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# Fuelwood Production in the Form of Discs

## Proizvodnja ogrjevnog drva u obliku diskova

### SHORT NOTE

#### Kratko priopćenje

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**ABSTRACT** • *The proposed method comprises a small-scale production of fuelwood from felled and delimbed tree trunks in private households by slicing them into roundwood discs. The time consumption of this method was compared to that of the traditional method, which consists of cutting roundwood into log sections that are subsequently split into split billets. Production of fuelwood by the novel method was 2.2 times faster compared to the traditional method. The reason for the higher productivity of the novel method is the smaller number of operations. The application of this pioneering approach resulted in a 25 % lower fuelwood production cost, if compared to the commonly applied practice.*

**KEYWORDS:** *fuelwood production; chronometry; roundwood; fuelwood discs*

**SAŽETAK** • *Metoda predložena u priopćenju obuhvaća proizvodnju ogrjevnog drva u malom opsegu – od posječenih debala bez grana u privatnim kućanstvima piljenjem na diskove. Utrošak vremena za tu metodu uspoređen je s utroškom vremena tradicionalne metode koja obuhvaća piljenje oblovine na dijelove trupaca koji se potom cijepaju na cjepanice. Proizvodnja ogrjevnog drva novom metodom pokazala se 2,2 puta bržom od tradicionalne metode. Razlog veće produktivnosti nove metode jest manji broj operacija. Primjena tog pionirskog pristupa rezultirala je 25 % nižim troškovima proizvodnje ogrjevnog drva u usporedbi s troškovima u uobičajenoj praksi.*

**KLJUČNE RIJEČI:** *proizvodnja ogrjevnog drva; kronometrija; oblovina; diskovi ogrjevnog drva*

## 1 INTRODUCTION

### 1. UVOD

Nowadays wood as a fuel is an important energy source (Mydlarz and Wieruszewski, 2024; Anselmino *et al.*, 2025; Bont *et al.*, 2025). Wood can serve as a substitute for fossil fuels as an energy carrier (Schulze *et al.*, 2022). To fulfil the ambitious task of reducing greenhouse gas emissions in Estonia, it is substantially

significant to expand the application of fuelwood as a renewable energy source (Padari *et al.*, 2023).

There are many technical solutions for producing fuelwood. The applications range from traditional methods where roundwood is sawn into log sections and split into billets with an axe afterwards, to more advanced semi-automatically operating technologies that perform both tasks simultaneously (Manzone and Spinelli, 2014). Technically more advanced solutions

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enable higher productivity (Lindroos, 2008) but are more expensive, requiring large production volumes to assure cost effectiveness (Kärhä and Jouhio, 2009). For example, a study conducted in Latvia revealed that cutting grey alder stand was faster with machine-cutting method but economically more effective when cut manually (Liepinš *et al.*, 2015). According to Moradpour *et al.* (2016), optimization of wood cutting conditions can lead to the decrease of relevant cutting forces, which is ultimately related to the energy consumption.

Slicing roundwood into fuelwood discs on the felling site enables avoiding most of the lifting operations that are needed in the traditional split billet making with chainsaw and axe. The discs must be lifted only twice: first, when loading onto a vehicle, and second, when unloading from the vehicle to woodshed for drying. In traditional fuelwood production, where logs are cut into lengths suitable for splitting, the wood is typically lifted four times: first, when loading the logs onto the truck; second, when unloading them for splitting; third, when placing them onto the splitting block; and fourth, when stacking the split fuelwood. Each lifting operation adds time to the process. Additional time is also required during splitting, as sections of larger logs often need to be repositioned on the splitting block multiple times.

In the process of preparing small quantities of fuelwood, it is also important to consider the time required for loading and unloading the wood. Therefore, one of the objectives of this study was to investigate whether different preparation methods affect the speed of manual loading and unloading, as the shape of fuelwood pieces is different depending on the preparation method used.

## 2 MATERIALS AND METHODS

### 2. MATERIJALI I METODE

To determine whether cutting grey alder (*Alnus Incana* (L.) Moench) roundwood into fuelwood discs offers a time-saving advantage compared to the traditional method of sawing similar roundwood into billet-length sections and splitting them with an axe, a comparative chronometry experiment was conducted. The experiment was carried out at a forest felling site. For time measurement, sections of already felled and delimited tree trunks (logs) were used.

To ensure comparable conditions for both test materials, the same chainsaw – a Stihl 023 with a power output of 1.9 kW and the width of the chainsaw chain of 7 mm – was used for cutting in both methods. The saw chain was sharpened in the same manner prior to applying each method. During the work process, no rapid dulling of the chain occurred; the chain did not come into contact with soil, metal, stones, or any other

materials that could have significantly reduced its sharpness and remained sharp after processing the entire volume of roundwood.

