Chances and Challenges for LCA on Pilot Scale Technologies – the Case of EnAlgae

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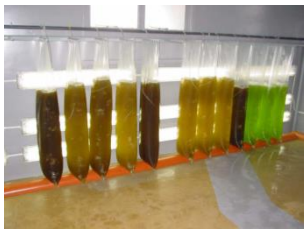
Objective of the EnAlgae project

- Algal biomass for energy application
- Nine microalgae and macroalgae pilot facilities across NW Europe
- KIT task:
  - Sustainability evaluation with LCA studies to evaluate existing pathways of algae production
  - Expert-based LCA based on “real” data from the pilot facilities

Microalgae Production System

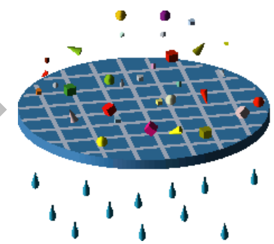


Inoculum production

Energy, Materials

Microalgae cultivation

Energy, Materials



Concentration/ Microfiltration

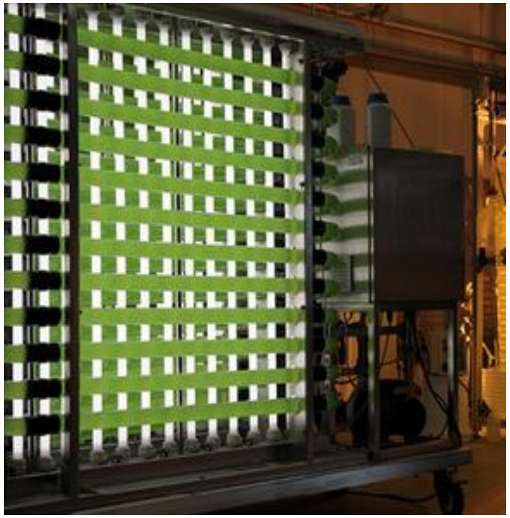
Energy, Materials

Biogas production

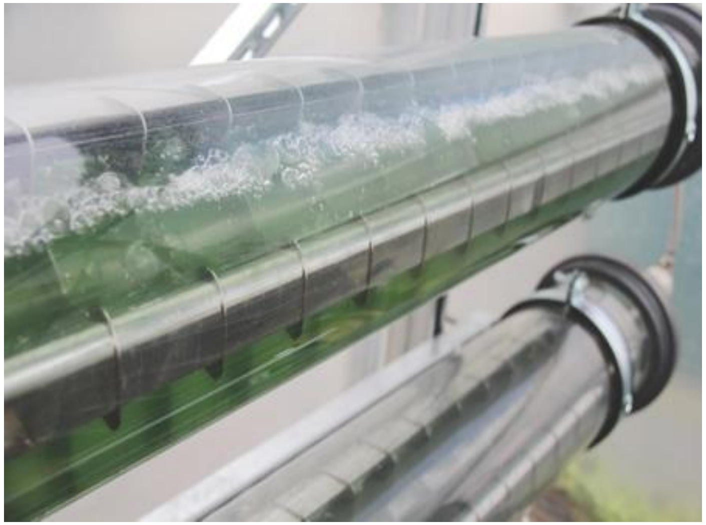
Energy, Materials

1 MJ of biogas (Methane)

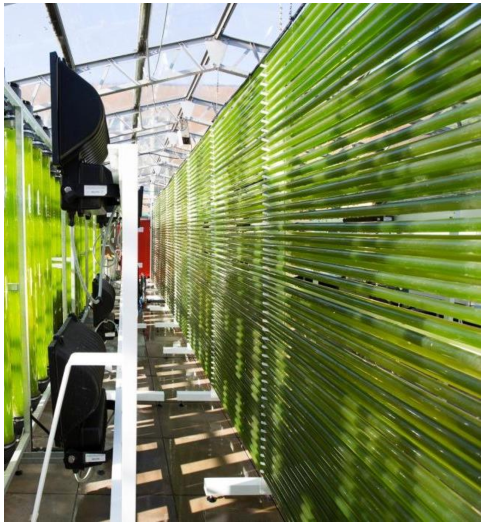
Pilot Plants for Microalgae Cultivation



htw saar



InCrops



Swansea University (SU)

