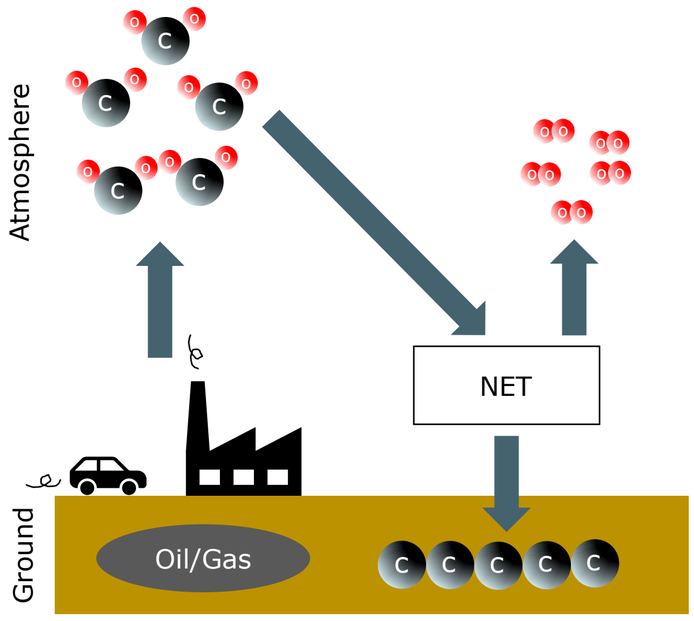
HSLU Hochschule Luzern

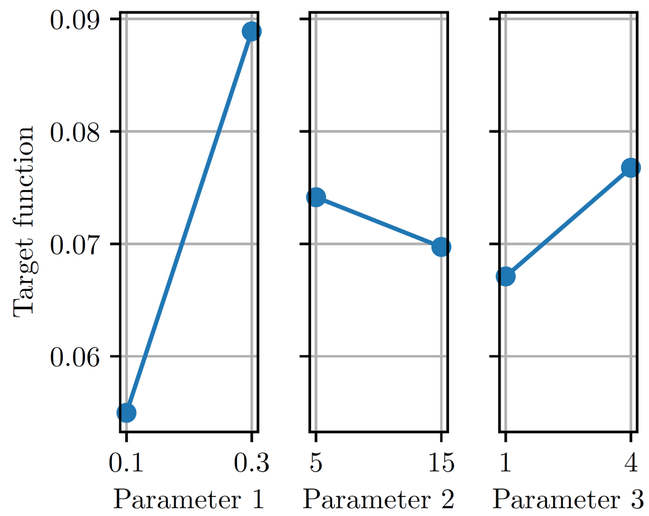
Technik & Architektur

Master-Thesis Energy and Environment

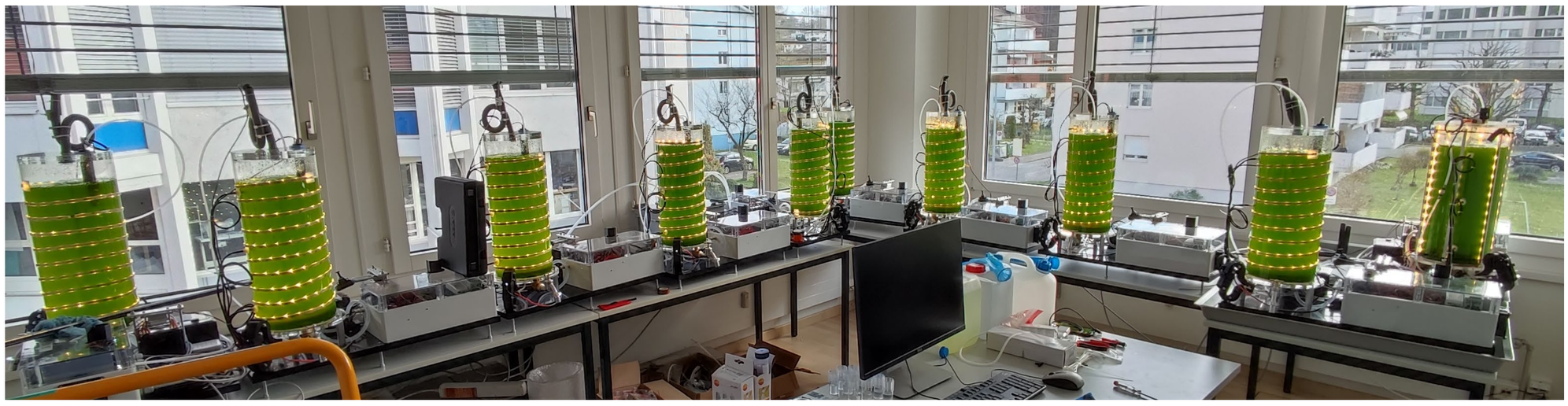
Theoretical and Experimental Evaluation of Maximum CO_2 Sequestration Productivity of Microalgae in Photobioreactors with subsequent Reactor Design for Carbon Dioxide Removal



Left: CO_2 point sources and mobile CO_2 sources, right Negative emissions.



Resulting mean target function biomass increment per day for the two-level full factorial design with three parameters of the first measurement series.



Test reactors during experimental investigation.

Problem & Objective
In order to counteract anthropogenic climate change, not only anthropogenic CO_2 emissions must be reduced quickly and significantly, but also Negative Emission Technologies (NET) must be employed on a large scale.

The NET include numerous approaches such as afforestation, ocean fertilization, replacement of concrete and metals with woods, etc. The growth of plants on land through photosynthesis sequesters CO_2 from the atmosphere and stores it long-term if the biomass is removed from the natural cycle. If the goal is to maximize the production rate of biomass with high energy and space efficiency, photosynthesis of microalgae in Photobioreactors (PBR) is significantly superior to photosynthesis of land plants by a factor of 10 to 50 under suitable conditions.

The objective of this work is to theoretically and experimentally gain knowledge of suitable algae species and cultivation conditions.

Solution Concept
In a first step, a detailed literature research on microalgae and their cultivation was carried out. In addition, a market and patent research in collaboration with the Swiss Federal Institute of Intellectual Property (IGE/IPI) was conducted in order to obtain suggestions and ideas regarding reactor designs and cultivation concepts as well as to chart the market situation.

In the second step, the experimental investigations were planned and carried out. Therefore, ten test reactors were built and tested. After that, three measurement series with eight test reactors were conducted by varying different operational parameters on a two-level full factorial design with the help of Design of Experiments (DoE). Based on the results and findings of the experimental investigation, two concepts for pilot plant scale reactors were developed.

The results of the experimental investigation show the dependencies of the target functions maximum biomass increment per day and maximum biomass concentration achieved on three variation parameters. It showed that the first parameter has the greatest influence on the target function biomass increment per day, while the influences of the other two parameters are not significant for a 95% confidence interval. For reasons of confidentiality, no precise details of the parameters are given.

For future studies, the parameter space should be extended and the most influential parameters should be investigated on a three or more-level full factorial design. The first of the two developed concepts for pilot plant scale reactors aims at minimum energy consumption while the second concept aims at maximum area related productivity. The two concepts were worked out in detail. However, components still have to be defined and selected for real implementation.

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