PLANT TO FUEL

Cost- effective and sustainable method of clean bioenergy generation from *Chlorella vulgaris,* an aquatic plant

BIOENERGY

AFFORDABLE AND CLEAN ENERGY | CLIMATE ACTION

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Project Abstract:

UNADAP is seeking towards addressing the SDG's of, **AFFORDABLE AND CLEAN ENERGY** & **CLIMATE ACTION** through this **Plant to Fuel** project. This project aims at investigating an alternative clean, cost-effective and sustainable energy source, alternative to fossil fuels.

Bio-hydrogen being a clean energy source with high-energy output is chosen as one of the key product of this project. This project is one of its kind due to its uniqueness in employing a novel pre-treatment method for the source (*Chlorella vulgaris*) using solar light as the sole energy input, thus making the process practical. A number of researches have been carried out using *C. vulgaris* as an energy source to produce either biohydrogen or bio-oil but not simultaneous production of both, which is an added highlight of this experiment. The faction to benefit from this project would be people from developing and underdeveloped countries who cannot afford the current, high-priced renewable energy. The total estimated cost for this project is USD$1,106,540 (One Million, One Hundred and Six Thousand, Five Hundred and Forty). Expenses include; laboratory setup, researcher's salary & training, rent, purchase of required equipment, etc.

Statement of need:

In recent decades, the world is ever more often experiencing the effect of the changing climate, only to be exacerbated by the ongoing pollution and use of fossil fuels. We are at a critical juncture where we might have our last chance to safeguard a future with a life-sustainable environment. In order to change tides, we have to break free from our dependency on fossil fuels, and, as a global society, make the move to sustainable energy. To ensure full participation, we need a cost-effective energy source that is sustainable and obtainable to everyone in the world.

Project Description:

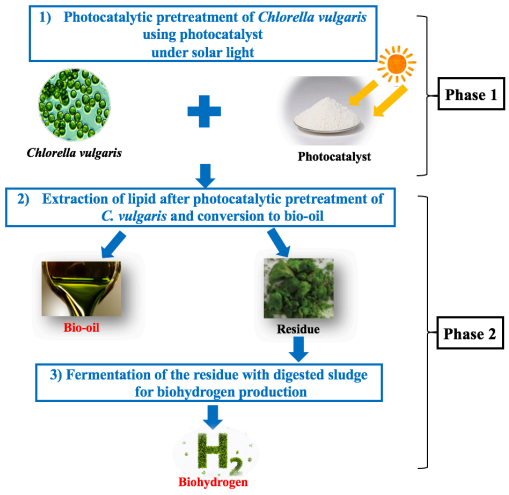
Project for generating clean bioenergy in the form of bio-oil and biohydrogen through a novel, cost effective and sustainable method as the ultimate solution to the global crisis of energy and pollution. Biohydrogen, due it's non-polluting nature (as the only by-product on

combustion is water vapor), has taken scientific interest in particular. Consequently, UNADAP has decided to work on the same as a sustainable energy source and alternative to fossil fuels.

Recently, aquatic plants like microalgae have drawn a lot of attention due to its characteristics such as rapid aquatic growth and wide distribution [1, 2] which can be considered as a large potential for sustainable productivity. Among various microalgae, *C. vulgaris* is a typical type of microalgal biomass which is composed of 12-55 % carbohydrates, 42-58 % proteins and 5-58 % lipids, the key components that are converted to bioenergy [3]. Therefore, in this project plan, *C. vulgaris* is proposed as a viable source to generate bioenergy in the form of biohydrogen and bio-oil from carbohydrate and lipid respectively, via fermentation. However, microalgae like *C. vulgaris* pose some serious limitations for bioenergy production due to their thick cell wall (outer covering). The thick cell walls make it difficult for the bacteria to convert the components to bioenergy. In order to overcome these limitations, pre-treatment of microalgae under high temperatures, ultraviolet rays, acidic or alkali conditions, etc., is necessary [4]. However, these conventional pre-treatment methods are cost ineffective and require high-energy input.

