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Woody biomass processing: Potential economic impacts on rural regions

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ABSTRACT

This paper estimates the economic and environmental impacts of introducing woody biomass processing (WBP) into a rural area in central Appalachia. WBP is among the most promising additions to energy generation portfolios for reducing import dependency while at the same time providing economic opportunity to stimulate regional economies, especially in rural regions where economic development options are often limited. We use an input-output framework to assess WBP under three different pathways, fast pyrolysis, ethanol and coal-biomass to liquids. We find that the proposed WBP will increase regional output by 0.5–1.3% of gross regional product; it will increase income by $17.32 to $51.31 million dollars each year, and regional employment by 218.1–1127.8 jobs, depending on the chosen pathway. Of these impacts, the direct portions are 63–77% of the total impact, depending on the chosen pathway. The economic analysis and the results from the accompanying environmental assessment show that only the ethanol pathway has both economic and environmental benefits. We conclude that because long-run economic development strategies in rural regions are limited and negative impacts do not alter dramatically the regional environmental profile, regional policymakers should include WBP among their development portfolio options.

1. Introduction

Energy use in the United States (U.S.) far exceeds the domestic energy supply, and according to the Energy Information Administration (EIA), imports accounted for 9.6% of the 97.528 quadrillion Btu used in 2015 (Energy Information Administration, 2017).[1] Woody biomass processing (WBP) is the transformation of cellulosic biomass (woody biomass) into bioenergy products such as biofuels (Liu, 2015). WBP has gained attention, and for some is among the most promising additions to energy generation portfolios for reducing energy import dependency while at the same time providing economic opportunity, especially in rural areas where other economic alternatives are limited (Lauri et al., 2014). Woody biomass is of particular interest because unlike many other potential biomass sources, woody biomass does not include crops that are used for energy and food, but instead comes from forest resources that are mostly unused in rural areas. Moreover, Perlack et al. (2005) argue that among the current renewable sources, biomass is the only renewable that can produce liquid transportation fuels. The International Energy Agency (IEA) estimates that only 10% of the world's primary energy supply comes from biofuels and waste, while 81.7% is still based on fossil fuels. Despite relatively abundant forest resources, wood and wood-derived fuels generate less than 2% of the energy consumed annually in the U.S. (International Energy Agency, 2014).

Although woody biomass constitutes only a small percentage of total energy use, its consumption still accounts for 27% of all renewable energy sources (White, 2010). As an available renewable energy source with little negative impact on food supply, WBP has the potential to be a much more substantial contributor to energy generation. In its 2011 report, the U.S. Department of Energy (DOE) estimates that by 2030, the U.S. potential forest and agriculture biomass, at $60 per dry ton under high-yield scenario assumptions (1374–1633 million dry tons), can offset at least 30% of U.S. petroleum consumption (U.S. Department of Energy, 2011).

Using wood as a source for heating is as old as mankind, but processing woody biomass to generate fuel and electricity is in its infancy. Regardless of the way woody biomass is used, biomass processing can directly support local economies and local job markets, which is especially advantageous to rural economies where other economic opportunities are often limited. The forest-related energy-source literature emphasizes that the potential impacts of WBP energy on local and national economies is substantial. This renewable resource can improve forest health, reduce the dependency on imported fossil fuels, enhance

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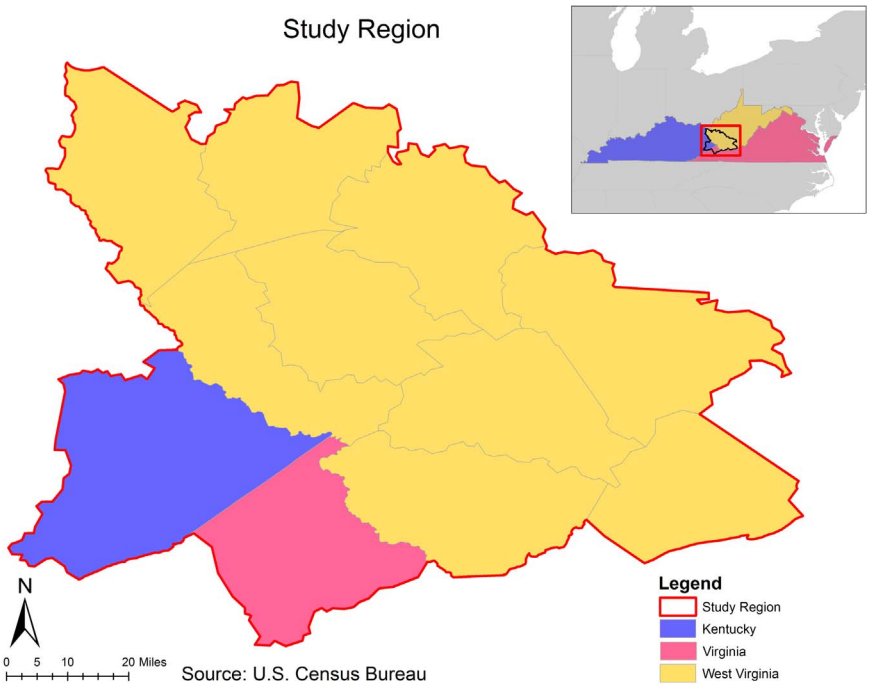

Fig. 1. Map of the study region.

sustainability, and potentially even reduce environmental impacts.

