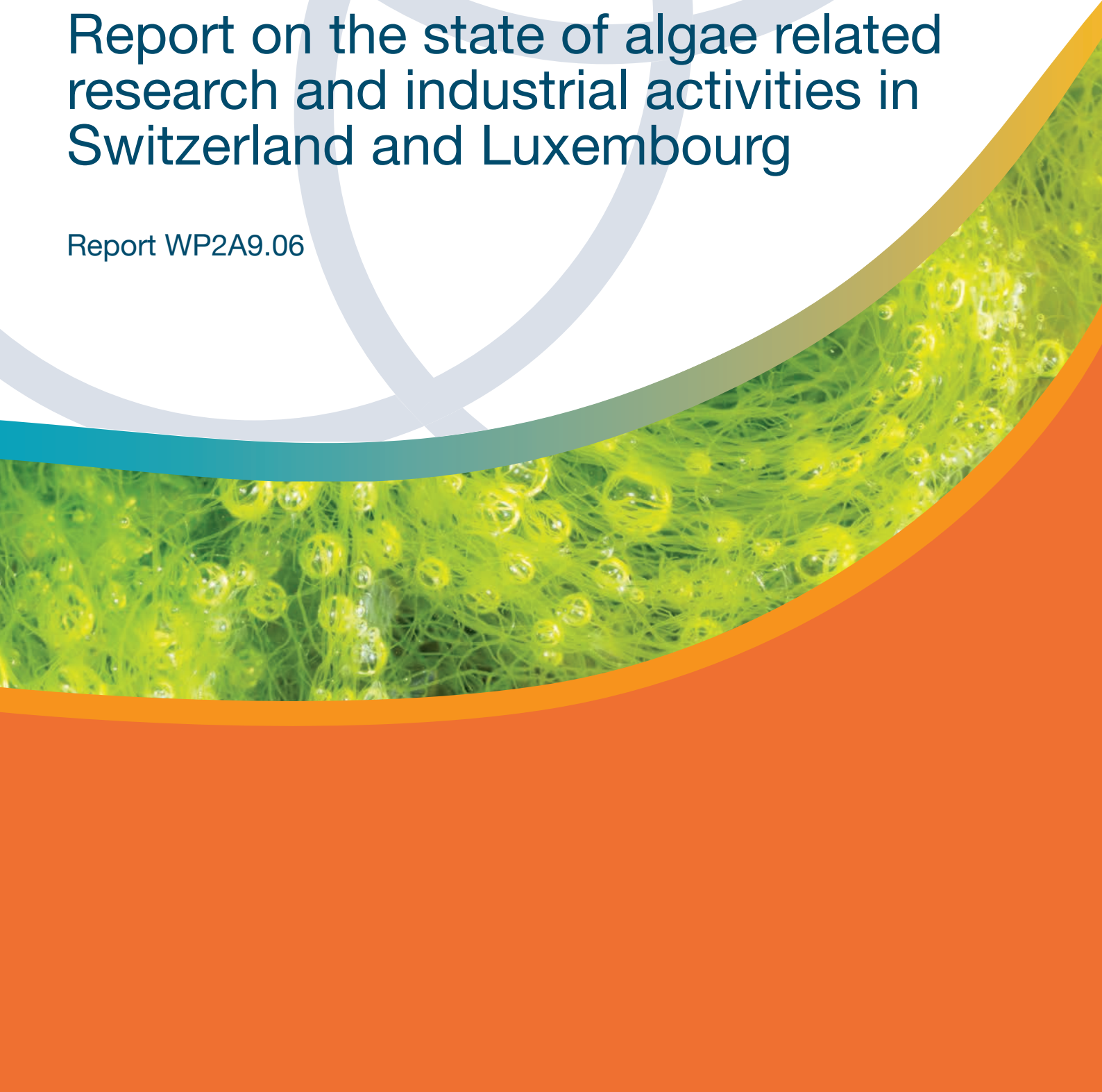


Report on the state of algae related research and industrial activities in Switzerland and Luxembourg

Report WP2A9.06



Energetic Algae ('EnAlgae')

Project no. 215G

Public Output

Output WP2A9.06 – Report on the state of algae related research and industrial activities in Switzerland and Luxembourg

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Please cite this document as follows:

Brinker,M-M. 2014. Report on the state of algae related research and industrial activities in Switzerland and Luxembourg. EnAlgae project report WP2A9.06, Swansea, June 2014, 9pp.

