the ENERGY lab

PROJECT FACTS

ICCS – Area 2

Recovery Act: Carbon Dioxide Conversion to Fuels and Energy

Background

Worldwide carbon dioxide (CO_2) emissions from human activity have increased from an insignificant level two centuries ago to annual emissions of more than 33 billion tons. The U.S. Department of Energy's (DOE) National Energy Technology Laboratory (NETL) is committed to developing technologies to capture, separate, and reuse CO_2 in order to reduce greenhouse gas (GHG) emissions without adversely influencing energy use or hindering economic growth. Therefore, practical technologies to use CO_2 to produce useful products are needed.

One possible use is to stimulate growth of algae that can be used to produce biofuels. Microalgae are single-cell organisms, some species with high oil content, that use photosynthesis to fix CO_2 into biomass for rapid growth. The CO_2 from power and industrial plants could enrich water to cultivate algae. The oils harvested from the algae can be used to produce fuels including biodiesel, green diesel, green gasoline, and green jet fuel.

The emerging biofuels industry has some significant technical and economic obstacles to overcome before commercial status can be realized. DOE partnered with UOP, LLC (UOP) to further develop an algal CO_2 sequestration pilot program to advance the commercial viability of biofuel technology.

Project Description

The research team planned facility modifications to capture CO_2 from exhaust stacks at UOP's Caprolactam Plant in Hopewell, VA, and converted it into biofuel. This site was selected due to its large onsite emission generating equipment. UOP completed its final design for the pilot-scale algal CO_2 plant during Phase I of the project. During this time, UOP also finalized site preparation, utilities, and permitting requirements for constructing and operating the proposed system. The plant design included the following elements: CO_2 capture technology, CO_2 delivery and control system, algal cultivation system, algal harvesting, and oil extraction. The plan included a CO_2 monitoring and process control system, as well as an environmental study.

Had DOE selected the project for continuation to Phase II, UOP would have completed the permitting process, installed its pilot-scale system at the Hopewell site, and connected it to a CO_2 delivery system and the pilot-scale algal CO_2 sequestration unit. Algal oil samples would have been analyzed to determine suitability of feedstocks for the UOP Ecofining™ and Green Jet Fuel™ processes. The production of fuel from these oils would have then been evaluated using UOP engineering models to estimate

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PROJECT DURATION

Start Date
01/01/2010

End Date
09/30/2010

PROJECT COST

ARRA Funded

Total Project Value
$1,978,019

DOE/Non-DOE Share
$1,552,549 / $425,470

Government funding for this project is provided in whole or in part through the American Recovery and Reinvestment Act.

the yield of fuel and by-products. The biomass remaining after extraction of algal oil would have been evaluated for suitability as a pyrolysis feedstock using benchmark-scale pyrolysis tests. The conversion of the residual biomass to bio-oil and char would then have been modeled to determine yields and final GHG savings.

Goals and Objectives

The goal of this project was to provide a preliminary design for a cost-effective and efficient method to capture CO_2 from exhaust stacks at the Hopewell Caprolactam Plant. The main objective was to deliver the captured CO_2 to an algal cultivation system for sequestration into biomass that would become a feedstock for biofuel production, power generation, and slow release agricultural fertilization.

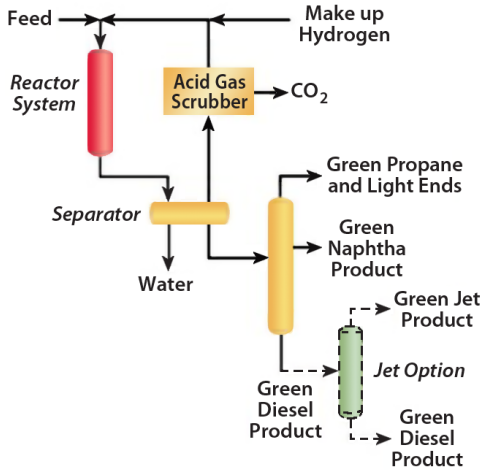
Accomplishments

UOP completed Phase I of the project. The impact of CO_2 addition and monitoring was assessed through delivery of bottled CO_2 to the algal cultivation pond. The team established the best approach to extract lipid oil from the algal biomass, and compared solvent extraction methods against direct liquefaction to determine the most cost-effective approach for oil yields. The team completed the National Environmental Policy Act (NEPA) Categorical Exclusion B and constructed the pilot plant facility. The team completed the test matrix and began testing on the algal pilot facility. DOE did not select the project for continuation to Phase II.

Benefits

This project demonstrated that re-use of CO_2 from exhaust stack emissions can be deployed through various applications at a commercial scale. The technology can be used on other plants of this type and be adapted to other types of plants to reduce the amount of CO_2 released into the atmosphere. The widespread application of CO_2 capture technologies will help the United States meet its goal of reducing GHG emissions.

Ecofining Flow Diagram



UOP's Ecofining™ process flow: algal biomass fed with carbon dioxide captured from the Hopewell plant could be used as a feed and then refined to produce various biofuels.

UOP's Caprolactam Plant in Hopewell, VA