Algae-Based Biofuel Prospective in Bangladesh

A thesis dissertation submitted in requirements for the completion of the degree of Bachelor of Science in Electrical and Electronic Engineering from the Department of Electrical and Electronic Engineering

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DECLARATION

This is to certify that 'Md. Golam Rabby' and 'Angkon Kumar' completed their thesis work named "Algae Based Biofuel Prospective in Bangladesh." at the Department of Electrical and Electronic Engineering, Daffodil International University, Dhaka, Bangladesh. The above thesis work, or any portion submitted anywhere for the awarding of any degree, and the research work has been undertaken completely without plagiarism or any violation of research ethics and precepts.

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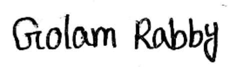

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APPROVAL

The thesis entitled "**Algae-Based Biofuel Prospective in Bangladesh**" submitted by **Md. Golam Rabby(191-33-868) & Angkon Kumar(191-33-910)** has been done under my supervision and accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering in December.**

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ABSTRACT

Coal, natural gas, and petroleum all contribute to meeting the world's energy needs today, even though oil prices are soaring. Additionally, global geopolitical unrest may raise it, and demand is also expected to rise. Energy crises and environmental degradation are two serious new issues that the world is currently facing. A global recession is inevitable if this keeps on, and there is little doubt that the depletion of global reserves will quicken. The globe produces more fuels and energy, which has an adverse effect on the environment. As a result, several studies have been conducted to identify an alternative source of energy that is both environmentally beneficial and technically practical. Recently, it has been discovered that biodiesel is a more environmentally friendly, non-toxic, and energy-efficient technology that is also biodegradable. The primary sources of biodiesel are about 350 oil-bearing plants, namely rapeseed, soybean, jatropha, sunflower, linseed, and coconut. These edible material sources, however, are impractical in situations when demand is significantly more than supply. However, many recently developed nations like China, Malaysia, and India are accepting this technology in production and export. Non-edible materials like algae are acceptable sources of biodiesel not just in research but also in many of these nations' recent development. This study gives a general overview of the production of algae biodiesel in Bangladesh, where the cost of fossil fuels (coal, oil, and gas) is rising daily, and the country must make a time-consuming decision to use biodiesel as a substitute to maintain a clean environment. The analysis is done on both mechanical and chemical processes used to make biodiesel. Microalgae energy basic research in China has a solid technical and technological foundation. Algae biodiesel was predicted to become China's largest source of energy within a few years based on several initiatives that began in 2005. Malaysia's national biofuel strategy aims to boost productivity and maximize profits in the market for second-generation biofuels like biodiesel made from algae. In India, they began with biodiesel made from jatropha before conducting thorough research to determine whether algae that produce hydrocarbons are to blame for the presence of hydrocarbons in the water. Government must play a significant role in promoting the growth of the biofuels industry in Bangladesh by adapting technologies to local needs, which raises questions about technology transfer. For Bangladesh to achieve sustainable growth and environmental preservation, improved biodiesel manufacturing methods are essential.

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LIST OF ACRONYMS

FAME	Fatty acids and methyl esters
PBR	Photobioreactors
KAHRC	Khwaja Agri-Horticultural Research Centre
GDP	Gross Domestic Product

CHAPTER 1
INTRODUCTION

1.1 Introduction

Fuels are the types of substances that store potential energy in ways that can be practically released and utilized as heat energy [1]. Large sources of energy are created from fuels to create steam, electricity, and power transportation systems. The ability of fuels to address some of the problems of daily life has long been recognized, although they have come to be associated with contemporary industrial civilization [2]. The most widely used fuels come from coal, uranium, natural gas, and oil. Around 87 percent of the world's energy supply comprises oil, natural gas, coal, and nuclear energy combined; this percentage has been relatively stable over the past few decades [3]. However, these are non-renewable sources of energy, making it imperative to explore alternatives to address the coming global energy problem. Biodiesel, bioethanol (methanol, ethanol, and butanol), chemically stored energy (batteries, fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, and other biomass sources are a few well-known alternative fuels [4].

A non-petroleum-based diesel fuel known as "biodiesel" is made of long-chain alkyl (methyl, ethyl, or propyl) esters. Therefore, the term "bio" designates a biological source as opposed to gasoline based on petroleum. Lipids, mainly vegetable oil or animal fat (tallow), and alcohol are chemically combined to create biodiesel. It is created via a chemical process that turns natural oils and fats into fatty acids and methyl esters (FAME), a clean-burning renewable fuel [5]. Recent studies have shown that biodiesel is a more environmentally friendly, non-toxic, and energy-efficient technology that is biodegradable. Biodiesel is a sustainable, clean-burning alternative to diesel that is lowering American reliance on imported oil, generating employment, and enhancing the environment. The primary sources of biodiesel are about 350 oil-bearing plants, namely rapeseed, soybean, jatropha, sunflower, linseed, and coconut. However, the increased demand for fuels is not being met by these sources. Microalgae may offer a workable answer in these reverse situations. The tiny algae known as microalgae are often found in freshwater and marine environments. They are single-celled organisms that can exist alone, in chains, or in groups [6]. Microalgae are often prokaryotic or eukaryotic, uni- or tiny multicellular organisms. Microalgae are solar-powered cell factories that transform carbon dioxide into potentially useful products including high-value bioactive, meals, and feeds [7,8]. These photosynthesis-based bacteria can also be used for bioremediation [9] and as nitrogen-fixing bio-fertilizers [10]. Several different forms of sustainable biofuels may be produced from microalgae. Among these is biodiesel made from microalgal oil [12,13], bio-hydrogen created by photobiology, and methane produced by the anaerobic digestion of the algal biomass [11]. The concept of utilizing microalgae as a source of fuel is not new [16], but it is now being seriously considered due to the rising cost of petroleum and, more crucially, the growing worry about global warming brought on by the usage of fossil fuels [17]. The lipids, or oils, that are present in the walls of algal cells can be eliminated in a variety of methods. Surprisingly, none of these are especially revolutionary techniques. Wet extract procedures, which target disrupting algae cells in solution, and dewatering techniques, which remove algae from aqueous water solutions and then physically or chemically disrupt the cells, made up the trials themselves [18].

This study explores the importance of biodiesel production for guaranteeing a secure environment and a healthy economy for Bangladesh based on a thorough literature analysis. This document provides an overview of the production of biodiesel from microalgae and is one of several publications that analyzed the future of biodiesel in this nation in detail. Some wealthy nations, like China, Malaysia, and India, have already begun producing biodiesel, although based on Guan PI, palm oil, and jatropha, respectively. But each of those nations has taken the initiative to generate biodiesel from microalgae, which is more practicable than any other and is also examined in this study, after extensive investigation. To pinpoint the precise species of algae, more research is required because various microalgae have varying amounts of oil and availability.

1.2 Algal Biodiesel and Its Extraction Process:

Biodiesel is classified into four groups based on the sources. There are four sources: edible, inedible, animal, and algal/fungal. However, when comparing the oil yield (L/Acre) between microalgae and other sources of biodiesel, it is evident that microalgae have the greatest oil output (19000-57000 L/Acre). In contrast, maize has the lowest yield (68.13 L/Acre), and other well-known sources like sunflower, jatropha, and palm oil have 386.07 L/Acre, 788.33 L/Acre, and 2403.47 L/Acre oil yield, Microalgae require more than 350 times less space than maize, whereas 31 times and 10 times less space is needed for jatropha and palm oil, respectively [19]. Algae are also environmentally favorable sources of biodiesel since they lower the level of carbon dioxide in the atmosphere. When algae are expanding and have the greatest consumption rate when compared to other plants, more carbon dioxide is required. The locations of the algae-growing facilities might be next to power plants, with the created carbon dioxide being sent straight to the algae so that it can grow and produce oxygen. This technique may be used to purify coal power plant flue gas, which contains 10 to 30 times as much carbon dioxide as regular air [20].

Taking oils or lipids out of algal cell walls is referred to as oil extraction. Wet extract operations, which aim to disrupt algae cells in solution, and dewatering methods, which remove algae from aqueous water solutions and then physically or chemically disrupt the cells, are the two main processes.

1.2.1. Wet extraction process:

Freezing:
The cell walls will break from the inside out or be damaged by the compressive pressures as a result of the expansion of the water within and surrounding the cell. After three freeze cycles, the samples were examined, and the algae cells started to group [21].

Homogenization:
In a mixture, the particle size should be decreased to produce a homogenous media. Homogenization is the word for this lowering action. Two distinct tissue grinders with varying homogenizing capacities were examined to determine the viability. This procedure is transmitted through small valves by expelling the mixture at high pressure. On a lab size, homogenizers with Nano-tolerance are a promising source for oil extraction, but they are very challenging to replicate on an industrial scale. [21, 22]

Sonification:
Ultrasonic waves may be employed to cause cavitation bubbles to form near the algal cell wall. Ultrasonic reactors can be used to produce these ultrasonic waves. When cavitation bubbles create pressure, shock, and eventually the release of trapped oil, the cell wall will collapse. [22]

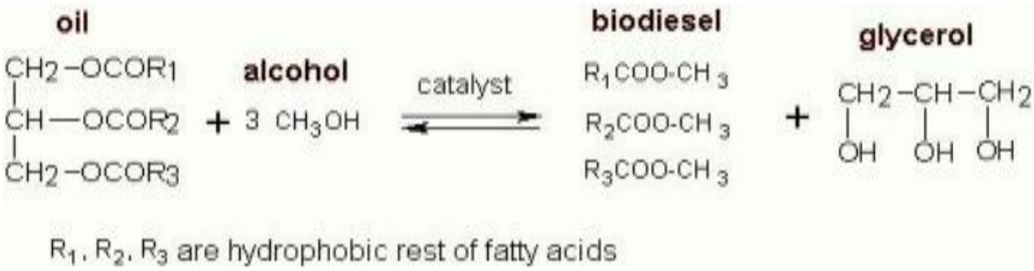
1.2.2 Dry extraction process:

Expeller Method or Mechanical Disruption:
Mechanical disruption is the term used to describe pressing and bead milling. By using this technology, microalgal biomass, such as seeds or nuts, is subjected to high pressure or pressing, which causes the cell walls to break down and ultimately release oil [21]. The process of bead milling, which is typically employed in combination with solvents to recover oil, is most efficient and cost-effective when cell concentrations are high and when the extracted products can be readily separated after disruption [22]. Many industrial vegetable oil producers use mechanical pressing with chemical solvents to extract the oil [23].

Hexane Extraction:
The plasma membrane of an algal cell traps oils inside of it (cell wall). However, as the algal cell becomes dry, the plasma membrane degenerates and the ability to hold oil is reduced. The oil inside the cell will dissolve if hexane, an organic solvent, is added to the dried samples. Hexane will do this by penetrating the cell wall. The hexane is then taken out of the algal sample, and the oil-dissolving hexane is likewise transferred outside of the cell. Hexane and oil are distinguished by distillation [21]. This strategy works well when combined with the "expeller technique." More than 95% of the oil from algal cells may be removed by combining the expeller and hexane extraction methods after the oil has been extracted using the expeller technique for the leftover pulp [23].

1.3. Synthesis of Biodiesel:

The process known as transesterification, sometimes known as alcoholization, is used to turn the oil collected from algal cells into biodiesel. In the presence of a catalyst, it transforms the oil into biodiesel. Appropriate alcohol (ethanol, methanol, butanol, etc.) is used to degum oil that has been purified of all impurities [24]. This is a representation of the reaction:



Temperature, Process time, and the ratio of oil to alcohol are variables that affect the transesterification reaction [25]. As both the reactants and the reaction's products are liquids, the entropy change will gravitate to zero [26]. It is possible to determine a reaction's viability using thermodynamic characteristics.

