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Fibre use, net calorific value, and consumption of forest-derived bioenergy in British Columbia, Canada

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ABSTRACT

The lack of data about current bioenergy production in British Columbia severely limits stakeholder analyses of the true value and growth potential of bioenergy within the province and the forest industry's sustainability. Fifty-two facilities were surveyed to gather statistics on rates of fibre use for energy, thermal and electrical energy capacity and net production. We estimated that from 2000 to 2011, on average 9.4 Mt of wood fibre (oven-dry) was used annually to produce energy, which was about one-third of the total harvested biomass. However, bioenergy does not drive the harvest. Bioenergy uses residual fibre from other operations—primarily black liquor from pulp mills. In total, the forest sector produced approximately 118 PJ of thermal and electrical energy in 2011, based on the net calorific value provided by respondents. Based on these results, we concluded that wood-based bioenergy supplied approximately 10% of British Columbia's energy demands in 2011. Forestry sector commodity and economic statistics likely underestimate the more than 640 M$ worth of energy it produced. The survey results also showed a wide variation in the efficiency of energy production between different facilities. Given the large discrepancy between the theoretical high heating values and what the producers achieved, it may be prudent to use an operationally-derived net calorific value or low heating value for estimating energy supply from biomass, especially for policy or business development.

1. Introduction

Forest-based bioenergy has been presented as a potential revenue source for a struggling industry [1] and an opportunity to increase renewable energy supply by various agencies across Canada and globally. The Government of British Columbia, Canada, emphasized bioenergy in the 2009 Energy Plan, and subsequent requests by BC Hydro (an electricity utility corporation owned by the Province) for proposals from bioenergy producers indicate growth in bioenergy in the near future. These documents assume that British Columbia (BC) has the capacity and potential to greatly expand bioenergy production because the province has extensive forests (550,000 km^2 [2]). However, there is little information available on the availability of feedstock supplies and the existing production of bioenergy. For example, estimates of the production and surplus of residues from forest product

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manufacturing range by millions of tonnes, and one attempt to estimate the flow of harvested fibre into commodities revealed that 33% of the harvested fibre is unaccounted for in traditional commodity statistics and manufacturing studies [3,4]. Although pollution control regulations to reduce aquatic and marine damage from release of black liquor have been in place since the late 1970s and air pollution controls on burning since the mid-1990s, there is no public information on where those residues end up. This lack of data severely limits government, industry, and other stakeholders' analyses of the true value and growth potential of bioenergy and the sustainability of the forestry sector.

Current literature indicates that bioenergy is a growing and important component of lumber milling and paper production in North America and Europe. On average, the Canadian pulp sector is estimated to produce 57% of its own energy consumption from biomass [5]. In the United States in 2002, 98% of wood residues within the forest product sector were being used, largely for bioenergy [6]. In 2004, European pulp mills produced 639 PJ of energy, which accounted for 50% of the energy demand of the sector and represented 27% of total bioenergy production in the associated countries [7].

Bioenergy is also a growing source of energy for many countries in the European Union. In 2009 and 2010, bioenergy was a significant source of thermal energy in Sweden: bioenergy supplied 22% of the total energy in the country, the third largest supply after oil (32%) and nuclear power (27%) [8]. Finland was the first developed country that derived a significant proportion of its electrical energy from biomass. In 1995, it derived 10% of its electrical energy and almost 18% of its total energy from biomass [9]. In comparison, in Canada, bioenergy provided an estimated 3% of the energy supply in 2007 [10].

The bioenergy information that exists for BC is primarily capacity data, and those estimates vary. The Canadian Bioenergy Association and the Canadian Industrial Energy End-use Data and Analysis Centre estimate energy capacity for the pulp sector in BC at approximately 136 PJ y^{-1} [11]. However, according to Statistic Canada's production numbers, pulp and paper mills in BC produced more than 194 PJ of energy in 2010 [12]. These numbers suggest that production is about 143% of capacity. Other organizations provide capacity data, but there is wide variance among the different reports. In addition, many of these data sources do not give facility-level data, or estimate the amount of fibre consumed in BC to produce bioenergy, or describe the source of that fibre. At least these three types of information are needed to gauge the amount and nature of bioenergy production in the province. Once those data become available, it will be easier to assess the current and potential use of fibre for different commodities for the industry, investors, consumers, and policy makers. Furthermore, compiling these data will enable forest industries around the world to assess their products and efficiencies in comparison with BC and globally as data availability grows.

Given the noted discrepancies between production and capacity in BC, it is unlikely that national-level statistics, at least for Canada, include all the bioenergy that is produced and consumed within the forest industry. If the Canadian experience is repeated around the world, current global energy use and renewable energy production may be significantly underestimated. This underestimation is acknowledged by the International Energy Association, which requires statistics to exclude the consumption of thermal energy by the producing facility [13]. However, it does request separate estimates of thermal energy consumption by producing facilities, while acknowledging the difficulty in obtaining those estimates, in particular for bioenergy.

The lack of wood fibre consumption and bioenergy production statistics also limits the ability to estimate greenhouse gas emissions and therefore opportunities to mitigate climate change. Combustion of biomass produces carbon dioxide and methane, both of which are greenhouse gases. Some or all of those emissions are taken up over time as the forest regrows. Improved modelling and tracking of fibre use, including combustion [4] and forest carbon dynamics [14], allows climate change mitigation scenarios and options to be modelled for the combined forestry and forest products sectors [15].

Statistics and flows of wood fibre for use in different products, including biofuels are available in some parts of the world, e.g. Finland [16] and the EU [17]. In Finland, these statistics are compiled annually by The Finnish Forest Research Institute where energy production is treated as a forest industry product along with pulp or particle board [18]. In contrast, for the broader EU, the flow of wood fibre into energy and trade in biofuels has been largely uncharted until recently [17]. Their study relied on forest product statistics from the Food and Agriculture Organization and EUStat however those statistics only include wood fibre as a fuel in firewood or charcoal form and do not include energy as a forest product [19]. The renewable energy statistics provide more information, but the fuel is not necessarily specified to the forest industry or to a particular type of facility within the industry (i.e. pulp mills), e.g. Ref. [20]. This may limit the application of the data to the scale of the EU rather than local or national scales.

Traditional forest product commodity statistics do not account for about one-third of the harvested biomass in BC and available local and international information indicates that bioenergy is likely a significant part of the forestry industry, but data are incomplete and inconsistent. Therefore, the purpose of this study was to survey all forest-based bioenergy facilities in BC to quantify their energy production and consumption 1990 to 2011. Specifically, our objectives were to gather data on fibre-use (quantity and types of feedstock), annual energy production (thermal and electrical), capacity (thermal and electrical energy), use of the energy (consumption on site, sold, vented), and net calorific value (quantity of energy produced per tonne of wood fibre). Where only partial historical data were available from the surveys, we estimated the missing data for pulp mills because they were the largest energy producers. Where the respondents could not provide an operational net calorific value we used a benchmark for the industry based on information from other respondents. Our hypothesis was that approximately 33% of the harvested biomass was used for energy, based on the gap between harvested biomass and forest product commodity statistics in Dymond [3]. We collected provincial-scale supply and demand data regarding fibre used for bioenergy to inform future plans, investments, and stakeholder opinions on forest