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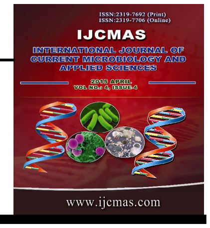

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Review Article

Evolution, impacts and sustainability assessment of renewable energy

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A B S T R A C T

Environmental pollution is increasing due to industrialization and economic growth by the consumption of different types of fossil fuels. The current energy supplies in the development of world are unsustainable from economic and environmental aspects. An essential and growing need for humans is energy which is used for agriculture, transport and industries. This energy is generated by fossil fuels whose availability is limited and is non-renewable. Governments have initiated the use of alternative renewable sources of energy to minimize environmental pollution, hence ensuring energy security and generating employments. Biofuels generally refers to any fuel in the form of solid, liquid and gas which is made from the breakdown or decaying of biological sources like that vegetable oil, animal fats and non edible plant feedstocks. The production of biofuels for transport has increased rapidly in recent years. It represents only 1% of total transport fuel consumption and only 0.2 to 0.3% of total energy consumption worldwide. In this context, biofuels are an important alternative source of energy which provides 10.6% of the primary energy of the global demand. This paper focuses on how the biofuels can be used as a source of energy and mitigate greenhouse effects & environmental impacts of biofuel production which play a key role in sustainable development.

Keywords

Environment, Economics, Nonrenewable Energy, Greenhouse Gas, Sustainable development

Introduction

Biofuels are fuels produced directly or indirectly from organic material biomass including plant materials and animal waste. Overall, bioenergy covers approximately 10% of the total world energy demand. Traditional unprocessed biomass such as fuel wood, charcoal and animal dung accounts for most of this and represents the main source of energy for a large number of people in developing countries who use it mainly for cooking and heating. Bioenergy is mainly used in homes (80%), to a lesser extent in industry (18%), while liquid biofuels for transport still play a limited role (2%) (FAO, 2008)**.**A relatively recently popularized classification for liquid biofuels includes "first-generation" and "second-generation" fuels. A first-generation fuel is generally one made from sugars, grains, or seeds, i.e. one that uses only a specific (often edible) portion of the above-ground biomass produced by a plant, and relatively simple processing is required to produce a finished fuel (NYK Geneva., 2008).The sustainable and economic production of 1st-generation biofuels has however come under close scrutiny (IEA, Bioenergy task, 2009)**.**Second-generation fuels are generally those made from non-edible lignocellulose biomass, either non-edible residues of food crop production (e.g. corn stalks or rice husks) or non-edible whole plant biomass (e.g. grasses or trees grown specifically for energy). The potential for producing rural income by production of high-value products (such as liquid fuels) is attractive (NYK Geneva, 2008).This rapidly growing industry has recently raised important concerns. In particular, the sustainability of many first-generation biofuels which are produced primarily from food crops such as grains, sugar cane and vegetable oils has been increasingly questioned over concerns such as reported displacement of food-crops, effects on the environment and climate change.The increasing criticism of the sustainability of many first-generation biofuels has raised attention to the potential of so-called second-generation biofuels (IEA, 2010).

Environmental impacts of biofuel production

To assess the net effect on greenhouse gas emissions of replacing fossil fuels by biofuels, we need to analyses emissions throughout the whole process of producing, transporting and using the fuel. Greenhouse gas balances differ widely depending on the type of crop, on the location, and on how feedstock production and fuel processing are carried out. Biofuels from some sources can even generate more greenhouse gas emissions than fossil fuels.A significant factor contributing to greenhouse gas emissions is the amount of fossil energy used for feedstock production and transport, including for fertilizer and pesticide manufacture, for cultivation and harvesting of the crops, and or in the biofuel production plant itself. Emissions of nitrous oxide are another important factor (Table 1:Biofuels toxic emissions compared to standard fuels). It is released when nitrogen fertilizers are used and its greenhouse gas effect is about 300 times stronger than that of carbon dioxide (FAO, 2008)**.** By-products from biofuel production such as proteins for animal feed make a positive contribution to climate change mitigation because they save energy and greenhouse gas emissions that would otherwise have been needed to produce the feed by other means. Most studies have found that producing first generation biofuels usually yields reductions in greenhouse gas emissions of 20 to 60% when fossil fuels are replaced provided the most efficient systems are used and carbon dioxide emissions from changes in land-use are excluded. When forest or grassland is converted to farmland to produce feedstocks or to produce crops that have been displaced by feedstock production, carbon stored in the soil is released into the atmosphere. (FAO, 2008)**.**

Biofuel production stimulate agricultural growth and poverty reduction in the longer term

The emergence of biofuels could increase the demand for agricultural products and help revitalize agriculture in developing countries. The world's poorest countries could become major agricultural producers, while supplying feedstocks for liquid biofuel production. Agricultural growth, over the long term, helps to improve food security by generating rural income opportunities and reducing food prices for consumers (Table 2: Biofuels yield from different feedstocks). Growth in Gross Domestic Product (GDP) in the field of agriculture is at least twice as effective in reducing poverty as growth in other sectors. (FAO, 2008). Government assistance to improve access to credit and infrastructure including local roads allows farmers to boost their incomes, and intensify food production. Increased farm productivity will be important to avoid long-term increases in food prices and excessive expansion of cultivated area. The introduction of nonfood crops, which yield cash flow, can also encourage private investment. Technological change is the biggest driver of agricultural growth. However, the high research cost means that public funding remains essential (FAO, 2008).

