Available at www.sciencedirect.com

ScienceDirect

http://www.elsevier.com/locate/biombioe

Community-based model for bioenergy production coupled to forest land management for wildfire control using combined heat and power

Jessica Yablecki [a,*], *Eric L. Bibeau* [a], *Doug W. Smith* [b]

[a] *University of Manitoba, Winnipeg, MB, Canada*
[b] *Entropic Energy, Vancouver, BC, Canada*

ARTICLE INFO

Article history:
Received 20 October 2009
Received in revised form
7 February 2011
Accepted 10 February 2011
Available online 9 April 2011

Keywords:
Bioenergy
Wildfires
CHP
Mechanical treatment
Sustainable communities
Renewable transportation

ABSTRACT

We propose a community-based model of land management for pre-emptive action to reduce the risk of wildfires in small communities situated in forested areas. This proposed approach transfers the responsibility of wildland–urban interface administration to the local community, giving them control in reducing their risks of property damage. A combination of community forest management using local labour and bioenergy power generation mitigates the cost of forest treatment, reduces the local cost of energy and revitalizes the community. The proposed solution achieves sustainable land management practices, sustainable ecology, sustainable energy production, and provides enhanced cost-benefits to the community. More important, it provides simultaneously renewable heat, transportation and power to the community using local labour and without reliance on external aspects beyond community control. This study proposes a viable method based on the installation of an appropriately sized combined heat and power bioenergy system. A remote off-grid community is modeled and simulated using three different small-scale bioenergy systems and two operating scenarios by way of example.

1. Introduction

Forest practices have altered natural fire cycles artificially by land management practices over the last few decades. Trends are showing increased fire size and severity over the last 20 years, resulting in increasing property damage [1]. Forested lands have thus accumulated a large quantity of hazardous biomass. For example, experience of uncontrolled wildfires in British Columbia, Oregon, and California overrunning communities has expanded public awareness of this hazard. Communities within forested areas are reviewing their exposure to wildfire risks and looking to develop proactive plans. Many small-unincorporated districts may lack the human resources to produce effective forestland management plans. Moreover, smaller communities are at greater risk of wildfire considering their greater encroachment into the forests, resulting in limited access and reduced insurance coverage. It is imperative that pre-emptive land management for wildfire control strategies consider the needs of these smaller and more remote communities. Many of these communities are not on the electrical power grid, use diesel generators for electrical power generation and import heating oil for heat. The combination of land management for wildfire control and community energy production using wood residue as a source for renewable energy to produce heat and electricity would provide the community with extended benefits including protection from rising energy costs, reduced oil dependence, reduced carbon emissions, and self-sufficiency.

* *Corresponding author.*
E-mail address: jyablecki@gmail.com (J. Yablecki).
0961-9534/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biombioe.2011.02.011

2. Forest land management

2.1. Wildfire control

There are three broad approaches to land management for wildfire control: reactive, prescribed burns, and mechanical treatment [1]. Ignoring the issue defaults to reactive wildfire suppression with little or no pre-emptive control. Even if this approach results in the accumulation of a large quantity of forest fuel loading, it is extensively applied. The second approach is that of prescribed burns in which, under selected times and locations, intentional fires destroy the forest fuels to leave the woodland less susceptible to unplanned, uncontrolled wildfires. This practice is subject to weather conditions and smoke regulation. The third approach is that of mechanical treatment in which low lying biomass is harvested to reduce ladder fuels, along with a planned removal of selected larger trees to reduce crown fire spreading [2].

Many experts recognize the reactive approach as no longer acceptable. Ladder fuels and closely spaced trees allow fires to develop and expand beyond the capability of effective fire fighting [3]. In the interface zones between forests and communities, where homes are constructed within the edge of the forest, the results of such fires can be devastating. The prescribed fire approach is a pre-emptive method to reduce the fuel loading in the forest, however, prescribed burns cannot be implemented when there are high fuel loadings, short windows of suitable climate conditions, risk of escaped fire in the wildland–urban interface, or where air quality concerns exist [4].