On the other hand, photocatalysis is an advanced oxidation process, where chemical products in the presence of sunlight breakdown complex molecules to simpler forms. Photocatalysis has been widely used in wastewater treatment to decompose contaminants and complex dyes [5-7]. Apart from the immense practical applications of photocatalysis, it has other advantages such as operating under ambient temperature and pressure, high stability, reusability and usage of solar light as an energy input source.

In the light of the above background, project on the utilization of photocatalytic pre-treated *Chlorella vulgaris* for simultaneous bio-oil and biohydrogen generation, using digested sludge from waste water plant as bacterial source is proposed. The steps involved in the proposed research is as outlined below:



Procedure

The photocatalyst 'A' coated on glass tubes will be connected to each other using plastic connectors to form a cyclic system. The *C. vulgaris* solution will pass through the cyclic system for photocatalytic degradation under solar light. On photocatalytic pre-treatment, components such as carbohydrates, proteins and lipids will be released as a result of destruction of the cell wall of *C. vulgaris*. This pre-treatment will facilitate the extraction of lipids which can be further purified to bio-oil.

The left-over residue-after extraction of lipid is rich in carbohydrates and proteins and can be subjected to fermentation using digested sludge as bacterial source. Biohydrogen will be produced as a by-product of fermentation thus, completely utilizing the components of *C. vulgaris*.

Therefore, photocatalytic pretreatment can be a promising pre-treatment for microalgae to generate bio-oil and biohydrogen by using solar light as the energy source.

Expected results:

From previous researches, photocatalyst 'A' has shown remarkable results in degradation of organics. Consequently, it is efficient in breaking down the cell wall of the microalgae completely, thereby, enabling lipid extraction to a great extent. The lipid extracted can be further purified to be used as bio-oil. The residue after lipid extraction with high source of carbohydrates will be converted to biohydrogen by using digested sludge as bacterial source.

Since, the photocatalysis will use sunlight as an energy source, the only energy consumed in the process is the fermentation bioreactor. But the energy output is in the form of bio-oil and biohydrogen, thereby, making the overall process sustainable and practical.

Evaluation:

Repeated analysis and experiments will be conducted to optimize the process and obtain highest bio-oil and biohydrogen productivity. Energy evaluation will be conducted for the process in order to minimize the energy input and maximize the energy output. The quality of the products will be tested and scrutinized through practical application.

Goals and objectives:

