# TECHNOLOGICAL AND ECONOMIC VALUATION OF LOGGING RESIDUES PRODUCTION FOR ENERGY: A LITHUANIAN CASE STUDY

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# ТЕХНОЛОГИЧЕСКАЯ И ЭКОНОМИЧЕСКАЯ ОЦЕНКА ПРОИЗВОДСТВА ОТХОДОВ РУБОК ДЛЯ ЭНЕРГИЧЕСКИХ ЦЕЛЕЙ НА ПРИМЕРЕ ЛИТВЫ

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В исследовании анализируются затраты времени, производительность труда и затраты на производство отходов лесозаготовок. Данные были собраны на лесосеках лесного хозяйства Шакяйского лесхоза (SFE) путем регистрации времени выполнения технологических операций и пути передвижения машины. Результаты показывают, что основным фактором, влияющим на производительность и издержки производства, является расстояние транспортировки. По данным 2016 год экономически оправданное расстояние производства порубочных остатков составило 500 м, которое может варьироваться в зависимости от цены на лесозаготовительные отходы.

**Ключевые слова**: лесозаготовительные отходы, производительность, себестоимость продукции.

**Introduction.** In order to reduce the Lithuanian energy sector's dependence on expensive imported fossil fuels, especially natural gas and petroleum products, it is essential to maximize the use of renewable energy resources. The largest share of the renewable energy resources in Lithuania takes energy wood, including timber harvesting residues. Energy resources include timber firewood and logging residues - branches, tops and small trees in precommercial thinning.

Lithuanian forest sector is increasing production of logging residues, especially in state forest enterprises. SFE produces and sells logging residues at logging sites, extracted to the roadside, or chipped.

The main part of the costs in production of fuel wood from logging residues is extraction expenses (Laitila et al. 2013). According to Asikainen (2000), logging residues harvesting cost depends on the site and stand parameters, the road network, technological solutions and human factors. The role of modern information systems is also increasing nowadays. Analysis of biofuel production and transportation costs made by Dzenajavičienė, Kveselis, Tamonis (2013) showed that the most important factors that determine the result of biofuel production is the extraction distance, volume of residues per ha, as well as transportation distance to biofuel boilers. Other authors conclude that costs of residues extraction are high because of the small trailer loaded on waste volume (Potassium, Leinonen, 2005). Making production decisions easier, marginal units of income and costs, rather than total ones should be calculated and valued. In this case, the production should be extended until the marginal costs equals the marginal income for an additional unit of output (Krugman, Wells, 2013).

The aim of the study is to evaluate time consumption, productivity and costs of extraction of logging residues as well as economic viability of production, taking into account the extraction distance.

**Materials and methods.** Data of logging residues extraction was collected in clearcut area of Šakiai SFE. Forwarder Ponsse Wissent was used for extraction. The work cycle was broken into the following elements:1. Driving, unloaded, 2.Collection of load, 3. Driving, loaded; 4. Unloading; 5. Other operations (maintenance, etc.); 6. Regulated breaks; 7. Unregulated breaks.

Duration of the elements was measured and recorded. In addition, by using a GPS receiver Topcon FC-25A coordinates of machine movement were recorded every 3 seconds. Driving distances for each operation were calculated using ArcGIS application. Forwarder operational costs were calculated as a sum of labour, operational and capital costs (Mizaras, 2012).

**Results.** It was found that efficiency of logging residues extraction is mainly determined by an average distance of the extraction (Fig. 1).
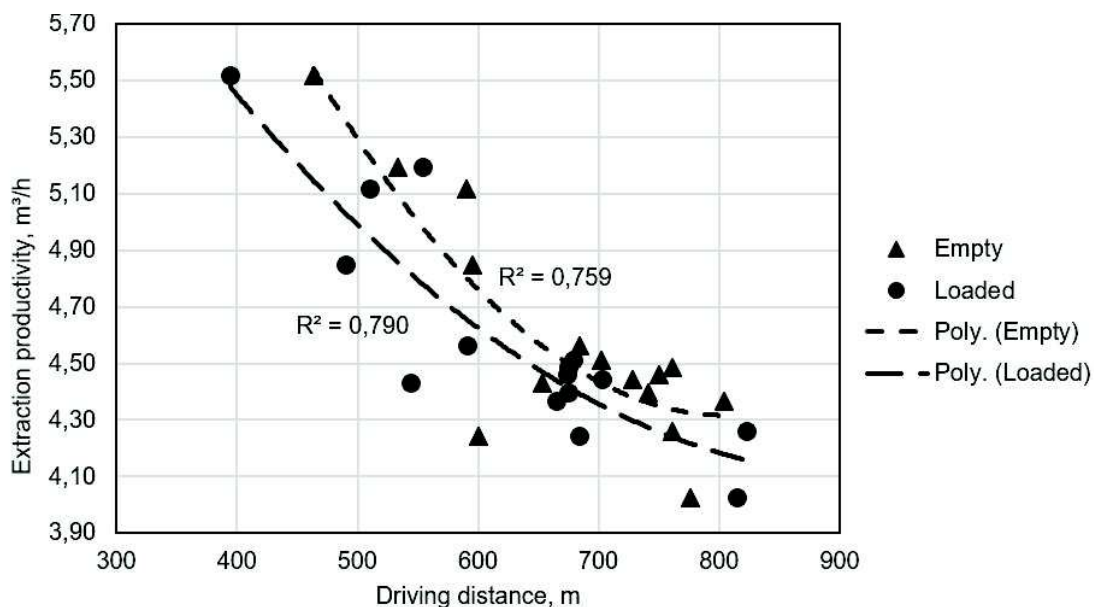