CHAPTER 2

Biofuel Energy System

2.1 Biofuel Technology:

Algae growth occurs through light energy to chemical energy. Biofuel technology is new to many countries around the world. In Bangladesh, it is comparatively new also. We know Bangladesh is a riverine country. In our country, we have many rivers, ponds, canals, etc. Also, in the rainy season, we have enough rain to fill water containers. So, Bangladesh is perfect for algae cultivation. Here is a chart of rainfall in the rainy season

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Barishal	0.27	0.69	1.73	2.96	6.95	11.14	12.73	17.49	9.97	7.73	0.84	0.36
Bhola	0.57	2.55	4.82	7.08	19.15	13.22	12.17	9.48	5.08	4.75	0.05	0.30
Bogra	0.45	0.42	0.77	2.27	7.34	9.11	19.22	4.20	8.13	4.26	0.50	0.06
Chandpur	0.55	0.42	2.33	4.55	12.20	8.97	13.30	14.04	9.06	6.66	1.18	0.09
Chittagong	0.41	0.44	1.81	3.28	4.79	18.17	26.91	17.02	8.95	6.65	2.04	0.37
Comilla	0.29	0.38	1.41	4.52	9.17	11.19	14.18	9.69	8.85	6.09	1.00	0.13
Cox's Bazar	0.47	0.70	3.09	7.04	24.91	38.08	14.39	10.97	7.80	3.65	0.34	0.19
Dhaka	0.31	0.70	1.61	5.00	12.27	11.97	11.95	9.85	9.59	4.86	1.01	0.29
Dinajpur	0.69	0.27	1.19	2.01	6.70	10.25	21.73	14.60	9.96	3.06	0.21	0.07
Faridpur	0.28	0.84	1.74	3.70	7.75	13.46	12.61	11.20	7.41	4.15	0.90	0.20
Hatiya	0.47	0.69	2.11	4.14	10.50	22.26	23.25	18.40	11.85	5.79	1.92	0.44
Ishurdi	0.32	0.73	1.22	1.76	6.67	16.57	13.42	9.25	7.41	5.66	0.53	0.19
Jessore	0.54	0.92	1.47	1.92	4.49	8.49	8.83	12.94	8.74	5.53	0.71	0.22
Khepupara	0.64	0.89	1.43	2.14	6.26	9.22	21.30	15.41	14.58	7.44	1.83	0.23
Khulna	0.19	0.76	1.54	2.28	6.19	9.89	11.41	11.15	9.89	4.94	0.75	0.09
Kutubdia	0.26	0.39	2.55	2.56	2.28	35.59	16.30	6.28	6.80	5.43	2.18	0.21
Maijdi Court	0.25	0.89	1.56	3.62	10.44	15.64	24.77	25.80	9.98	8.54	1.44	0.34
Mymensingh	0.40	0.58	0.82	5.35	8.24	13.61	11.77	9.64	9.59	7.05	0.55	0.05
Patuakhali	0.81	0.72	1.15	3.44	11.50	12.83	17.42	16.00	17.26	5.85	2.38	0.33
Rajshahi	0.61	0.54	0.86	1.23	4.20	10.16	11.79	13.18	8.40	4.95	0.30	0.20
Rangamati	0.43	0.56	1.38	3.86	6.58	17.23	18.17	14.23	10.26	6.13	1.84	0.50
Rangpur	0.46	0.44	2.28	2.98	10.13	12.84	21.79	13.61	10.25	4.16	0.26	0.07
Sandwip	0.49	0.55	1.47	5.27	10.21	20.63	28.19	22.21	9.25	7.33	1.47	0.40
Sitakunda	0.32	0.44	1.53	5.45	12.91	17.22	23.94	35.92	8.12	11.60	1.79	0.09
Srimongal	0.59	0.89	2.35	7.39	14.21	17.03	13.60	13.19	7.68	7.87	1.28	0.21
Sylhet	0.84	2.20	4.25	13.63	19.01	31.38	26.56	20.62	15.88	8.02	1.00	0.15
Teknaf	0.57	0.31	0.28	2.43	5.77	29.97	27.07	24.58	10.55	5.67	2.19	0.17
Barishal	0.46	0.74	1.81	4.14	9.66	16.52	17.73	14.85	9.68	6.07	1.13	0.22
Bhola	0.51	0.66	1.74	4.70	9.32	16.48	17.39	13.39	10.01	4.96	1.28	0.25
Country	0.46	0.74	1.81	4.14	9.66	16.52	17.73	14.85	9.68	6.07	1.13	0.22
Normal	0.51	0.66	1.74	4.70	9.32	16.48	17.39	13.39	10.01	4.96	1.28	0.25

Table 2.1: Rainfall of different regions in Bangladesh in 2009

From that chart we have some perfect places in Bangladesh, such as Sylhet, Chattogram, Barisal, Khulna, etc. for algae cultivation. Also, around Bangladesh, we can use some other techniques to produce algae. Mainly we can use two techniques to produce algae. They are:

1. Open pond algae cultivation.

2. Closed container algae cultivation.

2.1.1 Open Pond Algae Cultivation:

The oldest type of system is an open pond, which may be divided into both natural and man-made water ponds or containers. The most popular artificial method for bulk microalgae culture is raceway ponds. It consists of a pond shaped like a racetrack and is typically between 0.2 and 0.5 meters deep. Its length can reach thousands of meters. The raceway ponds replicate how algae develop in their natural habitat, using a paddle wheel to move the liquid around the pond and control algae growth and production. Typically, raceway ponds are constructed of poured concrete that has been compacted into the ground using a white plastic liner. In open pond systems, algal medium and their nutrients are added in front of the paddle wheel and cycled utilizing the loop for continuous production cycles. Another form of open pond system utilized for algal culture is the circular pond. By utilizing an algal culture, is increasingly widely used for wastewater treatment. These ponds have a spinning arm in the center that mixes the algae culture. Raceway and circular ponds are open, mixed pond systems that maintain an algal culture in suspension. There are also a few unmixed open pond systems used for the cultivation of algae. Technologies using open ponds for large-scale algal production are less expensive than alternative systems. These can be used in places with low potential for crop development since they do not compete for land with already-existing crops. Additionally, they take less energy to operate. Open pond systems are subject to routine upkeep and cleaning and can provide a significant amount of net energy. Dunaliella salina, a frequently farmed algae strain, produced dry biomass at a cost of roughly €2.55 per kg in 2008, which was deemed to be too costly for the generation of biofuel.

2.1.2 Major Issues of Open Pond Systems:

Temperature regulation is a big problem in open ponds since it often varies during the day and is challenging to regulate because it varies seasonally. Another important problem is the evaporative water loss from open pond systems, which makes algae's ability to use CO_2 considerably less effective than in other systems. This prospective CO_2 shortage may lower biomass production. Ineffective stirring causes the algal culture to mix poorly, which might hurt the mass CO_2 transfer rate. Low algal biomass production may also be caused by low light intensity caused by the top layer's thickness. This system is exposed to just a restricted number of algal species that can endure very salty and alkaline settings due to severe contamination by local species. For instance, the species Chlorella, D. Salina, and Spirulina may adapt to live in nutrient-rich environments, very salinity- and alkalinity-rich.

2.1.3 Closed Systems:

The development of closed photobioreactors (PBRs) has resolved the primary problems with open pond cultures, including poor cell densities, contamination problems, evaporation, environmental management, and large land needs. Indoor artificial light and outdoor natural light both support closed systems. PBRs are less scalable and call for larger capital expenditures. Contrary to open pond systems, closed systems enable the long-term cultivation of a single algae species with little chance of contamination. These systems' closed nature makes it simpler to control possible contamination. Systems of the tube, flat-plate, and column photobioreactor types make up closed systems. Higher cell mass production and lower harvesting costs are achieved in closed systems. A variety of straight glass or plastic tubes are used to construct photobioreactors.

Also, there are some other systems to cultivate algae. Those also included here.

2.1.4 Tubular PBR:

The most popular PBR is tubular in shape and is made up of a variety of straight glass or plastic tubes. These tubes typically have a diameter of 0.1 m or smaller and can be arranged in a helix, vertical alignment, inclined alignment, or horizontal alignment. These tubes enable enough sunlight to enter to facilitate photosynthesis. A reservoir receives the culture after it has been cycled via the tubes. The airlift pump inside the reactor maintains turbulent flows while recirculating the algae biomass. Through agitation and mixing with gas exchange chambers, an excessive quantity of dissolved O2 in the medium is minimized.

Helical PBR:

A cylinder and parallel, transparent tubes that have been wound tightly together make form helical PBRs. Compared to tubular PBR, the higher surface area of helical PBR allows enough sunlight to reach, increasing production. But it was less well-liked because of its unusual design and higher price.

Airlift PBR:

A lift by air A straightforward vertical cylinder constructed of clear glass or plastic makes up a PBR. An air intake is located at the bottom of the tube to circulate air bubbles through the column to provide adequate mixing and gas exchange. Compared to a tubular reactor, these devices increase the aerial production of algae.

Flat Panel (Flat Plate) PBR:

Flat panels, often referred to as flat plate PBRs, are formed of rectangular boxes that are completely transparent to maximize solar energy absorption. Algal culture pours across the flat plate in a thin layer. Bubbles produced by the air intake at the bottom of the tank sufficiently mix and transmit gases. Due to its extensive surface area exposed to illumination and minimal dissolved oxygen build-up, it is the oldest type of closed system that has been the subject of study on mass cultures of algae. In comparison to open pond systems, flat plate PBR achieves better algal productivity because of the increased surface area for light. For instance, in a study of the algae S. platensis, a flat panel PBR generated 2.15 g L1 day 1 of algal biomass, while an open pond produced 0.15 g L1 day 1 of algal biomass.

Hybrid Production System:

The hybrid two-stage cultivation technique combines several development phases in open ponds and photobioreactors. The first step takes place in a photobioreactor with regulated conditions that minimize microbial contamination and encourage continuous cell proliferation. To increase the synthesis of the desired lipid product, the second production step aims to subject the cells to nutritional stressors [27,28]. Open pond systems are best suited for this stage because moving the culture from photobioreactors to the open pond allows for the natural occurrence of the environmental stressors that drive production.

When producing oil and astaxanthin (used in salmon feed) from Haematococcus Pluvial is using a two-stage method, Huntley and Redalje [28] were able to produce an average annual microbial oil production rate of >10 toe ha−1 with a maximum rate of 24 toe ha−1 per annum. In addition, they showed that species with greater oil contents and photosynthetic efficiency might be used to achieve rates of up to 76 toe ha−1 year under identical conditions.

Rodolfi et al. [27] developed a hypothetical two-stage oil production process in which 22% of the production plant was devoted to biomass production under situations of sufficient nitrate and 78% of the plant was devoted to oil production under conditions of deficient nitrate. Thus, lipid production of 90 kg ha−1 per day (10 and 80 kg ha1 per day in the first and second stages, respectively) would be achieved. Additionally, according to Rodolfi et al. [27], such a hybrid system may produce lipids at rates of 20 to ha−1 annually, and for production systems in more advantageous tropical climes, the rate could reach 30 toe ha−1.

2.2. Classification of biofuels:

There are two types of biofuels: primary and secondary. Primary biofuels are those produced directly from the burning of woody plants and dry animal waste, whereas secondary biofuels are further broken down into first, second, third, and fourth-generation biofuels. First-generation biofuels involve the fermentation of agricultural plants like maize and sugar cane. When edible plant components are used for the manufacture of biofuels, it has a detrimental effect on food security. This is true of first-generation biofuels. This restriction opens the door for the development of second-generation biofuels using lignocellulosic material from non-food biomass such as straw or other agricultural waste materials as feedstock [29]. Complex carbohydrates including cellulose, hemicellulose, and other polymers are highly concentrated in these waste products. Because the proper saccharolytic enzymes are typically missing, these complex sugars are typically inaccessible to microorganisms [30]. The third generation of biofuel is made from microorganisms, microalgae, and seaweed. A good way to address the needs of the entire world is to produce third-generation bioethanol [31].

The most promising sustainable and affordable biomaterials for the manufacture of biofuels are plant leftovers. First-generation bioethanol is used as a fuel for vehicles and, in contrast to fossil fuels, lowers CO_2 emissions. First-generation bioethanol demand calls for a greater volume of feedstock, which might put food and fuel in competition. Because second-generation bioethanol production focuses on non-food bio-resources like lignocellulosic material because they are cheap and readily available in huge numbers, it may be possible to circumvent these difficulties. Bagasse from sugarcane is the most widely used lignocellulosic material for the manufacture of second-generation bioethanol. To produce biofuel from sugarcane bagasse, both thermal and biological platforms are employed [32].

