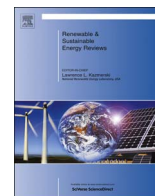




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Microalgal biodiesel: A possible solution for India's energy security



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ARTICLE INFO

Article history:

Received 17 November 2015

Received in revised form

28 May 2016

Accepted 14 August 2016

Keywords:

Biodiesel

Microalgae

Feedstock

Transesterification

Energy security

GHG emission

ABSTRACT

Extreme accession in industrialization and urbanization is responsible for huge demand of fossil fuels which are depleting day by day. Hence, search for renewable energy resource has become a considerable challenge in recent years. Biodiesel has been recognized as an alternative fuel, non-toxic and biodegradable which is capable to replace the diesel fuel. In developing countries such as India, there is crisis of edible oil and the edible oil is imported to accomplish the demand. Based on the outline presented, it is observed that search for biodiesel sources should consider the feedstocks that do not require fertile land, do not compete with food crop, help in reduction of greenhouse gas emission as well as decrease the dependency on other nations. So, recently microalgae have emerged to be very auspicious feedstock for production of biodiesel. The present study deals with the systematic analyses of energy demand and GHG emission statistics of various nations as well as all the steps involved in overall process from algal strain selection to biodiesel production. With these challenges, the solutions in biodiesel production from microalgae were also shown. Though, biodiesel is economically viable, more inquisition as well as technological evolution is required in this direction. To overcome these problems, policies based on usage of bio fuels derived by various nations which encourage biodiesel production, making them rival of conventional energy sources are needed.

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1. Introduction

1.1. Global energy crises

In recent years, due to increasing population there has been drastic expansion in urbanization and industrialization, which are responsible for energy crises. As a result, the need arises for the use of alternative source of energy which can meet the energy necessities. In such a situation, renewable energy which is also known as non-conventional energy, will prove to be an option. Fossil fuels which are non-renewable source of energy are diminishing in quality and quantity day by day. Their usage at major scale cause health hazards mankind because of emission of hydrocarbons, sulfur, carbon monoxide, nitrogen oxide, poly aromatic hydrocarbons, GHG, etc. [1].

The appliance of energy, primarily supplied by fossil fuels has inexorably expanded over past few decades and with this, corresponding rate of emission of greenhouse gases has also increased dramatically. Origin of this growth are developing countries which are expanding in population as well as in their economic activity. These factors are responsible for increment in energy demand. Energy growth varies between developed and developing nations. The IEO 2011 projected that the developing countries, India and China consumed about 21% of the world's total energy in 2008. In 2035 this energy use is expected to be more than their double constituting 31% of energy usage all over the world [2]. Morally, all up to 95% of projected growth for energy consumption is in non-OECD nations, escalating at the rate of 2.3% p.a. in during 2012–2035. As compared to non-OECD nations, OECD consumption will record an increment at 0.2% p.a. over the period and will start decreasing from 2030. The major contributors in the growth of energy consumption is China and equal contribution is also expected from India. In case of China, demand of global liquid consumption has is expected to rise from 8 Mb/d to 18 Mb/d till 2035. Whereas, India and other Middle East nations are the ensuing major contributors and both rise by 4.6 Mb/d and the non-OECD Asia seems to be about 3.1 Mb/d growth. Though, China shows largest rise in demand for liquid energy but during the year 2030–2035, its demand rises only up to 0.9 Mb/d which makes India as the largest contributor for the growth of 1.3 Mb/d in demand

during 2030–2035 [3].

Greenhouse gases (GHG) concentration has been increasing due to industrialization by 25% and which is about three quarters of carbon dioxide generated due to excess use of fossil fuels [4,5]. Energy and transportation sectors are the major sources which are responsible for 60% and 20% emission of GHG in European Union [6]. One of the considerable problems in decreasing crude oil reservoir with extraction and processing difficulties causes increment in their cost [7]. Currently there are many alternative sources being explored and are being executed in practice. Examples are Hydropower, Geothermal, Solar, Wave (Tidal), Wind and Biofuels [8,9] and these sources have own merits and demerits.

Gas and oil play important role to reach energy necessity of various countries in the world and it has been assessed that gas and oil sectors provide up to 45% of the overall global energy requirement [10]. The International Energy Agency (IEA) has reported that primary energy need of the world projected to rear between year 2005 and 2030 by 55% and having 1.8% of annual rate per year [11]. 27% of this primary energy is consumed by transportation sector [11]. According to International Energy Agency World Energy Outlook 2013 [12], energy demand increases towards south Asia. Primary energy demand of China will be highest as compared with other countries that it will be 4060 Mtoe in 2035. It also specifies that energy demand grows towards South Asia with prepotence of China and India becoming more attractive in global energy trade. According to IEA, projected energy consumption by United States will remain near to 100 quads through 2040. As compared with United States, China will consume much more energy and will reach up to 200 quads by 2030. In that case, India's consumption will be one fourth of US in 2020 and will likely get doubled by 2040 [13].

In developing countries like India, there is regular increment in fuel import which compels Govt. and scientific workers to search for alternative liquid fuels to diesel which has largest application in agriculture and transportation sector [14]. As compared to other countries where gasoline is dominant over diesel, in India diesel consumption is nearly five times more than gasoline. Roughly, annual consumption of diesel in India is ~64 Mt, or 450 million barrels per year which is far larger than gasoline consumption, which is up to 84 million barrels only [15]. Diesel consumption is

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