Fuel 143 (2015) 414–423

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

Review article

Assessing the potential of algal biomass opportunities for bioenergy industry: A review

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ARTICLE INFO

Article history:
Received 3 April 2014
Received in revised form 22 October 2014
Accepted 22 October 2014
Available online 20 November 2014

Keywords:
Algae biomass
Biofuel
Energy production
Bioenergy industry

ABSTRACT

In many developed and developing countries, algal biomass is no doubt considered a significant source of energy to be used for local industry and transportation but the fact remains that the information on current utilization of algal biomass is still estimated and partial. Much more information will have to be gathered on the use and availability of algal biomass; particularly the limitations of first and second generation biofuel have given rise to the current interest in algae as a promising alternative to these conventional biofuel sources. It is therefore in this context that the present communication focuses its efforts to have region based database able to provide information on specific biomass production, their utilization with the respect to sectors like region, industries, transportation, etc., also taking into consideration the strong need for research on third generation biofuel production. In the present review, a comprehensive survey on algal biomass resource for future, is addressed.

Contents

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http://dx.doi.org/10.1016/j.fuel.2014.10.064
0016-2361/

1. Introduction

Undoubtedly, the primary energy consumption in world has increased to manifolds (~38%) since 1990s. Such high demand and finite reserves not only cause shortage of primary energy but also leads to the problem of increasing GHGs emissions in the world. In 2009, 43% of CO_2 emissions from fuel combustion were produced from coal, 37% from oil and 20% from gas. Two sectors, electricity and heat generation and transport, produced nearly two-thirds of global CO_2 emissions [1].

Energy plays a central role in the global economy. Changes in energy costs have significant effects on economic growth. Increasing oil prices, rising energy demands and concerns over global warming have encouraged many countries to develop biofuels. In order to support the emergence of the biofuel sector, many countries have introduced incentives, such as consumption targets, tax breaks, production subsidies and reduced border tariffs. This has stimulated the growth of biofuel production and trade globally during 2000–2011 [2,3].

An important potential constraint for biofuel expansion in global is the ongoing discussion on criteria for sustainable production, energy balances and green house gasses savings of biofuels, which could become protectionist barriers discriminating against supplier countries. The European Union has just passed new regulations requiring a minimum 35% net reduction of green house gasses emissions for biofuels [4] along with specific requirements on environmental and social impacts, which may pose new challenges for imports of ethanol from maize or biodiesel from soya. Also, if carbon emissions from land use change are accounted for and high carbon density lands are cleared for biofuel production, most crop-derived biofuels will not qualify to be sold in Europe.

The transportation sector accounts for 21 percent of current global fossil fuel CO_2 emissions to the atmosphere, second only to emissions from power production (Fig. 1). With global economic growth assumed to average 3.2 percent per year to 2030, growth in energy and demand for transport are forecast to increase at an average annual rate of 2.1% over the same period. Transport sector contribution to the total anthropogenic greenhouse gases emissions is projected to increase to 23 percent in 2030 [5]. Bioenergy has been recognized as a significant component in many future's energy scenarios. Substitution of fossil fuels by biofuel appears to be an effective strategy to meet not only the future world energy demands but also the requirement for reducing carbon emissions from fossil fuels. Although there is an increasing demand for fossil energy due to rising economic activities in the emerging markets, especially China and India, soaring oil prices have encouraged major consumers worldwide to sharply increase their use of "green" biofuel [6,7].

First generation biofuel sources have been exploited for nearly three decades but have proved grossly inadequate to augment rising global requirements. Instead, their continued use has contributed toward global food for fuel crisis, necessitating a gradual shift toward the second generation biofuel sources, which offer greater potentials. However, the main argument against the second generation fuels is based on land availability and the protection of global ecosystems. It is true that these fuel sources have immense potentials but there are indications that algal biomass could well be the panacea to raising the global demands for transport fuels. Various assessments advanced by different scholars indicate that algae offer great potentials as a biomass resource for the provision of the future green transport fuels but also for the direct use in carbon sequestration in many parts of the world.

Although the precise quantity of algae that can be grown, harvested and processed in a sustainable manner appears unclear, much effort has been made in the application of algae as a biomass resource especially for the provision of food supplements and specialty products. The present communication highlights the evolution of transport biofuel while giving primary attention to algal biomass as a potential source of the future's biofuel. Areas that require further R&D as well as some limitations of certain technological approaches will be discussed.

2. Role of land in biofuel source

In order to achieve future biofuel demands, forest lands can be either cleared to plant biofuel crops, or kept as productive forests and harvested for sustainable wood-for-energy production. Leaving sustainability considerations apart, both alternatives are technically viable. However, it is not yet clear which one will be more profitable in the emerging biofuels market.

The oil crisis of the early 1970s triggered interest in the adoption of the land-based agriculture-derived fuels known as biofuel in a bid to augment the supply of fossils. Although, it was thought that mass cultivation of these first generation biofuel resources such as sugarcane, corn, soybean, rapeseed, oil palm trees, etc., could resolve both problems of edible oil and fuel at the same time, it became obvious with time, that the increasing global demand for fuel could not be met sustainably by these fuel sources.

Established technological approaches for transport biofuel production – such as the American corn to ethanol and soybean to biodiesel programmes, the European Union rapeseed to biodiesel and sweet sorghum to ethanol programmes, the Brazilian sugar cane to ethanol process, the Malaysian palm oil to biodiesel experience, etc., – are still heavily dependent on the first generation sources that only generate about 0.3% of all global transport fuels presently [8].

No doubt, bioenergy with the potential to meet 50% of the world energy demands while reducing carbon emissions from fossil fuels appears to be a potential energy resource but increased biofuel production on arable land could have long term severe consequences for the global food supply.

2.1. First generation biofuel

First-generation fuels allude to the biofuel a product of sugar, starch, vegetable oil, or animal fats utilizing conventional technology [9]. These fluid biofuels include the accessible fuels such as pure plant oil from oil yielding crops, biodiesel from esterification of immaculate plant oil or waste vegetable oils, bio-ethanol from sugar or starch crops maturation, and ethanol derivate ETBE (i.e.