Available online at <http://www.enalgae.eu/publications.htm>.

This document is an output from the Energetic Algae ('EnAlgae') project, which has received European Regional Development Funding through the INTERREG IVB NWE programme.

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1 Introduction

In 2012-2014 an inventory of North-West European algae initiatives was carried out to provide an impression of research and commercial activities connected to algae production and utilization. The collected data has been reviewed in country specific reports and collated and summarized in an overview report covering the whole North-West-Europe region (including Great Britain, Ireland, Germany, Belgium, France, Switzerland, Luxembourg and the Netherlands).

Data was obtained via a comprehensive questionnaire that was distributed among stakeholders identified in a preliminary scoping exercise. Not all questionnaires were filled out by the stakeholders and returned to the EnAlgae programme. In these cases, publically available information was used for the landscaping study. The questionnaire aimed to gather more information on focus, expertise and applied technology of the addressed institutions. It was also designed in a way that allows its use as an information sheet in EnAlgae's web-based information portal and the Decision-Support-Tool (DST).

This report summarizes the results of the analysis of data collected in Switzerland and Luxembourg. As only very few stakeholders were identified for Switzerland and no algae stakeholders were identified for Luxembourg, the analysis is rather biased towards those stakeholders who filled out the questionnaire extensively as compared to those who gave only minimal information of whose information was added after research in public domains.

It must be emphasized that this report cannot claim to reflect an exhaustive list of all stakeholders active in algae research and business. The reasons behind this are:

It is a rather broad area and in some cases only very limited information is available about respective activities. In addition, there is a lot of movement in the algae sector with regard to new start-ups and the closing down of business operations, making it difficult to maintain an up-to-date overview. If too little information could be found about certain institutions they were not included in this survey.

However, this study nevertheless represents the most important institutions active in the algae area, allowing conclusions to be drawn about the main fields of interests, technology and market opportunities for algal research in Switzerland.

2 Swiss stakeholders

In total 13 institutions working directly with algae could be identified in Switzerland. A majority of stakeholders (62%) work research oriented whereas 38% are mainly commercial institutions. Table 1 gives an overview on the identified stakeholders, sub-divided into commercially active representatives and academic research oriented stakeholders. However it should be emphasized that some of these organizations work on the borderline between these two fields which make the separation by some means artificial.

Table 1: Overview of Swiss stakeholders active in the broader algae area.

Commercial stakeholders	
Alvigor AG	The ALVIGOR AG is a young and dynamic company, working together with a network spanning the globe, comprising renowned experts and university professors. They have consciously specialized in ecologically sensible energy systems in the sector of renewable energies as well as a worldwide unique technology on the efficient reduction of CO ₂ . Their partners hold revolutionizing international patents, among other things for marketable technology on the favorably priced industrial cultivation of microalgae. Alvigor will start its algae projects mid-2014.
Foundation Antenna Technologies	Antenna Technologies researches and disseminates technologies which are appropriate to the basic needs of the most vulnerable communities. They are registered as a Swiss charitable foundation. The <i>Spirulina</i> genome was sequenced entirely in July 2009, by Antenna Technologies and three other institutions. Foundation Antenna enables and engages in R&D on a range of durable technologies (including the production of <i>Spirulina</i>) which are low-cost and simple in their use, and appropriate to the basic needs and socio-cultural conditions of the poorest of the poor. They facilitate the dissemination of these technologies in developing countries with local and international partners. The Antenna Nutrition project deals with local cultivation and distribution of <i>Spirulina</i> , a microalga with exceptional nutritional value which offers a solution to malnutrition.
Georg Fischer Piping Systems	GF Piping Systems is one of three companies within the Georg Fischer group and a leading supplier of plastic and metal pipe systems with a global market presence. GF Piping Systems is closely involved in the research and development of bioreactors for algae production. The new piping system designed for this application is made of transparent plastic.
Infors AG	INFORS HT is a specialist for bioreactors, incubation shakers and bioprocess control software.
Spiralps	The Spiralps® Company (SpirAlps SA) is a new Swiss based company developing natural beverages, using algae as its core functional component.

