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Analysis

Back to the past: Burning wood to save the globe

Craig M.T. Johnston [a,*], G. Cornelis van Kooten [b]

[a] Department of Forest & Wildlife Ecology, University of Wisconsin-Madison, USA
[b] Department of Economics, University of Victoria, Canada

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ABSTRACT

In an effort to reduce CO_2 emissions from fossil fuel burning, renewable energy policies incentivize use of forest biomass as an energy source. Many governments have assumed (legislated) the carbon flux from burning biomass to be neutral because biomass growth sequesters CO_2. Yet, trees take decades to recover the CO_2 released by burning, so assumed emissions neutrality (or near neutrality) implies that climate change is not considered an urgent matter. As biomass energy continues to be a significant strategy for transitioning away from fossil fuels, this paper asks the question: To what extent should we value future atmospheric carbon removals? To answer this, we examine the assumptions and pitfalls of biomass carbon sequestration in light of its increasing use as a fossil-fuel alternative. This study demonstrates that the assumed carbon neutrality of biomass for energy production hinges on the fact that we weakly discount future removals of carbon, and it is sensitive to tree species and the nature of the fuel for which biomass substitutes.

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1. Introduction

In an effort to reduce carbon dioxide (CO_2) emissions from fossil fuel burning, renewable energy policies have promoted 'carbon neutral' biomass as an energy source. The Intergovernmental Panel on Climate Change (IPCC) is the governing authority on climate change and, in particular, the rules concerning carbon accounting (Sedjo, 2013). Working under the auspices of the United Nations' Framework Convention on Climate Change (UNFCCC), the IPCC (2006) says the emissions from biomass energy would be reported in the Agriculture, Forestry and Other Land-Use (AFOLU) sector at the time of harvest, and not the Energy sector when the wood is burned. Therefore, biomass energy may be viewed as 'carbon neutral' since emissions are subsequently removed by future growth. Many developed countries draft their domestic legislation in light of the IPCC carbon accounting principles, including those committed to the Kyoto Protocol of the UNFCC.

Yet trees may take decades to recover the CO_2 released by burning, so assumed emissions neutrality implies that climate change is not considered an immediate threat. That is, the carbon neutrality of biomass hinges on the fact that we count CO_2 removals from the atmosphere equally independent of when they occur (e.g., Schlamadinger and Marland, 1999). When there is greater urgency to address climate change, however, more emphasis should be placed on immediate removals of CO_2 from the atmosphere and much less on removals that occur in the more distant future.

How pressing is the need to mitigate climate change? According to Article 2 of the UNFCCC, atmospheric greenhouse gas concentrations must be stabilized in a timely manner to prevent potentially dangerous climate change. The latest IPCC report indicates that the observed impacts of climate change are already "widespread and consequential" (IPCC 2014, p.93), while the U.S. National Climate Assessment (NCA) reiterated the warnings of the IPCC regarding climate change, suggesting that a once distant concern is now a pressing one as future climate change is largely determined by today's choices regarding fossil fuel use (NCA, 2014).

To reduce emissions of CO_2 from fossil fuel burning, many countries intend to substitute biomass for coal in existing power plants, with some already having done so. This is appealing because extant coal plants can be retrofitted to burn biomass at relatively low cost. Thus, it is estimated that, as of 2011, some 230 coal plants co-fire with biomass on a commercial basis (IEA-ETSAP and IRENA, 2013). Biomass use in coal plants is bound to increase as more countries will need to rely on its assumed neutrality to meet their CO_2 emission reduction targets (Cremers, 2009).

In Europe, countries originally agreed to a binding target requiring 20% of total energy to come from renewable sources by 2020 (Directive 2009/28/EC). Then, in early 2014, the European Commission proposed a new framework with a more ambitious EU-wide renewable energy

* Corresponding author.
E-mail address: craig.johnston@wisc.edu (C.M.T. Johnston).

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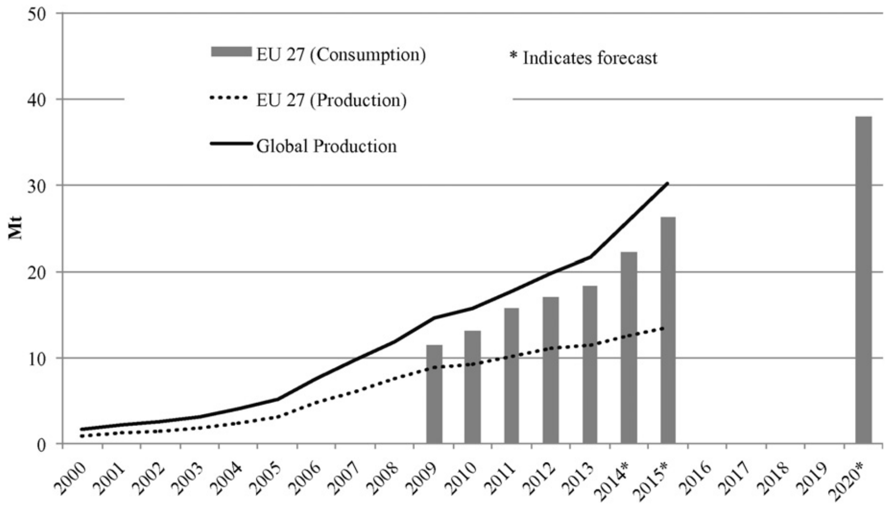

