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A review of the ecological and socioeconomic effects of biofuel and energy policy recommendations

Xi Ji *, Xianling Long

School of Economics, Peking University, Beijing 100871, PR China

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ABSTRACT

Many countries have attached great emphasis on biofuel because it is universally acknowledged renewable and sustainable. However, there remain doubts regarding biofuel's renewability, cleanliness, and ecological friendliness. In addition, its impacts on income, employment, and food security have been widely discussed. Therefore, the effect of developing biofuel as an important method of resolving the energy crisis and climate change is questioned. Based on the rocketing concern on the multiple effects of biofuel, this paper provides a comprehensive and updated review of the literature on biofuel's ecological effects and socioeconomic effects. The literature included in this paper is selected English language papers being published since 2004. We find that existing studies have not arrived at a consensus regarding the ecological or the socioeconomic effects of biofuel. There remain uncertainty and doubts toward biofuel's renewability and cleanliness. Biofuel's impacts on water and biodiversity are also questioned. Although biofuel is widely regarded to have positive impacts on income and employment, many studies prove that biofuel influences food security negatively. Besides, biofuel's economic cost is likely to be the barrier to its promotion. Because of the uncertainty of biofuel's impacts, this study recommends cautious attitude toward biofuel development, especially for those countries where biofuel development would be inappropriate, and suggests that policy makers engage in "demand side management" instead of unsustainable "supply side management".

Contents

* Corresponding author. Tel.: +86 10 62755283; fax: +86 10 62754237.
E-mail address: jixi@pku.edu.cn (X. Ji).

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1. Introduction

Energy is not only a strategic national resource but also an important material foundation for a country's social and economic development. Recent decades have witnessed scarcity in coal, oil and other fossil energy, along with environmental problems caused by the use of fossil energy, both of which have seriously hindered global development. Many countries have regarded the development of new energy both as a primary method of resolving the energy crisis and as an important development strategy.

Renewable energy is the key to new energy development [1]. Biofuel is widely regarded as a renewable energy[1] [2,3]. As seen in Fig. 1, biofuel production in developed and developing countries such as the United States and China is experiencing a rising trend. Global biofuel production has jumped from the equivalent of 10,021 thousand tons of oil in 2001 to the equivalent of 58,457 thousand tons of oil in 2010, an increase of nearly 500%.

There seems to be a global consensus that biofuel has advantages such as renewability, cleanliness, or economic efficiency, which not only can resolve fossil energy supply problems, optimize energy structure and ensure national energy security but also can lower greenhouse gas emissions, reduce ecological degradation, promote regional economic growth, and increase farmers' income. However, problems and conflicts caused by its development continue to emerge. Skepticism about the advantages of promoting biofuels has grown [10]. Biofuel policies based on the idea of supply side management also show drawbacks and potential risks.

The volume of published literature on biofuel has been increasing in recent years. Multiple effects of biofuel have been analyzed in these studies, ranging from its impacts on the environment and natural resource, to its impacts on economy and society. In this paper, the biofuel's impact on the environment and natural resource is defined as ecological effect, and its social and economic impact is regarded as socioeconomic effect. The selected literature concerning both the two aspects is reviewed in this paper. The objective of this paper is threefold: First, to provide a comprehensive literature review of the ecological and socioeconomic effects of biofuel; Second, based on the results of literature review, to discuss the effects of biofuel policies as an energy strategy based on supply side management, comparing with the thinking of demand side management; Third, based on the overview of biofuel, to propose strategic suggestions for rational biofuel development and scientific energy management.

The remainder of this paper will be structured as follows: Part 2 presents the material and methods applied in this review, including the search sources, search methods and search results; Part 3 provides the literature review of biofuel's ecological effects, mainly from four aspects of biofuel's renewability, cleanliness, its impact on water resources, and its impacts on biodiversity; Part 4 reveals the literature review of its socioeconomic effects, and its impact on income and employment, the impact on food security, and its economic costs are involved; Part 5 summarizes the results and make further discussions on the effect of biofuel development as a energy strategy based on the thought of "supply side management" accordingly; Part 6 draws conclusions based on the results and proposes energy policy recommendations, and detailed suggestions on improving rational biofuel development and proposals on scientific energy management based on the thinking of "demand side management" are put forwarded.

[1] According to different sources and technical methods, biofuel can be divided into three generations: the first generation biofuels refer to conventional biofuels such as biodiesel and ethanol [4]; the second generation biofuels, also known as advanced biofuels, refer to biofuel produced from a wide array of feedstock, ranging from lignocellulosic feedstocks to municipal solid wastes [5,6]; the third generation biofuels are derived from algae [7–9].

2. Material and methods

The search platform *Web of Knowledge* and search engine *Google Scholar* are primarily used to collect the relevant literature. In addition, backward searches through bibliographies of academic studies and reviews as well as hand searching websites of academic projects and conferences on biofuel are also applied. Only literature in English is included in this paper so as to ensure accessibility. Since the rapid progress of this research filed, literature is also limited to the papers published in or after 2004. The literature reviewed is selective and critical. Highly rated journals in scientific indexes are the preferred choice. We carefully select 124 papers which are considered as important or innovative studies, or comprehensive reviews offering us a big picture of biofuel. The literature review is categorized into two topics:

- *Ecological effects* (see Section 3): Biofuel's ecological effects refer to its renewability as an alternative energy, its cleanliness measured by its CO_2 and other pollutants emissions, its impacts on water resource and biodiversity.
- *Socioeconomic effects* (see Section 4): Biofuel's impacts on income and employment, food security and its economic cost are the main socioeconomic focuses the existing studies paid attention to. Among these aspects, food security is always a key in the field of biofuel. This paper summaries the biofuel's impacts on food security from two perspectives of food supply and food accessibility.

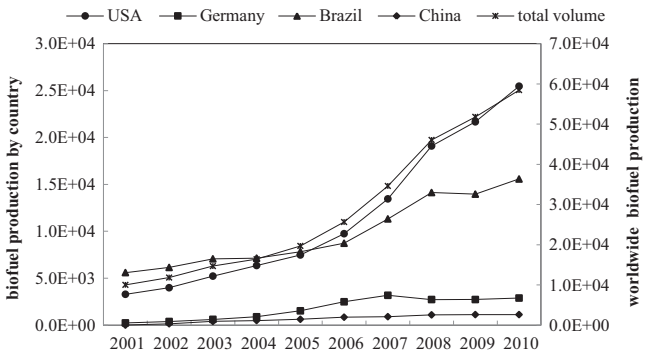

Fig. 1. Biofuel production in selected countries and global production in 2001–2010 (unit: thousand tons of oil equivalent).
Source: BP Statistical Review of World Energy 2012.