The production of bioethanol is rising, but the usage of arable land and the depletion of water supplies have raised concerns. Food crops are insufficient because of the excessive use of arable land to generate biomass for the manufacturing of bioethanol, raising questions about the sustainability of the practice. Algae utilization is becoming more important for producing biomass for bioethanol to solve this issue. Marine, freshwater, and terrestrial environments all include algae. This shows that algae may flourish in a variety of environments. Algae as a renewable energy source will thereby provide energy security and self-sufficiency. Because algae have higher photosynthetic efficiency than terrestrial plants, they generate 5–10 times more biomass [33]. Algae are devoid of lignin, which is a barrier to enzymatic hydrolysis. This characteristic of algae is advantageous in the pre-treatment and enzymatic hydrolysis stages of ethanol synthesis [34].

Primary Biofuels	Secondary Biofuels			
Natural Biofuel produced from	First generation	Second generation	Third generation	Fourth generation
-Firewood - Plants - wood chips - Forest - Animal waste - Landfill gas - Crop residues	-Wheat, Baeley -Corn, Potato -Sugarcane beet -Oil seed (Soybeans coconut,sunflower,rapeseed) -Animal fat, used cooking oil	-Cassava -Jatropha -Miscanthus -Straw -Grass -Wood	-Microalgae -Microbes	-Genetically engineered Microalgae

Table 2.2: Biofuel classification

2.2.1 First-generation biofuels:

First-generation biofuel production includes direct ethanol production from edible sources. Ethanol is typically produced through the fermentation of six carbon sugars, mainly glucose, using traditional or genetically engineered yeast strains such as Saccharomyces cerevisiae. To produce first-generation bioethanol, sugarcane or corn is the primary feedstock. Brazil is one of the top countries in manufacturing biofuels from sugarcane. To make ethanol, sugarcane is crushed in the presence of water to extract sucrose, which is then filtered to yield ethanol. Another important feedstock for ethanol is maize, which is a high carbohydrate source. In the case of corn as feedstock initially, hydrolysis of starch is required to release sugars that are then fermented to ethanol. Amylase is the enzyme used in starch hydrolysis [35].

2.2.2 Second-generation biofuels:

Three types of biomasses are utilized to make second-generation biofuels: feedstock, such as municipal solid waste, homogeneous, like white wood chips, and quasi-homogeneous, such as agriculture and forestry residues. Such biomass is tricky to convert to bioethanol [35]. Concerning cellulosic biomass, trees are an intriguing source that can be used to produce second-generation biofuels. Since trees often contain a lot of carbohydrates, they are better suited to producing biofuel than food crops. Compared to grain biomass, cellulosic biomass is a cheap, renewable resource that does not threaten the food supply. The breakdown of cellulose, a polysaccharide with a high molecular weight, is an important step in bioethanol creation. Different enzymes might be used to degrade cellulose, however, because cellulose has amorphous and crystalline areas, degrading it is more challenging than degrading starch. Exoglycanase, also known as -glucosidase, cellobiose, also known as cellobiohydrolases, and endoglucanases are the three types of cellulose-degrading enzymes that make up cellulose [36,37]. These enzymes could break down the cellulose chain into soluble cello oligosaccharides. In comparison to petroleum fuels, lignocellulosic ethanol is made from sugar molecules extracted from cellulose by enzymes and cuts greenhouse gas emissions by 90%. Low-cost lignocellulosic biomasses include wood chips, grass, sludge, livestock manure, and crop residues that may be hydrolyzed by the action of enzymes to generate fermentable sugars for the manufacture of biofuels hydrolysis process's high cost and low yield make it unsuitable for use in large-scale commercial manufacturing. The expense of cellulase makes it difficult to employ procedures to turn cellulose or starch into fermentable sugars, although these materials are less expensive as feedstocks than materials that contain sugar. Additionally, because lignin in cellulosic wastes is hydrophobic and covers the cellulose present, it prevents the formation of ethanol. As a result, pre-treatment is necessary to remove lignin, which raises the cost of bioethanol production. Due to these reasons, the second-generation feedstock cannot be commercialized, serve as an affordable source of transportation fuel, or facilitate the development of third-generation fuel [38].

Bagasse, coconut shells, wheat straw, rice straw, rice husks, maize cobs, cotton stalks, jute sticks, and other lignocellulosic materials make up this biomass, which is acquired from the agricultural sector. Lignocellulosic biomass also includes a small amount of municipal solid waste or might be forestry waste like sawdust, bark, and wood chips. Hemicellulose biomass mostly contains cellulose (40–60%), lignin (10–25%), and hemicellulose (20–40%). Because they are crystalline, cellulose fibrils are resistant to enzyme-mediated digestion. When cellulose is nanocrystalline, it may be hydrolyzed by enzymes. Enzymes adhere to lignin in this manner and are permanently blocked from acting on the cellulose chains by the enzyme. As a result, certain pre-treatments are necessary to decrease the enzyme's adsorption on lignin. Increased enzyme accessibility and cellulose's dissolution of its crystalline structure are both necessary for effective hydrolysis [39].

2.2.3 Third-generation biofuels:

Third-generation biofuels are biofuels derived from algal biomass [40]. Biofuels are chemicals that are produced directly from biological processes or are obtained from the chemical conversion of biomass by organisms, primarily photosynthetic organisms (vascular land plants, photosynthetic micro-algae, photosynthetic macro-algae, and photosynthetic bacteria). Plant biomass has long been used as a source of biofuels, but algal biomass is now seen as an intriguing option for biofuel generation. Plants and algae are distinguished by their ability to photosynthesize. Because photosynthesis is a method of accumulating biomass. Biomass generated from plants and algae is used as a raw material in the manufacture of biodiesel, bio alcohol, and biohydrogen via fermentation [41].

Generation biofuels are biofuels derived from algal biomass. The manufacture of energy-rich biofuels is referred to as biofuels. In comparison to lignocellulosic biomass, algae have a different growth yield. With the usage of algal biomass, the production of biofuels from algae is often dependent on lipid content [40]. Algae are a kind of is often dependent on lipid content. Algae are a kind of photosynthetic organism that may be further divided into macroalgae (multicellular) and microalgae (unicellular). Microalgae play a significant role in biofuel development. Microalgae often float on the surface of the water and, like seaweeds, can be found adhering to rocks. Petroleum fuels such as triterpene hydrocarbons, isobutyl alcohol, bioethanol, and iso - butyraldehyde may be produced by algae. Several bacterial species with ethanol production potential have been found, and genetically engineered bacterial species such as Escherichia coli and Bacillus subtilis can also create large amounts of fatty acid derivatives, isoprenoids, and bio alcohol. Thermococcus, Caldicellulosiruptor, and Pyro coccus species have the potential to create more hydrogen while producing less ethanol. Ethanol might be efficiently generated by co-culture of Thermoanaerobacter species with Thermology, and cellulolytic microbes. Saccharomyces cerevisiae is a well-known model organism for the efficient synthesis of ethanol [41].

2.2.4 Fourth-generation biofuels:

The existing range of biofuel production techniques are insufficient to replace fossil fuels and lessen their influence on the inventory of Green House gases in the earth's atmosphere due to their ecological footprint and economic performance. Algae metabolic engineering is the foundation for the manufacture of 4th generation biofuel that can fill this demand. First-generation biofuels are mostly derived from agricultural goods like maize and sugarcane. In the case of second-generation biofuels, they are often based on cellulosic biomass (technical term). The "algae-to-biofuels" technique is heavily utilized in the third and fourth generations of biofuels; the former involves the metabolic engineering of algae to produce biofuels from oxygenic photosynthetic microorganisms, while the latter focuses on the fundamental processing of algal biomass for biofuel synthesis. Fourth-generation biofuels will be based on raw materials that are essentially limitless, affordable, and widely accessible. This biofuel is produced by turning vegetable oil and biodiesel into gasoline.

2.3 Algae of Architecture

A biorefinery infrastructure that can handle all the requirements needed for algae growth is required for a more efficient and fruitful system of cultivating algae. The bioreactor must be built, the supply of nutrients and resources must be effective, and the logistics of water are also a part of the bioreactor (Wijffels & Barbosa, 2010; Wijffels et al., 2010). Harvesting and extraction should be done on-site to avoid transport energy loss. It is necessary to make advances in microbial fermentations, strain alterations, and technological advancements (bioreactor design, process control, harvesting, and extraction) (Wijffels & Barbosa, 2010).

Light source:

Microalgae can glow in specific situations. UC San Diego biologists have successfully used fluorescent proteins found in algal cells to produce colorful algae. They can now produce fluorescent proteins in the colors blue, cyan, green, yellow, and orange. The algae will shine, and it may be used in façade designs with various colors and as a little light source.

Artificial light using LEDs, like in the Original helix photobioreactor, can be used as light for microalgae, but it may also be attractive as public furniture where people can sit and observe the microalgae grow. At night, it could function as lighting for the public space and grow microalgae (figure 2.1). Additionally, Pierre Calleja is developing algal street lighting. He created a large tube that serves as a light column for street lighting. The column may take in CO2 from the air and utilize it as a fertilizer for growing microalgae (Scholtus, 2012). The bioreactor's batteries are recharged by photosynthesis during the day. The batteries' stored energy is used for lights at night.

Figure 2.1: Algae street lamps (Calleja, 2012)

To avoid dark respiration and maintain high production, microalgae growing may be done at night using artificial lighting. Artificial lighting requires electricity, but a public building that leaves its lights on throughout the night is providing free energy to the community. Since the growing biomass may be transformed back into energy, some of the lighting energy can be utilized again to produce new energy.

Colors of microalgae

Figure 2.2: colors of microalgae (Wolkers et al., 2011)

Microalgae can come in a variety of hues. This depends on the type of microalgae present and how dense they are in the water. Less dense cultures have more transparency and brighter hues, whereas denser cultures produce deeper colors with no transparency. If the microalgae concentration is very low, the substance just has the appearance of water and is completely transparent.

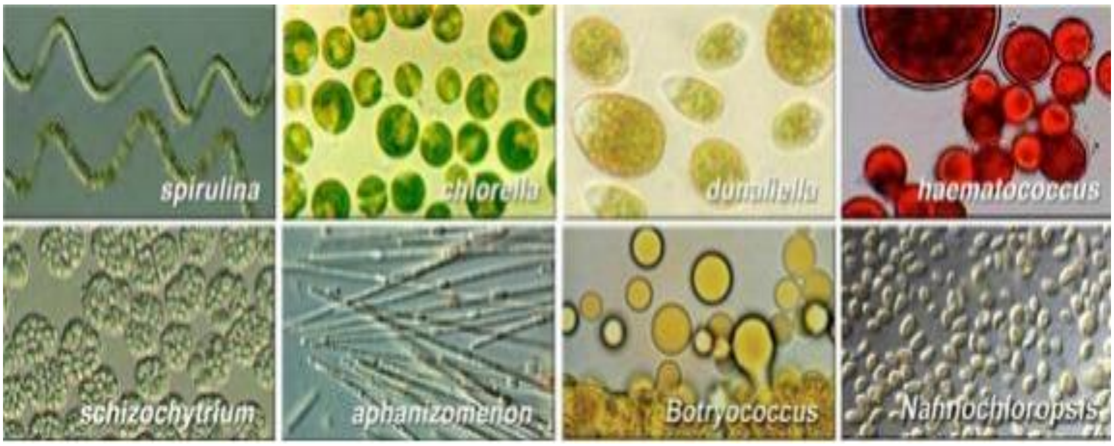


Figure 2.3: commercial microalgae (Hendrikson, 2012)

Sun shading with microalgae

Microalgae that develop quickly can provide dynamic sun shade. Microalgae have a 1–10 day harvesting cycle. The B.I.Q. building's photobioreactors can function as an adjustable sun shade. The amount of light that can flow through the panels depends on the biomass content, which rises with increased solar intensities. When continuous harvesting is stopped, the amount of shade might increase in a single day. The technology is interactive, and changing the harvesting process can alter how much light is sent (Wurm, 2012). It's also fascinating to see the microalgae in PBRs grow and change color to a deeper shade. The outside of the structure is constantly changing.

