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An economic analysis of the carbon benefits of sawmill residues' use in South Korea

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ABSTRACT

In this study, a methodological basis is used to analyze the carbon economic effects of sawmill residue use. The usage of sawmill residues, which is classified in two main categories: energy source and base material for products, leads to different economic effects and benefits. When analyzing the economic effects of using wood as an energy source, the benefits stem from reduced carbon emissions and related costs. When sawmill residues are used as a base material, the primary usage relates to construction materials and household goods. The economic effects are analyzed and calculated in terms of the amount and interest rates of carbon retained in the base material. This study predicts the total economic effects of the carbon sinks stored within the system boundaries of construction materials and household goods until 99.9% of the stored carbon sinks are released. The results demonstrate that the economic benefits of sawmill residues are substantial, but differ based on the type of use. The economic benefits of using sawmill residues as a base material increase with time and match the benefits of using the residues as an energy source—when used for construction purpose, the economic benefits reach that of using wood as an energy source in 13 years and for household goods purpose in 16 years. More specifically, the dollar value per ton of sawmill residues is USD 9.85 when used as an energy source, USD 15.94 as a construction material (for 33 years), and USD 10.95 as a base material (for 30 years) for household goods. The economic benefits of the base material use eventually surpass the economic benefits of energy use. The findings illustrate that base material usage of sawmill residues leads to more economic benefits from a long-term perspective; the specific numbers may differ by country, but our methodology provides an appropriate guideline for other countries and situations.

1. Introduction

Fossil fuel has long been a trusted energy source, but it engenders problems. Primarily, the large-scale combustion of fossil energy is the main cause of the build-up of carbon dioxide (CO_2) in the atmosphere, which leads to global climate change (IPCC, 2014). Another concern with regard to this currently major energy source is its non-renewable nature (Hirsch et al., 2005). Most countries recognize these problems and prefer to use renewable energy over fossil fuels. Biomass is a potential alternative to fossil fuels (REN21, 2017). For example, woody biomass solves the problems by using coal and oil; as wood is renewable, it increases carbon sinks, and thereby reduces carbon emissions (IPCC, 2006).

The development of renewable energy sources is an important task for every country, and Korea is not an exception to this; the Korean government has been promoting renewable energy sources (KMOTIE, 2005). By adopting the policy of "low-carbon green growth," the government introduced a plan to explore and create new forms of renewable energy. One form of renewable energy source promoted by this policy is wood pellets (KMOTIE, 2005). The objective of this initiative is to generate, by the year 2020, approximately 50 million tons of wood pellets, which are renowned for their usage as boiler fuel in agriculture and greenhouse horticulture, replacing the most common boiler fuel, kerosene. The wood pellets generated are expected to replace 16% of agricultural fuel and 50% of greenhouse horticultural fuel (KFS, 2009). However, due to the promotion of wood as an energy source, the industries that have long been using it as a base material

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for production are facing problems with regard to obtaining a supply of sawmill residues (KMOE, 2012).

The environmental superiority of biomass for energy production has been widely recognized, and the market for wood pellets is gradually growing due to this awareness (Thrän et al., 2017; Sikkema et al., 2011). Essentially, the energy system of wood pellets is found to be more efficient than fossil fuel-based systems in many studies based on the life cycle approach (AEBIOM, 2013; Lippke et al., 2012; Repo et al., 2012; Turconi et al., 2013; Wang et al., 2017; Ehrig and Behrendt, 2013; WNA, 2011). However, recent research has raised the question of whether the energy usage of wood actually results in reducing greenhouse gases when several of its effects are considered, such as carbon stock (Agostini et al., 2014; Cherubini et al., 2011; Matthews et al., 2011; Walker et al., 2010; Holtsmark, 2012), land use (Curtright et al., 2012; Sathre and Gustavsson, 2006; Valin et al., 2016), and resource circulation by recycling (Brunet-Navarro et al., 2017; Olsson et al., 2016).

As briefly aforementioned, primarily, wood pellets contribute to the reduction of greenhouse gases by replacing fossil fuels (Turconi et al., 2013; Ehrig and Behrendt., 2013; Lippke et al., 2012). They also increase carbon sinks when used in making board products (Pingoud et al., 2003; Kay et al., 2014). The United Nations Economic Commission for Europe defined carbon benefits of wood products in terms of contributing to mitigating climate change by forming a storage pool of wood-based carbon and substituting environmentally damaging sources of energy, such as fossil fuel. Recent researches in Canada (Sikkema et al., 2013) and Finland (Soimakallio et al., 2016) reported the effective use of wood at the national level.