To avoid contact between the saw chain and abrasive soil particles splashed onto the tree stems from the ground during rainfall, the stems used in the experiment were felled at least one meter above the root collar. The chainsaw air filter was cleaned before the start of the experiment, and its cleanliness was checked during each refuelling break to prevent any loss of engine power due to filter clogging during the test work. A special fuel for 2-stroke engines (*Aspen 2*) and chain oil (*Stihl ForestPlus*) were used in processing both woodlots in the chronometry test.

The quantities of fuelwood produced using both methods were similar in the experiment, but inevitably not identical, as the stems used varied in length and diameter. However, since the comparison focused on the time spent per unit of volume, the amounts of produced fuelwood did not need to be exactly the same. For both methods, long logs (stem sections) of similar diameter and length were selected. All the trees used in the experiment grew in close proximity within the same forest subcompartment and were of the same age and height. The proposed method involved sawing roundwood into 10 cm thick discs (Figure 1).

The traditional method consisted of sawing roundwood into 30 cm long log sections, splitting them into fuelwood billets on the same tree stump in the forest. 30 cm long log sections with a diameter greater than 20 cm were split into four billets (pieces), while those of 20 cm or less in diameter were split into two. All volume calculations were based on the solid volume of wood (without air gaps) and bark volume included. For all roundwood volume calculations, the following formula of truncated cone was used:

$$V = \pi / 12 \cdot (d_1^2 + d_1 \cdot d_2 + d_2^2) \cdot L \cdot 1000 \quad (1)$$

Where  $V$  – volume in  $\text{dm}^3$ ,  $d_1$  – diameter on bark measured from thinner end (m),  $d_2$  – diameter on bark measured from thicker end (m),  $L$  – length of stem section or log section or distance between the ends (m).

In addition to analysing the time required for fuelwood preparation using the proposed and traditional methods, this study also examined the speed of loading in the case of these two studied methods. Manual loading was chosen as the most likely loading for small-scale forestry. For this purpose, additional chronometry experiments were conducted. At the beginning of chronometry tests for loading, both discs and split billets were initially heaped loosely on the ground, and after transport, both fuelwood types were not stacked in the woodshed when unloading. Instead, they were thrown through the shed door onto the shed floor into a loose pile. All the work operations, for both pro-



**Figure 1** Grey alder stem cut into 10 cm thick discs with 1.9 kW Stihl 023  
**Slika 1.** Deblo drva bijele johe raspiljeno na diskove debljine 10 cm pilom Stihl 023 snage 1,9 kW

posed and traditional methods were carried out by the same person having a chainsaw operator certificate. During the work operations, the weather was without precipitation, 1-6 degrees above zero degrees Celsius and with moderate wind. The efficiency of both methods was compared by applying prices to the spent work time and the consumed roundwood volume.

### 3 RESULTS AND DISCUSSION

#### 3. REZULTATI I RASPRAVA

The comparative results of the chronometry tests are as follows. The average time required for the preparation of 10 cm-thick disc fuelwood (proposed method) was  $(2.1 \pm 0.3)$  s/dm<sup>3</sup>. For the traditional production of fuelwood billets by splitting 30 cm log sections with an axe, the relevant average time was  $(4.6 \pm 1.9)$  s/dm<sup>3</sup>. Comparison of time consumptions on loading and unloading fuelwood produced by proposed and traditional methods to and from a vehicle is given in Table 1.

When taking into account loading and unloading speeds from Table 1 and the production speed, the average of the proposed method is 1.0 s/dm<sup>3</sup>. The corresponding value in the case of traditional method is 1.9 s/dm<sup>3</sup>. Despite the finding that fuelwood production in the form of discs is approximately twice as fast, if compared to the traditional approach, a technical issue arises with discs of small diameter (estimated at less than 20 cm), which cannot be stacked as stably as billets. The reason is that discs under 20 cm in diameter do not interlock sufficiently to form a stable pile. Consequently, such discs must be heaped rather than stacked for storage and drying. An alternative approach is to store and dry the discs in mesh bags. The mesh

bags can be stacked up. The effectiveness of drying billets in mesh bags has been previously demonstrated in a test (Pari *et al.*, 2020).