Any type of PBR horticulture may be used to provide sunshade, which is then applied to the building's surface. Plastics, panels, and tubes can all be used to create them. The experience and efficiency of the sunshade will vary depending on the configuration. It can be incorporated into the facade or used as an additional layer. The same strategies used for a façade can also be used to shade a glass roof if one exists.

Figure 2.4: left (Bouck, 2010b), right (Bouck, 2010a)

Tubular PBRs can be arranged in different arrays and forms for a window design. Different-sized tubes are shown in figure 13. The large tubes produce more vibrant shading and glow in strong sunlight. Smaller tubes have denser cultures, which cast darker shadows, but they also let in more sunlight, which brightens the structure. To provide extra shading, additional tubes can be added. Although these tubes are positioned vertically, they might also be used horizontally. The bubble columns are upright, independent tubes. For the horizontal tubes to work, they must be tubular continuous cycles.

The same as with solar panels, flat panels can be utilized. For best effectiveness, it can and ought to track the sun while also shading the area behind the flat panels.

Transparency and panel volume

The number of microalgae in the bioreactor affects how transparent the panels are. Higher microalgae concentrations cause more light to be absorbed, resulting in a deeper hue and reduced transparency in the panel (figure 2.5). But in reality, the water will be more turbid, making it impossible to see through the medium and creating a gradient of color (figure 2.6)

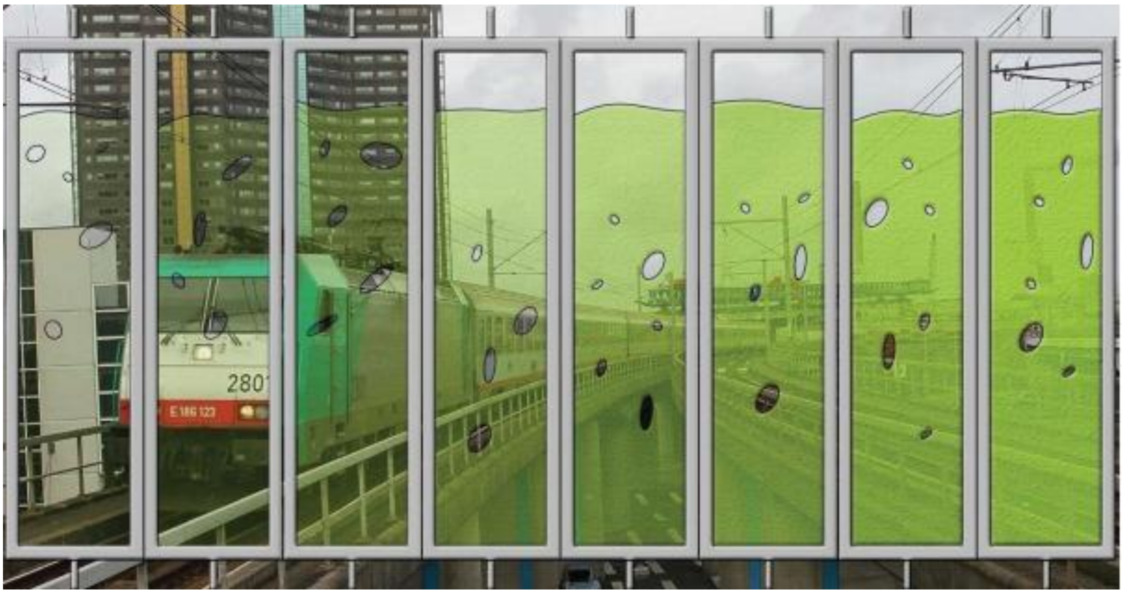


Figure2.5: different stages of transparency (Qiu, 2013)

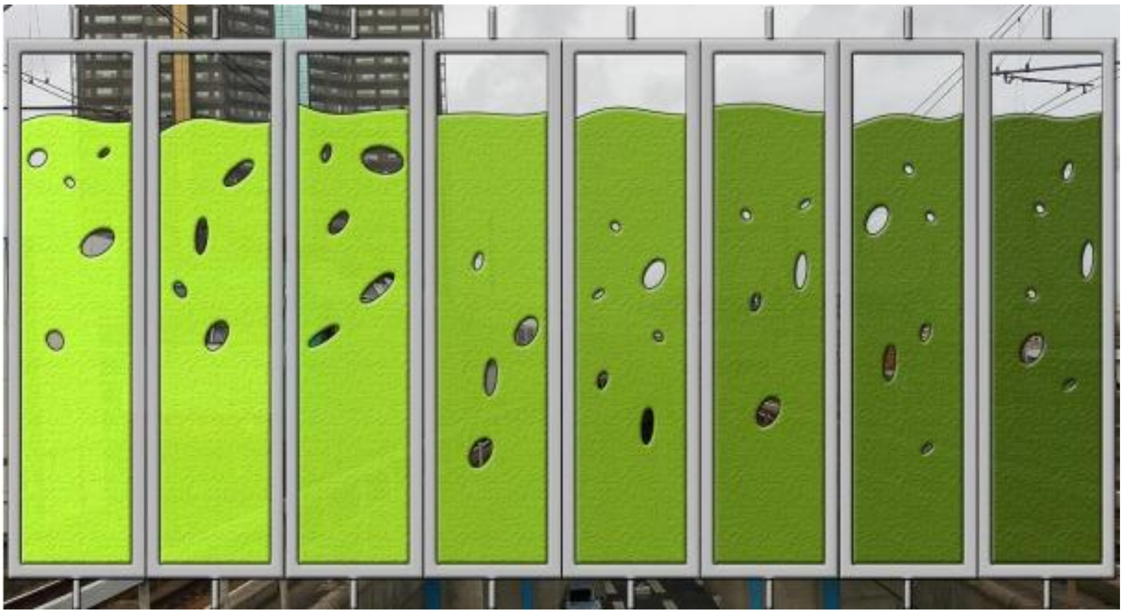


Figure 2.6: turbid microalgae panel gradient (Qiu, 2013)

Because each panel is a closed system, the volume of the microalgae media may be altered separately. When the volume is altered, the production will either rise or decrease, but in this way, the transparency and light penetration may be affected for greater comfort when necessary (figure 2.7).


Figure2.7: adaptable water levels for transparency (Qiu, 2013)

Maintenance

Maintenance Low pH, low CO_2, and low N tend to cause microalgae to adhere to the interior of the clear tubes (figure 2.8). Less light may enter the growth media because of the microalgae layer in the bioreactor, which lowers the productivity of the entire bioreactors (Hemming et al., 2012). Baikal (KOH + K_2CO_3) is added to the culture water in modest amounts (1ml/l) by Hemming et al. (2012) to clean and disinfect the photobioreactors. Most of the sticky microalgae are dissolved by Baikal within a day, returning it to the water (Hemming et al., 2012).

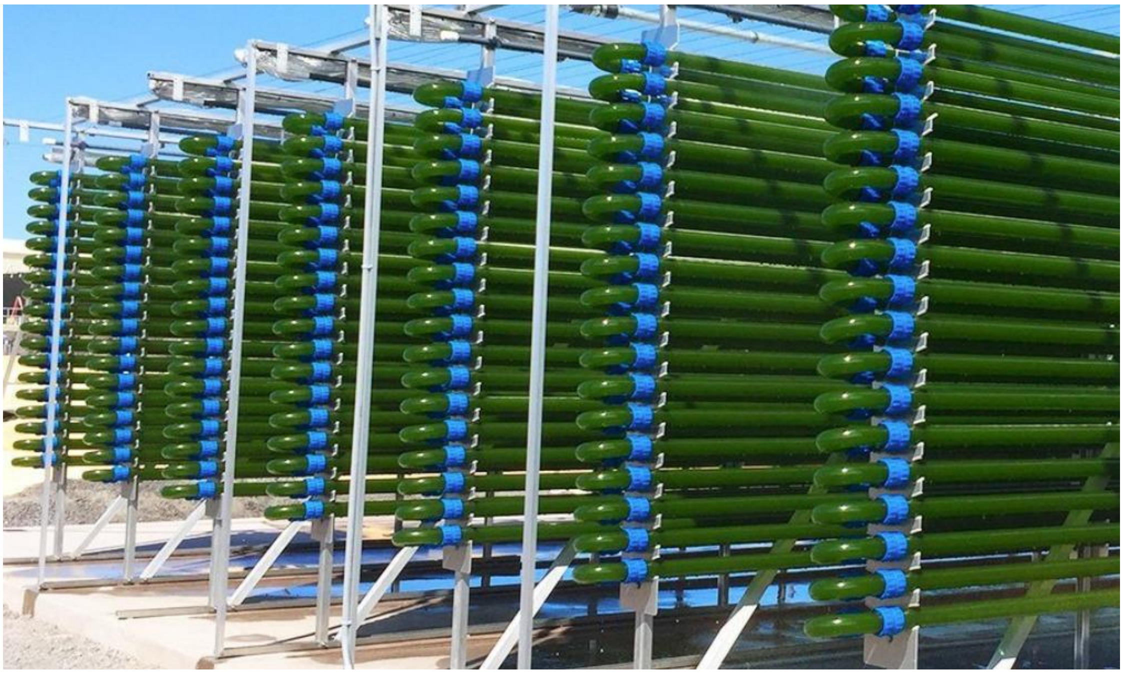


Figure 2.8: microalgae growing on the inner surface of the tubes (Hemming et al., 2012)

Parameters

The tubes' diameters are the PBRs' specifications. The diameter has an impact on how the structure looks and how much light can get through it to cultivate microalgae. Space between the tubes allows for a line of sight from the inside to observe the outside world as it is, which is not feasible via a PBR while it is operating at full capacity. The experience of the area and the structure itself depends on these lines of sight. It alters the interior space's atmosphere. Additionally, the microalgae's density might be so great that the PBR will be completely dark. Functions that require natural light should have access to it elsewhere, or the façade should be built with PBR apertures.

The tubes can be provided or expanded to the required length. When something goes wrong with a long-running continuous loop, the entire cultivation system should be shut off. Making smaller loops would be a better idea to keep things more manageable. Although biomass production benefits from an orientation toward the sun, microalgae may also thrive in dispersed light. PBRs put adjacent to one another will dilute the light and reduce production per panel, but overall production will increase on the same ground surface (figure 2.9). (Hu, Fairman, & Richmond, 1998). Additionally, too much light will reduce the output of the microalgae. When compared to an ideal horizontal reactor, the efficiency gap can be as much as 20%.

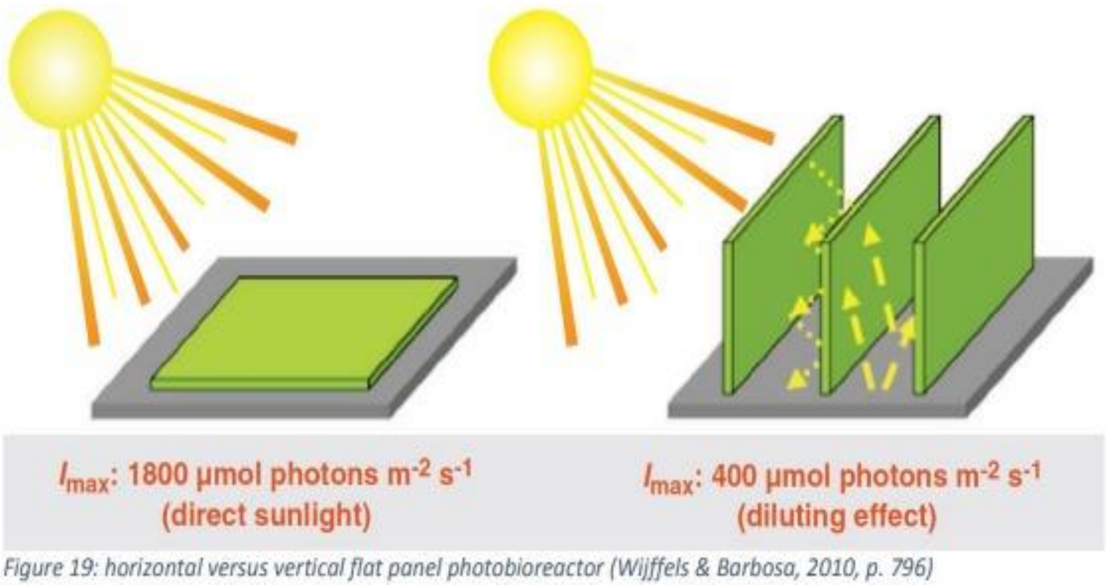


Figure2.9: horizontal versus vertical flat panel photobioreactor (Wijffels & Barbosa, 2010, p. 796)

Both the façade and the roof are suitable locations for flat panels. The productivity of this system depends on its direction and exposure to sunshine. This depends on where the PBR is located (Appendix A). For areas with latitudes above 35oN, an east-west facing flat panel is more effective than a north-south facing flat panel and intercepts more solar energy (5% annually) than a horizontal PBR (Sierra et al., 2008).