Scientific Stakeholders	
Eawag - aquatic research	Eawag is an aquatic research institute. Eawag has expertise in bioavailability and effects of metals on algae as well as on microcosm's technology to examine natural algal communities. The department of Environmental Toxicology researches different effects on algal communities and populations.
University of Applied Sciences and Arts Northwestern Switzerland FHNW - Institute of biomass and resource efficiency	The Institute of biomass and resource efficiency (IBRE) is researching on the supply of energy sources, direct thermochemical conversion as well as the acquisition and optimization of material and energy flows. The Institute conducts research in the field of production and use of fuels from biomass. Goal is the development of methods to produce synthetic natural gas from organic waste such as algae or sludge.
Hochschule Rapperswil - UMTEC Institute for environmental and process engineering	The core competency of UMTEC lies in traditional environmental engineering with focus on water and waste treatment. In these fields they support their clients with innovative processes and products that aim at minimizing environmental impact. UMTEC is involved in solving challenges in harvesting and dewatering of microalgae.
Competence Center Energy and Mobility (CCEM)	The Competence Center Energy and Mobility contributes to the development of a more sustainable energy system. Research focuses on the efficient provision of energy services, efficient and «zero-emission» energy conversion and on the substitution of fossil energy carriers by low-CO ₂ primary energies. The CCEM is involved in the research project SunChem.
Paul Scherrer Institute	The Paul Scherrer Institute, PSI, is the largest research centre for natural and engineering sciences within Switzerland, with its research activities concentrated on three main subject areas: Matter and Material, Energy and the Environment, and Health. The PSI develops, constructs and operates complex large-scale research facilities. The Chemical Processes and Materials (CPM) group of the PSI leads the research project SunChem, transforming algal biomass into methane.
Zurich University of Applied Sciences - Life Sciences and Facility Management	The School of Life Sciences and Facility Management of the Zurich University of Applied Sciences is one of the leading centres of excellence in Switzerland on nutrition, health, society and the environment. The department was involved in the EUREKA-project "Alganol" which resulted in the production of a micro-algae production plant in Grüental.
Swiss Federal Institute of Technology Zurich - Institute of Energy Technology	The professorship of Renewable Energy Carriers at the Institute of Energy Technology at the ETHZ is carrying out a combined research project with the University of Sao Paulo (Brazil) on algae gasification using concentrated solar power.
École polytechnique fédérale de Lausanne (EPFL) - Laboratory for Environmental Biotechnology	The laboratory for Environmental biotechnology of the EPFL aims at the multidisciplinary integration of sciences and engineering in order to utilize the huge biochemical potential of microorganisms, plants and parts thereof for the restoration and preservation of the environment and for the sustainable use of resources. The laboratory carries out research in the field of microalgae cultivation to produce renewable biofuels and added-value chemicals. EPFL is also involved in the joint research project SunChem.

3 Types of algae

All algae stakeholders in Switzerland work with microalgae. Research or commercial activities with macro-algae were not observed in Switzerland.

Approximately half of the stakeholders provided information about the algae species, on a varying degree of accuracy (ranging from answers like 'fresh water algae' to species names). In Switzerland the stakeholders work with green algae (table 2) or with cyanobacteria. Although these bacteria are not algae from a scientific perspective, they are often mentioned in the context of algal activities.

Table 2: Used algae types in Switzerland.

Algae Type	Algae species	No.
Green Algae	Chlorella	3
	Scenedesmus	1
	Pseudokirchneriella subcapitata	1
	Nannochloropsis sp.	1
	Phaeodactylum	1
Cyano bacteria	Arthrospira platensis	2
	Synechococcus leopoliensis	1

4 Cultivation facilities

Over the last decade, constant and innovative research and development has been taking place in the area of algae cultivation technology. The presently used cultivation systems can be subdivided into open/half-open and closed photobioreactor systems (table 2).