In the loading test, it took 27 % more loading time in the case of split billets than in the case of discs. One possible explanation may be that when the 30 cm long stem part was sawn into 3 discs, each with thickness of 10 cm, the 30 cm long log section was split into 4 billets. Therefore, the number of split billets was one third higher than that of discs. To make the same number of split billets and discs, the log sections had to be split into three billets instead of four. It can be assumed that throwing more split billets than discs requires more time. Data presented in Table 2 shows that the cost for producing one m<sup>3</sup> of fuelwood is a quarter cheaper in case of discs despite of bigger roundwood losses to sawdust. The same relation is also valid after considering the labour cost of loading and unloading transportation vehicles. Purchase price of the roundwood was arbitrarily set to €25 per m<sup>3</sup> of solid volume including bark. Labour costs, incorporating tool amortisation as well as fuel and oil expenses, were arbitrarily set at €20 per hour.

Loading discs was supposedly faster because the discs were of the same thickness, and flat surfaces of discs were easier to grasp by hand compared to split billets that are in the form of sectors. When taken by hand, the sector-shaped split billets have always at least one sharp edge against the fingers. That is uncomfortable and may cause slower movements to reduce the acceleration pressure of the sharp edge to hand.

In the current work, species with relatively soft wood (grey alder) was used. Its absolutely dry specific gravity is 0.46 g/cm<sup>3</sup> (Miezite and Dreimanis, 2006). Tree species with higher absolutely dry specific gravity

**Table 1** Time consumptions on loading and unloading fuelwood produced by proposed and traditional methods to and from a vehicle

**Tablica 1.** Utrošak vremena za utovar i istovar ogrjevnog drva proizvedenoga predloženom i tradicionalnom metodom

Method <i>Metoda</i>	Volume of fuelwood, dm <sup>3</sup> <i>Volumen ogrjevnog drva, dm<sup>3</sup></i>	Loading time, s <i>Vrijeme utovara, s</i>	Unloading time, s <i>Vrijeme istovara, s</i>	Loading speed, s/dm <sup>3</sup> <i>Brzina utovara, s/dm<sup>3</sup></i>	Unloading speed, s/dm <sup>3</sup> <i>Brzina istovara, s/dm<sup>3</sup></i>
Proposed <i>predložena</i>	360	130	190	0.4	0.6
Traditional <i>tradicionalna</i>	290	190	220	0.5	0.7

**Table 2** Comparison of estimated costs of production methods

**Tablica 2.** Usporedba procijenjenih troškova proizvodnih metoda

Production costs of 1 m <sup>3</sup> solid volume of end product and their comparison <i>Troškovi proizvodnje 1 m<sup>3</sup> cjelovitog volumena gotovog proizvoda i njihova usporedba</i>	Discs <i>Diskovi</i>	Split billets <i>Cjepanice</i>	Unit <i>Jedinica</i>
Labour cost with costs of fuel, oil, and amortisation <i>trošak rada s troškovima goriva, ulja i amortizacije</i>	12	26	€
The volume of roundwood needed to produce 1 m <sup>3</sup> of end product <i>količina oblovine potrebne za proizvodnju 1 m<sup>3</sup> gotovog proizvoda</i>	1.06	1.02	m <sup>3</sup>
Cost of roundwood <i>trošak oblovine</i>	27	26	€
Cost of roundwood lost as sawdust <i>trošak oblovine izgubljene u obliku piljevine</i>	1.5	0.5	€
Costs of roundwood, labour, fuel, oil and amortisation altogether <i>ukupni troškovi oblovine, rada, goriva, ulja i amortizacije</i>	41	54	€
Price difference between methods <i>razlika u cijeni među metodama</i>	-13	13	€
Price difference between methods in % <i>razlika u cijeni među metodama, %</i>		24	%
Labour cost for loading and unloading vehicle <i>trošak rada za utovar i istovar vozila</i>	5.0	7.7	€
Labour cost difference for loading and unloading vehicle <i>razlika u cijeni rada za utovar i istovar vozila</i>	-2.7	2.7	€
Labour cost difference for loading and unloading vehicle in % <i>razlika u cijeni rada za utovar i istovar vozila, %</i>		35	%
Total costs of all production and loading operations <i>ukupni troškovi svih proizvodnih i utovarnih operacija</i>	46	62	€
Cost difference of all production and loading operations <i>razlika u cijeni svih proizvodnih i utovarnih operacija</i>	-16	16	€
Cost difference of all production and loading operations in % <i>razlika u cijeni svih proizvodnih i utovarnih operacija, %</i>		26	%

like birch, ash, maple etc. need more energy for sawing and are therefore slower to process. In the future, additional tests with other fuelwood species will be conducted for comparison of the two methods.

