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Economics of co-firing coal and biomass: An application to Western Canada

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ABSTRACT

Co-firing biomass and coal in retrofitted power plants is an efficient means to reduce carbon dioxide emissions in the energy sector. Under IPCC reporting rules, the impacts of energy produced from biomass would not be reported in the energy sector, thereby effectively lowering the emission intensity of a power plant. In this study, a carbon tax is compared to a feed-in tariff for incentivizing conversion of coal plants to co-fire with biomass. In the application, a model of the Alberta electrical grid with an intertie to British Columbia is linked to a fiber transportation model for these provinces. Results indicate that there is an upper threshold on a carbon tax after which retrofitting of coal plants is less efficient than increasing natural gas generating capacity. This is not the case with a feed-in tariff as it specifically targets biomass energy. Although the optimal generating mix achieved with a carbon tax leads to lower aggregate emissions than the mix achieved using a feed-in tariff, it will result in higher average generating costs. Results indicate that it is optimal for Alberta to retrofit approximately 500 MW of current coal capacity (8.6%) to co-fire with biomass, although Alberta wood pellet production acts as a constraint on further conversions.

1. Introduction

Many countries are hoping to transform their energy sectors away from coal power to renewable sources to reduce their carbon dioxide (CO_2) emissions. One option is to co-fire biomass with coal to reduce the CO_2 emissions intensity of coal plants. Co-firing biomass in existing coal-fired power plants is appealing due to the low incremental investment required to retrofit established facilities and because energy produced from biomass is considered to be carbon neutral (IPCC, 2006). Under IPCC reporting rules the impacts of energy produced from biomass would not be reported in the energy sector but in the Agriculture, Forestry and Other Land-Use (AFOLU) sector (previously the LULUCF sector). Carbon emissions from biomass energy are considered carbon neutral since the IPCC Guidelines assume that carbon lost during harvest equals carbon gained through regrowth. Consequently, many coal plants have been or are in the process of being retrofitted to co-fire with biomass (e.g., see IEA (2009)).

Whether biomass burning should be considered carbon neutral is debatable. As argued by Johnston and van Kooten (2014), biomass burning is only carbon neutral if there is no urgency in addressing climate change, in which case the timing of CO_2 flux is unimportant. It only matters that over the harvest cycle the same amount of CO_2 is removed from the atmosphere by tree growth as was emitted producing electricity. If there is some urgency to address climate change, however, future removals of CO_2 from the atmosphere must be considered less important than current emissions, in which case biomass burning can no longer be considered carbon neutral.

The increased demand for biomass energy has resulted in the creation of new wood product markets, primarily in the form of wood pellets. Driven largely by EU policies, global wood pellet production has increased from 1.7 million tonnes (Mt) in 2000 to 15.7 Mt in 2010 (Lamers et al., 2012), primarily for use in the European market.[1]

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[1] European countries have agreed on a binding target to achieve a 20% share of renewable energy in total energy consumption by 2020. Co-firing biomass with coal is becoming more common in EU countries, with the Netherlands, the UK and Belgium leading the way. These countries have implemented various incentives for retrofitting coal plants. In the Netherlands, power producers receive a feed-in tariff of €67/MWh under the 2002 MEP (Milieukwaliteit van de Elektriciteits Productie). In the UK, electricity generators are required to obtain 12% of their energy from renewable sources, including biomass. It uses Renewable Obligation Certificates (ROC) to incentivize retrofitting of coal plants to co-fire biomass; the average price of an ROC was €55.9/MWh in 2012. Similarly, Belgium relies on Green Certificates (average price in 2012 was €118/MWh) to encourage large-scale retrofitting of coal plants.

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Although Europe is also a large producer, there is limited capacity to increase European pellet production. As a result, the wood pellet manufacturing sector in Canada has emerged as a significant supplier, exporting 1.9 Mt representing 90% of its pellet production to Europe in 2011.[2] As of 2012, British Columbia (BC) had 1,875,000 tonnes of wood pellet manufacturing capacity, accounting for 65% of Canadian capacity and production (WPAC, 2012). This sector has traditionally utilized low-cost mill residuals as feedstock, although significant increases in production will require incorporation of more costly fiber from forest operations. As a result of these European incentives, BC exported 840,000 tonnes of wood pellets to the UK and 240,000 to the Netherlands in 2012 (Industry Canada, 2013).

There are numerous risks to expanding or even maintaining exports of pellets from BC to Europe, including potential changes in European energy policies, the rapid rise of exports from lower-cost competitors and relatively high shipping costs. It is logical therefore to examine potential new markets as a hedge against too large an exposure to the European market, especially considering the high degree of policy risk associated with pellet exports to Europe. A logical market may be developing close to home.

Under the Copenhagen Accord, Canada agreed to reduce its greenhouse gas emissions by 17% from 2005 levels by 2020. Currently, coal-fired electricity generation in Canada is responsible for 77% of the CO_2 emissions from the electricity sector, despite generating only 15% of total production. With this in mind, the Government of Canada (2011), through an amendment to the Canadian Environmental Protection Act (1999), imposed an emission intensity standard for generating electricity from thermal power plants, although it would initially apply only to new plants and those refurbished because of their age. The standard was set at an emission intensity level commensurate with that for high-efficiency combined-cycle gas turbines (CCGT), initially determined to be 375 tCO_2/GWh but later raised to 420 tCO_2/GWh.

