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Biofuels from microalgae? A systems analysis

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Why microalgae for energy production?

- High growth rates
- Potentially high oil content
- Consume concentrated carbon dioxide
- Cultivation in closed systems on non-arable land
- Use of salt- or wastewater

Aspects of sustainability assessment

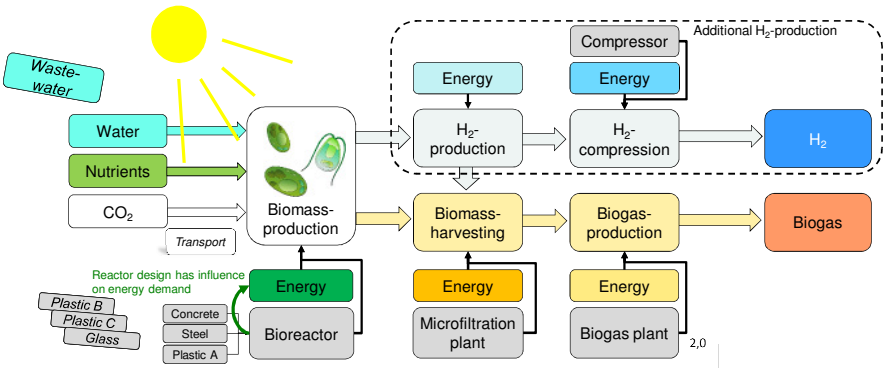
- *Energy input* for biomass growth and downstream processing
- Water and nutrient requirements
- Carbon dioxide requirements
- Costs of production system and end-product
- Environmental impacts of the process

Potential energy carriers from microalgae

- Biogas, Biodiesel, Bioethanol, Hydrogen

Methods

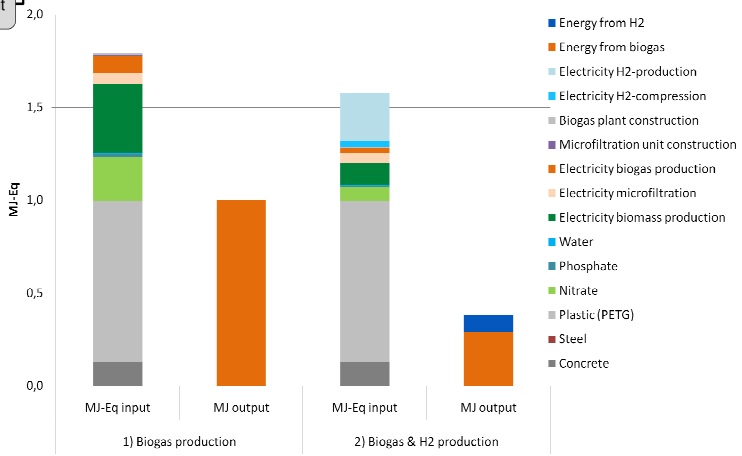
- Modelling the life cycle of energy production with microalgae (software: umberto®, database: ecoinvent ®)
  Key data from literature and personal communication
- Calculation of the cumulative energy demand and selected life cycle impacts of the full process chain for the respective energy carriers and bioreactor designs and thereby identification of weak points of the process.



Process flow chart, example

Table: Data for the calculation of the energy balance (figure on the right).

	Biogas	Biogas and H_2
Biomass production per cycle of operation	7 d	7 d
H_2 production per cycle	-	15 d
Cleaning time per cycle	1 d	3 d
Total operation time per year	248 d	250 d
Maximal biomass concentration	6 g DM l^{-1}	6 g DM l^{-1}
H_2 production rate (Kim et al. 2010)	-	1.7 ml g DM^{-1} h^{-1}
Energy for mixing	30 W m^{-3}	30 W m^{-3}
Biomass output per hectare and year	31 t ha^{-1} y^{-1}	10 t ha^{-1} y^{-1}



Preliminary results: comparison of energy balances for the production of energy in a novel bioreactor
1) Biomass production and conversion to biogas
2) 1) + additional hydrogen production

Conclusions

- With the assumed data, the additional production of hydrogen is not advantageous.
- The reactor design (material and energy input) influences the energy balance considerably (data not shown).
- Significant progress in R&D is necessary for energy production with microalgae – both in the development of algae strains and in the process design.

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