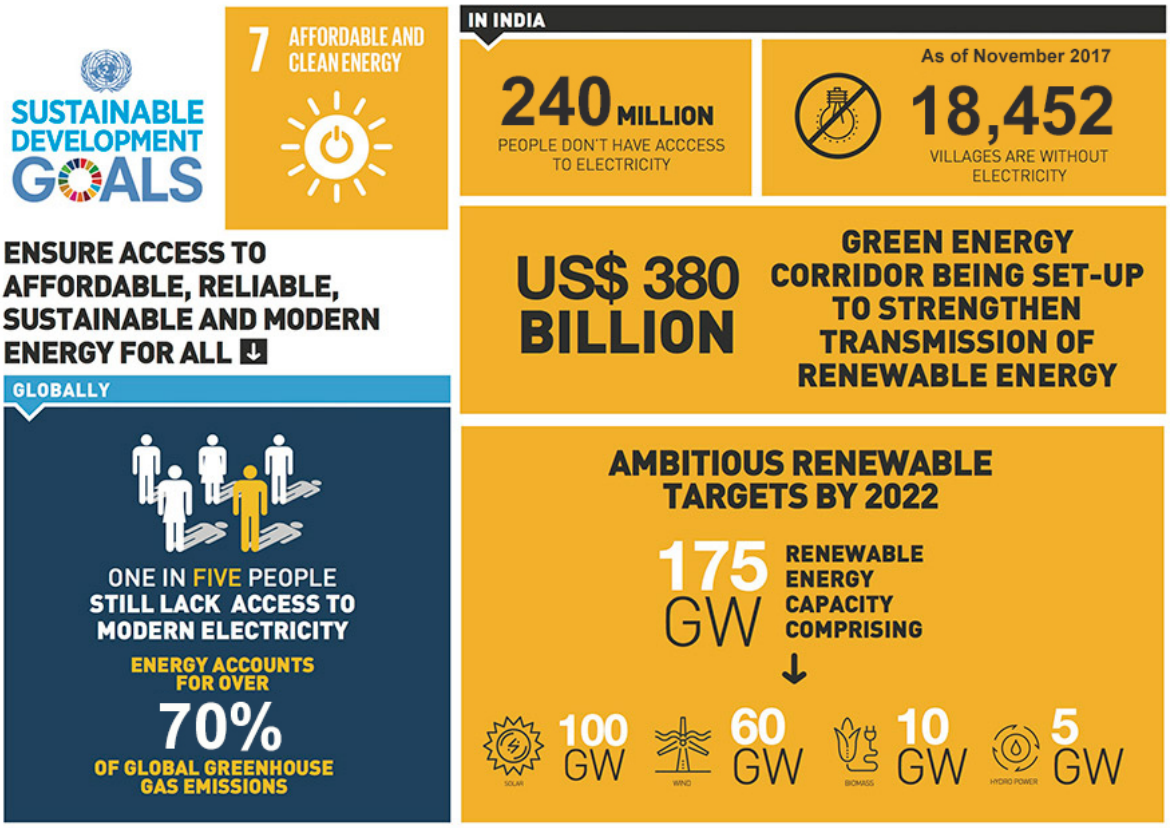
The goal of the Plant to Fuel! Project is to provide an alternative clean, sustainable and cost-efficient energy source for vehicles and household to combat the socio-economic climate and energy crisis. We aim at achieving an outcome that can be afforded and utilized by developed, developing and underdeveloped countries.

The main objectives include:

- Investigate cost-effective photocatalytic pre-treatment of *Chlorella vulgaris* using solar light and its optimization.

- Efficient lipid extraction from pre-treated *Chlorella vulgaris* and subsequent conversion to bio-oil to be used in products.
- Efficient conversion of left over residue to biohydrogen using digested sludge via fermentation, to be used as fuels for vehicles.

Benefits of the Plant to Fuel Project



The looming climate change and depletion of fossil fuels has given rise to alternate sources of energy. Although, India has taken up various projects to utilize various waste resources to produce alternate energies, we still are far behind from a revolution. Considering the massive number of vehicles and households running on fossil fuels in India and the pollution caused by them; a clean and sustainable energy is essential in order to concoct an era without fossil fuel.

Through this research project, the biohydrogen and bio-oil generated can be used to fuel thousands of vehicles and household in India, as a measure to overcome pollution and bases of climate change. Also, the bacterial source for fermentation of the energy source (*C. vulgaris*) can be used from the copious wastes generated (12 billion L/day), thereby, dealing with their disposal simultaneously and in a productive way. As an outcome, this

project can prevent waste accumulation, generate cost-efficient and sustainable bioenergy and provide employment opportunities to many as means of tackling unemployment problems in India.