This study assesses the potential economic and environmental impacts of introducing WBP in an economically distressed rural region in central Appalachia. We compare three different WBP pathways, namely biomass to ethanol (WBP-ETH), biomass to biofuel via fast pyrolysis (WBP-FP), and coal-biomass to liquids (WBP-CBTL). The three biomass-to-liquids pathways include five logistic systems: biomass collection, transportation, storage, preprocessing, and conversion. Although the pathways have similar logistic systems, they can and do vary, especially as a result of differences in the composition of material inputs. Conversion systems most clearly differentiate the three pathways, as not only do output compositions differ, but so, too, does the nature of the underlying conversion processes, which is explained in greater detail in Section 5.1. The production parameters that we use for the WBP-FP conversion process are based on Jones et al. (2009), for WBP-ETH the process is based on Phillips et al. (2007), and the WBP-CBTL process is based on Jiang and Bhattacharyya (2014). Our direct source for conversion process data is Liu (2015), who, in conjunction with a project funded by the U.S. Department of Agriculture – National Institute of Food and Agriculture, provided us with data on input and output prices and quantities along with a unit-process technical requirements matrix based on a life cycle assessment (LCA). These data allow us to create three separate WBP production functions for embedding – each in turn – in a regional input-output (IO) table for our study region, depicted in Fig. 1, which is composed of nine counties in southern West Virginia and one county in Kentucky and Virginia.[2]

We use IO analysis to estimate the impacts of the wood-to-fuel industry on regional output, income, employment, and environment. The results provide useful information for policy makers assessing WBP as a sustainable regional economic development alternative.

2. Related literature

Woody biomass processing has experienced a rapid expansion in recent years because of a series of economic and environmental concerns. We can divide previous studies into three broad types: WBP as a renewable energy source, environmental issues in the utilization of woody biomass, and economy-wide impacts of WBP. We briefly canvas these topics below to situate our study in the related literature.

2.1. Woody biomass as a renewable

WBP has many benefits as a renewable energy source compared to fossil fuels. Numerous studies have assessed the potential contribution of a wood-based energy source as an inexhaustible, while sustainably harvested, alternative for energy generation on a regional, national, and worldwide level (Hall, 1997; McKendry, 2002; Parikka, 2004; Baxter, 2005; Hoogwijk et al., 2005; Prasertsan and Sajjakulnukit, 2006; Vries, 2007; Gokcol et al., 2009; Lauri et al., 2014; He et al., 2014). These studies focus on the competitiveness of WBP – as a non-food crop – with other indigenous energy alternatives. Further, while this literature tends to focus on woody biomass as a source of energy, only a few studies examine implications for specific regions. Exceptions include Hall (1997), He et al. (2014) and Prasertsan and Sajjakulnukit (2006) who study Austria, Denmark, Finland, Sweden and the U.S., the U.S. only, and Thailand, respectively. The consensus in the literature is that woody biomass is clearly a relatively low-cost, renewable and reliable source of energy. Lauri et al. (2014) notes, “Large unused woody biomass resources and an increasing need for climate change mitigation has awakened policymakers' interest in woody biomass energy potential” (p. 20). While finding new sources of natural gas in the U.S. will cover some portion of energy demand, scientists must still consider issues related to climate change and the environment related to the combustion of natural gas.

2.2. Woody biomass and the environment

One strand of WBP literature focuses on the correlation between fossil fuel consumption and damage to the regional environment in terms of pollutant concentration and human health (Klass, 1998; Martinsen et al., 2010; Popp et al., 2014; Herbert and Krishnan, 2016; Paiano and Lagioia, 2016; Sikarwar et al., 2016; Chang et al., 2017). The threat of global climate change can be partly attributed to the combustion of fossil fuels. With the new discoveries of oil and gas

[2] The counties that compose our study region are: Boone, Lincoln, Logan, McDowell, Mercer, Mingo, Raleigh, Wayne, and Wyoming in West Virginia, Buchanan in Virginia and Pike in Kentucky.