**Fig. 1 – Productivity of logging residues extraction**

When logging residues extraction productivity is 36,48 m³ per 8 hours shift, extracting cost reaches € 6,92/m³. The major part of the cost per shift includes operational costs, namely 46 percent, or 116 €/shift. The capital cost is 31 percent, or 78.2 €/shift. The remaining 23 percent accounted labour costs (Fig. 2), 58 €/shift.
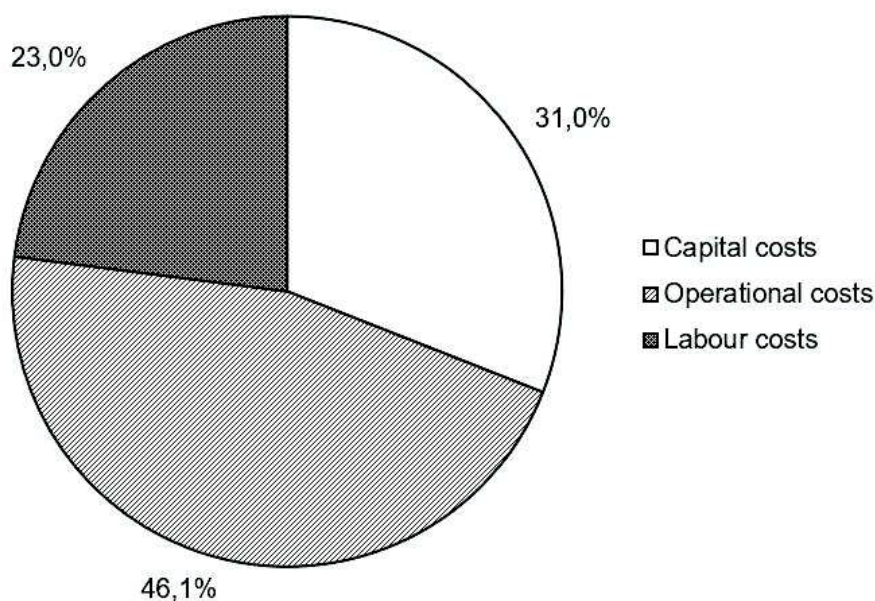


**Fig. 2 – Structure of logging residues extraction costs**

According to logging residues price declared by General State Forest Enterprise in 2016, marginal economically viable distance of logging residues extraction distance is 1200 meters, while according to local price of Šakiai State Forest Enterprise, reasonable extraction distance is only 500 m (Fig. 3).
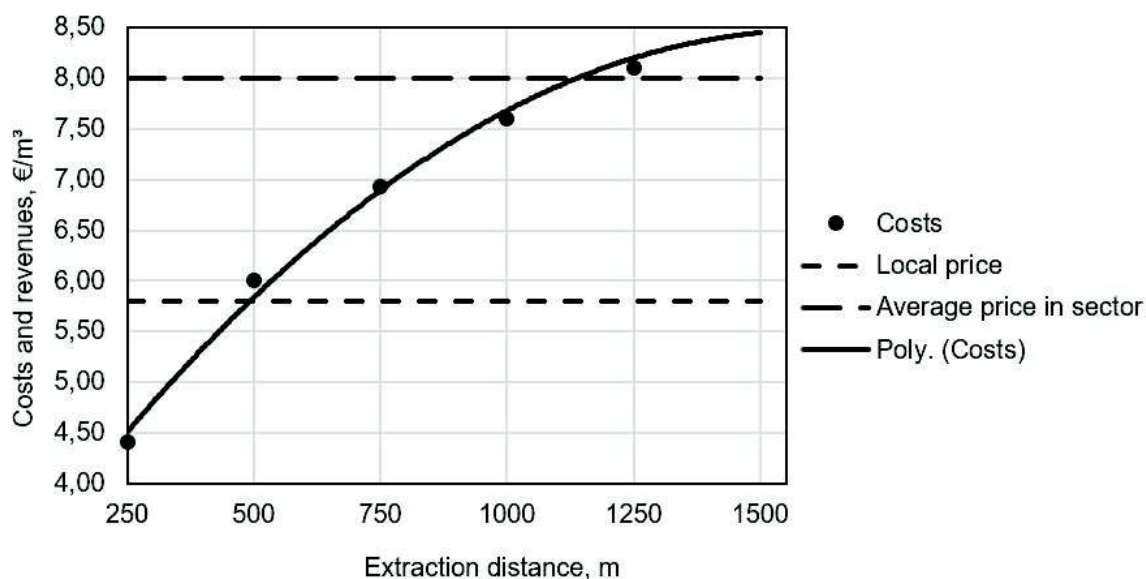


**Fig. 3 – Economically rational distance of logging residues extraction**

**Conclusions.** The study confirmed that the main factor influencing productivity and costs of logging residues production is distance of residues transportation to the roadside. Additionally, decisive factor of logging residues production profitability is current price for energy wood.

Operational productivity of logging residues extraction with forwarder Ponsse Wissent was 4.56 m³/h, the total productivity, measured including regulated breaks - 4.31 m³/h. Gross productivity, including all breaks, reached 4.21 m³/h.

Economical expediency of logging residues extraction depends on transportation distance. According to Šakiai SFE data for 2016, at the logging residues price of 5.8 €/m³, economically viable marginal extraction distance that ensures profitable production would be 500 m.

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