Closed cultivation systems have the advantage of better controlling the cultivation conditions and, consequently, to guarantee the best temperature and light regime under almost sterile conditions.

Table 3: Cultivation systems.

Open/ Half-open production systems
<ul style="list-style-type: none"> • Open-Ponds • Race-Way-Ponds • Longlines
Closed photobioreactor systems (PBR)
<ul style="list-style-type: none"> • Flat bed/ Plate/ Flat panel reactor • Tubular reactor • Bag/ Flexible tube reactor • Rain creating stack system („Horizon“) • Fermentation vessel (heterotrophic cultivation)

Closed photobioreactors (PBRs) are the most favored facilities for cultivating algae in Switzerland. The most common PBR-systems are tubular reactors followed by fermentation vessels.

Wild harvest of algae species is only carried out by Eawag, an aquatic research institute. They use the algae harvested in its natural environment for example as indicators for metal contamination.

The UMTEC Institute for environmental and process engineering is in this assessment the only algae stakeholder in Switzerland which produces algae in a raceway pond. They also utilize tubular bioreactors as well.

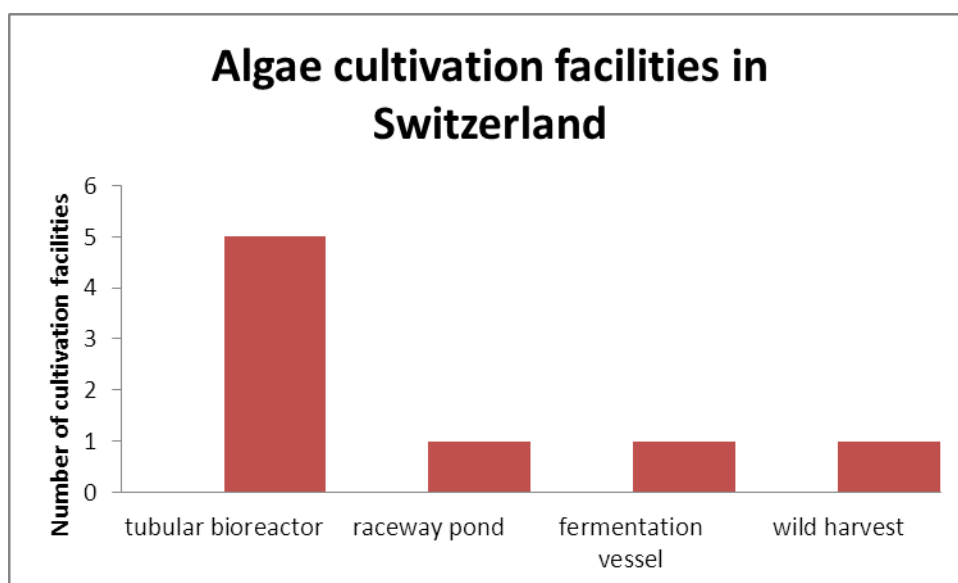


Figure 1: Algae cultivation facilities in Switzerland.

It should be noted that in Switzerland two of the five commercial algae companies have specialized in bioreactor production.

Too little information on the size of the cultivation facilities or the volume of algae cultures was made available to be able to state a range of cultivation sizes.

5 Growth conditions

In respect to growth conditions, the survey did not go into too much detail, but rather concentrated on the origin of the three main substances: water, light and carbon dioxide. Multiple answers were possible. Approximately 30 % of the stakeholders provided no information about the conditions in their respective algae growth facilities.

In regard to the growth medium, 5 stakeholders cultivate their algae in fresh water and 2 respondents grow algae in waste water. It was not indicated what kind of waste water was used for algae cultivation. No salt water was used for algae cultivation in Switzerland.

Commercial institutions were only using fresh water for their algae production (figure 2).

