BIOMASS AND BIOENERGY 52 (2013) 34–42

Available online at www.sciencedirect.com

SciVerse ScienceDirect

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

The influence of two different handling methods on the moisture content and composition of logging residues

*Bengt Nilsson**, *Åsa Blom* [1], *Thomas Thörnqvist* [1]

Linnaeus University, Department of Forestry and Wood Technology, SE-351 95 Växjö, Sweden

ARTICLE INFO

Article history:
Received 3 October 2011
Received in revised form
1 February 2013
Accepted 22 February 2013
Available online 29 March 2013

Keywords:
Forest fuel
Wood fuel
Storage
Logging residuals
Needles
Norway spruce

ABSTRACT

The most frequently used handling method in Sweden for the extraction of forest fuels is one in which logging residues are piled in harvester heaps to dry within the clear-cutting area before stacking into larger windrows. This handling method, however, requires multiple stages and the amount of handling involved results in a significant loss of biomass that could have been used for energy. This study compares two handling methods for the extraction of logging residues in stands dominated by Norway spruce. The traditional “dried-stacked” method was compared to the “fresh-stacked” method in which logging residues are collected simultaneously during normal logging operations and stacked in windrows at or near the roadside to dry. Determination of fraction composition and moisture content was carried out on the biomass provided to the energy-converting industry shortly after comminuting the logging residues. The results show that the fresh-stacked logging residues contained a higher amount of needles (8%), compared to 4% for the dried-stacked logging residues. However, the amount of needles was considered to be low in both handling methods. Both handling methods were proven to provide adequate drying with moisture content levels at approximately 36% for fresh-stacked and 31% for dried-stacked logging residues. These results indicate that weather and forest conditions have a greater impact on the moisture content than handling method. An acceptance of fresh-stacked logging residues, preferably connected to ash recycling, would afford the energy-converting industries the opportunity to use new technologies, reduce costs and extract a greater biomass total.

1. Introduction

The need for sustainable energy is increasing throughout the world. As a result, forests are shouldering an even more important role when it comes to future energy supply. The total energy supply in Sweden in 2010 was 614 TWh, of which approximately 22% came from bioenergy, which was mainly from the forest sector [1]. In order to enhance the efficiency of forest fuel, the raw material must be handled in the most favorable manner possible to obtain high energy content and to keep costs down. In Sweden, logging residues from clear-cutting areas are often used for energy. The two main tree species at clear-cutting areas used for extraction of logging residues are Norway spruce (*Picea abies* (L.) *Karst*) and/or Scots pine (*Pinus sylvestris* L.), the stands also contained some broad-leaf trees, mainly birch (*Betula* spp.).

The handling method most frequently used in Sweden for extracting logging residues is one in which logging residues

* *Corresponding author*. Tel.: +46 772 28 80 00; fax: +46 470 70 85 40.
E-mail addresses: bengt.nilsson@lnu.se (B. Nilsson), asa.blom@lnu.se (Å. Blom), thomas.thornqvist@lnu.se (T. Thörnqvist).
[1] Tel.: +46 772 28 80 00; fax: +46 470 70 85 40.
0961-9534/$ – see front matter
http://dx.doi.org/10.1016/j.biombioe.2013.02.026

are piled in small harvester heaps (heaps of logging residues resulting from the delimbing process) within the clear-cutting area during the logging operation. The logging residues are then left to dry during a growth period (summer) before they are forwarded to a landing (a larger windrow), preferably with connection to a road. The logging residues are stored in these windrows throughout the autumn and winter; the windrows are covered with cardboard to prevent moisture increase from precipitation. The logging residues are then stored in windrows at the site for up to one year before they are comminuted, e.g., with a chipper, often immediately before the energy-converting industry is in need of forest fuel. The comminuted logging residues end up in a container and are then transported by lorry to the energy-converting industry facilities. This handling method is referred to as "dried-stacked" logging residues. This handling method provides dry forest fuel containing low amounts of needles, as requested by the energy-converting industry. A high amount of needles in logging residues is often highlighted as problematic for combustion, fraction composition of forest fuel is of great importance for most boilers reliability and efficiency [2]. However, any type of fine fraction is likely to pose as much of a problem as needles, given their light weight, that comes with unburned biomass following with the flue gases from the boiler [3].

