

CO₂ Biofixation Technology Roadmap: Pathways to the Development and Application of Microalgae Systems for Greenhouse Gas Abatement

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Microalgae mass cultures enable the direct biofixation of CO₂ from concentrated sources, such as power plants, into algal biomass that can be a source of renewable biofuels such as methane, ethanol, biodiesel and hydrogen and fossil fuel-sparing products (fertilizers, biopolymers and lubricants). Processes for the large-scale cultivation of microalgae, including for the beneficial re-use of CO₂ and production of biofuels has been the subject of active R&D for several decades. Currently microalgae are used commercially to produce food- and feed-grade algal biomass and for wastewater treatment, but these processes are presently too expensive for large-scale applications to greenhouse gas abatement. The major technological and economic barriers are the need to further increase the productivity of algal mass cultures, the high capital cost of the raceway ponds and the operating costs of algal harvesting. Engineering cost analyses project sufficiently low costs if large (> 100 hectare) open-pond cultivation systems were deployed and higher algal biomass productivities (>100 metric tons/hectare/year) could be achieved. These targets will require long-term applied R&D into algal photosynthesis and physiology, their large-scale cultivation, harvesting and processing.

To advance the development and application of microalgae biofixation processes for greenhouse gas abatement, the U.S. Department of Energy and EniTecnologie, the R&D arm of the Italian oil company Eni, have organized an International Network on Biofixation of CO₂ and Greenhouse Gas Abatement with Microalgae. The Network, managed by the IEA Greenhouse Gas R&D Programme, involves the participation by major energy companies, government organizations and other funding agencies with an interest in supporting R&D activities in this field. It provides for research coordination, for the development of bi- or multi-lateral projects, for technical assistance in evaluation of processes and R&D projects and supporting techno-economic analyses and resource assessments. The strategic goal of the Network is to demonstrate within five years the technical and economic feasibility of novel technologies for GHG mitigation based on microalgae biofixation and achieve practical demonstrations within the decade.

As a tool for guiding future R&D activities an "R&D Roadmap" was developed, to help integrate into a common vision the projects carried out by the Network members. The roadmapping process involves consensus development among technical experts to identify the key scientific and technological developments needed to achieve specific program goals within stated time frames. Four general, multipurpose microalgae processes that could meet the Network objectives have been identified by the Roadmap. These combine CO₂ utilization and biofuels production with additional environmental services, such as wastewater treatment and nutrient recycling, along with the production of higher-value co-products. Major R&D issues, common to all the proposed processes and required for their practical development, will be discussed.