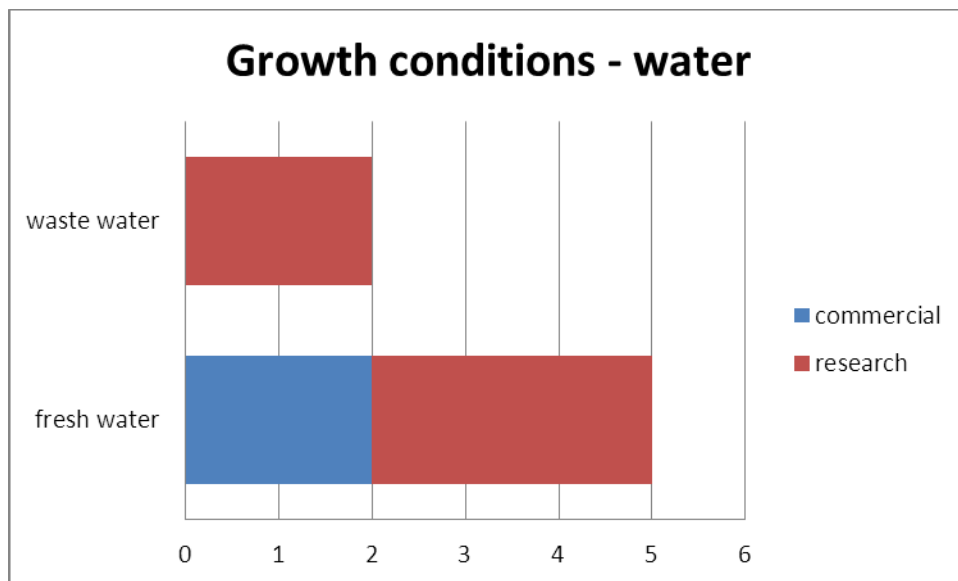


Figure 2: Growth condition – water.

In terms of the light regime, the majority of the stakeholders, who provided information, use artificial light for growing algae: 5 stakeholders use artificial light whereas 3 stakeholders rely on natural radiation as an option (figure 3). Only one research facility experiments with growing algae without light addition.

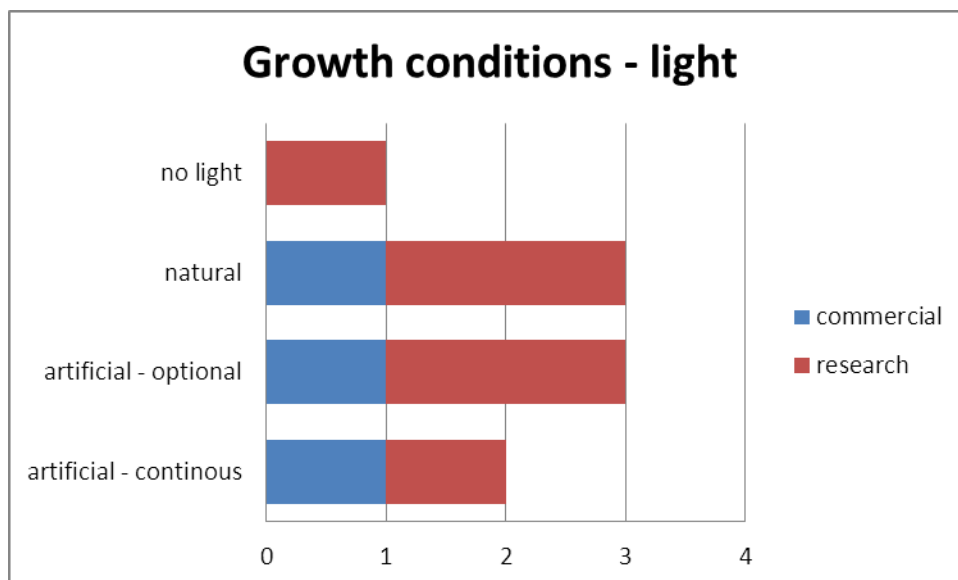


Figure 3: Growth condition – light.

6 Markets

As in the section on algal cultivation conditions, it needs to be emphasized that multiple answers were permitted since most algae stakeholders aim for more than one single product respectively market sector. In order to determine the most promising market sectors for algae, the targeted products have also been grouped accordingly. Due to the low number of organizations participating in the survey a comparison between the targeted markets of research and commercial stakeholders demands a reduction of detail (figure 4). Only the targeted markets which were of actual interest for the Swiss stakeholders are presented.

