

Chapter 2

Biofuels: An Emerging Industry

Abstract Dealing with the nonrenewable nature of fossil fuels, and with the effect of carbon dioxide emissions on global warming, requires transformation of the energy sector toward renewable, carbon neutral resources. This chapter introduces the biofuel industry, which relies on the energy derived from living organisms or from their metabolic products, in the contest of global energy supply.

Keywords Biofuels • Carbon dioxide • Energy • Fossil fuel • Global warming • Greenhouse gas

Development of our modern society has been strictly dependent on the consumption of fossil fuels. However, these energy resources are being depleted much faster than the millions of years they take to form, leading to the concept of nonrenewable resources. World energy consumption has duplicated in the past 40 years, reaching 8,000 Mtoe (Million Tonnes of Oil Equivalent), of which 80 % is still covered by fossil fuels, namely, oil, coal, and natural gas (data released by IEA, the International Energy Agency, in the 2014 Key World Energy Statistics, <http://www.iea.org/publications/freepublications/publication/key-world-energy-statistics-2014.html>). Assuming nine billion world population and 100 % fossil fuel use, fossil fuel reserves would be extinguished by 2070 (considering 3 % economic growth and use of proved reserves only) or by 2110 in the best scenario (considering 1.5 % economic growth and use of ultimately recoverable reserves) (Stephens et al. 2010). The problem of the exhaustion of fossil fuels is added to the perceived effects of climate change and global warming due to greenhouse gases emission related to fossil fuel combustion. The use of fossil fuels releases 7.8 billion tons per year of carbon (equivalent to 29 billion tons per year of CO₂) (data released by the Intergovernmental Panel on Climate Change, IPCC, Ciais et al. 2013) that cannot be counterbalanced by the CO₂ cycle of forests and oceans (Fig. 2.1). CO₂ is one of the primary greenhouse gases, affecting the global temperature by absorbing infrared radiation. In the absence of efforts to stabilize the atmospheric concentration of greenhouse gases, the average global temperature rise is projected to be at least 6 °C by 2050. This corresponds to the 6DS scenario, as described by IEA. While the average global temperature rises, anomalous weather conditions may be observed locally.

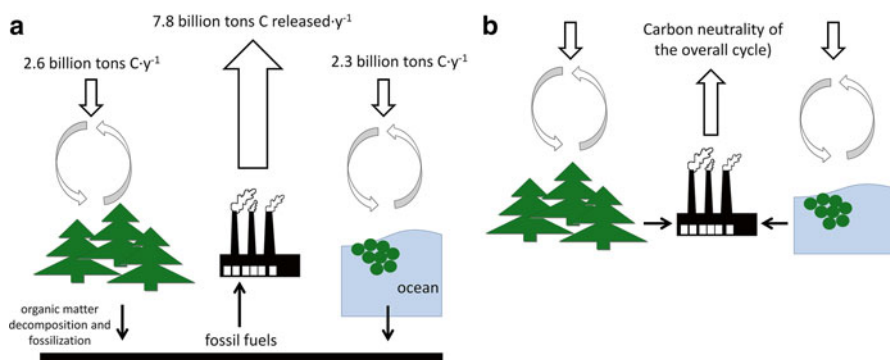


Fig. 2.1 Comparison between fossil fuels and biofuels in terms of carbon emission. **(a)** Net annual increase in atmospheric carbon due to combustion of fossil fuels. The carbon stored in fossil fuels derives from organic matter that fossilized in millions of years. The release in carbon is not compensated by the carbon cycle of uptake and emission by the biomass in forests and oceans. **(b)** The potentiality for carbon neutrality of biofuels. Carbon in the form of CO₂ is assimilated during photosynthesis, by land plants and aquatic photosynthetic organisms, i.e., algae. The carbon that is not released by respiration and other metabolic activities accumulates in the form of biomass. The resulting biomass is a biofuel resource, releasing its carbon content during combustion. The release in carbon is equal to the carbon uptake that sustained growth of the biomass

The alternative 2DS scenario, proposed by IEA and supported by OECD (the Organization for Economic Co-operation and Development), sets the target of limiting average global temperature rise to 2 °C by 2050. In particular, there would be an 80 % chance of limiting average global temperature increase to 2 °C if CO₂ and greenhouse gases emissions are cut by more than half in 2050 (compared to 2009). This goal would be successfully achieved only if we ensure that such emissions continue to fall thereafter. Major changes are required in policy and technologies to significantly make the difference. However, transformation of the energy sector alone would be insufficient. Part of the effort has to be targeted to the combined reduction and/or optimization of energy consumptions by non-energy sectors.

Reorganization of the energy sector toward renewable resources and CO₂ neutral technologies is already taking place. The 2014 IEA Key World Energy Statistics report that biofuels, i.e., fuels derived from living organisms and their metabolic by-products, plus industrial, agricultural and municipal waste, account for 10 % of the world primary energy supply. Global biofuel production increased from 20 billion liters in 2001 to 100 billion liters in 2010 and is for the 80 % represented by Brazilian and US bioethanol. The USA also produces 3.7 billion liters of biodiesel per year. Biofuels account for 2 % of world transportation fuel; however, this could increase to 27 % by 2050 (IEA, Biofuels for transport, <http://www.iea.org/publications/freepublications/publication/technology-roadmap-biofuels-for-transport.html>). Brazil, together with the USA, leads the world production of bioethanol. Since 1976 the Brazilian government made it mandatory to blend gasoline with 10–22 % of anhydrous ethanol, from alcoholic fermentation of sugarcane feedstock.

The bioethanol project did not start in Brazil in order to reduce greenhouse gases emission, that was not an issue at that time, but because the country could not afford to buy oil.

The conversion of a fossil fuel-dependent society toward a portfolio of alternative energies would decrease global oil demand and influence oil prices. In addition, exploitation of renewable resources would decrease CO₂ and greenhouse gases emission compared to combustion of fossil fuels (Fig. 2.1). The rationale of biofuels derived from photosynthetic biomass, such as currently exploited energy crops, is that their combustion would release CO₂ not exceeding the carbon content in the biomass, that in turn is equal to the CO₂ previously assimilated through photosynthesis during growth. If renewable energy is also employed to supply the biorefinery demands, a 100 % reduction in CO₂ emissions could be achieved compared to fossil fuels. For instance, during bioethanol production from sugarcane fermentation, the residual cane-waste (bagasse) is used to produce heat and power, which results in a very competitive price, a high energy balance and 100 % reduction in CO₂ emissions compared to fossil fuels (IEA, Biofuels for transport). In general, the role of bioenergy systems in reducing greenhouse gas emissions is evaluated by comparison with the energy systems they replace, taking into account all the production and distribution processes.

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Formighieri, C.

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