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Review

Developing bioenergy to tackle climate change: Bioenergy path and practice of Tianguan group

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Abstract

Biomass energy would become the most potential renewable energies, for whether wind power or photovoltaic, would be restricted by the nature thus cannot provide stable power, while biomass energy is the only renewable energy that can be used in the form of gas, liquid or solid stage, it could replace the fossil energy, lead a positive influence on the control of the greenhouse gases. Across the globe, the biomass produced through photosynthesis is about 200 Gt, or 99 Gtce per year. If 10% of the biomass is utilized, more than 4 Gt of fuel ethanol and other bioenergy products can be produced, equivalent to 4.13 Gt of petroleum consumed by the world in 2014. Therefore, bioenergy can be a feasible alternative to fossil energy.

Keywords: Climate change; Bioenergy; Greenhouse gas

1. Introduction

According to the Greenhouse Gas Bulletin 2014 published by World Meteorological Organization (WMO, 2015), concentrations of major greenhouse gases (GHGs) hit another record in 2014, with the average concentration of CO_2, CH_4, and nitrous oxide being 397.7×10^{-9}, 1833×10^{-6}, and 327.1×10^{-9}, constituting 143%, 254% and 121% of the pre-industrial (1750s) levels, respectively.

Derived from more observations, IPCC Fifth Assessment Report (AR5) proves that the world continues to become warmer (IPCC, 2014). AR5 analyzes the causal relationship between human activity and global warming, and highlights the urgency of mitigating climate change and minimizing GHG emissions. It also suggests the prerequisite for the world temperature rise to be no more than 2 °C.

After more than two centuries of industrial civilization, humans have to struggle with a “carbon challenge”, that is, the ever increasingly serious concerns about the environment and climate brought about by application of fossil energy, which has fueled significant progress of the society. The future sustainability of China and even the Earth calls for humans to turn from industrial to ecological civilization based on a new energy revolution that uses green and low-carbon energy in place of high-carbon ones (Du, 2013, 2014).

He (2013, 2014) predicted that, by 2030, non-fossil energies, most being renewable, will become comparable to coal, oil and gas, and other fossil energies, accounting for 20%–25% or even 30% and boasting an annual supply of more than 1.5 Gtce. By 2050, new and renewable energies will account for 1/3 or even 1/2. In the second half of the 21st century, the energy system will be sustainable as it will be primarily composed of new and renewable energies. The economic and

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social growth will no longer rely on the limited non-renewable resources on the Earth and CO_2 emissions will approach zero. This will be in line with the trend of new energy revolution and the adaptation to climate change around the globe.

When plants grow through photosynthesis with sunlight, solar energy is stored in the form of chemical energy in biomass and can be converted to conventional fuels of solid, liquid, or gaseous state. Because sunlight and its energy are inexhaustible, bioenergy is consequently called renewable. This is the one and only way for carbon to be renewable in nature.

2. Bioenergy and emission reduction

At present, bioenergy primarily includes the highly commercialized fuel ethanol, industrial marsh gas (biogas), and biodiesel, as well as compressed solid fuel, biomass gasification, gasification for electric power generation, and bio-oil produced through thermal cracking. All these types of bioenergy have been used in different economic sectors.

At the present stage, the main products of global biomass are going through a shift from the first bioenergy generation to the second. The first bioenergy generation, or the traditional bioenergy, is using agricultural products and their byproducts as raw materials. It has been industrialized with commonly improved industry chain in many countries, such as the U.S. and Brazil. While the first generation is facing serious problems during its industrial development, it requisitions the agricultural products which were to use for human consuming and food processing, may results problems such as food safety and price rising. Also, the first bioenergy generation may result in the secondary environmental pollution during its production. Regarding the possible limitations, many attentions are paid to the second bioenergy generation, which mainly focuses on the development of lignocelluloses. Nowadays, the second generation is still in the technological innovation stage, most of the enterprises are facing negative profit situations, thus it haven't been proper industrialized. While it is no doubt that the second bioenergy generation is the inevitable trend in the bioenergy development.