The new standard is likely to have its biggest impact on Alberta since Ontario had already mandated the elimination of coal-fired power in 2007, using financial incentives for biomass energy as an additional policy tool.[3] The Alberta electricity sector will play an important role if Canada is to comply with the Copenhagen Accord, as it has 5795 MW of installed coal-fired capacity, which represents 53% of its current electricity output. In 2007, Alberta became the first jurisdiction in North America to put a price on carbon; it introduced what amounted to (but was not called) a carbon tax that targeted large industrial emitters. Large emitters are required to reduce their carbon emission intensity by 12% or pay a \$15-per-tonne tax on CO_2 emissions. A recent government proposal could see the tax increase to \$40/tCO_2 in hopes of mitigating emissions by 28%.[4] It is estimated that companies currently pay \$1.80/tCO_2 and that this would rise to \$16/tCO_2 if the tax was increased (Kleiss, 2013).[5]

While Alberta and British Columbia (which has no coal plants) have carbon taxes (albeit of different forms), the EU and Ontario rely on feed-in tariffs (FITs) that are implemented as a premium paid to energy produced from biomass (although the EU also employs carbon trading). Unlike a carbon tax, which penalizes emission-intensive technologies across the board, a FIT is designed to encourage investment in renewable energy technologies. As a result, it is expected that reliance on a carbon tax as opposed to a FIT will result in a much different generating mix.

In this paper, we examine optimal investment in generating assets in response to market incentives to reduce CO_2 emissions. We use the Alberta energy sector as our case study because of its significant reliance on fossil fuels, especially coal but also natural gas. Additionally, Alberta's proximity to BC allows it to have access to a significant amount of wood pellet manufacturing capacity for co-firing biomass and coal. Indeed, this may provide an opportunity for BC to expand its market while reducing its exposure to the risk of changes in foreign energy policies. In response to an increasing demand for climate change mitigation while providing reasonably priced electricity, co-firing may be beneficial for both provinces. The objectives of the current research are therefore (1) to examine the impact of different market incentives for encouraging the co-firing of biomass with coal; (2) to investigate the potential of reducing CO_2 emissions through co-firing biomass with coal; and (3) to determine the feasibility of marketing BC wood pellets in Alberta.

2. Carbon tax versus feed-in tariff

In this section, we examine how carbon taxes and feed-in tariffs differentially affect the generating mix. Consider Fig. 1 where the 2012 hourly Alberta load is depicted in panel (a). By sorting the hourly load in descending order, we derive the 2012 load-duration curve as shown in panel (b). The minimum load is referred to as the base load and is generally met with base-load power plants that rarely need to vary output. Nuclear, coal and CCGT assets constitute the main types of base-load plants.

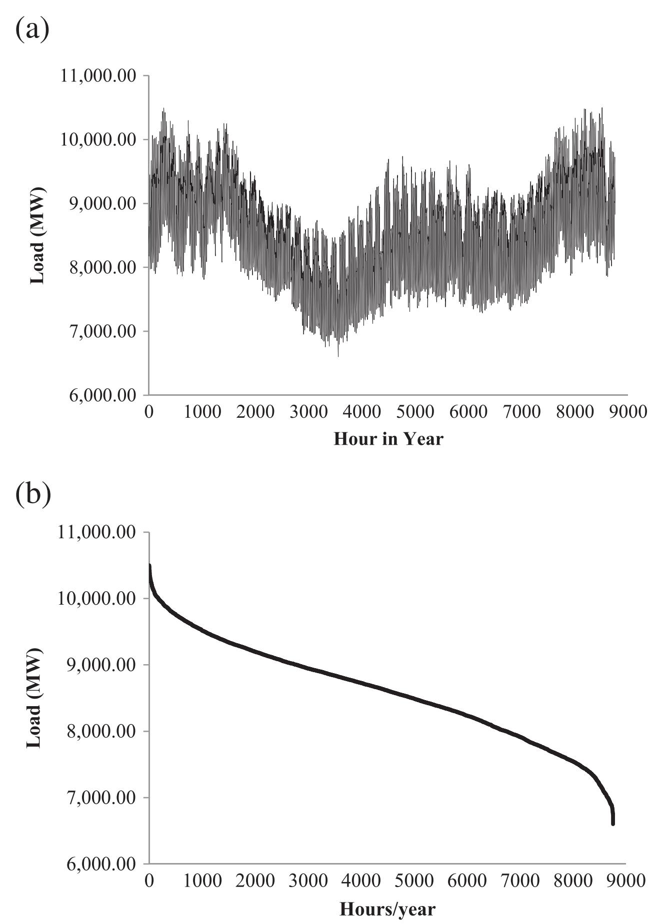

Fig. 1. 2012 Alberta load (panel a) and load duration curve (panel b).

[2] http://www.pellet.org/production/production (accessed July 10th, 2013).

[3] Ontario's The Green Energy and Green Economy Act (2009) subsequently introduced feed-in tariffs for electricity generated from renewable sources, including a subsidy on biomass electricity of 13.0–13.8 ¢/kWh, which was increased to 15.6 ¢/kWh effective August 26, 2013. Two coal-fired power plants are currently undergoing a retrofit to burn biomass, including Nanticoke Generating Station which had been the largest coal plant and one of the largest single sources of emissions in North America. Ontario's capacity to convert biomass residuals to wood pellets is also increasing, with three wood pellet plants under construction and seven more proposed as of 2013 (Canadian Biomass, 2013).

[4] Alberta Environment Minister Diana McQueen has proposed a '40/40 plan' to come into effect by 2020; it raises the emission reduction target to 40% and increase the carbon price to C\$40 per tonne.

[5] Unless otherwise indicated, all monetary units are in Canadian currency.