Methodological framework for sustainability assessment

Production pathway assessment appears as a critical step in process design, which involves screening of alternative processes to the desired product based on various criteria. There were several assessment works involve the criteria of economy performance, environment impact, society concern, safety and health, etc. (Li, et al. 2011. Narayanan, et al. 2007. Othman et al. 2010). To ensure the reliability of the simulation process, models development, input data gathering as well as reasonable assumptions are critical. Baseline performance of the process is usually simulated based on operating conditions of typical conventional process. Subsequently, several alternatives of production pathway are established and used for comparison based on single or multiple objectives (Liew, W. H. et al, 2013). For multiple objectives analysis, the models should consider the contributions from all the chosen criteria. Each process is assessed for all the chosen criteria through various available methods including matrix and index-based method. Besides those two methods, the other approaches available for production pathway screening are i.e. sustainability root cause analysis, decision support tool, knowledge-based process synthesis method, mathematical optimization; as well as the cost-focusing methods like Bio-Trans model, value engineering and target costing (Pokoo A. et. al. 2010).

Policies ensure environmental and social sustainability

Higher agricultural and food prices driven, among other things, by an increased demand for biofuels, are having negative impact on food security in food-importing developing countries, and especially on the many of the poorest households. A sustained effort is needed to protect the poor and food-insecure. In the immediate context, the most vulnerable people may require direct food distribution, targeted food subsidies, cash transfers, and nutritional programmers such as school feeding. In the short to medium term, social protection programs must be developed. In the medium to long term, higher food prices could be mitigated by increasing food supply provided that policy interventions do not disrupt trade flows and that investments are made in infrastructure for storage and transportation. Higher prices for agricultural products can present opportunities for agricultural and rural development in developing countries, but sustained improvements in research, infrastructure, and access to credit and risk management instruments are also needed to increase productivity. Measures should specifically address the needs of poor smaller farmers by securing their access to natural resources and by ensuring that their land rights are respected (FAO, 2008). Policies must ensure that further expansion of biofuel production is environmentally sustainable and will provide a positive contribution to climate-change mitigation. Therefore, an improved understanding of how biofuels affect land-use change is urgently needed, since this can have a significant negative effect on greenhouse gas emissions. Promotion of good agricultural practices could help to reduce the negative effects of expanded biofuel production. Sustainability criteria are needed for biofuels that do not create trade barriers, particularly for developing countries. There is a need for an appropriate international forum to debate and agree on sustainability criteria. Biofuel policies need to be reviewed as they have had limited success in achieving energy security and climate-change mitigation. Rapid expansion of biofuel production may increase rather than reduce greenhouse gas emissions. Subsidies and mandates have created an artificially rapid growth in biofuel production, exacerbating some of its negative effects and promoting biofuels compared to other sources of renewable energy(FAO, 2008).

Sustainability of next generation biofuels

Next generation biofuels are regarded as sustainable and secure energy alternatives to first-generation biofuels and can be produced from a variety of various feedstocks, such as lignocellulosic biomass and microalgae. According to the IEA assessment, next generation biofuels will account for 90% of all biofuels in 2050 (Renssen S., 2011). The potential of lignocellulosic material to provide valuable feedstock for biofuels production has not been fully realised (Naik, S. N. et.al. 2010). However, such feedstock forms a readily available biomass source from harvesting activities and does not require any additional land management activities (IEA,2010). Although lignocellulosic biofuels have a positive environmental and economic impact in terms of increasing energy efficiency, reducing net carbon emissions and creating job opportunities, deployment of high-quality second-generation biofuels is not yet commercialized and not regarded as priority in many developing countries (except Brazil) due to high associated costs and lack of technologies (NurmukhanbetovaG., SuleimenovaA. 2012). Another type of next generation biofuels comprises microalgae which are sometimes referred to the third generation biofuels. Microalgae cover unicellular and multicellular microorganisms (e.g. cyanobacteria, green algae, red algae and diatoms) capable of all year round photosynthetic production (Brennan, L. et.al. 2010). They also have a short harvesting cycle (1–10 days), which allows continuous harvests with substantial energy yields. Oil content of algae accounts for 80% of their dry mass which reflects in 25–200 times higher oil yields compared to crop-based biofuels (Boeing, 2008). Furthermore, algae do not require heavy fertilizers to grow. In fact, they can produce proteins and other valuable co-products which can themselves be used as livestock feed and fertilizers (Brennan L. &OwendeP. 2010). Commercial algae production can be based either on the use of natural resources required for their growth, i.e. sunlight, water and nutrients, or artificially replicated conditions. Under artificial conditions, algae are subjected to fluorescent lighting compatible with the absorption spectra of algal photosynthetic pigments and constantly supplied with minerals and CO_2 fed into the algae media in the form of carbonates or from external sources. Overall, algae are able to assimilate up to 150,000 ppmv CO_2 and potentially make use of carbon emissions released by power plants (Chisti Y. 2007).

