Advances in Computer Science Research (ACSR), volume 73
7th International Conference on Education, Management, Information and Computer Science (ICEMC 2017)

Case for Algae Biofuel

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Keywords: Algae; Biofuel; Raceway; Transportation fuel; Transesterification

Abstract. In recent years, the third generation biofuel, such as algae, has become a promising alternative source of energy.

This paper deals with a specific case for algae biofuel, which weaved a relatively practical envision about algae industry. In this envision I firstly chose the type of technologies to cultivate and get large amount of algae, and chose the possible location after considering natural and economical factors.I designed the facility parameters, and then discussed the environmental impacts, calculated the economical feasibility, finally talked about social acceptance.

Type of Technology

First, we choose the chlorella as the feedstocks. Not all microalgae are suitable for the production of biodiesel, which requires a high oil content and a high growth rate. High growth rate means that we can get a large amount of biomass in a short time and reduce the risk of bacterial infection[1]. And high oil content can guarantee high yields, and can reduce cost of production. Considering these two factors, Chlorella is an ideal feedstock for biodiesel production, which is also easily to be found and cultivated.

And for the cultivation, we will use wheel-paddle raceway open ponds because it's cheap and simple.

And for the next step, we choose flocculation for harvesting , which satisfies low energy requirement.

Once the algae is harvested, the lipids will be extracted from the walls of the algae cells. At present, this process is a costly. Extraction can be broken down into two methods: the mechanical methods and the chemical methods. For the chemical methods, people usually use the hexane solvent method which extracts up to 95 percent of oil from algae[i].

Nowadays, we usually use a combination of mechanical pressing and chemical solvents.

After cultivation and harvest, the lipids we get is triglyceride. Triglyceride is highly viscous and can't be used as diesel fuel directly. So a reduction in viscosity is needed. The most common methods used to reduce oil viscosity currently is transesterification[ii]. After the transesterification, the molecular mass and the viscosity can be reduced to 1/3 and 1/8 of the original ones respectively.

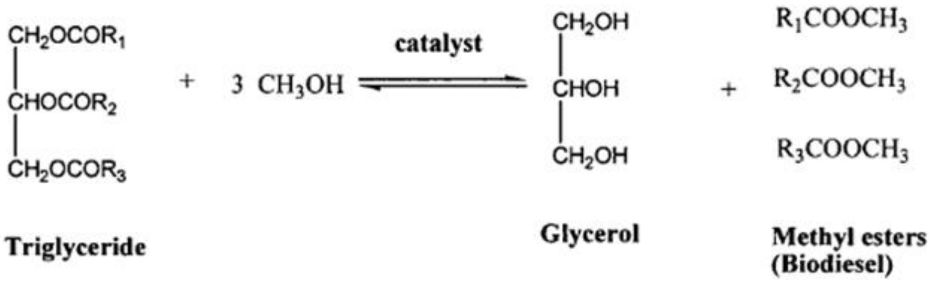

Figure 1. Transesterification Reaction

Dubini A, Mus F, Seibert M, Grossman AR, Posewitz MC: Flexibility inanaerobic metabolism as revealed in a mutant of Chlamydomonas reinhardtii lacking hydrogenase activity[J]. J Biolchem,2009, 284:7201-7213.

Location

As for the location, there are a lot of considerations. It's roughly divided into two: natural factor and the economical factor. Economical feasibility will be presented later. For the natural feasibility, the sunlight, temperature, water, CO_2, land use, and nutrients are considered below.

First is climate, including sunlight and temperature. The isolation must be sufficient, which means more than 2800 hours sunshine per year. And the temperature must be averagely warm enough, which is above 55 degree Fahrenheit[iii]. Too drastically seasonal fluctuation should also be avoided. About the water. There are three sources of water 1)seas, oceans, lakes 2)groundwater 3)rainfalls. Because algae have not too many restrictions about water quality, so we first consider about the seas, lakes. Then it can be groundwater-- saline aquifers that avoid drinking water resources. Rainfall probably is not enough considering the water consumption. And CO_2, since eastern US has a more intense CO_2 concentration, it is tempting to locate at southeast corner.