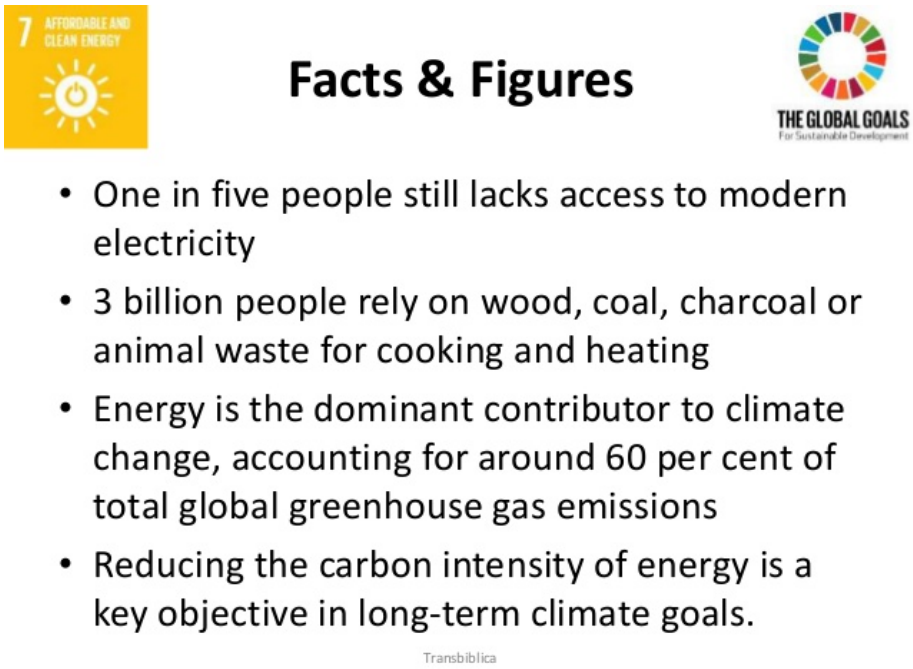
India and Goal 7

India is projected to be a significant contributor to the rise in global energy demand, around one-quarter of the total. According to 2013-14 figures, the total installed capacity for electricity generation in India registered a compound annual growth rate of 7%. However, as of 2015, 237 million people in India do not have access to electricity. The government's National Solar Mission is playing an important role in the work towards

renewable energy, and interventions in rural electrification and new ultra mega power projects are moving India towards achieving universal energy access.

Targets for Goal 7

- By 2030, ensure universal access to affordable, reliable and modern energy services.
- By 2030, increase substantially the share of renewable energy in the global energy mix.
- By 2030, double the global rate of improvement in energy efficiency.
- By 2030, enhance international co-operation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.
- By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing states and land-locked developing countries, in accordance with their respective programmes of support.



If a project like this can be implemented all over India, we strongly believe that we can combat many of the problems and underlying causes of bigger problems. Although, this project was written keeping India in mind, the problems faced by other countries are of similar nature. Therefore, realization of this project in one country will open equal opportunities in other developing countries as well. We hope that projects like these will carve a way for global development to finally attain a 'perfect world' to live in.

Timeline:

Activities	
Submit Grant Proposal	**August 2018**
Expected Grant Notification	**November 2018**
Obtain permission at Research Institute	Jan 2019
Recruit Researchers	March 2019
Set up laboratory	June 2019
Conduct experiments	November 2019
Repeat experiments	November 2020
Conduct large-scale experiments	March 2021
Prepare results report	March 2022

Budget:

The budget includes funds for renting a laboratory, recruiting & training researchers, purchase of equipment's and products for experiment. It also includes the cultivation of *Chlorella vulgaris* for a more practical result.

Product	Price	Quantity	Total
C. vulgaris cultivation (fertilizers, power, labor, misc.)	$ 29.02/ kg	~ 5000 kg	$1,45,100
HPLC machine (analyzing the microalgae and its components)	$ 34,000	2	$ 68,000
Gas Chromatograph machine (measuring the gas production)	$ 60,000	2	$120,000
UV/ VIS Spectrophotometer (optimization of photocatalyst)	$ 3,200	2	$ 6,400
Laboratory glassware	$ 29,000	N/A	$ 29,000
Chemicals	$ 4000 / month	40 months	$160,000
Laboratory Rent	$ 1,451 /month	40 months	$ 58,040
Salary for Researchers	$ 2,200 / month/ person	40 months – 5 persons	$ 440,000
Miscellaneous	$ 2000/ month	40 months	$ 80,000
			$ 1,106,540

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