Data Collection and Validation

- Data collection via questionnaire
- Visit of the pilot plants to gain an impression of the site and system
- Skype interviews for consultation on and validation of data

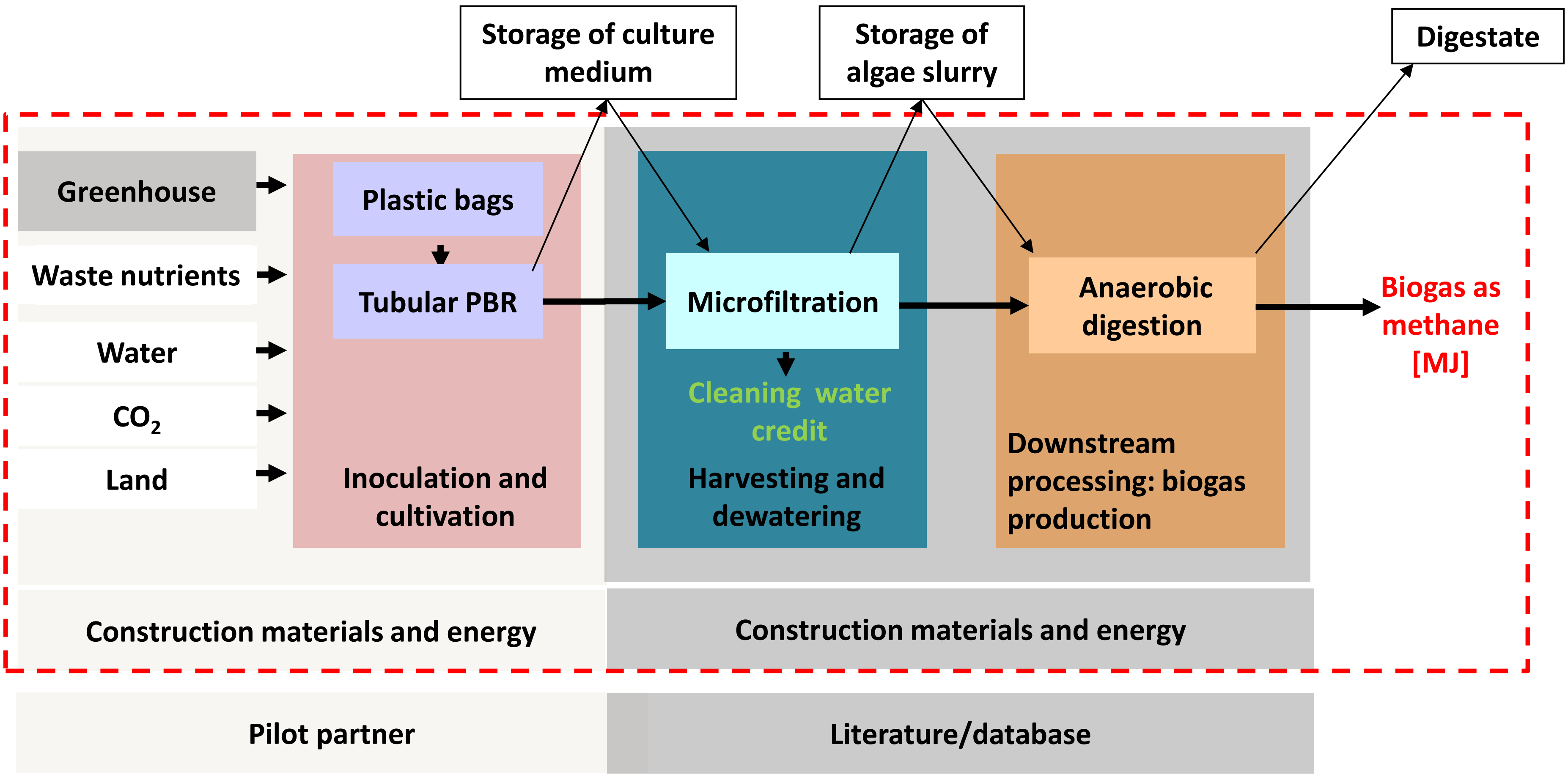
→ The cultivation systems were modelled in close cooperation with the pilot operators

