Life Cycle Assessment of Added Value Compounds Production with Microalgae

Cristina Onorato, Christine Rösch
Institute for Technology Assessment and Systems Analysis (ITAS),
Karlsruhe Institute of Technology (KIT), Germany

Microalgae are an alternative to produce sustainable fuel, food and high-value compounds such as carotenoids and terpenes for nutraceutical supplements and cosmetics. Algae production is focusing on these high-value compounds, as their selling price can guarantee the return on investment and they are bio-based ingredients. Against this background, the EU-project ABACUS was developed. Within this research project, we are assessing the environmental impacts of the technologies applied to produce carotenoids and terpenes by Life Cycle Analysis (LCA) methodology. We investigated the impact of algae cultivation on the LCA results by comparing the three most relevant photobioreactors (PBR) available on the market: the flat panel airlift (FPA), the horizontal tubular unilayer PBR (HTU-PBR) and the green wall panel (GWP). We also started to analyze the downstream processes (harvesting and extraction) and then we studied the influence of the characteristics of the PBR location by carrying out a sensitivity analysis for both indoor and outdoor cultivation in different European regions.
Our preliminary LCA results based on data from pilot scale production indicate that location has a significant impact due to different algae productivities and energy demand for lighting, heating and cooling. We found that in particular for indoor systems, the electricity consumption is the main contributor to the GWP and that the related impact would decrease significantly if the share of renewable energy would increase. Moreover, our results indicate, that a crucial issue for assessing the algae technology is that processes at laboratory and pilot scale are not optimized and unfavorable LCA results are due to a poorly designed system. For this reason, we tried to develop together with engineering experts an upscaling methodology applicable for the different cultivation systems. Already with our first LCA results, we could successfully start to exchange ideas and advise our industry partner. We found that the results of our sensitivity analysis helped technology developers to understand to which extent the different stages of the process influence the results and how the environmental impacts could be reduced by changing the system configuration or energy sources.
The results are based on the project ABACUS, which receives funding from the Bio-Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation program (Grant Agreement N° 745668).