For the PBR to be effective, temperature regulation is crucial. The PBRs will be exposed to ambient temperatures and changes in temperature throughout the day if they are left outside. It will take both cooling and heating to maintain the desired temperature. By adjusting the temperature of the culture water, heating and cooling may be accomplished. A heat exchanger may be utilized with either warm or cold water, and this energy can be stored below and used for the structure as needed. When growing indoors, temperatures do not fluctuate as much as they do outside, making it simpler to regulate the PBR's temperature. In the water itself, cooling or heating can be achieved. PBRs can be submerged in water to maintain the temperature more consistent because the water has a greater thermal mass than air.

Design tools

The illustrations from appendices B, C, and D give a summary of the many available cultivation strategies. The configuration will determine how the building will look and can also affect how people will interact with it and how they will see it from within. The most adaptable system is the tubular PBR, which can be made longer by affixing more tubes to it. However, it can also change direction and angle based on the connector in between the tubes (figure 2.10). Although plastic film bioreactors can be in any form, there are restrictions on how big a single panel can be. Additionally, the panel's inside form may be modified to provide transparency and closed components using microalgae.

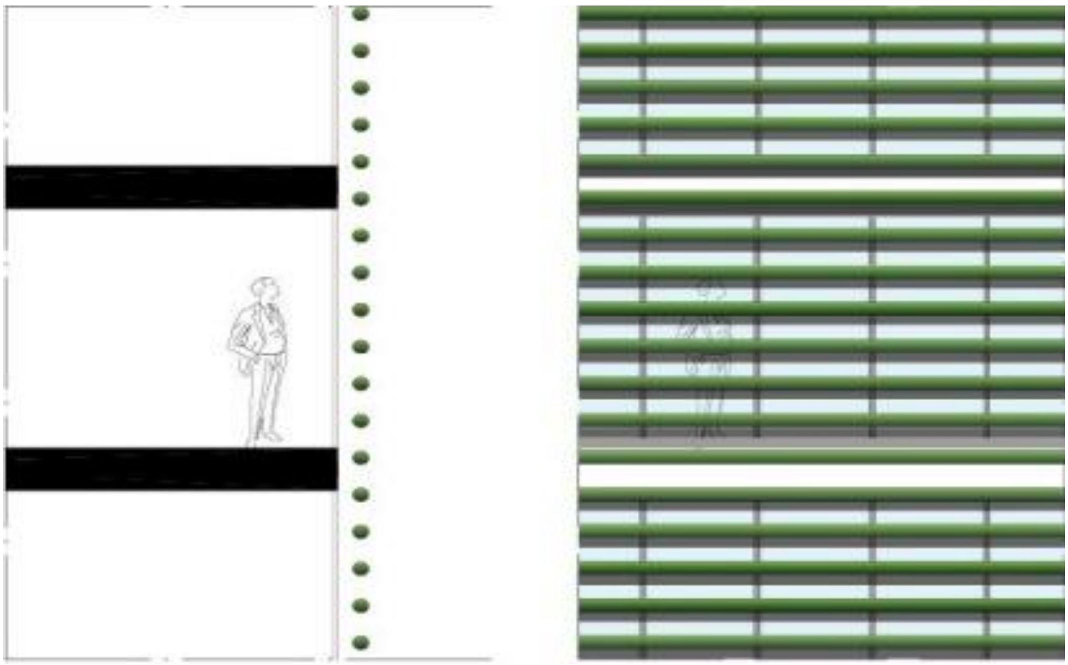


Figure2.10: tubes diagram (Qiu, 2013)

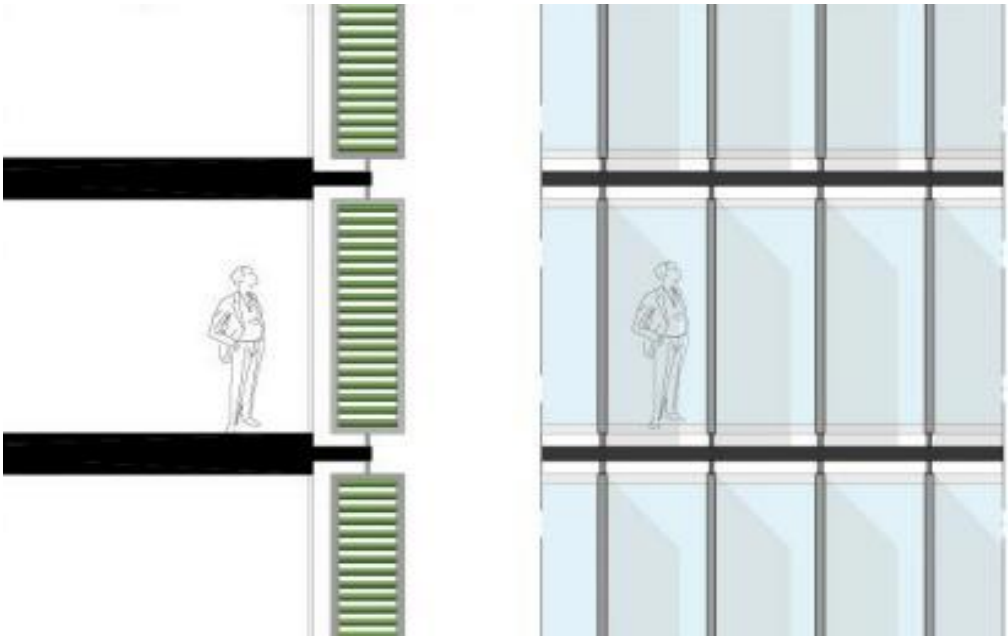


Figure2.11: tubes in panel diagram (Qiu, 2013)

Integration in the existing structure
Microalgae photobioreactors can be installed inside the current Sloterdijk train station. Bioreactor tubes can be included in the platforms' current roof design. The beam of the supporting structure has holes where tubular PBRs may pass through to serve as a sunscreen and a place to grow microalgae. Microalgae can also be grown on the space frame structure over the train station. PBRs can be manufactured to order in any shape that will fit inside the space frame's triangles. Microalgae tubes at the top of the new glass façade provide shade for the newly constructed space without obstructing ground-level views.

Figure2.12: Impression railway station Amsterdam Sloterdijk with algae bioreactors

2.4 Current Trend in Biofuel System:

Biofuel production is increasing day by day using modern technology and biological process advantage. From biofuel, we get waste and residue that can be used for recycling. Even we can get food from the algae. There is much research going on in this biofuel that is carbon neutral to the environment. There are four generations of biofuel advances forward that are represented graphically. [42]

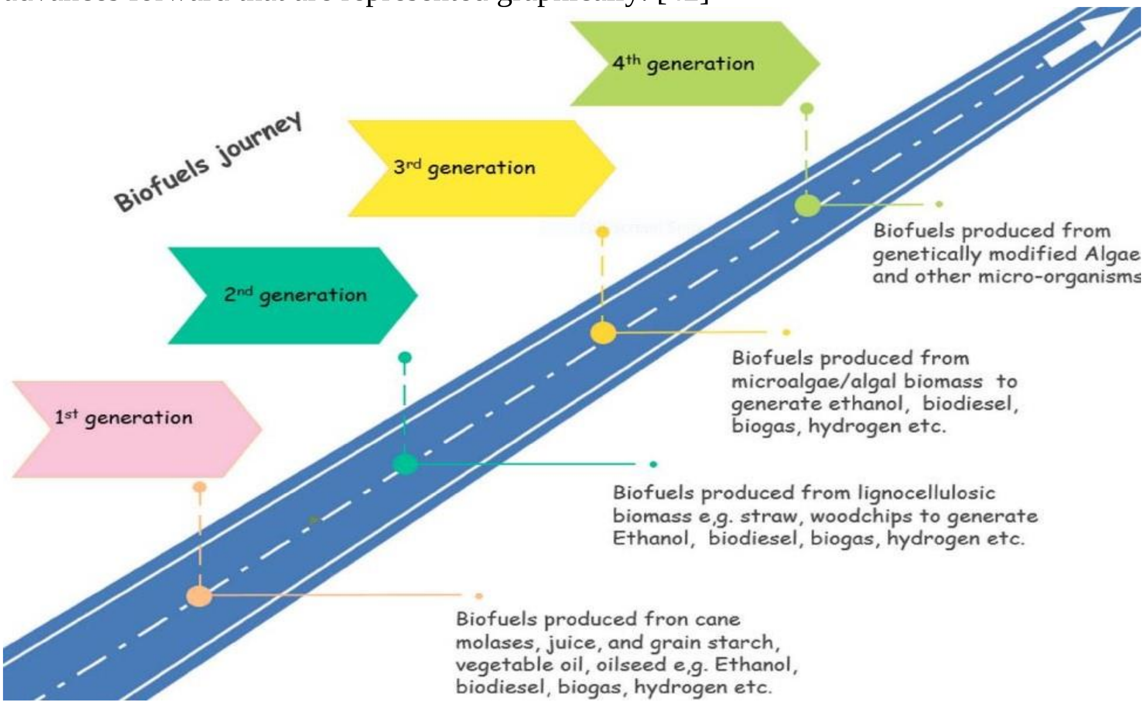


Figure 2.13: Production of biofuel advancement

Biofuel is making a great impact on the modern world. It is influencing society, locally, globally, environmentally, etc. Many conflicts are arising in the biofuel energy market but apart from that, it is becoming popular among researchers and conscious people. Because biofuel contributes to global house gas reduction. Worldwide different initiatives are being taken to transmit current energy supply from bio-friendly objects. Here algae or biofuel is a great initiative. Bioenergy is getting popular, which is represented graphically [43].