Characteristic Parameter for Pilots (Examples)

Parameter	Pilot plants for microalgae cultivation		
	htw saar, DE	InCrops, UK	Swansea University, UK
Reactor type	Horizontal tubular	Horizontal tubular (internal rotor)	Horizontal tubular
Biomass conc. (g/l)	3.0	1.0	1.2
Areal productivity (t/ha and year)	29.0	1.6	19.7
Culture volume (l)	100	100	600
Nutrient source	Chemical fertilizer	Waste water from Cambridge Water PLC.	Waste nutrients from cattle (cleaning credit)
Artificial lighting (h/d)	18 (the whole year)	-	8 (during winter time only)
Heating/cooling	-	-	Heating during winter time
Location	Laboratory	Greenhouse	Greenhouse (built up)

System Boundaries of the LCA

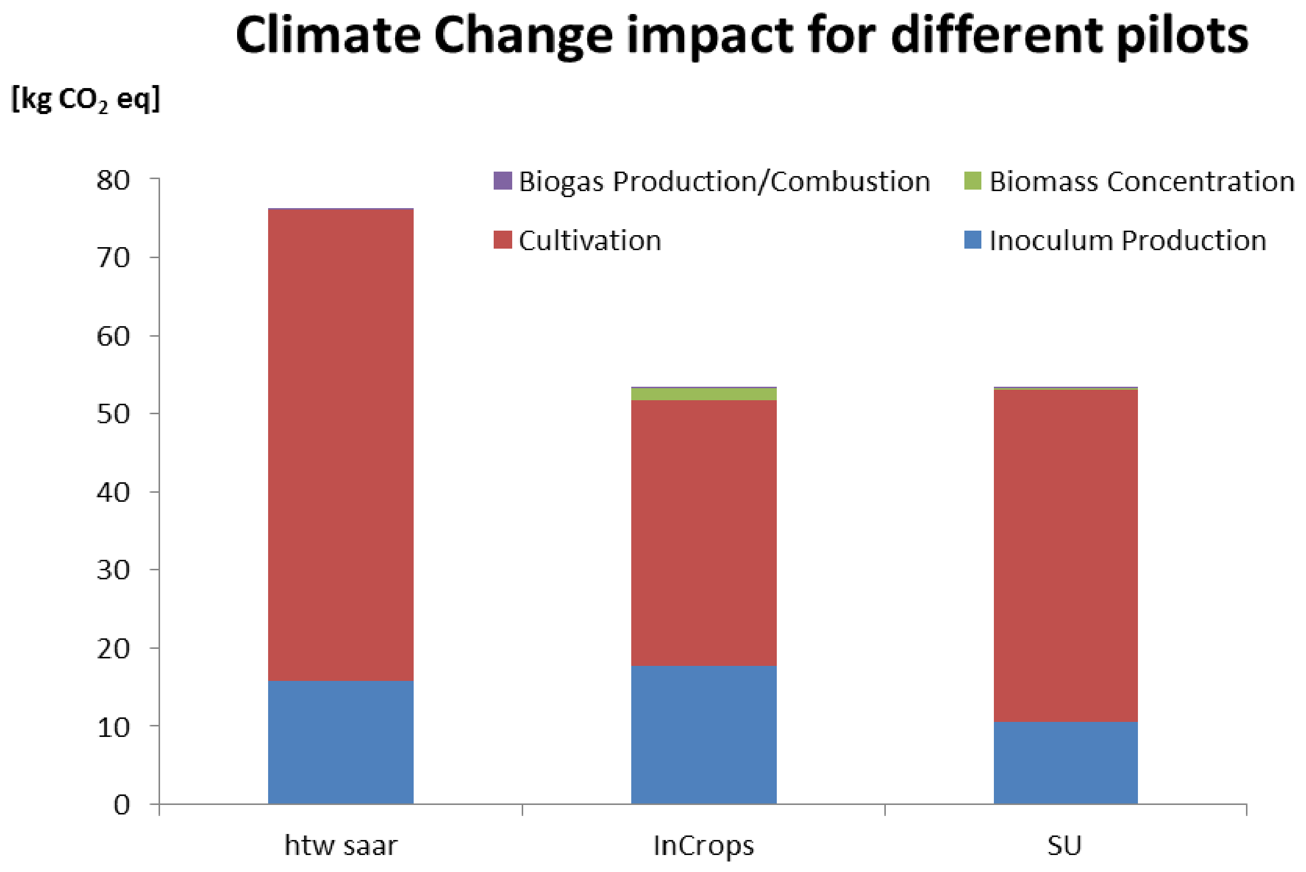
(Example: pilot plant of Swansea University)



