



# GLOBAL WARMING AND CLIMATE CHANGE: NEXT GENERATION BIOFUELS AND ROLE OF BIOTECHNOLOGY.

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## ABSTRACT

Global warming and resultant climate change poses threat to the human population, agriculture, flora and fauna. Increase in the atmospheric concentrations of green house gases results in warming of earth temperature. This can have adverse effect on agricultural crops, result in faster melting of glaciers and rising sea levels, excessive rains, floods and droughts. CO<sub>2</sub> is major green house gas and fossil fuels contribute major share of CO<sub>2</sub> emissions. Within a short span of 200 years the atmospheric CO<sub>2</sub> concentrations have increased by about 40 percent with more than half the increase occurring since 1970. During last 100 years global mean temperature has increased by about 0.8 ° C. Most of the plants have a capacity of absorbing Carbon di Oxide and store it in themselves for long time in form of woody biomass. The use of biomass for energy and industry allows significant quantity of hydrocarbons to be consumed without increasing the CO<sub>2</sub>. This makes a positive contribution to the Greenhouse effect and offers solutions to the problems of "global change". Biotechnology plays an important role in developing synthetic organisms for better conversion of lignocellulosic biomass into biofuels. Some of the recent findings shall be reviewed.

**KEYWORD:** *Biomass, Fossil fuels, Greenhouse gases, Global warming and Climate change.*

## INTRODUCTION

The warmth and the moisture content of the earth's lower atmosphere have increased as a result of human-emitted greenhouse gases. Global warming has assumed serious proportions and climate change is taking place at a rapid pace. Significant change in average temperature, precipitation and wind patterns is taking place globally. Carbon dioxide (CO<sub>2</sub>) is the most important greenhouse gas and increasing the use of biomass for energy is an important option for reducing CO<sub>2</sub> emissions. Carbon dioxide emission is projected to grow from 5.8 billion tonnes carbon equivalent in 1990 to 7.8 billion tonnes in 2010 and 9.8 billion tonnes by 2020<sup>1-3</sup>. Biomass is renewable, non pollutant and available worldwide as agricultural residues, short rotation forests and crops. Biomass can play a dual role in greenhouse gas mitigation related to the objectives of the United Nations Framework Convention on Climate Change (UNFCCC) i.e. as an energy source to substitute for fossil fuels and as a carbon store. The fact that nearly 90 percent of the world's population will reside in developing countries by about 2050 probably implies that biomass energy will be with us forever unless there

are drastic changes in the world energy trading pattern. Plant biomass provides 10% of global primary energy today and is widely expected to provide on the order of a quarter of primary energy in prominent low-carbon scenarios for 2050<sup>4</sup>. Biomass provides opportunities for carbon removal that must be deployed at a large scale to have more than a 50% chance of achieving the 2 °C goal<sup>5</sup>. Biomass should be used instead of fossil energy carriers in order to reduce i) CO<sub>2</sub> emissions ii) the anticipated resource scarcity of fossil fuels and iii) need to import fuels from abroad<sup>3,6</sup>. For countries dependent on oil or natural gas imports, biofuels offer a way to diversify energy supplies and reduce their reliance on a few exporting countries.

### *Climate change*

Human induced (Anthropogenic) climate change has recently become a well established fact and the resulting impact on the environment is already being observed<sup>7</sup>. Because of increased atmospheric concentrations of so-called greenhouse gases (GHGs, such as carbon dioxide (CO<sub>2</sub>), methane

(CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and chlorofluorocarbons), the average temperature of the earth's surface has increased. In order to mitigate climate change, countries have committed themselves to varying degrees to reducing GHG release into the atmosphere. The Kyoto Protocol, ratified by 182 countries and the EU, which entered into force in 2005, sets legally binding targets and timetables for cutting GHG emissions for the world's leading economies which have accepted it. In this context, replacement of fossil fuels, such as petrol, by biofuels for transport purposes has been advocated as an option for a country to reduce its GHG emissions. This is because most life-cycle studies indicate that the use of biofuels instead of fossil fuels reduces GHG emissions, as biofuels sequester carbon through growth of the feedstock<sup>8</sup>. These life-cycle studies typically estimate that when biofuel and fossil fuel GHG emissions are compared during the steps of making the feed stocks (e.g. maize or crude oil), refining them into fuel and burning the fuel in the transport vehicle, the combined GHG emissions from bioethanol (of maize or LC origin) exceed or match those from fossil fuels. However, when the calculations also include the fact that the growing biofuel feed stocks remove (sequester) carbon dioxide from the atmosphere through photosynthesis, the overall GHG emissions from biofuels are typically estimated to be lower than those from fossil fuels<sup>8</sup>.

