Energy Strategy Reviews 8 (2015) 56–65

Contents lists available at ScienceDirect

Energy Strategy Reviews

journal homepage: www.ees.elsevier.com/esr

Strategy of bioenergy development in the largest energy consumers of Asia (China, India, Japan and South Korea)

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ARTICLE INFO

Article history:
Received 1 April 2015
Received in revised form
17 August 2015
Accepted 10 September 2015

Keywords:
Bioenergy
Asia
Energy policies
Energy system

ABSTRACT

The last few decades have seen an unprecedented increase in global bioenergy production. China, India, Japan, and South Korea are currently Asia's largest energy consumers with fast-growing economies and populations. However, energy supply in these countries mostly depends on imported fossil energy. Their response has involved significant efforts to find alternative energy sources, including massive investments in bioenergy development. Apart from energy security issues, this study identifies rural energy access and climate change issues as the key drivers behind bioenergy policies. The results show how different driving forces and obstacles, such as food security and feedstock issues, have led these countries to establish their own pathways to bioenergy development. Lastly, the paper develops additional bioenergy development challenges, such as the impacts of changes in land use and bioenergy competition, which constitute potential obstacles to bioenergy expansion and ultimately need to be considered by policymakers.

1. Introduction

Energy consumption in Asia continues to rise rapidly following the economic growth of recent decades. According to the International Energy Agency (IEA) [1], Asia's share of global energy consumption was estimated at over 44% in 2011; Total Primary Energy Supply (TPES) in Asia was 5.8 gigatonnes of oil equivalent (Gtoe) compared to 13.1 Gtoe for the total world TPES. Among the Asian countries, China, India, Japan and South Korea (SKO) share about 72.5% of total Asia's energy consumption.

The energy consumption of China and India has dramatically increased in recent years. Compared to 2000, China's energy consumption rose by about 233% in 2011 while India's consumption increased by about 164%, and the trend continues, driven by strong economic and demographic growth. Meanwhile, in 2010, the government of SKO implemented a "Low Carbon Green Growth Policy and Law", including a national mid-term Greenhouse Gas (GHG) reduction target 30% below 2020 Business-As-Usual (BAU) levels [2]. Since then, SKO has succeeded in stabilizing its energy consumption, with an annual consumption growth rate of less than 0.7% since 2011 [3]. In Japan, decreasing population and changes in industrial structure have resulted in a decline in energy consumption reflected in its GHG reduction obligations under the Kyoto Protocol since 2007. According to the United Nations' World Population Prospects [4], the Japanese population started to decrease in 2010. This trend will continue over the next few decades and result in less energy demand from the residential sector. Furthermore, many Japanese manufacturers have shifted production offshore due to declining labor forces and the high cost of domestic production [5]. As a result, in 2012 Japan's TPES had dropped by 86% compared to 2000. Nevertheless, Japan is still the 3rd highest energy consumer in Asia after China and India.

Despite the huge amount of energy demand and its rapid growth rate, Asia lacks natural energy resources. Asia has the smallest reserve of oil, with 2.5% of global oil reserves [6]. Nevertheless, fossil fuel dependency accounts for more than 70%, of which, China (88.3%), India (72,3%), Japan (89,6%) and SKO (82.8%) [7].

Due to the fossil-fuel dependency of these countries, energy security and energy-related GHG emissions are attracting considerable attention in the region. In this context, bioenergy is highlighted as an alternative source of energy to fossil fuel.

The primary objective of this paper is to give an overview of bioenergy development in the four largest energy-consuming countries in Asia, i.e. China, India, Japan and SKO, and to analyze the key drivers of bioenergy

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http://dx.doi.org/10.1016/j.esr.2015.09.003
2211-467X/

policies. We then identify the main obstacles to bioenergy development. Lastly, the paper discusses the potential impacts of bioenergy expansion and attempts to characterize a bioenergy development plan for this region.

2. Methodology

Investigation of bioenergy challenges and issues in Asia was conducted by qualitative content analysis approach. At first, quantified data was collected from international statistical sources as IEA, U.S. Energy Information Administration (U.S. EIA), World Bank statistics to ensure data homogeneity. Based on this data, we analyzed energy consumption profiles and historical evolution of bioenergy deployment in the four studied countries. Then, bioenergy related policies and documents have been retrieved from the official governmental websites. This policy review was compared with the corresponding observations made from data analysis. Lastly, through a review of several research papers and global publications, we examined the main drivers and obstacles for bioenergy development to understand current energy policy direction and point out the requisites for further development.

3. Current status of bioenergy development

The bioenergy share in TPES is particularly low here. Of the four countries studied, in 2011 China (8%) and India (25%) had a greater bioenergy share than Japan (2%) and SKO (1%) (Fig. 1).