LCA Modelling

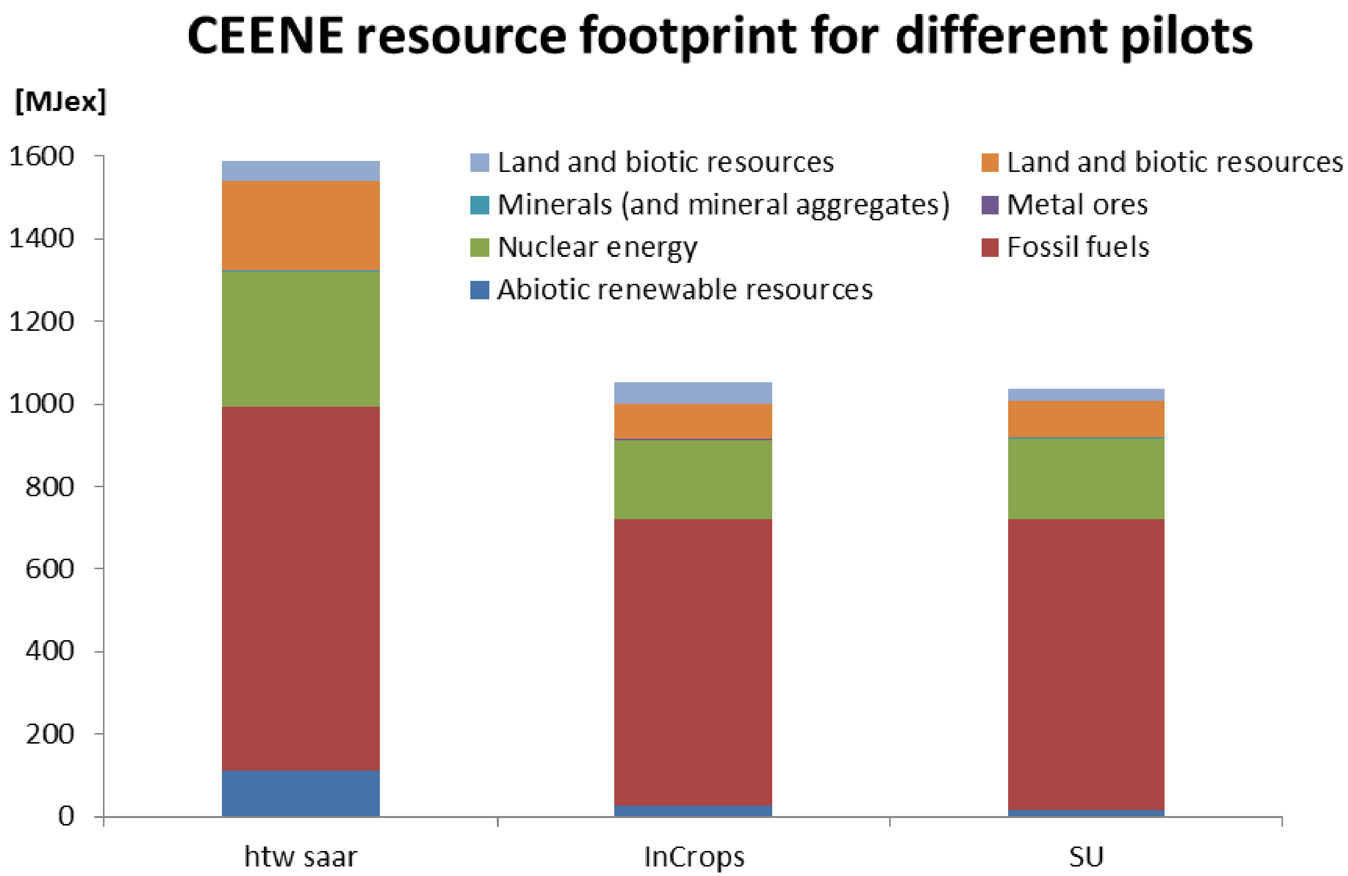
- Software: Umberto NXT LCA (ifu Hamburg)
- Database: Ecoinvent 2.2
- Impact assessment methods:
  - ReCiPe 1.11: 18 Midpoint categories (e.g. Climate change)
  - CEENE: Resource footprint
- Fossil reference: 1 MJ natural gas

