Biorenewable Systems

TSM/ABE 325

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On-Site Sequestration of CO_2 from Ethanol Production

Introduction

- Yeast converts sugar to ethanol and carbon dioxide in fermentation
- Near 50/50 mass ratio of ethanol to carbon dioxide
- Large portion of products is carbon dioxide gas
- What if all of the carbon dioxide stream was converted into a valuable co-product?
- Algae production produces oil and feed, which are also produced by ethanol plants

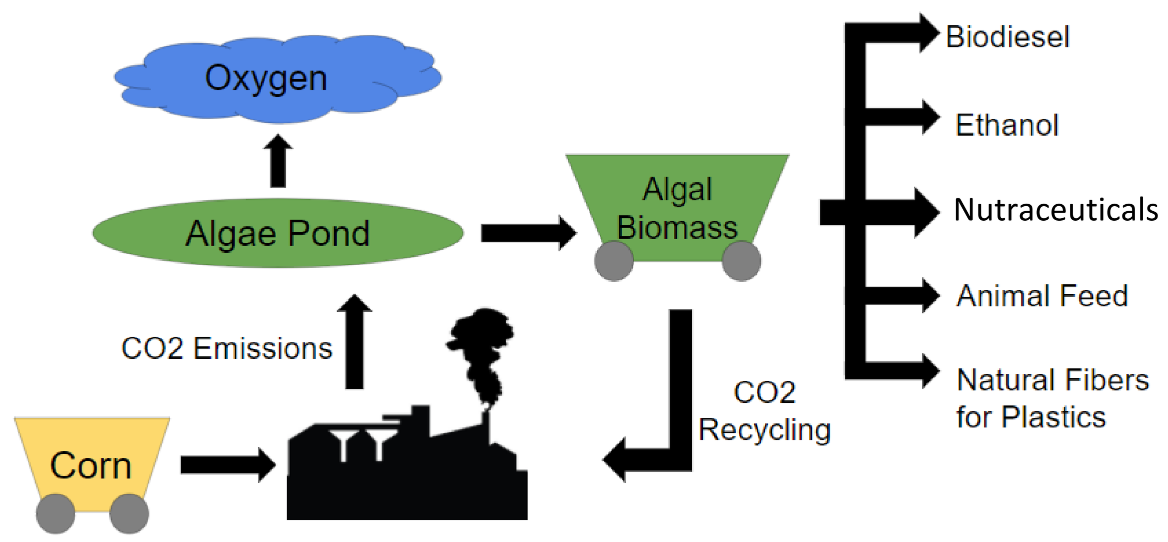

Figure 1. Flowchart of the proposed co-location of algae farm and ethanol plant

- Co-location of algae farms and ethanol plants is a potential strategy to improve the utilization of waste streams as shown in Figure 1.
- Potential to add diversity to biochemical production

Background Information

- Autotrophic microalgae are cultivated on land in large ponds, or in enclosed photobioreactors using enriched CO_2, as shown in Figure 2.