This study attempts to address the problem of sawmill residues' allocation considering the economic impact of the carbon benefits of sawmill residues' usage as energy and material: wood pellets as alternative fuel for kerosene boilers and as the base material for fiberboards and particleboards. This will allow us to compare the effects of the two pathways and encourage more environmentally sound use of sawmill residues.

2. Economic analysis of the usage of sawmill residues

As displayed in Fig. 1, sawmill residues are created during the process of saw milling and veneer production. Sawmill residues are the main source of wood pellets, though simultaneously they are critical base materials for many products, including fiberboards and particle boards. These are used in manufacturing construction materials and household furniture. Wood pellets can be used as fuel within a broad range of facilities—from industrial to agricultural to domestic—and different alternative systems can be established according to their uses.

When analyzing the economic effects of using wood as an energy source, the benefits stem from reduced carbon emissions and related costs. When sawmill residues are used as a base material, the primary usage relates to construction materials and household goods. The economic effects are analyzed and calculated in terms of the amount and interest rates of carbon retained in the base material.

2.1. Sawmill residue as an energy source

As regards the energy usage of wood pellets instead of kerosene, the CO_2 reduction is calculated using the life cycle assessment methodology. As in Eq. (1), the economic effects of using sawmill residues as energy, namely their carbon benefit (CBe), can be calculated by multiplying the amount of CO_2 emission reduction (CER) from fossil fuel (i) substitution, with the current market price of CO_2 per unit mass (P_{CO2}) (Chen, 2009; Katers et al., 2012; Wang et al., 2017). Here, fossil fuel "i" refers to kerosene, and the amount of CO_2 emission reduction is obtained by subtracting the amount of CO_2 generated during pellet production from the amount of CO_2 generated as a result of the production and utilization of kerosene. The quantity of CO_2 emitted during the combustion of wood pellets is regarded as "0 (zero)" as wood emits carbon absorbed during the plant's growth.

$$CB_e = CER_i \times P_{CO2} \tag{1}$$

CB_e: Carbon benefit of using wood as an energy source per 1 ton of sawmill residues [$/BDT*]
CER_i: CO_2 emission reduction through fossil fuel (i) substitution per 1 ton of sawmill residues [(ton CO_2)/BDT]
P_{CO_2}: Price of CO_2 per ton [$/(ton CO_2)]
* BDT: Bone dry ton

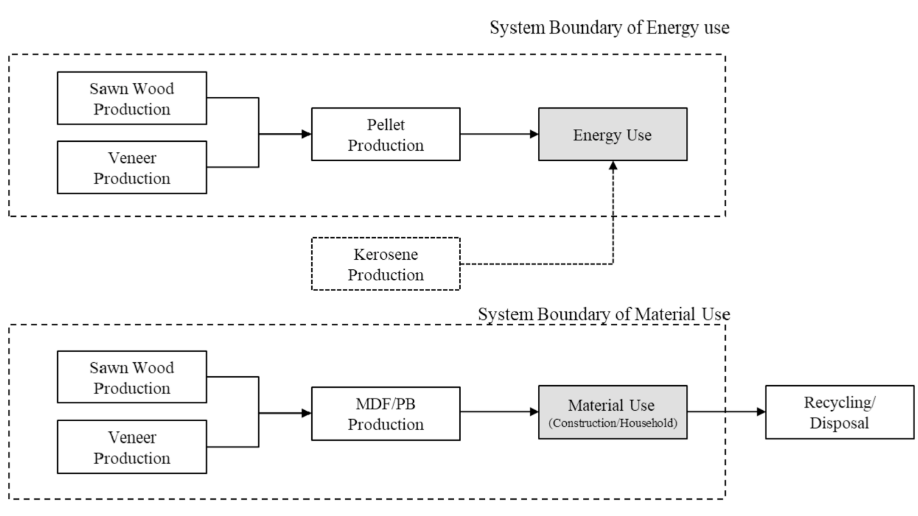

Fig. 1. System boundaries for the usage of sawmill residues as energy and material.