Results on Climate Change (ReCiPe 1.11)



Functional unit: 1 MJ algae biogas

Results on the Resource Footprint (CEENE)

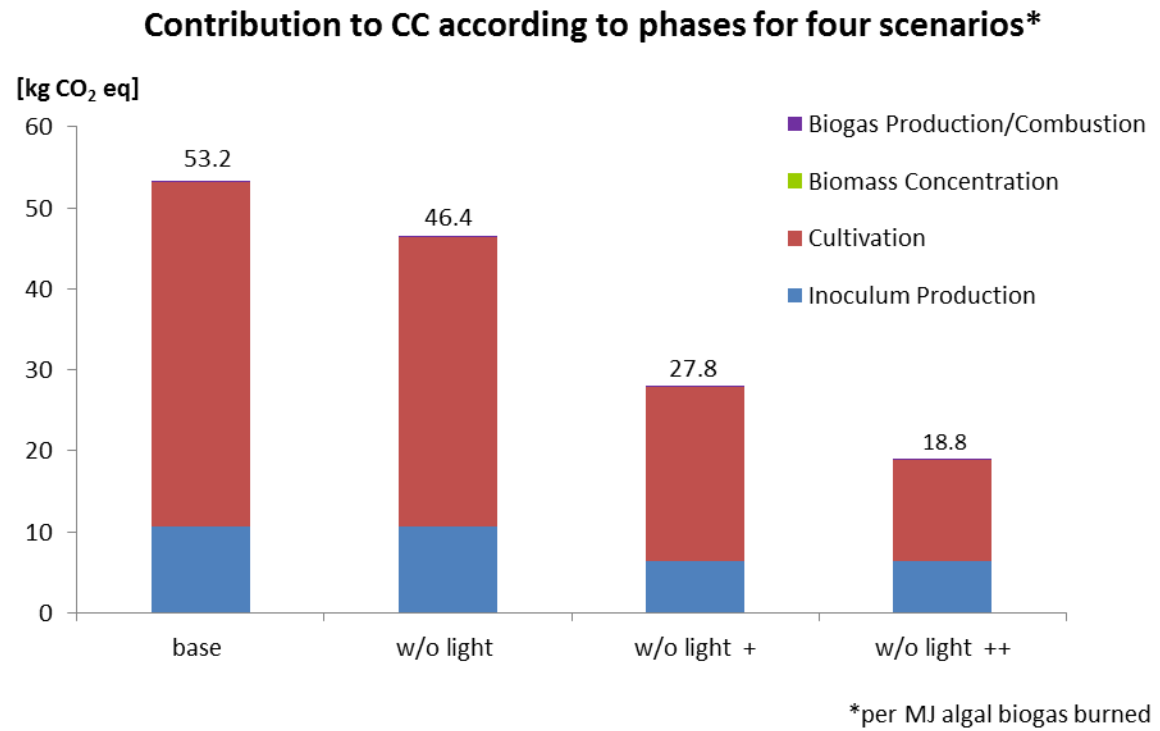


Functional unit: 1 MJ algae biogas

LCA of algae production scenarios (example SU)

