Project Title: Intensified and energy efficient cultivation, processing, and conversion of flue gas produced algal biomass to aquafeed

Applicant: Auburn University

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This project aims to demonstrate the economical and environmentally sustainable conversion of flue gas generated in pulp and paper mills and wastewater from aquaculture farms to algae-based single cell protein (SCP) as aquafeed. The conversion will be achieved in a novel greenhouse-style "dry" biofilm photobioreactor (TRL 5 upon project completion). This project will enable significant improvement over the current algae state of technologies, including cultivation productivity by 200%, biomass concentration by 300%, as well as significant reduction in cost and energy demand – reducing production cost by 50% and greenhouse gas emission by at least 10%. The technical targets will be evaluated through at least two 30-day continuous outdoor campaigns using real flue gas and aquaculture wastewater. In addition to prototype demonstration and aquafeed chemical-nutritional characterization, comprehensive and rigorous TEA and LCA will be conducted to evaluate the techno-economic feasibility and environmental sustainability of the proposed technology.

The success of this project relies on the leverage and integration of various innovations and advancements: (1) Using "dry" microalgae biofilm as biocatalysts to intensify the flue gas (CO_2) conversion process, which utilizes microalgae biofilm as a highly concentrated biocatalyst. By making the biofilm "dry," mass transfer of the gaseous carbon substrates to the biocatalyst is further enhanced drastically, therefore significantly enhancing the productivity or throughput of CO_2 conversion. (2) Adapting mature, energy efficient pulp dewatering and drying for algae dewatering and drying, as they share many remarkable similarities. State-of-the-art techniques in pulp dewatering and drying processes will be leveraged to significantly enhance energy efficiency, hence drastically reducing the costs of algae dewatering and drying. (3) Systems engineering approaches that integrate different components to significantly improve process efficiencies, including feedstock integration, logistic integration, process integration, and energy integration. The integration of these key components is critical for achieving technical and economic feasibility, as well as energy, water, and environmental sustainability.

The proposed technology innovation is expected to provide a robust, flexible, and economically attractive pathway for co-valorization of industrial concentrated anthropogenic CO_2 and aquaculture wastewater. (1) The proposed technology will significantly improve environmental and social sustainability of rural communities, where pulp and paper plants and aquaculture farms are located, by reducing GHG emissions and land, water, and air pollutions, as well as creating jobs. (2) The modular design, distributed deployment, and profitability (to be demonstrated in this project through TEA) of the proposed technology pathway will enable broad application at or near the source of industrial anthropogenic CO_2 and aquaculture wastewater. (3) Economic algae cultivation can play a vital role in developing a circular aquaculture industry by serving as the critical link in the conversion of aqua waste (*i.e.*, wastewater) into aquafeed.