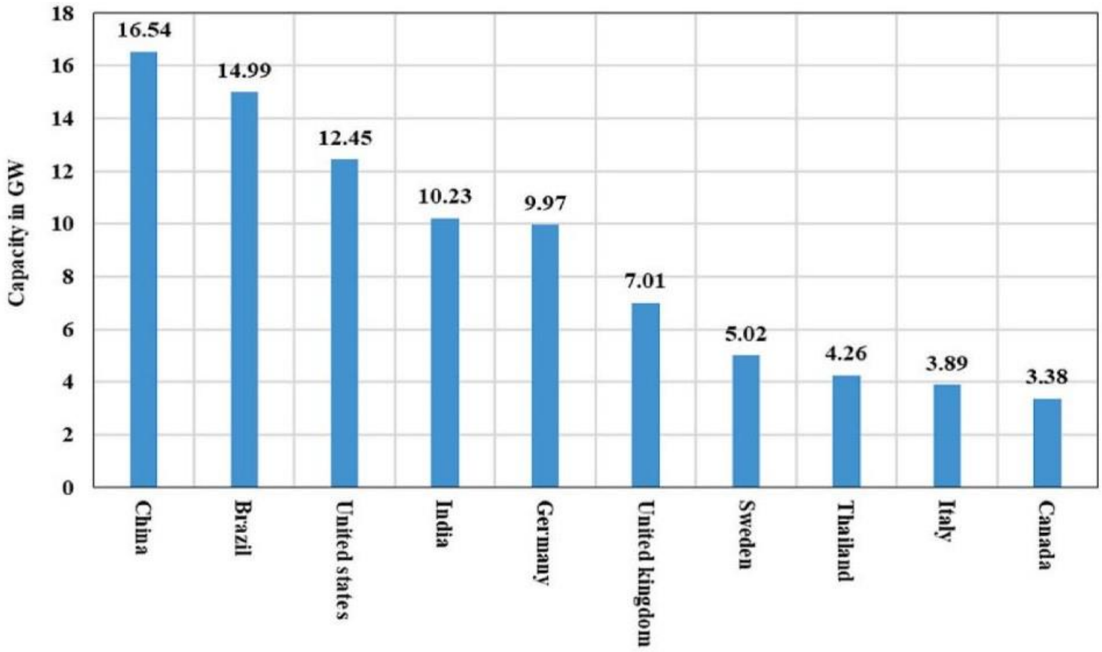


Figure2.14: Bioenergy power ranked around the world by country 2019
Source:
https://www.statista.com/statistics/274168/biofuel-production-in-leading-count ries-in-oil-equivalent/

Different county's governments are encouraging for bio-friendly fuel. Because vehicles, industry, schools, and colleges are increasing and we need to convert energy like electrical or mechanical, etc. Biofuel is a great alternative to them. Like Brazil is one of them which has a nice footprint in biofuel technology [44]. Biofuel production by different regions is given below:

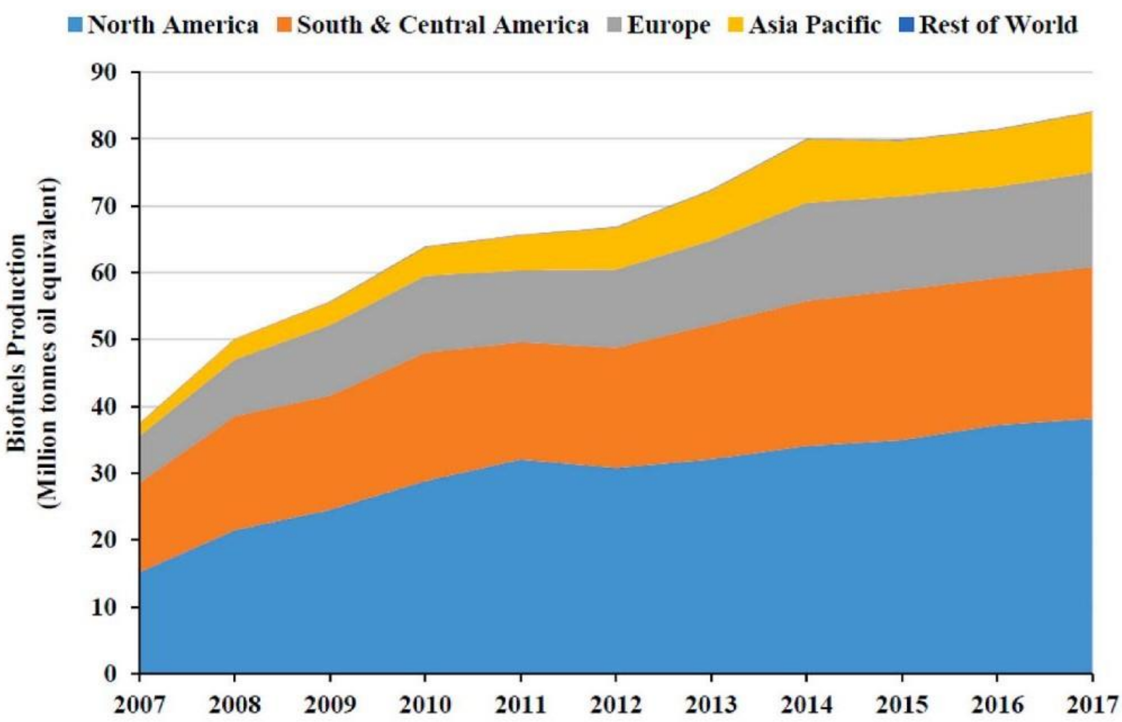


Figure2.15: Biofuel production worldwide

Source:
(https://blogs.nottingham.ac.uk/geography/2020/06/25/global-biofuel-produc tion-trend-theinevitable-energy-bio-future-for-achieving-global-climate-target/.)

From this graph, we can see that North America is expanding day by day. Also South and Central America are improving day by day.

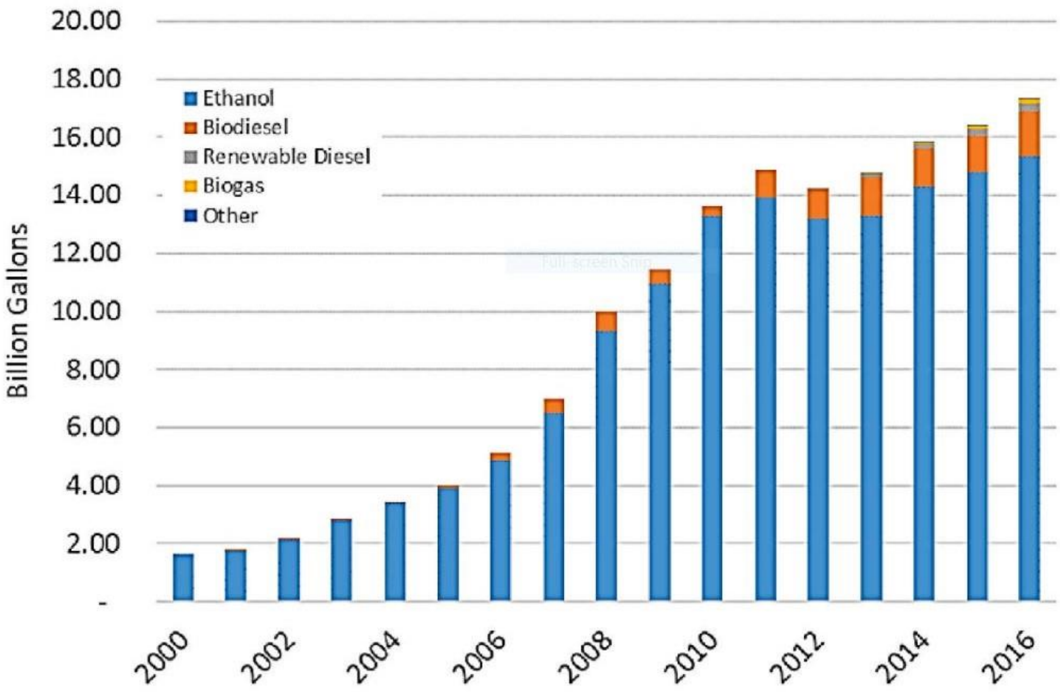


Figure2.16: Globally biofuel production from 2016 to 2016
Source: (https://www.ers.usda.gov/data-products/us-bioenergy-statistics/)

In this graph x-axis denotes different years and the y-axis denotes billion gallons production. From this graph, we see ethanol and biodiesel are getting popular.

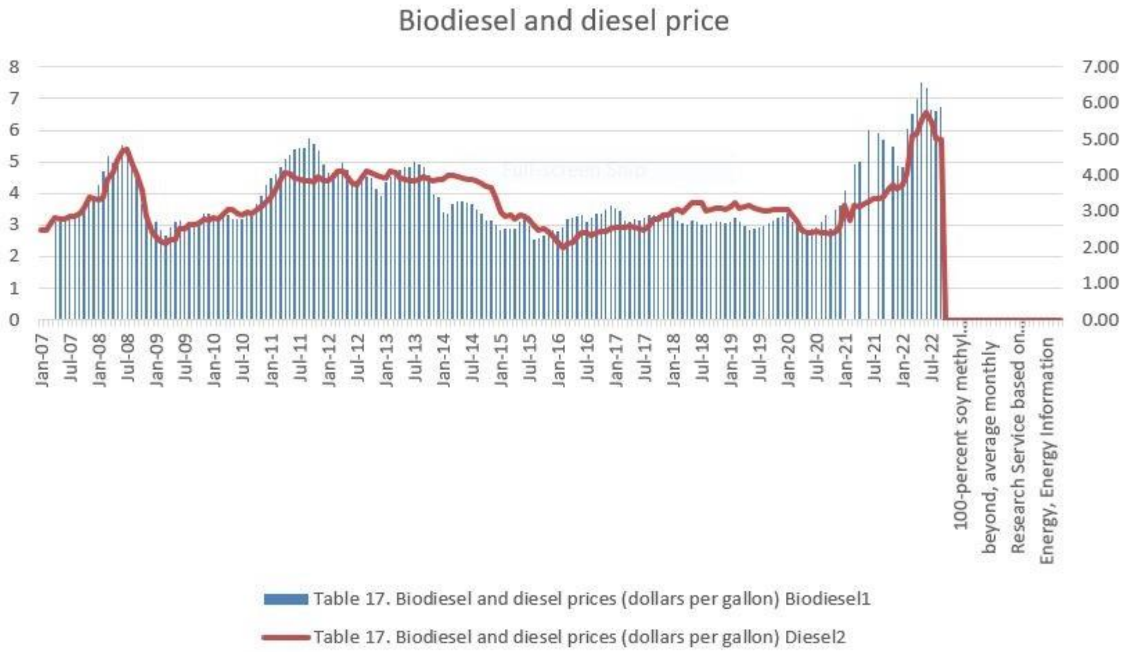


Figure 2.17: Biodiesel and diesel Price from 2007 to 2022

Here On the x-axis month-year is denoted and on the y-axis dollar per gallon is denoted. From the graph, we see biodiesel price is a little bit high in 2022. But there are up and down. If the production of biofuel increases then the price will decrease.

Chapter 3

Biofuel Production using Algae cultivation key challenges in algae-based biofuel production:

Microalgae can be grown using batch, semi-batch, or continuous processes. Batch culture involves a single cell injection in a medium container throughout several days of development until the cell density reaches a maximum/desirable level ready to be moved to more significant culture volumes to continue growing before reaching the stationary phase. A part of the culture can be harvested and replaced with new media using the semi-batch method. Two forms of culture—turbid state and chemostat—can be applied in a continuous system. The turbid state culture adds new media to the culture while the cells continue to divide and expand until the density reaches a predetermined threshold. A modest yet consistent flow of new medium is continuously added to the chemostat culture, and any extra culture overflows are collected. Algae are grown in two different types of reactors: open system (like raceway ponds) and closed system (like photobioreactors).

References	Oil content	Species
Vasudevan and Briggs (2008)	28–53%	*Chlorella sp.*
Sajjadi et al. (2018)	62%	*Parietochloris incisa*
Vasudevan and Briggs (2008)	25-56%	*Nannochloris sp.*
Sajjadi et al. (2018)	22%	*Nostoc commune*
Abdulkhaliq et al. (2016)	11%	*Syne.chocystis sp.*
Stewart (2014)	43%	*Heterosigma akashiwo*
Sajjadi et al. (2018)	4–11%	*Spirulina Platensis*
Sun et al. (2014)	50–77%	*Schizochytrium sp.*
Sajjadi et al. (2018)	43.8%	*Emiliania huxleyi*
Vasudevan and Briggs (2008)	35–65%	*Neochloris oleoabundans*
Sajjadi et al. (2018)	6–25%	*Dunaliella salina*
Jeon et al. (2015)	22.7%	*Chlamydomonas sp.*
Sajjadi et al. (2018)	12–14.5%	*Chroomonas salina*
Caprio et al. (2015)	30–50%	*Scenedesmus obliquus*
Sajjadi et al. (2018)	9–14%	*Porphyridium cruentum*
Sajjadi et al. (2018)	19–35%	*Mesotaenium sp.*
Sajjadi et al. (2018)	25–30%	*Tetraselmis tetrathele*
Sajjadi et al. (2018)	23%	*Dunaliella*
Rodríguez et al. (2012)	13–24%	*Chaetoceros muelleri*

Table 3.1 Oil content of microalgae

3.1 Technical Challenges:

Today's world entirely depends upon fuel. In 2030 the demand increases by up to 30% and most of the energy come from petroleum and diesel [45]. That's why scientists are searching for new alternatives like renewable energy. Here biofuel is one of the promising sides. The major technical challenges are

- Energy efficient treatment plant.
- Efficient coproduct utilization.
- Establish biofuel standards.
- Socio-economic acceptance.
- Logistics.
- Effect on the environment.

