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Unintended consequences of bioethanol feedstock choice in China

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HIGHLIGHTS

- Corn grain and wheat grain had bad performances.
- Sugarcane was the possible hitting-point of sugar-based feedstocks.
- Cellulose-based feedstocks had good performances.
- Environmental problem-shifting in ethanol production should be considered.
- Key processes were identified for solving potential environmental problems.

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ABSTRACT

Economic, energy, and environmental impacts of 11 types of bioethanol feedstock in China were evaluated using a mixed-unit input–output life cycle assessment model. Corn grain and wheat grain had higher negative economic, energy, and environmental impacts. Sweet sorghum, cassava, sugar beet, and sugarcane showed better economic performance but increasing negative energy and environmental impacts. Cellulose-based feedstocks in general showed positive economic, energy, and environmental performance; but may lead to increasing negative impacts on freshwater use, global warming, toxicity, and aquatic ecotoxicity. Sugarcane-based bioethanol had the potential to provide positive economic, energy, and environmental impacts in China. Scrap paper-derived ethanol could also become promising under significant government support.

1. Introduction

The first generation biofuels are widely produced including corn-based ethanol in the United States and sugarcane-derived ethanol in Brazil (Sims et al., 2010). Mass production of the first generation biofuels has led to unintended environmental consequences such as increase of life cycle greenhouse gas (GHG) emissions (Sims et al., 2010). Subsequently, the second generation biofuels using cellulosic biomass as feedstock have received increasing attention from the government, industry, academia, and the general public.

China is currently the world's top energy consumer (BP, 2012) and CO_2 producer (Gregg et al., 2008). Developing renewable energy has become a critical strategy for China to maintain its rapid economic growth and improve its environmental sustainability. Bioethanol plays an important role in China's renewable energy development plan (NDRC, 2007). On the other hand, crop residues generated in China each year account for approximately 17.3% of the global total (Lu and Zhang, 2010). Nearly one third of China's crop residues are not properly utilized and cause a variety of issues such as increasing environmental impacts and traffic accidents (Lu and Zhang, 2010). Thus producing ethanol from crop residues can not only utilize otherwise wasted biomass resources but also contribute to China's renewable energy development.

There are currently three types of feedstock available for ethanol production: starch-based feedstock, sugar-based feedstock, and cellulosic feedstock. Crop residues belong to cellulosic feedstock. Given that the development of the first generation biofuels has caused significant unintended consequences, various feedstocks need to be compared from a systems perspective to ensure appropriate feedstock choice for particular regions. Such comparison needs not only to consider environmental impacts but also to take into account impacts on economic growth and energy production.

Numerous studies have been conducted to evaluate life cycle environmental impacts of biofuels derived from a variety of feedstocks (Halleux et al., 2008; Hill et al., 2006; Mishra and Yeh,

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