## 4 CONCLUSIONS

### 4. ZAKLJUČAK

The cost for producing one m<sup>3</sup> of fuelwood from grey alder roundwood in the form of discs is a quarter cheaper than the costs for producing traditional split billets.

Higher work speed is achieved mainly through omitting two time-consuming lifting operations when producing fuelwood from roundwood in the form of discs compared to the traditional manual production of split billets.

The work should be continued with other fuelwood species due to their different density.

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## 5 REFERENCES

### 5. LITERATURA

1. Anselmino, A.; Piedra-Jimenez, F.; Rodriguez, M. A.; Dondo, R. G.; Cocco, M. E., 2025: Strategic optimization of short-rotation woody crops for bioenergy production. *Biomass and Bioenergy*, 195: 107686. <https://doi.org/10.1016/j.biombioe.2025.107686>
2. Bont, L. G.; Gemperle, F.; Perry, N. T.; Werder, M.; Schweier, J., 2025: Derivation of a nationwide wall-to-wall map of fuelwood potential. *Journal of Cleaner Production*, 494: 145010. <https://doi.org/10.1016/j.jclepro.2025.145010>
3. Kärhä, K.; Jouhio, A., 2009: Producing chopped firewood with firewood processors. *Biomass and Bioenergy*, 33 (9): 1300-1309. <https://doi.org/10.1016/j.biombioe.2009.05.019>
4. Liepinš, K.; Lazdiņš, A.; Liepinš, J.; Prindulis, U., 2015: Productivity and cost-effectiveness of mechanized and motor-manual harvesting of grey alder (*Alnus incana* (L.) Moench.): a case study in Latvia. *Small Scale Forestry*, 14: 493-506. <https://doi.org/10.1007/s11842-015-9302-1>
5. Lindroos, O., 2008: The effects of increased mechanization on time consumption in small-scale firewood processing. *Silva Fennica*, 42 (5): 791-805. <https://doi.org/10.14214/sf.227>
6. Manzone, M.; Spinelli, R., 2014: Efficiency of small-scale firewood processing operations in Southern Europe. *Fuel Processing Technology*, 122: 58-63. <https://doi.org/10.1016/j.fuproc.2014.01.025>
7. Miežite, O.; Dreimanis, A., 2006: Investigations of Grey Alder (*Alnus Incana* (L.) Moench) Biomass. In: Proceedings of the 12<sup>th</sup> International Scientific Conference – Research for Rural Development 2006, Jelgava, Latvia, pp. 271-275.
8. Moradpour, P.; Scholz, F.; Doosthoseini, K.; Tarmian, A., 2016: Measurement of wood cutting forces during band-sawing using piezoelectric dynamometer. *Drvna industrija*, 67 (1): 79-84. <https://doi.org/10.5552/drind.2016.1433>
9. Mydlarz, K.; Wieruszewski, M., 2024: The energy potential of firewood and by-products of round wood processing—Economic and technical aspects. *Energies*, 17 (19): 4797. <https://doi.org/10.3390/en17194797>
10. Padari, A.; Mitt, R.; Pärn, L.; Kurvits, V.; Kaasik, S.; Muiste, P., 2023: The impact of extra long-term storage of logging residues on fuel quality in Estonian conditions – a case study. *Forestry Studies (Metsanduslikud Uurimused)*, 79 (1): 51-65. <https://doi.org/10.2478/fsmu-2023-0012>
11. Pari, L.; Rezaie, N.; Suardi, A.; Cetera, P.; Scarfone, A.; Bergonzoli, S., 2020: Medium rotation eucalyptus plant: a comparison of storage systems. *Energies*, Special Issue: Renewable Energy Production from Energy Crops and Agricultural Residues, 13 (11): 2915. <https://doi.org/10.3390/en13112915>
12. Schulze, E.; T., Bouriaud, O.; Irslinger, R.; Valentini, R., 2022: The role of wood harvest from sustainably managed forests in the carbon cycle. *Annals of Forest Science*, 79: 17. <https://doi.org/10.1186/s13595-022-01127-x>
13. Spinelli, R.; Magagnotti, N.; Lombardini, C.; Mihelič, M., 2021: A low-investment option for the integrated semi-mechanized harvesting of small-scale, short-rotation poplar plantations. *Small-Scale Forestry*, 20: 59-72. <https://doi.org/10.1007/s11842-020-09456-3>
14. Spinelli, R.; Lombardini, C.; Marchi, E.; Aminti, G., 2019: A low-investment technology for the simplified processing of energy wood from coppice forests. *European Journal of Forest Research*, 138: 31-41. <https://doi.org/10.1007/s10342-018-1150-z>

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