In this case, mechanical treatment of forests becomes a preferable option. This approach consists of harvesting the underbrush, low-level biomass, and dead and dying trees as well as conducting some forest thinning. Recent studies have shown that mechanically treated areas can lessen the severity of wildfires and reduce uncontrolled wildfires from a crown to a surface fire making it more manageable by fire fighters [5]. The United States has brought in recent legislature such as the Healthy Forest Restoration Act [6], and policy initiatives like the Ten Year Comprehensive Strategy and Implementation Plan [7], to address the issue of wildfire control and fuel reduction [8]. Mechanical fuel treatment programs need to remove large quantities of small trees; if left in the forest, these become ladder fuel, further increasing wildfire risk [1]. Biomass removed during mechanical treatment methods must be consumed elsewhere as land filling would just shift the problem. Mechanical treatment of forestlands offers the potential for productive use of biomass collected, however, most of this solid biofuel has no merchantable value and long-distance transportation generally precludes economic benefit from the valued material: distance to biomass markets from harvesting sites must generally be kept below 100 miles to remain economical [9].

2.2. Forest land management costs

A major concern of land management for wildfire control is the cost of proactive programs. The reactive approach requires the least upfront investment, but leads to the greatest uncertainty in budgetary planning with potential expenditure difficult to predict. A single uncontrolled wildfire that encroaches into a populated area could cost many times more than any of the pre-emptive programs. If the forest fuel loading is high, then few reactive strategies can be relied upon to ensure that property damage does not ensue. The costs of fire fighting, property destruction, employment losses, insurance claims and legal implications can exceed $1 billion in a single season in the USA although this is a statistical result and not a comparative, per acre cost [3].

It is not possible to make a direct comparison between the costs of the pre-emptive and reactive treatment programs on an annual basis. Prescribed burns are the least-cost pre-emptive strategy, with an estimated cost of $130 to $1000 Cdn per hectare [4], but this method has restricted application. Prescribed burns have no secondary benefits available. A related approach is to cut, pile and slash burn the forest fuels. This uses a combination of mechanical clearing with a more controlled in-forest burn: it has similar air quality concerns as the prescribed burning approach and estimated to cost more from $370 to $2800 Cdn per hectare [4].

Mechanical clearing and removal is a more costly pre-emptive strategy than prescribed burning but it can offer secondary benefits if the available biomass is used for economic purposes. It costs between $865 to $2997 Cdn per hectare [9,10] to mechanically clear and remove biomass from the forest; however, even higher costs could be possible. These costs are dependent upon but not limited to such factors as forest density, the type and size of biomass for removal, mechanical equipment available, local landscape and forest conditions [4]. Mechanical forest treatment would be an attractive option if the cost structure improves through recovery of some revenue and community benefits. If collected biomass can provide power and heat to the community to displace existing energy expenditures, then the recovery of value mitigates part of the forest treatment cost.

2.3. At-risk small communities

Estimates show that 20 000 communities are at-risk for wildfires in the USA and that support for planned forest management is increasing [11]. The largest risk for communities occurs at the interface zones between the community and the forest. We postulate that attention is more likely to be given to larger communities that boarder forests because of economies of scale; however, property damage risk is as great for smaller communities. We further assume that smaller communities are more likely to lack professional fire-fighting equipment and training, are more integrated with the forest with more limited escape routes from approaching fires, and many will be less organized to address the issue. As fewer people represent smaller communities, they may have reduced capability to have their concerns and needs heard.

For large and small communities alike, the interface lands can be an unresolved area of responsibility. These lands are often outside the tenures of the forest companies, so land management is not a company issue. They are most likely outside municipal boundaries for large communities and there are no municipal boundaries for unincorporated small communities, thus these lands can default to government