After considering all these factors, we choose a coastal lot near to the Santa Barbara, CA. The reasons we choose this place are listed as below. 1) It's near to the sea, which tackles the problem of water. 2) It's fringe land, relatively cheap comparing to other places in CA. 3) It's near to the city, about 18 mi to Santa barbara, which meet the requirements for transportation of our products and required raw material. 4)it's near to the University of California. As we said, the algae industry is still immature due to the technical issues, it will be convenient to be in the vicinity of a research institute. 5) The ideal local temperature, ranging from 12 ℃ to 21 ℃ for a year.[iv]

Size of Facilities and Other Parameters

We decide the area of cultivation is 10 hectares. And the raceway used is RW101. The area of one raceway is $101m^2$, so the number of raceway is 990. The place of one raceway is like the picture.

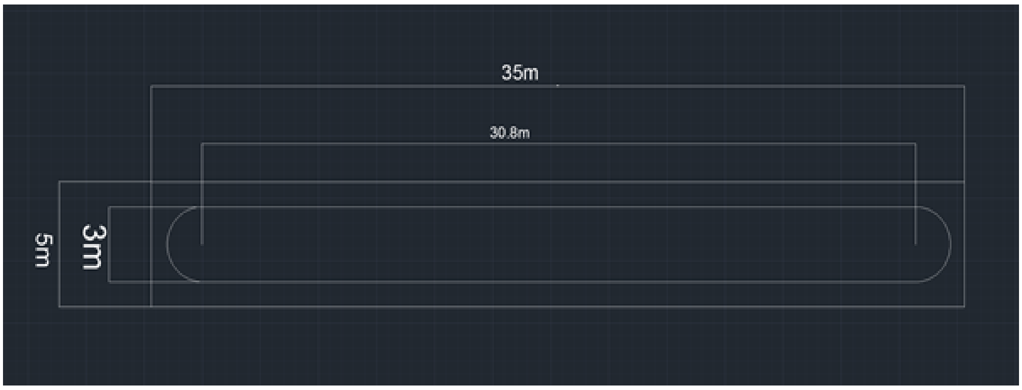

Figure 2. Place of raceway pond

So the place of one raceway is $175m^2$. And the total area of raceway is 17.325ha. We decided that the total area of our factory is 20 hectares.

The main facility of transesterification is under picture. The important facility is ultrasonic processor, and we choose the processor – VCX2500 from Sonics & Materials. The power of VCX 2500 is 2500W. It is a big power, so it can process the temperature will hold on about 65℃.

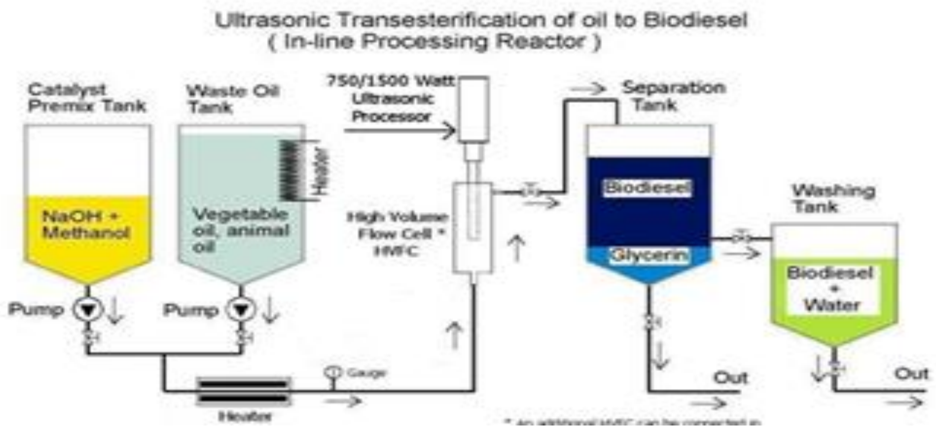

Figure 3. Ultrasonic transesterification of biodiesel [v]

The output of biomass is 0.02kg/(m^2·day). So we can get about 2000 kg dry algae per day. And the oil is only 30% of the dry algae. So the output of oil is 750L/day. And the transfer efficiency of reaction is 95%, so the output of biodiesel about 712.5L/day. The time of reaction is 20 min, so we can solve around 120L oil per hour. And we just need one machine to process the reaction.