In 2011, more than 95% of bioenergy source was primary solid fuels in China and India (Fig. 2). A large share of bioenergy in China and India came from the use of biomass in households for cooking and heating, while in Japan and SKO most solid bioenergy was used in industry. In India, 99% of supplied bioenergy was made up of primary solid biofuels, of which 82% was consumed in the residential and commercial sectors. Traditional biomass is still the major source of energy for the Indian population. 66% of the population depends on traditional biomass for cooking. This dependency is intensified in rural areas. 75% of households in rural areas depend on fuelwood for cooking, and bioenergy satisfies 90% of domestic energy demand compared to urban areas, where bioenergy fulfills 40% of households energy demand [8].

In contrast, Japan and SKO have developed the use of municipal solid waste (MSW) for heat and energy. In 2009, MSW accounted for respectively 53% and 31.5% of biomass energy sources for electricity and heat generation in Japan [9]. The SKO's waste-to-energy system is more developed than in any other country. SKO's use of waste for energy, mostly to generate electricity and heat, accounts for about 76% of the total bioenergy supply. Japan and SKO also have a high potential of woody biomass. According to FAO (Food and Agriculture Organization) [10], forest covers more than 63% of land area in Japan and SKO. Solid biofuel use in these two countries is expected to grow under the renewable portfolio scheme (RPS) and with further development of woody biomass.

Biogas has a similar use and production profile as solid bioenergy. According to IEA [1], biogas production data exist for China, Japan and SKO but not for India. In India, family-size biogas digesters are installed to use for cooking and the quantity of biogas produced from small-scale plants is not accounted for IEA statistics. Research and development of biogas technology in India started in the 1920s. Through several biogas promotion programs such as the "All India Coordinated Biogas Program (AICBP)" in 1975 and the National Program for Biogas Development (NPBD) in 1981–1982, the number of small-scale plants reached 3.89 million in 2006 [11]. Biogas is also a significant source of energy for the Chinese population. According to IEA, China was the world's largest biogas producer in 2011. Anaerobic digestion technology to produce biogas is widely adopted in China, especially in rural areas [12]. Promotion of biogas production started in the early 1950s with household-size biogas digesters [13]. Currently, biogas conversion technology is being developed to use industrial organic wastewater and livestock manure. These data indicate the different purposes of biogas production as solid bioenergy in the studied countries. While in China and India all biogas produced in the residential sector was consumed for lighting and cooking, in Japan (100%) and SKO (72%), none of the biogas produced was used in households, but rather in electricity and heat generation plants and industry.

Biofuel is put forward as an alternative source to petroleum liquid fuels and hence many Asian countries are developing it.

China is making remarkable progress in biofuel production, especially bioethanol. According to British Petroleum (BP)'s statistical review of world energy [6], China is the 6th largest biofuel producer and the 3rd largest producer of bioethanol in the world [14]. China's development of fuel ethanol production started in the early 2000s as a way of using up grain surpluses such as stale corn, wheat, rice and other crops [15]. However, the rise in fuel ethanol production led to food shortages and a sharp increase in the

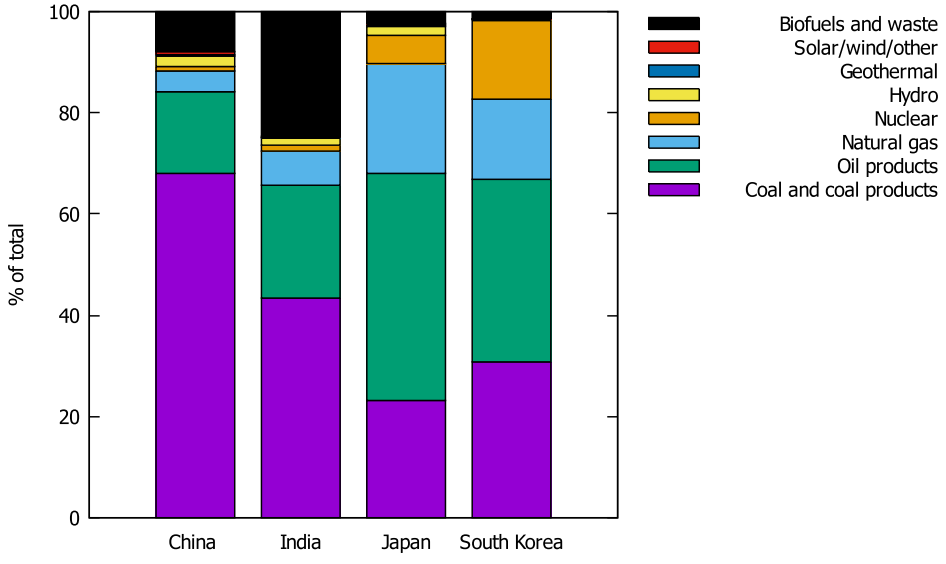

Fig. 1. Type of energy in TPES, 2011. (source: IEA world extended energy balance [1].)