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Assessment of social, economic, and environmental aspects of woody biomass energy utilization: Direct burning and wood pellets

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ABSTRACT

In this paper, we discuss the social, economic, and environmental aspects of utilizing woody biomass for energy. We first conducted a questionnaire survey to determine which energy utilization methods were preferred in Japan and to collect the data on the cost, workforce, and energy production relevant to each energy utilization method. The results of the survey indicated that energy recovery by direct combustion and combusting wood pellets were the preferred methods. Subsequently, we employed input–output analysis to compare certain factors pertaining to the two preferred energy utilization methods. The factors were compared in relation to energy generation from the unutilized woody biomass in Japan, which amounts to 8.58 million tonne annually. The relevant factors were the social effects of employment creation, the economic effect, and the reduction of CO_2 emissions. As a result, however, as direct burning has advantages on 13.7 million tonne of CO_2 emission reduction, there are few impacts on increase of production and employment creation. In addition, we found that combusting the wood pellets was advantageous because of the increase in production (981 million USD) and the creation of employment opportunities (24,700 jobs).

Contents

Abbreviations: ANRE, Agency for Natural Resource and Energy; FAO, Food and Agriculture Organisation; FIT, Feed-in Tariff; FY, Fiscal Year; IEA, International Energy Agency; IOT, Input–Output Table; LCA, Life Cycle Assessment; MAFF, Ministry of Agriculture, Forestry, and Fisheries; METI, Ministry of Economy, Trade, and Industry; MOE, Ministry of environment; MIAC, Ministry of Internal Affairs and Communications; NEDO, New Energy and Industrial Technology Development Organisation; NIES, National Institute for Environmental Studies; UNEP, United Nations Environment Programme

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1. Introduction

An increase in the usage of fossil fuels is directly linked to adverse climate change, and, thus, reducing the use of fossil fuels is quite important in Japan. In addition, relying on fossil fuel is unfavourable from the perspective of the national economy and the national energy security. As above-mentioned reasons, although the utilization of renewable energy has been increasing gradually, only 4.4% of primary energy is currently generated from renewable energy sources in Japan [1]. The Japanese government has promoted strategies for using renewable energy, such as the Feed-in Tariff (FIT) scheme that started in 2012. This scheme obliges an electric utility to supply power to a renewable energy producer at a fixed price and for a long-term period, as determined by the government [2]. A report by the Pew Charitable Trusts [3] has indicated that because of the FIT scheme, Japan has become the fastest-growing clean-energy market in the world, growing 80% between 2012 and 2013. In addition, according to the report, the country has gained two places in the Group of Twenty rankings to become the third-largest destination for clean-energy investment, attracting 28.6 billion USD [3].

The focus of the current study is on a specific source of renewable energy, namely woody biomass, which is classified into lumber, sawmill residues, and construction scrap wood. Lumber includes wood that is not utilized for construction, as well as other industrial materials, such as thinned wood and the roots of soft woods. Forests dominate the landscape of Japan, accounting for approximately 66.1% of the land surface of the country, which is comparable to that of Sweden (70.5%) and Austria (47.8%) [4]. Japan therefore has abundant woody biomass resources.

Fig. 1 shows the utilized and unutilized woody biomass in Japan [5]. The figure indicates that 95% of the sawmill residues and 90% of the construction scrap wood is already being utilized for energy recovery and manufacturing recycled materials. On the other hand, none of the 8 million tonne lumber available annually is utilized for energy recovery.

Although using woody biomass would be feasible and advantageous, certain problems are associated with such an endeavour.

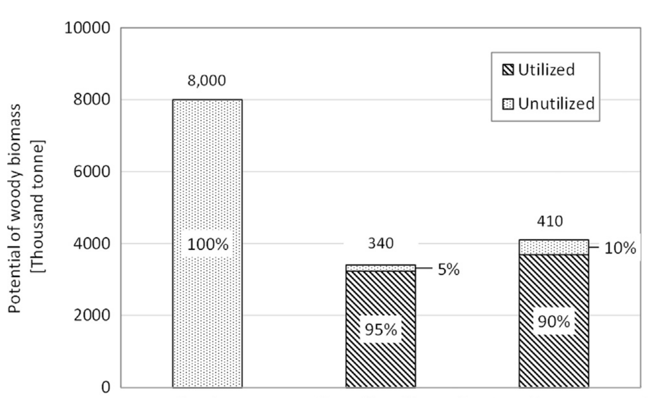

Fig. 1. Utilized and unutilized woody biomass in Japan [5].

1.1. Shortage of labour for tree trimming

The forestry sector in Japan is experiencing a severe labour shortage, as illustrated by the number of workers in forestry dropping from approximately 48,300 in FY 2002 (FY refers to the fiscal year, ending in March) to only 24,800 in FY 2011 [6]. Although Japan has abundant forest resources, the challenge is finding adequate labour for trimming, collecting, and transporting the woody biomass. In an attempt to improve the situation, the national government has started implementing several strategies, such as the nurturing of forestry staff and on-the-job training for new entrants to the sector [5]. However, despite these incentive measures, the number of workers has continued to drop. Tabata [7] has proposed a transfer scheme, encouraging the transfer of workers from other sectors to the forestry workforce to alleviate the shortage of labour experienced in that sector. Moreover, this author has estimated that 95% of the unutilized lumber could be used for renewable energy if an adequate number of workers were transferred successfully from the construction to the forestry sector.

1.2. High sourcing cost

The sourcing cost of woody biomass is high relative to fossil fuel [8,9]. As Larry [10] has pointed out, utilizing woody biomass was not cost-competitive because of the additional processes required, such as cutting the timber, chipping, drying, and transportation. However, if process improvements in forestry were implemented in Japan, the local sourcing costs could be reduced because of the economies of scale.

The FIT scheme has been beneficial to the utilization of woody biomass. As reported by ANRE [11], the installed capacity for the utilization of woody biomass for energy has increased by 711 kW from July 2012 to November 2013.

1.3. Direct and indirect social, economic and environmental impacts

The promotion of renewable energy sources could help to transform the conventional energy system that depends on fossil fuel and nuclear energy. If the direct environmental effect achieved by fossil fuel savings was defined as the reduction in environmental load, the reduction in the indirect environmental load achieved by converting the existing fossil-fuel-based energy system into a biomass-based system could be defined as an indirect environmental effect. Oil used for heating serves to illustrate this statement. In this instance, CO_2 is emitted not only when the oil is combusted (direct CO_2 emission) but also when it is produced (indirect CO_2 emission). Therefore, a fossil fuel saving strategy could contribute to the reduction of both direct and indirect CO_2 emissions. The transformation of the existing fossil-fuel-based energy system offers the possibility of converting the social activities of related businesses such as these in the future [12]. However, such transformation could lead to the economic decline of the existing energy sectors (oil, coal, and other related sectors). If the decline in production and the associated loss of employment in the existing sectors were larger than the increase in production and the creation of employment opportunities by