Environmental Impacts

As for the environmental impact, basically the algae biofuel has low footprint. But still, there are four aspects we may concern about. First is water resource. Because open pond requires a lot of water for periodical renewal, which decreasing the risk of contamination, it may cause water shortage for local residents.

Besides, the evaporation will also consume a large fraction of water, which lead water to a very critical consideration. Next is land. Since the water must be sufficiently shallow to dissolve CO2, vast land may be occupied. The third is nutrients-- phosphorus and nitrogen[vi]. If we use the fertilizer, there will be a problem of the phosphorus resource because the phosphorus stocks left not too much so it may raise the competition with the conventional agriculture. Beside the concerns about resource, there are potentially some environmental hazards, like the eutrophia, and the attempts avoiding toxic species of algae need to be made.

Economical Feasibility

Our facility was a relatively large facility, although it could have been larger. Our total annual operating costs totaled about $680,000[vii]. However, the total yearly revenue for the facility was slightly more than $719,000. This left us with a profit of approximately $37,000. For a large business, especially for an oil company, this is a rather small profit margin. This profit margin continues for about 22 years, at which point we break even on the capital costs of the facility. Most of our revenue never came from fuel products. Instead, a large portion of our revenue came from selling the dry algal biomass as animal feed. We only received $208,000 a year from the sale of algae fuel, but we made $511,000 a year from selling the dry biomass as animal feed.

Break even point		
Annual costs	$681,874.08	
capital costs	$4,350,260.00	
Annual fuel production	260,062.50 liters	68,701.23 gallons
fuel price (B100)		$3.03/gallon
revenue		
fuel	$208,164.73	
algae dry mass for animal feed	$ 511,000.00	
profit	$ 37,290.65	
time until capital is paid (years)	22.69	
yearly capital payments	$191746.1	
lifetime	40 years	
profitability over lifetime	$4,811,299.32	

Figure 4. Annual costs[viii]

Profit margins could be raised significantly by drastically increasing production. By selling more algae fuel and more dry biomass as animal feed, we could break even in a shorter amount of time. The costs of production of biodiesel would change only slightly, since we could reuse the hexane used to extract the oil, which would greatly reduce the cost of processing. Since gasoline has an inelastic demand curve, we could produce more biodiesel at a cheaper price, and sell it at standard gas prices, which in this case is $3.03/gallon.

Social Acceptance

The issue of social acceptance is not too much of a problem in the algae fuel industry. The production of algae fuel does not affect the supply of food crops the way that, for example, ethanol production from corn does. Our facility would reassure the people of Santa Barbara that their food prices would not rise. We would let them know that their fuel prices would drastically decrease, however. In order to build a reputation in the area as being a facility that is good for the future of the children of Santa Barbara, we would offer internships to students from the Santa Barbara campus of the University of California .

The only negative reaction that we expect from the people of Santa Barbara to our facility would be regarding genetic engineering. Genetically modified organisms, or GMOs, are a touchy subject in the United States. There is some worry about the effects of eating genetically modified foods, although there is no known harm from eating GMOs. This would be a concern for us because our dry algal biomass would be used as cattle feed, which the people would then eat, or drink the milk of. It could also find its way into cosmetics or into foods for human consumption. We would reassure the people, that we would not use genetic engineering in our algae production process, and that our algae was safe for human consumption.

Conclusion

In this paper, for the specific discussion, we chose the transesterification as manufacturing technic to produce biodiesel. As for location of the weaved facility, we select Santa Barbara, California for several climate and economical reasons. By given 10 hectare as total cultivating area, an estimation for size of facilities is followed. After that, though it is negligible, several potential environmental impacts are presented for the sake of comprehensive analysis. Again, but more concretely and accurately, financial calculation for this 10 hectare factory is shown by the presumption of 20 years life span. At the end of discussions, social acceptance is followed as supplement.

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