Real-Time Monitoring System for Efficiency and Cost Analysis of Forest Energy Biomass Transportation

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ABSTRACT

The purpose of the study was to determine the efficiency and costs of energy biomass transportations, when using a conventional monitoring system linked with Radio Frequency Identification (RFID) technology. In the study, truck-specific transportation monitoring was carried out with the help of a real-time web-based monitoring system. Both smart phones and reader gates were used for data transfer into the system with a wireless Internet connection. The experiments were carried out along the forest chip transportation from the forest roadside storages to the power plant by using either traditional solid-frame trucks or a truck with interchangeable containers. All the delivery containers were mounted with RFID tags. Afterwards, the statistics of the loads and the delivery performance ratio of the transportations were analysed. Additionally, the cost structures for the alternative truck and trailer combination were analysed and their unit costs were determined. Also, the functionality and the reliability of the real-time monitoring system were examined as a part of the demanding roadside chipping chain. The total number of the loads was 68 during the follow-up period. The container truck system was found to be as cost-efficient as the solid-frame truck systems. This paper demonstrates that RFID enables the tracking of the trucks on a real-time basis through the delivery chain, and that the data can be used to analyse the vehicle-specific time usage and the unit costs of deliveries.

KEYWORDS

Biomass, Efficiency, Monitoring, Radio Frequency Identification, RFID, Transportation

INTRODUCTION

Different kinds of monitoring systems have already been used with energy biomass logistics in Finland for a few decades, but Radio Frequency Identification (RFID) technology has not yet been exploited in the field of biomass monitoring systems. Although RFID technology is widely used in industry, so far it has almost no applications for energy biomass logistics (Ranta et al., 2014). Therefore, biomass logistics, especially delivery container logistics, offers an interesting target for this kind of applications. RFID technology enables the online tracking of biomass load information, keeping transaction logs and locating the load during the reading actions. Earlier, Holzleitner et al. (2013) used fleet management equipment to semi-automatically monitor the forest fuel supply processes, specifically regarding the time and fuel consumption. The monitoring was not fully automatic and required a great deal of attention from the drivers.

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In summary, RFID is a remote identification method that uses radio frequency signals for the automatic identification of objects (Sevinc & Kaya, 2012). A common RFID system consists of a reader and tags, their antennas, and electronics, which controls all the functions (Uddin et al., 2009). A magnetic or electromagnetic field is used by the reader device to communicate with the tag. The tag is a small electronic device consisting of a small integrated circuit that performs the modulation and acts as an antenna (Kumar & Roy, 2014). The tag is attached to the object that is being tracked. The reader device reads the information on tags wirelessly. Depending on the power feed, the tags are classified into active and passive tags (Periyasamy & Dhanasekaran, 2014). Passive tags derive their power from an electromagnetic field radiated by the reader. The advantages of passive tags are a long lifetime and freedom from maintenance. As for an active tag, it also has an internal power source for continued operation, but it needs to be replaced at regular intervals, due to its limited lifetime (Kaur et al., 2011).

According to the Finnish Ministry of Employment and the Economy (2014), the European Parliament and the Council have set a directive on renewable energy sources: the RES Directive. Country-specific targets for each member state have been entered in the directive about raising the share of renewable energy. Under the RES Directive, sustainability criteria are not applied to solid biofuels in energy production, for example, forest chips. At the moment, the directive applies only to liquid biofuels. In the future, according to the RES Directive, such requirements will also likely be applied to solid biofuels. If a company wishes to take advantage of the status of biofuel and continue using the energy support or tax advantage, the sustainability criteria of the directive have to be fulfilled. It is possible that a revision of the directive will enter into force in the years 2016–2017 (Jouhiaho, 2014). Nevertheless, it will be followed by a transition period, during which the member states can transpose the provisions into the national laws. The content of the directive draft may still change. However, RFID technology makes it possible to verify the origin of biomass through the entire supply chain from the forest to the energy plant.

So far, based on the author’s experience, the quality and movement of forest chip loads have not been monitored in real-time through the delivery chain in Finland; only loads with variable quality have arrived to the energy plants within the agreed delivery time. RFID technology would make it possible to monitor the loads in real-time throughout the entire delivery chain, and that would immediately enable a quick reaction to supply problems. The transportations would be able to stop from a poor quality biomass roadside storage as soon as the first load is delivered to the energy plant. RFID would also enable a container-specific inspection, enabling the delivery of different companies’ biomass fuel, using the same truck or train, and the invoicing would be taken care of via the ERP systems, container-specifically. Today, this procedure is not yet possible in Finland. Additionally, due to electronic systems, paper processing of various waybills would both end up in the offices and on the road, as all load data would be stored in the cloud, and if necessary, be available for download from there.

In the study, by means of the monitoring system, the moving trucks were tracked in the supply chain via the Internet portal. All tracking data were stored on a real cloud server, which was the memory bank of the load information. The monitoring system took advantage of the benefits of the RFID technology. Additionally, a GPS positioning function was built into the monitoring system. Previously, one problem of the monitoring system has been a poor supply chain transparency. The actions and performance of other members who are part of the supply chain have been poorly known throughout the chain. Thanks to the real-time identification of trucks, it was possible to deliver the information to appropriate members in the supply chain on a real-time basis and without significant effort.

Trucks delivered the forest chips from the forest roadside storages to the power plant, while the chipping of solid biomass was carried out by a mobile chipper on the spot by the roadside. The drivers had smartphones onto which the BioHake phone application was installed. The application enables the input of the load information in real-time onto a message-based monitoring system, using an
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