In the global energy system, the first biomass generation has become the second largest energy supplier ranking behind the fossil fuel. According to the statistics from Renewable 2013 Global Status Report released from Renewable Energy Policy Network for the 21st Century (REN21, 2013), among 2011 global energy consuming, fossil fuel has been the first time, took proportion under 80%, renewable energy has been the first time to supply more than 19% of all the energy, with the 9.3% contribution from traditional biomass energy. In addition, the International Energy Agency (IEA, 2010) predicts, to the year 2050, the annual global biomass energy production may reach 1500×10^{18} J.

From the view of global bioenergy industry distribution, it is concentrated in some developed countries and areas with less energy but abundant biomass materials. From the point of production scale, the total biomass ethanol production of the U.S. and Brazil has accounted for 70% of global output. From the bioenergy consuming proportion, Finland and Sweden stand the top. In the total energy consumption of Finland, more than 12% are provided from biomass energy (Zhang and Zhang, 2014).

In 2014, the world witnessed a 7.4% increase in bioenergy production and 6.0% increase in ethanol output for a consecutive second year, driven by the Central and South America and Asia−Pacific. In 2014, global biodiesel output was increased by 10.3% (BP, 2015).

Bioenergy is commonly recognized as green as its low CO_2 and SO_2 emissions. CO_2 is the dominant GHG, and SO_2 is the main reason for acid rain. Recently many researchers (Dwivedi et al., 2015; Dunn et al., 2013; Slade et al., 2009) have issues on bioenergy. The main focus is environmental issues such as CO_2 emissions.

The growth of biomass need to absorb CO_2 from the air, so theoretically, biomass energy has less CO_2 net emissions than fossil fuel, while these researches (Searchinger et al., 2008; Fargione et al., 2008) only considered a certain stage of biomass energy, for example, the grow, abstract and consuming process. The precisely analysis should take the whole life circle into account, and should consider the results of land use change in CO_2 emissions.

Currently the source of biomass is mainly agricultural crops. Farms would damage the forest and grassland when plant the crops, thus results in the carbon from forest and grassland to enter the atmosphere. If take this part into consideration, CO_2 net emissions from the conversion of crops to bioenergy would not be less than fossil fuel. Therefore, to precisely calculate the CO_2 net emissions of the bioenergy, it is needed to monitor and observe the whole carbon cycle caused by the biomass energy development and consumption. The CO_2 net emissions would be different for different produce methods. Disafforesting or destroying the local vegetations to grow crops and produce bioenergy, its CO_2 net emissions would be larger than the fossil fuel; utilizing local biomass and wastes from agriculture and forest, its CO_2 emissions would be reduced; reclaiming land and grow proper plants to supply bioenergy, the CO_2 net emissions would be even lesser (Hu et al., 2012).

Sun et al. (2014) have shown that E85 containing alcoholic fuels converted from biomass emits much less CO_2 equivalent than conventional gasoline does. GHG emissions measured in CO_2 equivalent in the pathway of biochemical transformation of cellulose are about 0.2−0.7 time (e.g. 20%−70%) of conventional gasoline, 0.6−0.9 time (e.g. 60%−90%) in the thermal chemical pathway, and 0.8−1 time (e.g. 80%−100%) in dry corn processing. Regarding the ester fuels converted from fat and oil biomass, the reduction of GHG emissions by biodiesel is animal fats > gutter oils, palm oil > soybean oil, and coconut oil > colza oil. Biodiesel made from animal oils and gutter oils does best in reducing GHG emissions by 70%−90%; while that from plants contributes to a reduction by 10%−90%. Among the hydrocarbon fuels converted from biomass, the renewable colza-oil-based jet fuel produced through oil hydrogenation reduces GHG emissions by 13%−55%. F-T synthetic oil reduces emissions better than those from oil hydrogenation. BTL (Biomass-to-liquid) generally