### ***Strategies to reduce Greenhouse gas emissions***

Important challenges have been identified for negative emissions technologies which have to be addressed, such as the potential competition between biomass and food production over land and water. The latest OECD-FAO Agricultural Outlook report provides an assessment of future prospects in the major agricultural commodity markets over the period from 2008 to 2017 and, for the first time, includes an analysis of and projections for global biofuel markets for

bioethanol and biodiesel<sup>9</sup>. Different strategies include adaptation as well as mitigation.

### ***Advantages of using biofuels***

There are several benefits of using biofuels. Biodiesel burns upto 75% cleaner than fossil diesel fuel. Biodiesel reduces PAH Particulate matter, unburned hydrocarbons, carbon mono oxide and Sulphur di oxide. The plant based biofuels are carbon neutral as they absorb Carbon di oxide to produce fuel and thus cause favourable balance and help in reducing green house gases.

### ***First-generation liquid biofuels***

Liquid biofuels are represented by bio-alcohols (ethanol, butanol, and methanol) and biodiesel<sup>10</sup>. In 2011, global production of bioethanol, mainly from corn and sugar bean, reached about 10 billion liters, and the expected volume of production in 2020 is 281.5 billion liters<sup>11</sup>. According to Larson<sup>12</sup> liquid biofuels can be classified into those that are "first-generation" and "second-generation", where the main distinction between them is the biomass (feedstock) used. First-generation fuels are generally made from sugars, grains or seeds, i.e. using only a specific (often edible) portion of the above-ground biomass produced by a plant, and relatively simple processing of the biomass is required to produce a finished fuel<sup>12</sup>. The two main first-generation liquid biofuels are currently biodiesel and bioethanol, representing about 15 and 85% of current global production respectively<sup>13</sup>. Investigations on several plant species have been carried out at Energy Plantation Demonstration Project Centre including *Euphorbia lathyris*<sup>(14-16)</sup> *Euphorbia tirucalli*<sup>(17-19)</sup> *Euphorbia antisiphilitica*<sup>20</sup> *Pedilanthus tithymaloides* ; *Calotropis procera*<sup>21</sup> *Euphorbia neeriifolia* and *E. caducifolia*<sup>3</sup> ; *Jatropha curcas*<sup>(6, 22)</sup> and *Simmondsia chinensis*<sup>23</sup>. Considerable work has been carried out on these plants<sup>(1-3, 22-28)</sup> (Fig 1).



**Figure 1**  
***Different laticifers Euphorbia tirucalli, Euphorbia antisyphilitica and oil yielding Jatropha curcas and different Jatropha products. Jatropha curcas biodiesel being used in a Govt of India vehicle at CSMCRI, Bhavnagar***

### ***Second-generation liquid biofuels***

Lignocellulosic biomass from a variety of sources, including agricultural residues such as corn stover and sugar cane bagasse, trees and grasses, is a potential source for 'cellulosic ethanol'<sup>(3,6,12, 20-31)</sup>. LC biomass, also called cellulosic biomass, is a complex composite material consisting primarily of cellulose, hemicellulose and lignin bonded to each other in the plant cell wall<sup>32</sup>. Ligno-cellulosic biomass can be converted to biofuels by thermo-chemical or biochemical (biological) processing and many efforts are being made worldwide to commercialise second-generation biofuels through both routes<sup>12</sup>.

### ***Application of biotechnologies for second-generation biofuels***

As compared to fermentation of first generation biomass the fermentation here is more complicated as it is a mixed-sugar fermentation (involving pentose and hexose sugars) and it takes place in the presence of inhibiting compounds released and formed during the first two steps of the process, i.e. pre-treatment and hydrolysis. Another approach is to focus on bacteria instead of yeast. Three bacterial species that have received much attention are *Escherichia coli*, *Klebsiella oxytoca* and *Zymomonas mobilis* and GM strains have been produced for each of them for bioethanol purposes. For example, *Zymomonas mobilis* has been shown to have higher ethanol yields and productivity than traditional yeast fermentations. However, like