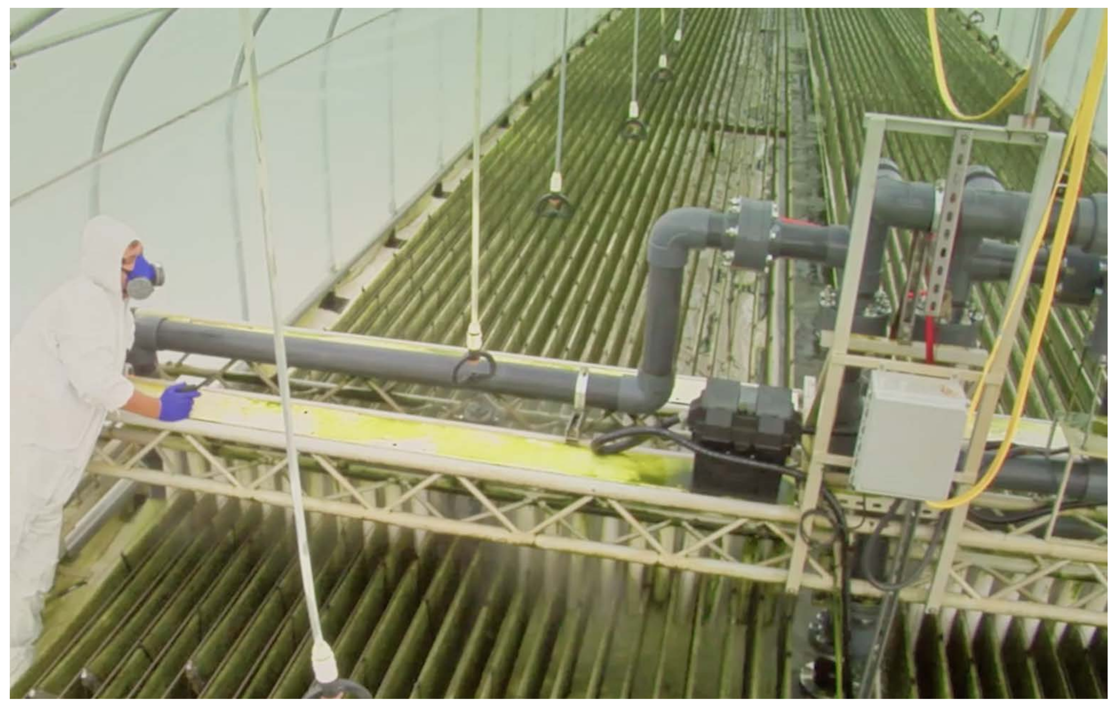

Figure 2. Photo of an algae photobioreactor [1]

- The CO_2 can come in the form of flue gases from power plants or be obtained from other fossil fuel combustion and from biorefineries. Thus they can help recycle greenhouse gases and reduce greenhouse gas emissions overall when the algal biomass is converted into biofuels or feed additives.
- Some plants currently capture their CO_2 and sell it to bottling companies. This generates an extra $14 million in revenue[2].

Constraints and Opportunities

- Unlike a coal power plant, an ethanol plant starts with a clean carbon dioxide stream.
- Ethanol plants are generally located in rural areas and land space is more available for large algae operations. With 370 acres of land covered with white plastic, land would be a significant capital investment.
- Aside from the availability of CO_2, ethanol plants also have waste heat that can keep algae at optimal temperature even during winter months and a nutrient rich backset that could work well as a growth medium.
- A tubular PBR system, similar to Figure 3, has a large install and operating cost.

Figure 3. The energy cost to pump the algae through the bioreactor is very significant for the tubular system [3]

Potential Solutions

- A typical 50 million gallon/year dry grind ethanol plant that currently produces approximately 160,000 tons of CO_2/year could produce 65,000 tons of algae on 370 acres of land.
- At current prices for corn oil and DDGS, 65,000 tons of algae equates to $24 million in added revenue as seen in Table 1.

elemental mass balance			etOH	50,000,000	gallons	
glucose	180		etOH	329,226,030	lbs	
ethanol	92	51%	co2	314,911,855	lbs	
co2	88	49%		157,456	tons	
789	kg/m3					
6.5845206	lb/gal					
Raceway			Tubular			
conversion efficency	55%	3		55%	3	
absorption efficency	35%	3		75%	3	
dry mass algae	30,115	tons	dry algae	64,531	tons	
oil	19,574	tons5	oil	41,945	tons5	
feed	10,540	tons3	feed	22,586	tons3	
$	$ 11,062,253.32			$ 23,704,828.54		
				11,517,745	gallons BD	
productivity	20	g/m^2*day	4			
	33	tons/acre*yr	Dirt	95	metric tons/ha yr	4
	925	acres		42	tons/ac yr	
				1526	acres	
			White Plastic	173	tons/ac yr	4
				372	acres	

Table 1. Potential economics of 50 MM gal/yr ethanol plant with combined algae harvesting

- To implement our solution, there needs to be advancements in the field to help reduce the cost of extracting the oil from algae and make it more economical.

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