Biofuel has a very important factor that controls the whole productivity. The factors are moisture, size of the sample, volume, and bulk density [46]. Other research found that biofuel particle size smaller than 5mmm is more suitable for converting biofuel. The main problem for biomass to biofuel conversion is moisture content. It is, directly and indirectly, reduces the biofuel conversion rate [47]. Moisture content created during the treatment plant decreases the quality of the biomass to biofuel. Bulk density affects the transportation and feedstock supply. Biomass's main components can affect biofuel properties. The main component of biofuel is lignin. Different processes for biomass to biofuel are pyrolysis, combustion, liquefaction, and gasification. Air classification is used for air content clarification [48].

Other factors that affect biomass to biofuel are acetic acid and volatile organic fraction. It is observed that volatile organic fraction reduces fermentation from biomass to biofuel. Volatile organic matter reduces the oil components of biofuel and lignin is also responsible for biofuel reduction which remains in biomass [49]. Lignin reduces the productivity of the ethanol during fermentation on the hand pyrolysis and combustion accelerates the bio-oil and heat value [50].

Also, we have other problems that as lignin and toxic substances. Here we have short-chain acetic acid, formic acid which produces in the pretreatment plants. They negatively impact the fermentation process. To solve this problem genetically improved stains can be used [51].

3.2 Environmental Challenges:

3.2.1. Climate:

The overall algal production is influenced by factors such as climate and temperature. Climate parameters that impact the viability of algal biomass production include solar insolation, temperature, precipitation, evaporation, and meteorological events. The economic viability of algae growth is primarily influenced by the availability of sufficient sunshine, climatic appropriateness, and temperature. In both open and closed culture techniques, photoautotrophic microalgal development is reliant on the presence of plenty of sunshine. The rate-limiting factor for the productivity of autotrophic algae is the average seasonal insolation factor. To accomplish a specific amount of product, downstream processing design capacity, amount of CO2, and amount of culture, daily, seasonal, and yearly change in solar insolation on the spatial surface area of cultivation systems is required. Along with insolation, other climatic variables such as temperature, cloud cover, precipitation, wind, etc. will also have an impact on the productivity and consistency of algal output. Despite strain differences in temperature tolerance, the ideal range for algal biomass development is between 20 and 35C. Reduced productivity rates may result from higher temperatures, whereas slower algal growth may result from very low temperatures (Pate 2013). Thus, lower latitude regions are ideal for algal development since they have a more constant temperature range (Pate et al. 2011; Lundquist et al. 2010; Pate 2013; Quinn et al. 2012). Different open, closed, and hybrid growth systems for algal culture allow the operational temperature range to be modified by the requirements. Evaporative water loss, solar gain during the day, pond depth, pond mixing, radioactive heat loss at night, thermal coupling, and bidirectional heat transfer within the pond can all have an impact on the ideal temperature in open pond systems. Comparatively closed photobioreactors (PBRs) are less vulnerable to climate change than open ponds. The minimal evaporative cooling of PBRs, however, necessitates temperature monitoring. Algal production is directly impacted by temperature and sunshine availability (seasonally and yearly), whereas other climate variations (precipitation, evaporation, and severe weather) have an impact on the quality and demand of water in open systems.

3.2.2. Climate and Temperature in Bangladesh:

Bangladesh typically has a moderate climate. The fundamental characteristics of Bangladesh's climate are dry winters and hot, humid summers. Bangladesh typically has four distinct seasons. Winter, Autumn, Summer, and Monsoon.

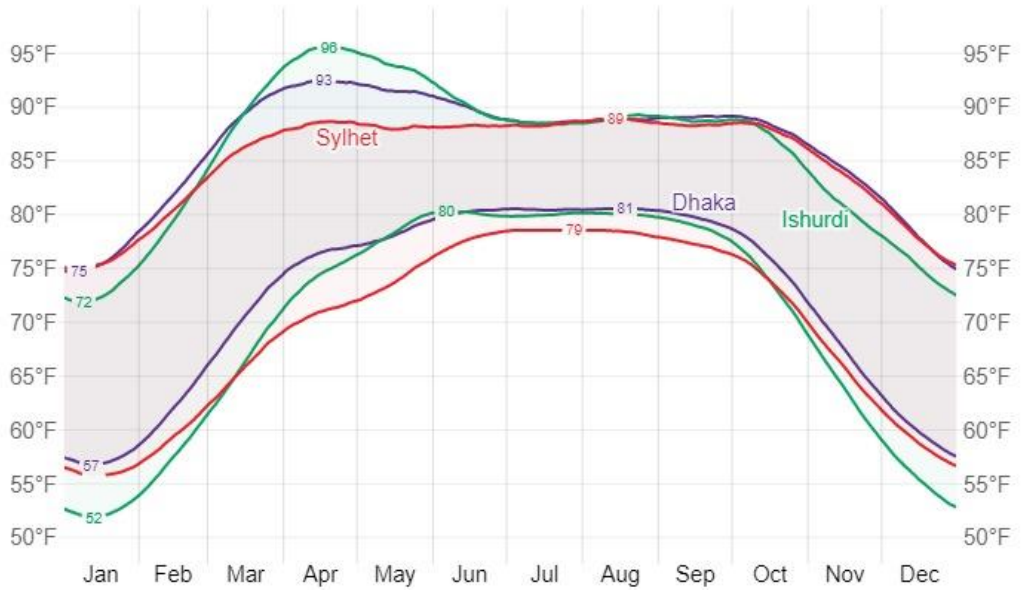


Figure3.1. Average High and Low Temperature in Bangladesh (January 1, 1980, to December 31, 2016)

High	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dhaka	76°F	82°F	89°F	92°F	92°F	90°F	89°F	89°F	89°F	88°F	84°F	78°F
Ishurdi	73°F	80°F	90°F	95°F	94°F	90°F	89°F	89°F	89°F	87°F	81°F	75°F
Sylhet	76°F	81°F	86°F	88°F	88°F	88°F	88°F	89°F	88°F	88°F	84°F	78°F

Low	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dhaka	57°F	62°F	71°F	76°F	78°F	80°F	80°F	81°F	80°F	76°F	67°F	60°F
Ishurdi	52°F	58°F	67°F	74°F	78°F	80°F	80°F	80°F	79°F	73°F	64°F	55°F
Sylhet	56°F	59°F	66°F	71°F	74°F	78°F	79°F	78°F	77°F	73°F	66°F	59°F

Table3.2: Average High and Low Temperature in Bangladesh (January 1, 1980, to December 31, 2016)

The temperature in Bangladesh varies from location to location, as observed in figure 3.1. The coldest and lowest temperatures in Bangladesh occur in January and February. The hotter months of Bangladesh's summer, from March through May, are called the summer. The rainy season in Bangladesh lasts from June to September. Bangladesh's fall season lasts from October to December. Every district in Bangladesh has monthly temperature variations. For instance, the highest temperature in Dhaka in January, February, and March is 76°F, 82°F, and 89°F, while the lowest temperature is 57°F, 62°F, and 71°F. Thus, Sylhet's maximum and lowest temperatures in January, February, and March are 76°F, 81°F, and 86°F, respectively, and 56°F,59°F, and 66°F. Every month, Bangladesh's temperatures change from one location to another. Any temperature that we choose will not allow us to produce algae. Considering that the algae we'll produce develops best in clear water at a specific temperature. It is impossible to grow algae when the temperature fluctuates in this way. Natural catastrophes occur in Bangladesh annually. First, we must be aware of factors like temperature, pressure, and others if we want to grow algae. We have to accept losses by growing algae when the temperature fluctuates.

Bangladesh has great biodiversity. Here it has vast cropland, riverside, forest, livestock, and most important manpower, etc. Manpower of this country controls the economy of the country and prospers the lifestyle of Bangladesh. Now Bangladesh has about 165 million population (Dhaka Tribune 26 July 2022) in this country. They all need food security. Algae can risk this in the food cycle and biodiversity. The reason behind the environmental risks are discussed below:

Crop Land:
We know algae cultivation need a vast area of land where we can use pond /open algae cultivation or closed container algae cultivation. In Bangladesh, we do have not that type of free vast area where we can easily use them. Due to the dense population, people don't want to lose their own land. If government occupies those land then a mass revolution may occur which can damage government property. Also, those who lose their own land may cut down forest areas and occupy that area to build the infrastructure. This type of situation is created in Sylhet, Chottagram, and Khulna areas. Mass people are cutting trees to build their houses. For that reason, wildlife is getting risks. Also, the food security of this country gets in a concern. In highlight, it can be said that biodiversity of the Bangladesh will be destroyed by this algae cultivation.

Water: Bangladesh has about 230 rivers around the country. That's why it is called the mother of river land. In the river, we have huge fish, and water animal resources. Algae cultivation in an open container or closed container has a high risk to destroy them because every year Bangladesh is affected by cyclones and floods. This natural or manmade calamity can break down the open and closed algae container. Then those water can mix with the normal pure water, river, fish cultivation ponds, and other commercial aquatic life. Again, we know, aquatic life needs oxygen to live. They get that oxygen from the water. But excessive algae block the way when the sun passes to water. As a result, aquatic life does not get enough light to roam oxygen. Fish gills may get blockage so they cannot take oxygen to live in. Also, some algae release poisonous gases that may destroy the ecosystem of aquatic life.

3.3 Regulatory Challenges:

The environmental authority has been linked to the country's different departments. the authority and department of the state regulation and control of different controversies. They collect data as the algae market does not fall and does not harm the environment. As a result of globalization biofuel, production and consumption have some controversies. Different environmental rights groups and NGOs are raising questions about biofuel companies. Food security of first-generation biofuel is giving a hard time to the country's different departments in biofuel regulation.

There are five challenges for fair-playing biofuel production:

● We have to organize sustainability and social criteria to distinguish fair fuel from regular fuel.

● We have to identify the public and private sectors in charge of implementing and identifying the label.
● We have to merge the biofuel certification and other globally accepted classification systems.
● We have to keep in mind WTO rules which have import restrictions and other tax, and subsidy-related topics.
● We have to take note of the US, UK, Brazil, and other countries like India, Indonesia, and other least developing countries so that developed and least developed countries get fair prices and trade.

Though certificates do not show the clarification of the authority research and eco-friendly initiative are the central authority of the country. Different volunteer groups and NGOs can come forward to help the biofuel industry. Again petrol, diesel, etc. are responsible for global warming. That's why the government should reduce them by about 20% so that people and the biofuel industry get encouraged and produce biofuel.

Chapter 4

4.1 Technical Solution:

Biofuel productivity is the main technical part. In open ponds or closed-pond systems, algae or biofuel can be contaminated by viruses or bacteria. That can make the producer financially disabled. That's why we need an energy-efficient biofuel treatment plant to research environment-efficient algae. The technical solution measure which we needed is given below

● **Filtration:** Filtration is a simple measure to separate the waste product and another unwanted particle. Due to a moderately little estimate of microalgal cells, filtration can be considered a viable strategy to evacuate natural organisms with expansive volumes, such as rotifers and copepods. In any case, in spite of rotifer grown-ups can be expelled utilizing work silk screens since of their huge sizes, the rotifer eggs and creating youthful people seem not to be totally evacuated. In arrange to clear the huge natural contaminations completely, microalgae fluid ought to be ceaselessly sifted over 3–4 days [52].

● **Environment Effect:** Environmental parameters have a direct and indirect impact on algae cultivation. Light is needed for photosynthesis and food preparation for algae. In algae cultivation, light energy passes to the PSI core of the algae. So light can be transmitted to the open pond system otherwise we need to install a closed-container algae system where artificial bulb lights can be used. Temperature is another factor that can infect the virus and bacteria in the cultivation plant. We need to fix pH value 3 for 1-2 hours to control rotifers [53].