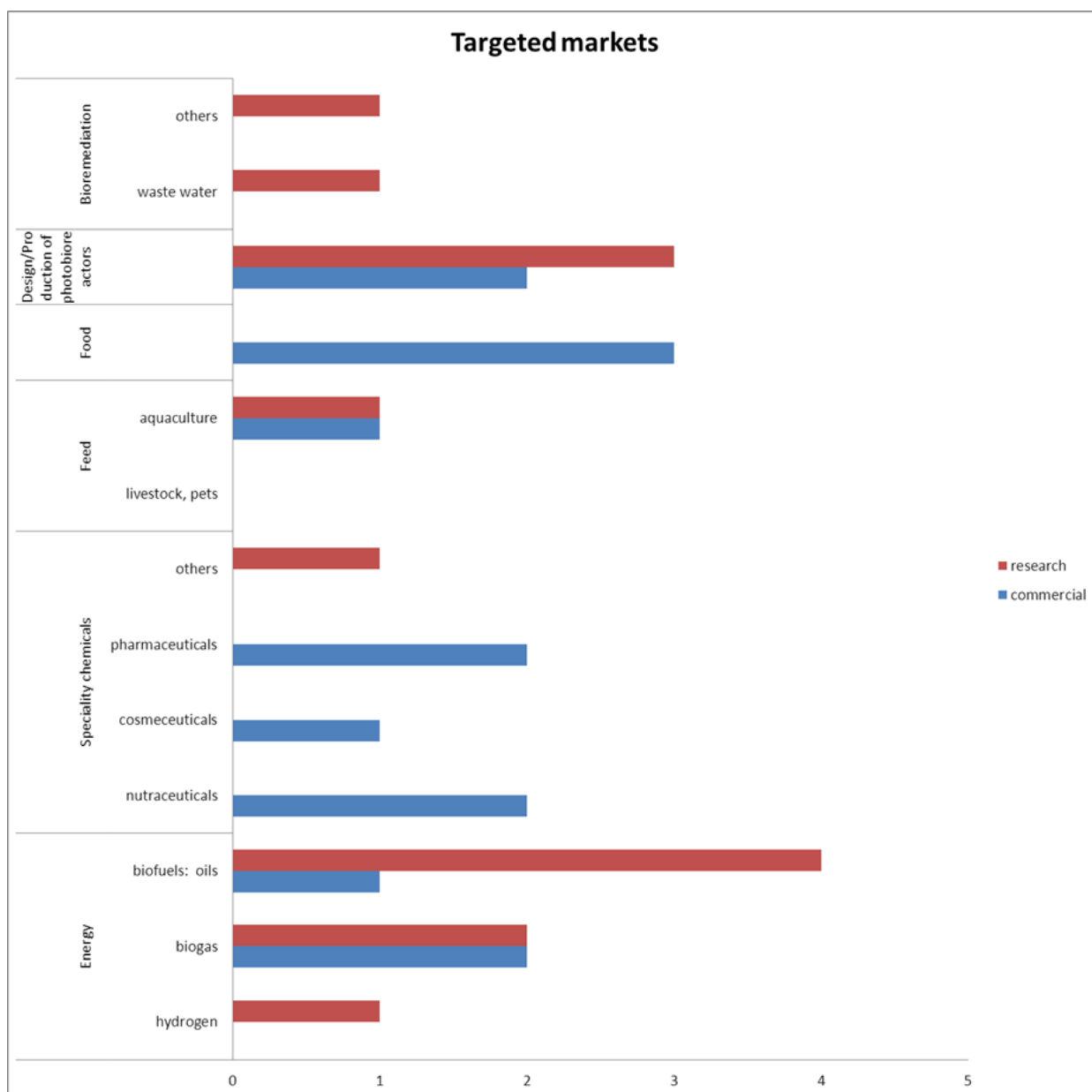


Figure 4: Targeted markets of the Swiss algae stakeholders (multiple answers were permitted), separated according to research or commercial stakeholders.