The handling of dried-stacked logging residues is very complicated and expensive since machines must be brought to the area at three different times: initial logging, forwarding the logging residues to the roadside and comminuting. Moreover, the many handling steps, as well as the storage, lead to the loss of biomass, as it is left in the forest [4]. Hakkila [5] demonstrates that during logging there will always be a certain amount of biomass that ends up between the harvester heaps and cannot be collected. This lost biomass consists mainly of fine fraction (needles and branches), but there is also a noticeable loss of more valuable coarse fraction that could have been used for energy. Furthermore, storing at the clear-cutting area makes the collection of the dry logging residues difficult since the lowest parts of the harvester heaps are often contaminated with soil [4]. It must be considered that the biomass left in the forest will provide nutrients for new plants [6]. However, according to Glöde [7], traditional forwarding results in a relatively poor distribution of needles, with most of the needles concentrated over about 15% of the surface of the clear-cutting area.

Given that fact, why not try to find a way of collecting more logging residues, and thereby more energy, and then use other sources for compensation (e.g., ash recycling) which can be more evenly distributed as nutrients in the forest. Considering this, the question has arisen: how can different handling methods affect the logging residues gained from the forest? In other words, how will moisture content be influenced and what will the composition of the gained logging residues (i.e., fine fraction, needles and coarse fraction) look like if the logging residues are collected into large windrows when the logging residues are still fresh and green (fresh-stacked)? Of course, this does not consider the problem of recycling nutrients, but this matter could be solved by using ash from energy-converting industries as fertilizer.

The advantages of using fresh-stacked logging residues would be a higher woody biomass yield and a less complicated handling process. According to Nilsson and Thörnqvist [8] the forwarding of fresh logging residues increases the total energy extraction as logging residues by approximately 30–40% at each clear-cutting area. An acceptance of fresh-stacked logging residues would open up possibilities for new technologies, thereby reducing costs and increasing total extraction from each individual clear-cutting area. This is because fresh logging residues are easier to collect. This also reduces the risk of pollution with soil and gravel and requires fewer entries at the clear-cutting areas.

Good quality, with respect to forest fuel, could be defined as meeting customer requirements. When it comes to forest fuel quality, in terms of fraction composition and moisture content, good quality is synonymous with uniformity for all energy-converting industries. But the idea that the energy-converting industry demands dry material is only partly true. Boilers with flue gas condensation perform independently of moisture content and can even benefit from slightly higher moisture content. But today's payment system is based on uniformly low moisture content. For this reason, the energy-converting industry requires dry logging residues with low amounts of fine fraction, since heating value decreases with higher moisture content and the presence of fine fraction can cause gas explosions in the dust separator [9]. The fine fraction will also cause problems during the drying and storing process. Differently sized fractions in comminuted forest fuel can result in varying density in the stacks, which can result in higher temperatures, and in the worst-case scenario, even self-ignition [10]. The composition of different fractions in logging residues is also important for the total energy content of the logging residues, because that moisture content and the heating value may differ between the different fractions [4]. When it comes to storage time, Gärdenäs [9] found that logging residues stored over the summer retain good quality as related to moisture content and fractional composition when comminuting in September and October. But whether logging residues where fresh-stacked or dried-stacked, the quality was consistently worse when chipped during the later winter months.

Fresh spruce logging residues have a composition of 33–45% wood, 20–29% needles, 12–18% bark, 13–14% branches and 4–9% fine fraction [4,11]. After having been stored in harvester heaps in the clear-cutting area from April to July, Thörnqvist [4] showed that approximately 10% of the biomass (as measured in dry weight) from the logging residues was lost because of the shedding of needles. Later on, needle loss was minimal, but total dry-matter loss continued to increase as a result of microbial activity. In October of the first year, the total dry-matter loss could be 27% [12]. The loss of dry matter was further exemplified by Flinkman et al. [11] who showed that 50% of the needles in logging residues were shed before July. According to Lehtikangas [13], a four-month storage during summer will render a 24–42% loss of the original quantity of needles. Gärdenäs [9] indicates that the amount of fine fraction is affected by both mixing tree species and the use of different chippers. Gärdenäs [9] also found a relationship in which a higher amount of fine fraction gives logging residues with higher moisture content; this is because, according to Jirjis [14], fine factions absorb more moisture than coarse fractions.