● **Logistics:** Biofuel will be profitable when its transportation will be good. The company needs to be professional about their work. fluid biofuel both within the frame of pyrolysis bio-oil, push vegetable oil, bio-ethanol, biodiesel, or other BTL fuel, show a higher vitality thickness in comparison to strong biomass and can be transported by trucks, rail, dispatch, and pipelines. Particular transport issues emerge in the case of tall thickness and destructive bio-oils, such as pyrolysis oils, that require stainless steel tanks with a normal 14% increment in transport costs. Transport of routine liquid fuels (per ton) is additionally expected to be 25% higher than for strong powers. Costs for fluid biomass by trucks are detailed in Table 3, agreeing to and considering pyrolysis bio-oil. In the case of biodiesel and bioethanol, these costs may well be decreased, since of the lower thickness (which means quicker loading/unloading rate) and nonattendance of destructive materials for tanks.

Numerous thinks about have appeared that the ideal estimate of biomass handling and change plants is huge when copious biomass is accessible, and low-cost transport frameworks are utilized; on the opposite, when the particular biomass transport fetched increments, since of moo vitality thickness of the feedstock and long transport separations, and scale economies and change efficiencies are less impacted by the estimate, the ideal plant measure tends to be lower [54].

● **Socio-economic acceptance:** Biofuel is getting popular in the developed world because it does not emit greenhouse gas. The graphical representation is given below:

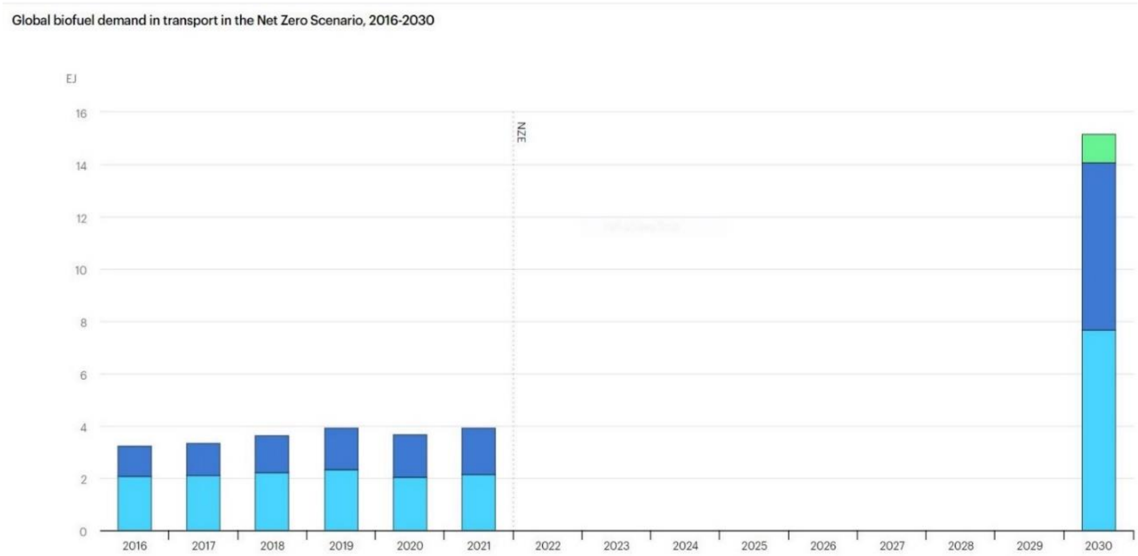


Figure4.1: Socioeconomic acceptance of biodiesel and bioethanol
Source: (https://www.iea.org/reports/biofuels)

From that graph light blue is ethanol, dark blue is biodiesel and green is jet kerosene. So, the government and non-profit organizations should take initiative to lower the price to the other conventional fuel like diesel, petrol, etc. Then normal people will get encouraged to use them more.

4.2. Environmental solution:

Bangladesh's open-water biodiesel will cause many issues. Our main difficulty with producing algae in open ponds is controlling the temperature. Because the algae we use develop in fresh water at a specific temperature, if we grow algae in an open pond, viruses and bacteria will attack, and we will then suffer from algae cultivation. Algae cannot be grown in Bangladesh's climate or environment. We won't encounter any issues if we can produce algae in a closed system. Algae is often grown in pure water. Our main problem, which this method might address, was the temperature. In closed systems, we may use cutting-edge technology to overcome issues with temperature and pure water. Our nation's environment is undergoing ongoing change. Temperature differences between morning, noon, and night are typical. You can utilize whatever is required in a closed system. We shall have the ability to control everything thanks to technology. We will be able to create a setting that will address all our issues in a closed system. The algae will then be protected from dangerous bacteria, viruses, and other contaminants.

4.3 Regulatory Solution:

Over the few years, biofuel production is increasing day by day. That is alarming for some reason. Because biofuel includes corn, sugar cane, potato, algae, rice, etc. are edible food for the living being [55]. I can risk all living beings. Many developed and developing countries are coming forward with some definite policies to restrict the overproduction of the product. That includes food item biomass should be reduced. Also, this food item needs fertilizer which reduces the soil quality. That's why OECD countries made some rules and regulations [56]. They give subsidies to nonedible food items for biofuel production. So that it reduces the soil quality. endowments can too be supported for biofuel generation. These are within the frame of speculation gifts (from government and/or open institutions) to guarantee that satisfactory start-up stages for rural feedstock conversion and productive conveyance at pumps take put. Besides, within the United States and European Union, shapes of fuel extract assess credit are permitted for biofuels blenders. These can claim the assess credit for the mixing substance of renewable fuel utilized in a unit of (fossil) fuel sold. Too, carbon dioxide extract charge exemption is additionally drilled in bolster of biofuels commodities utilization. Finally, an extra degree to back biofuels utilizes points at securing household industries through the utilization of taxes on imported biofuels products. This instrument is right now utilized over several nations or a square of nations and is more or less harming the competitiveness of worldwide trade.

A biofuel price regulatory board should be introduced. The will should be low to consume and a subsidy should be given to the common people to increase the biofuel market. Though it is carbon-free material it does not harm the environment so more and more biofuel cars should be introduced. As car number is increasing day by day. Government should make some Mou so that they can work collaboratively and improve research work. All biofuel-producing countries make organizations and try to find some path how to reduce the biofuel price and increase biofuel productivity.

The biofuel industry needs certification for importing and exporting the product. Without definite rules and regulations per barrel or per gallon, prices will vary so much and transportation needs to be handled because it is flammable if train people do not handle them then it can be devastating.

Chapter 5

Present and Future Condition of Biofuel in Bangladesh:

There is an energy shortage in rural Bangladesh because of the high price of petroleum products, the inadequate coverage of the electrical grid, gasification, and the diminishing availability of traditional fuel woods owing to deforestation. Massive deforestation was expected by environmental specialists if the problem is not resolved by alternate means. Due to current crises and the necessity for significant capital injections, the coverage of gas and electricity cannot be increased significantly [37]. According to a recent study, Bangladesh's GDP grows by around half a percentage point less because of power interruptions, which cost the country's industries $1 billion in lost productivity annually. As a result, the definition of the nation's economic and social sustainability now heavily depends on the use of renewable and ecologically benign energy sources. Biomass, hydropower, solar, wind, tidal energy, and other renewable energy sources must be developed and used more [38]. But while having a bright future, biodiesel and bioethanol are still in their infancy in Bangladesh. The third generation of biofuel feedstock in Bangladesh is thought to include algae [38].

Precise information is not known about the families of oil-producing plants, their production, and consumption in Bangladesh. Of course, exploited individuals rarely face a problem with food security. The three primary plants that might be used to produce biodiesel in Bangladesh are jatropha, mahua, and Pongamia. Jatropha and cassava were planted in 2009 as part of a project at the Bangladesh Atomic Energy Commission's Plant Biotechnology Division. However, the absence of a suitable strategy and adequate funding prevented this initiative from progressing. The first company in Bangladesh to make biodiesel from Jatropha seeds is the Khwaja Agri-Horticultural Research Centre (KAHRC), located in Gazipur. Bangladesh's climate is ideal for jatropha plantations since it can flourish everywhere from a dry subtropical area to a tropical rain forest. Cellulosic and alternative energy crops may also be utilized to make biodiesel [38].

There are no active biofuel production initiatives currently underway in Bangladesh. However, some projects need to be attended to in the future. According to Energy-Bangla, the Japanese industrial behemoth Honda Denki Co. Ltd has indicated an interest in investing up to US$1 billion in Bangladesh's green power, biofuels, and sugar industries [39]. As a developing country, Bangladesh has a constant energy demand.

Currently, Bangladesh imports all of its yearly fuel needs from Kuwait, Saudi Arabia, the United Arab Emirates, and India, totaling around 37 lac tons annually, including 24 lac tons of diesel [37]. Bangladesh has the potential for alternative fuel energy resources derived from algae in the hunt for biofuel energy sources, even if, unlike Jatropha biofuel, algae still need further research. Bangladesh can establish a small or medium-sized biodiesel business considering the country's growing energy needs, suffering from a lack of crude oil, and relying heavily on imported oil for both its economic and social growth. Advanced technologies are expected to be used extensively shortly with the change of pertinent rules and regulations and tight collaboration among scientific researchers, institutes, and businesses. For both sustainable development and environmental preservation, advanced technologies are essential [38].

Following analysis of all situations and actions conducted in relation to algal biodiesel in industrialized countries, certain recommendations are given. The suggestions for Bangladesh are as follows:

1)Bangladesh should establish a national center for algae research.
2)Bangladesh must create the molecular equipment necessary to transform algae into a biotechnological platform.
3)Algae farms should be used by the petroleum and refining industries as a GHG mitigation strategy since algae require a significant quantity of CO2 to flourish.
4)It must create algae strains for cost-effective biofuel generation.
5)The whole nation's water resources should be utilized to gather algae to produce biodiesel since it will be a more affordable and sustainable method.
6)All technical universities and research centers ought to be engaged in algal biodiesel research.
7)Bangladesh should try to learn from the developed world's experience in producing biofuel, especially biodiesel. Bangladesh might try to obtain technologies that could convert biomass into food, fuel, and chemicals.
8)Fuel is necessary for economic progress, while food is necessary for survival. We cannot allow our agricultural land to be overused to produce crops for biofuels. We need to find a balance.

Chapter 6
Conclusion

Energy is a crucial element that raises the standard of living for people by enabling industrial development and the provision of necessary services. There are several energy sources, but it is essential to find one that is practical and kind to the environment. The manufacture of algae biodiesel, also known as biodiesel, made from microalgae, is described in this study as occurring in several industrialized nations including China, Malaysia, and India. The only sustainable biodiesel that can replace liquid fuels made from petroleum totally is microalgae biodiesel, which is theoretically viable. The economics of manufacturing microalgae biodiesel must significantly improve if it is to be competitive with petroleum-based fuel. Microalgae farming can reduce CO_2 emissions and can clean wastewater. The usage of marine microalgae species, which use seawater as a medium, helps reduce the lack of fresh water. Algae are the most practical and environmentally benign source of biodiesel, yet they are still controversial due to their high cost. However, there is a lot of global research being done to reduce the price of producing algae biodiesel, and Bangladesh can effectively implement it. Tubular photo-bioreactors are anticipated to be employed in the production of a large portion of the microalgae biomass necessary for generating biodiesel, and the cost may be reduced by using the bio-refinery idea and photobioreactor engineering. Although oil production worldwide is dropping, oil demand is rising dramatically in all developing nations, including Bangladesh. Petroleum prices are rising due to the present shortage, and in that situation, Bangladesh might turn to biofuels as a substitute that can be easily incorporated into the country's existing transportation system. Because Bangladesh ranked first among vulnerable nations to climate change, it must transition to environmentally friendly biodiesel to fulfill rising fuel consumption, just like all other wealthy nations. Comparing biofuels to various petroleum alternatives, we can see that they can lower the net life cycle of greenhouse gases. Bangladesh must move quickly to introduce this environmentally friendly technology into the fuel production industry if it wants to keep its industries operational, boost their output rates, and protect the environment at the same time. Amid the current fuel crisis, algae-based biodiesel can both guarantee a pollution-free and secure environment and fulfill gasoline demand. Based on the situation in other industrialized nations, certain recommendations are provided for further study and analysis of algae biodiesel. Algal biodiesel might become an effective and efficient energy source in Bangladesh over the following ten years thanks to their proposals.

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