*Saccharomyces cerevisiae* it cannot naturally ferment pentose sugars. To overcome this, GM strains using genes from *Escherichia coli* have been developed which can also ferment xyloses and/or arabinoses<sup>33</sup>. For the future, it would also be desirable to combine cellulase production, enzymatic hydrolysis and fermentation - called consolidated bioprocessing (CBP)<sup>5</sup>

### ***Third generation biofuels***

Biofuels produced from Algae and Cyanobacteria fall under this category. Microalgae represent an exceptionally diverse but highly specialized group of micro-organisms adapted to various ecological habitats. Microalgae are unicellular photosynthetic micro-organisms, living in saline or freshwater environments that convert sunlight, water and carbon dioxide to algal biomass. Many microalgae have the ability to produce substantial amounts (e.g. 20–50% dry cell weight) of triacylglycerols (TAG) as a storage lipid under photo-oxidative stress or other adverse environmental conditions (22,34). Oxygenic photosynthetic microalgae and cyanobacteria (for simplicity, algae) represent an extremely diverse, yet highly specialized group of micro-organisms that live in diverse ecological habitats such as freshwater, brackish, marine and hyper-saline, with a range of temperatures and pH, and unique nutrient availabilities<sup>22</sup>. They are categorised into four main classes: diatoms, green algae, blue-green algae and golden algae. Biomass of modern cyanobacteria may be converted into

bio-oil by pyrolysis. Many cyanobacterial species are easier to genetically manipulate than eukaryotic algae and other photosynthetic organisms. This involves growing, harvesting, and then heating or chemically treating algae to recover the oil inside their cells. Algae that continuously secrete oil through their cell walls are in development<sup>34</sup>.

### **Metabolic engineering**

Recent progress in metabolic engineering, and synthetic and systems biology, have allowed the engineering of microbes to produce advanced biofuels with similar properties to petroleum-based fuels. Reconstruction of advanced biofuel pathways in genetically tractable heterologous hosts, such as *Escherichia coli* and *Saccharomyces cerevisiae*, has been attempted successfully<sup>22</sup>.

### **Synthetic biology for biofuels**

Synthetic biology has rapidly grown out of genetic engineering into a new science with new risks. It aims to construct synthetic life forms entirely from the beginning using DNA synthesizers, “the biological equivalent of word processors”. Synthetic biologists aim to design entirely new life forms with pre-selected functions, like the microbes which will digest trees and grasses and ferment them into biofuels, or the algae which will harvest solar energy to produce oil<sup>35</sup>.

## **DISCUSSION**

Total global greenhouse gas (GHG) emissions continue to show a steady increase, reaching approximately 52.7 gigatonnes carbon dioxide equivalent (GtCO<sub>2e</sub>) in 2014. Two years ago, at the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21), over 190 nations (including the United States) committed themselves to keeping the increase in global average temperature 2 °C below pre-industrial levels, with an aim of limiting the

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increase to 1.5 °C. There have been small variations around this longer trend. Notably, the rate of global greenhouse gas emissions increase during the period 2000 to 2010 was faster (2.2 per cent per year) than during the period 1970 to 2000 (1.3 per cent per year), increasing in 2010 and 2011 (3.5 per cent per year) and then slowing in 2012 to 2013 (1.8 per cent per year). The Fifth Assessment Report of the IPCC also covered 1.5°C pathways to a limited extent<sup>(36-37)</sup>

### **Summary**

Cultivation of biofuels can contribute to maintaining employment and creating new jobs in rural areas, avoiding land abandonment and reducing migration to cities. The extensive use of fossil fuels during the global industrialization of the past century has propelled development of the world economy. The demand for energy continues to surge in the 21st century. However societal concerns about soaring oil prices, global warming due to greenhouse gas emissions, and energy security are prompting policymakers and scientists to explore the feasibility of renewable, sustainable biofuels as alternatives and/or supplements to petroleum based fuels<sup>38</sup>. Climate action is needed for sustainable development goal.

## **CONCLUSION**

Green house gases are causing climate change and biofuels can provide Carbon neutral biofuels and improve climate. Studies were carried out on hydrocarbon yielding plants and oil yielding plants and agro technology was developed. Biofuels provide a solution to climate change problem and help in mitigation of greenhouse gases.

## **CONFLICT OF INTEREST**

Conflict of interest declared none.

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