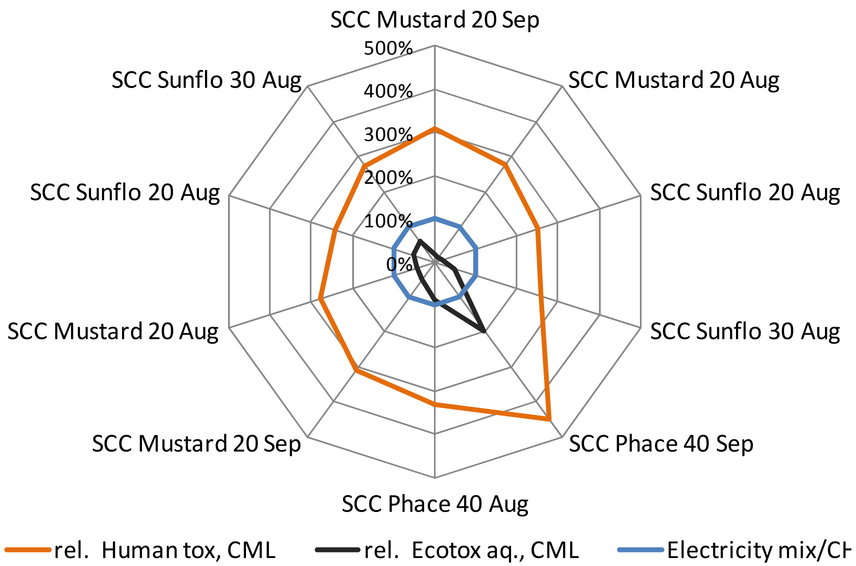
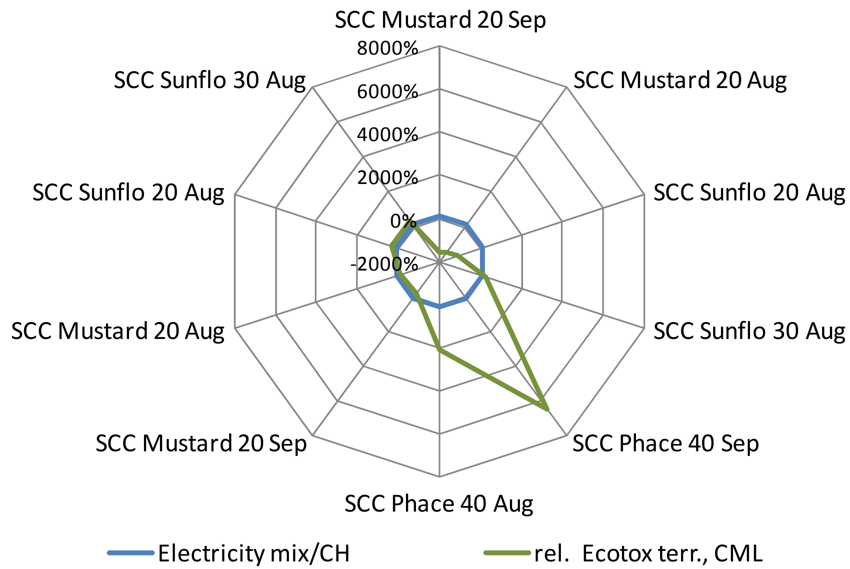
Human toxicity and ecotoxicity

human toxicity and aquatic ecotoxicity



terrestrial toxicity



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Conclusions and discussion

- The current electricity mix in Switzerland is mainly based on hydro- and nuclear energy resulting in low impacts per kWh
- Due to this fact
  - electricity produced with biomass from all analyzed catch crop variants shows a higher GWP
  - also acidification-, eutrophication-, human toxicity - and in most cases terrestrial toxicity impacts per kWh are higher
  - but some advantages regarding NRE and aquatic ecotoxicity exist

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Conclusions and discussion

- The conclusions are affected by
  - the current electricity mix
    - Even if 50% of the nuclear power will be replaced by imports of electricity from the UCTE grid the Swiss mix would be advantageous compared to electricity from catch crop biomass
    - However in comparison to the UCTE mix electricity from catch crop biomass would be advantageous in nearly all impact categories
  - the high emissions from biogas production
    - without a credit (e.g. for its green manure function) it is not possible to produce electricity from biogas based on catch crops with a lower GWP compared with the current mix

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Conclusions and discussion

- Green manure credit for catch crops
  - According to the ÖLN the cultivation of green manure or a catch crop is mandatory before maize
  - credit with a significant effect
    - The lower the intensity and yield the higher the credit per kg yield and per kWh. In consequence
      - extensive or late sown variants with a low impact per kWh when the credit is included
      - but with very high impacts if the credit is not included

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Conclusions and discussion

- If catch crops should replace UCTE electricity mix imports an important question to consider is the target, which might be;
  - a GWP per kWh as low as possible
  - a reduction potential per ha as high as possible
- depending on the target different variants are preferable
  - the first target could be fulfilled with extensive variants
    + \+ low additional environmental impacts compared to green manure
    + \- low yield and reduction potential
  - intensive variants preferable for the second goal
    + \+ high yield and also a high reduction potential
    + \- higher impacts per ha and also per kWh

Thank you!

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