Fig. 1. Production and consumption of wood pellets in the EU-27 (Mt), 2000–2013 and forecasts for 2015 and 2020 Source: Pöyry (2011); Lamers et al. (2012); FAO (2015).

target of 27% by 2030. Europe expects one-half or more of its renewable energy target to come from biomass as member states look to the IPCC carbon accounting guidelines for support (European Commission, 2013). To meet these targets, member states have individually adopted a variety of domestic policies to promote energy from biomass, including feed-in tariffs, a premium on market prices and tradable renewable energy certificates (RES-LEGAL, 2014). As indicated in Fig. 1, these measures are expected to increase European consumption of wood pellets to some 38 Mt. per year, requiring significant imports of pellets from outside the EU.

In Canada, performance standards on coal-fired power plants now impose an upper limit on emissions of 420 kg CO_2 MWh^{-1}—equivalent, according to the government, to new highly-efficient combined-cycle gas turbines (Government of Canada, 2012). The standard applies to combustion of coal and its derivatives, and all fuels burned in conjunction with coal, except for biomass which is deemed to be emissions neutral. This leaves open the option of blending 'zero-emissions' biomass to the point where the standard is met. As of 2014, two large-scale Canadian power plants have been retrofitted to run solely on wood biomass, including the Nanticoke Generating Station, which was the largest coal-fired power plant and one of the largest single sources of emissions in North America.

In the United States, a ruling by the Environmental Protection Agency in September 2013 (EPA, 2013) requires new coal plants to have carbon capture and storage (CCS) capability, or otherwise achieve a particular performance standard. The construction cost of CCS-capable plants is prohibitive, but other costs make CCS not only economically unattractive but an unlikely option as CCS process increases the energy required to produce electricity by some 28% (EIA, 2013). Again co-firing biomass with coal is viewed as an alternative compliance strategy to achieve emissions intensity in coal plants of 500 kg CO_2 MWh^{-1} (Edenhofer et al., 2011).

As biomass energy becomes increasingly important as a strategy for transitioning away from fossil fuels, and the CO_2 released from burning biomass takes some time to remove from the atmosphere by growing vegetation, it behooves us to ask how current versus future carbon fluxes should be valued. In particular, assumptions regarding the future carbon uptake potential in forest ecosystems affect the supposed carbon neutrality of biomass (Holtsmark, 2012; McDermott et al., 2015). The purpose of the current study is, therefore, to examine how climate change mitigation policies, and the urgency expressed in dealing with potential future global warming, change our view of the life-cycle analysis (LCA) of CO_2 from fossil fuel versus biomass burning. In essence, we argue for an alternative, policy-based perspective on LCA. In doing so, we demonstrate that the assumed carbon neutrality of biomass energy hinges on the fact that future removals of carbon are treated almost the same as current ones.

We begin in the next section with an overview of the LCA of CO_2 in energy production; the aim is not to offer a definitive review, but only to provide context for our shift towards a policy focused analysis. We then argue why carbon fluxes need to be weighted according to when they occur, especially if there is some urgency in addressing climate change. It is the latter that accounts for the policy oriented approach to LCA. A model of carbon fluxes is used to demonstrate how the degree of urgency (different weighting schemes) affects the effectiveness of bioenergy in dealing with climate change. Sensitivity analysis with respect to weights, tree species and fuel types for which biomass substitutes gives some indication of the robustness of our proposal. Finally, we consider further challenges to the use of wood biomass energy that might reinforce or weaken our conclusion that policies to expand biomass burning to mitigate climate change need to be rethought.

2. Tracking Carbon Fluxes: The Carbon Life-Cycle Analysis (LCA)

There exists a rich body of research on the greenhouse gas emissions impact of substituting forest bioenergy for fossil fuels (Miner et al., 2014; Sedjo, 2013). Much of the research has been by physical scientists, who have emphasized the carbon life-cycle characteristics of using biomass energy (Cherubini et al., 2011; McKechnie et al., 2011; Helin et al., 2013). In the various analyses, it is assumed that carbon dioxide from fossil fuel burning remains in the atmosphere indefinitely, so that any such emissions are considered to be irreversible. On the other hand, it is assumed that emissions of CO_2 from biomass burning can be removed from the atmosphere by the Earth's carbon sinks. These distinctions are important as discussed below.

The initial approach used by analysts can be understood in the context of Fig. 2. Suppose that electricity is generated in a given day or hour by a coal plant. In that case, an amount 0F, of CO_2 enters the atmosphere and remains there indefinitely as indicated by the horizontal dashed line. Suppose instead that the power delivered on that day or hour was generated by burning wood biomass rather than coal. In that case, an amount $0K > 0F$ of CO_2 enters the atmosphere at time 0, thereby creating a carbon deficit equal to $0K - 0F$. Because wood biomass has a higher carbon content (kg/GJ) than coal, the release of CO_2 from burning wood pellets exceeds that from coal (i.e., $OK > OF$).[1] This issue is discussed in greater detail below, when we investigate issues surrounding urgency and discounting.

[1] See http://www.ipcc.ch/meetings/session25/doc4a4b/vol2.pdf [accessed Sep. 29, 2015] where carbon intensities for many fuels are provided.

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