- ***Base scenario***: original data
- ***w/o light scenario***: Without lighting
- ***w/o light scenario+***: Without lighting + higher biomass concentration. (2 g/L)
- ***w/o light scenario++***: Without lighting + higher biomass concentration (2 g/L) + reduced pumping energy to 55 %

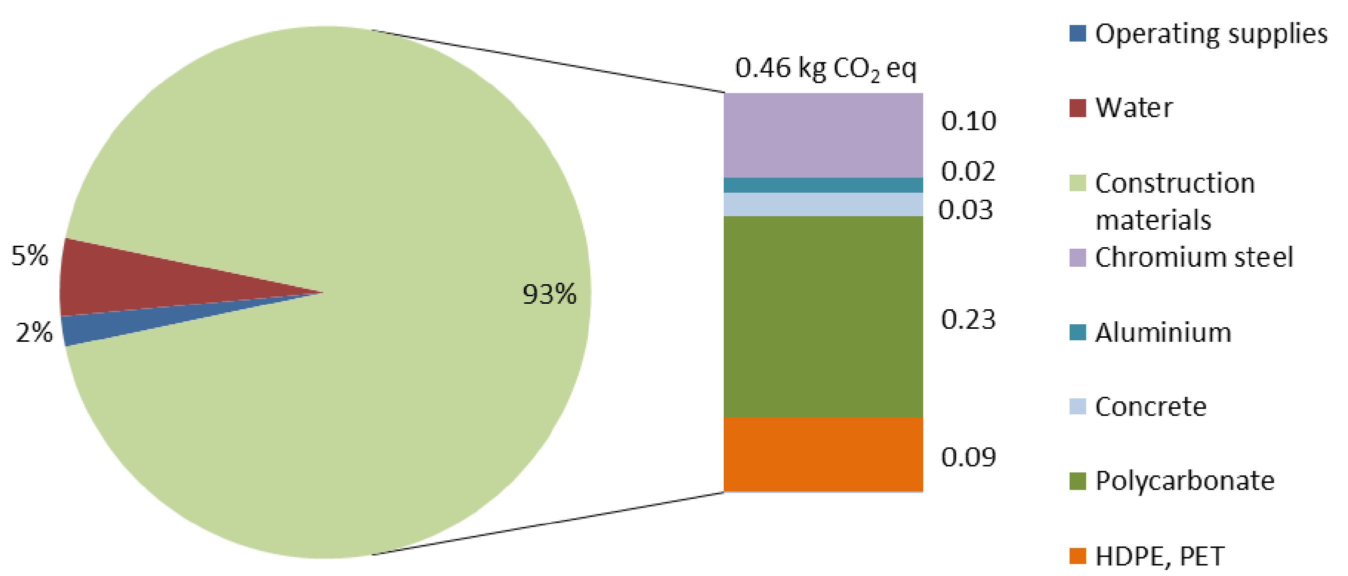
Impact of the Scenarios on Climate Change
(ReCipe 1.11)



Impact of Construction Materials on Climate Change

(“best” scenario w/o light ++)

Detailed contribution of construction materials to CC (electricity cut-off)



absolute value: 0.48 kg CO_2 eq/MJ burned algal biogas

Results

- Energy for cultivation represents the highest share in all impact categories
- Other contributors are not even visible in the total LCA and covered by energy impacts
- Optimization towards energy savings are crucial (independent of final product)

Chances

- Experimental data reflect real production
- Improved, valid assumptions for scenarios depending on data quality
- First approaches on small scale system improvements might already show realistic trends

Challenges

- Lab scale data hardly suitable for upscaling
- Technology readiness level important to apply learning curves and upscaling assumptions
- Literature review indicates that sometimes highly optimistic values are reported

→ Demo plants can help to improve the knowledge

Outlook

- Process optimization towards higher energy efficiency with engineering and breeding progress and new approaches such as the Photofuel concept

- Energy as co-product in algae production can improve the energy balance through energetic allocation, but algae application for food and feed puts high requirements on algae cultivation

Thanks for your attention!

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Investing in Opportunities

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INTERREG IVB

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