The majority of the commercially cultivated algae in Switzerland are used for material purposes, like specialty chemical (cosmeceuticals, nutraceuticals and pharmaceuticals) as well as food and feed.

The focus of the research stakeholders was not on specialty chemicals or food, but on energy mainly. Design and production of photobioreactors play a big role in both the commercial and research activities.

7 Underpinning technology and research

Besides their main focus of activity, some of the stakeholders are also involved in actions supporting their efforts in further developing and improving their targeted products. 8 of 13 of the stakeholders provided information about research on environmental impacts or underpinning activities.

R&D on processing as well as harvesting technologies is dominating the combined activities in this field. There are a relatively high number of organizations which opted for 'others' as underpinning activity. They work on a very broad spectrum of algae activities, ranging from phenotype anchoring of silver exposed algae over ecotoxicology of engineered nanoparticles to the empowerment of people in third world countries, fighting malnutrition and to economic analysis of algae production systems.

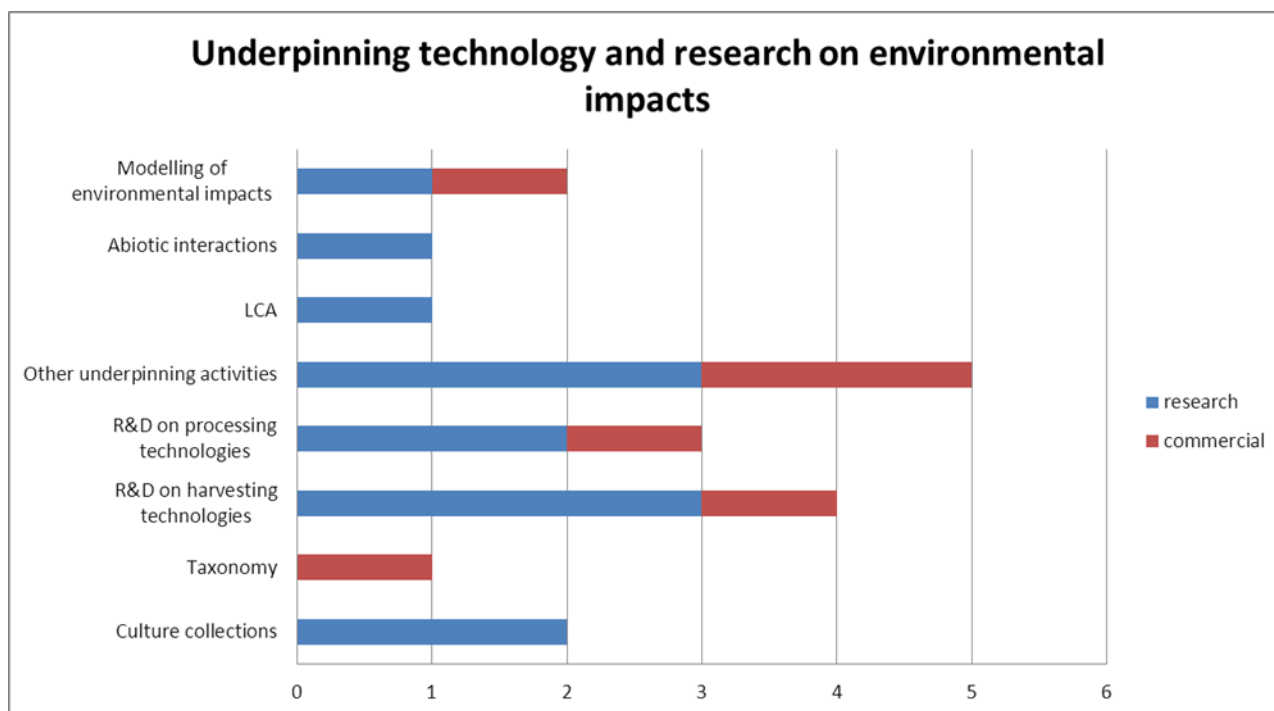
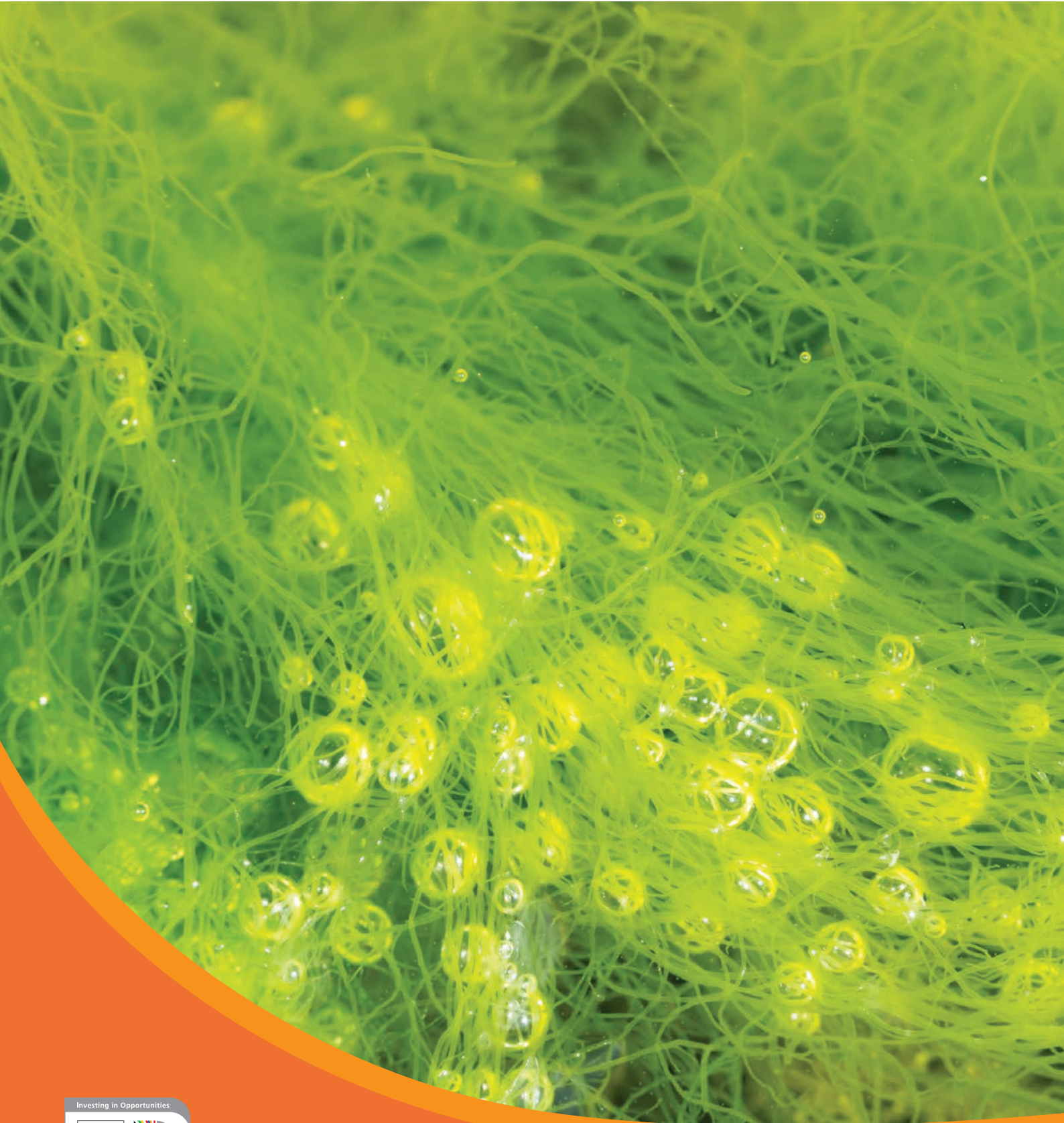


Figure 5: Number of commercial and research stakeholders involved in activities relating to environmental impacts or underpinning technologies (multiple answers were permitted).



EnAlgae is a four-year Strategic Initiative of the INTERREG IVB North West Europe programme. It brings together 19 partners and 14 observers across 7 EU Member States with the aim of developing sustainable technologies for algal biomass production.

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