Table.1 Typical Biofuel Toxic Emissions Compared To Standard Fuels

S.No.	Bioethanol (E85)	Biodiesel (B20 B100)	Fischer- Tropsch
1	15% reductions in ozone-forming volatile organic compounds	10% (B20) and 50% (B100) reductions in carbon monoxide emissions.	Nitrogen oxide reductions due to the higher cetane number and even further
2	40% reductions in particulate emissions	15% (B20) and 70% (B100) reductions in carbon monoxide emissions	Reductions with the addition of catalysts.
3	20% reductions in particulate emissions 10% reductions in nitrogen oxide emissions	10% (B20) and 40% (B100) reductions in total hydrocarbon emissions.	Little or no particulate emissions due to low sulphur and aromatic content.
4	80% reductions in sulphate emissions	20% (B20) and 100% (B100) reductions in sulphate emissions	Expected reductions in hydrocarbon and carbon monoxide emissions.
5	Lower reactivity of hydrocarbon emissions.	2% (B20) and 9% (B100) increases in nitrogen oxide emissions.	-
6	Higher ethanol and acetaldehyde emissions.	No change in methane emissions (either B20 or B100)	-

Source: USPA 2002 a 'Clean Alternative Fuels: Biodiesel'; USEPA 2002 b 'Clean Alternative Fuels: Ethanol' USEPA 2002c 'Clean Alternative fuels: Fisher- Tropsch'.

Table.2 Biofuel Yields for Different Feedstocks and Countries

S.No	Global National Estimates	Biofuel	Crop Yield	Conversion Efficiency	Biofuel Yield
			(Tonnes/ha)	(Litres/tonne)	(Litres/ha)
1	Sugar beet	Ethanol	46.0	110	5 060
2	Sugar cane	Ethanol	65.0	70	4 550
3	Cassava	Ethanol	12.0	180	2 070
4	Maize	Ethanol	4.9	400	1 960
5	Rice	Ethanol	4.2	430	1 806
6	Wheat	Ethanol	2.8	340	952
7	Sorghum	Ethanol	1.3	380	494
8	Sugar cane	Ethanol	73.5	74.5	5 476
9	Sugar cane	Ethanol	60.7	74.5	4 522
10	Oil palm	Biodiesel	20.6	230	4 736
11	Oil palm	Biodiesel	17.8	230	4 .92
12	Maize	Ethanol	9.4	399	3 751
13	Maize	Ethanol	5.0	399	1 995
14	Cassava	Ethanol	13.6	137	1 863
15	Cassava	Ethanol	108	137	1 480
16	Soybean	Biodiesel	2.7	205	552
17	Soybean	Biodiesel	204	205	491
Source: Rajagopal et al., 2007, for global data Naylor et al, 2007 for national data.					

Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, and Portunities 2008 see http:// www. fao org/ Docrep/ 011/0100e/i0100e00. htm}, chapter 2, section Biofuels and agriculture, p. 16

Environmentally sustainable biofuel production be ensured

The environmental concerns about biofuel feedstock production are the same as for agricultural production in general, and existing techniques to assess the environmental impact offer a good starting point for analysing the biofuel systems. The development of sustainability criteria or standards as already under way in a number of flora, such as the global bioenergy partnership and the roundtable on sustainable biofuels, should be established with the active collaboration of developing country partners and go hand in hand with training and support for implementation. Payments for environmental services may also represent an instrument for encouraging compliance with sustainable production methods and standards. Finally, for bioenergy to be developed sustainably, national policies will need to recognize the international consequences of biofuel development (FAO, 2008). First two can be produced by all algae species, the bio hydrogen production is restricted to selected groups of microalgae which can use sunlight to convert water to hydrogen (as protons and electrons) and oxygen (NurmukhanbetovaG., SuleimenovaA. 2012).

To assess the net effect on greenhouse gas emissions of replacing fossil fuels by biofuels, we need to analyze emissions throughout the entire process of producing, transporting and using the fuel. It should alsobe established with the active collaboration of developing country partners and go hand in hand with training and support for implementation.The environmental concerns about biofuel feedstock production are the same as for agricultural production in general, and existing techniques to assess the environmental impact offer a good starting point for analyzing the biofuel systems. The adoption of “good practices” in soil, water and crop protection, energy and water management, nutrient and agrochemical management, biodiversity and landscape conservation, harvesting, processing and distribution can contribute significantly to making bioenergy sustainable.

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