

## ENERGY EFFICIENCY OF THE WOOD-BASED PROCESSING MSMES IN THE NIŠ REGION

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**Abstract.** *In the Niš region, there are 185 companies involved in the treatment or manufacture of wood and wood-based products. According to the national register of enterprise activity classification, 22.7 percent of micro, small and medium enterprises are engaged in the business of wood cutting and processing, 27.03 percent are in the business of construction carpentry production, 29.73 percent are in the business of wood packaging production, 2.7 percent are in the business of pellet production, and 32.43 percent are in the business of other wood treatment production or services. This article uses a preliminary energy audit assessment technique to address the concerns of potential improvements in competitiveness, energy efficiency, and waste wood biomass use potentials in selected representatives of the indicated company groups from the Niš region. Energy usage benchmarks are established based on the audits of the selected sample enterprises.*

**Key words:** *Energy audit, waste wood, wood treatment enterprises*

### 1. INTRODUCTION

An energy audit is a key component of a database that tracks how much energy is produced and consumed in a state, region, city, municipality, or company [1].

It is a tool for analyst professionals and decision makers to utilize as the foundation for analysis, forecasting energy demand, creating future development scenarios, and establishing an entity's energy economic strategy. Energy auditing is also a key component of governmental monitoring and policy development for environmental protection.

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In order to identify energy-saving strategies on a local level, energy balancing allows for the creation of an overview of the structure of the supplied and consumed energy [2,3,4]. Two significant aspects of energy conservation should be highlighted here: the economic and environmental one. Lowering fuel consumption leads to increased reliability and quality of the utility service offered. As part of the audit technique, the amount of waste produced and the properties of the examined enterprises have been evaluated, and the potential for waste-to-energy technology has been identified. In contrast to a complete energy audit, which determines and calculates all energy and material streams of the company subject to audit, a preliminary energy balance can be utilized to obtain quick results.

The potential for waste utilization is examined and appraised in this article for wood treatment in micro, small and medium enterprises (MSME) in the Niš region. Data is acquired at the corporate level using the preliminary energy audit approach. Small and medium businesses, like the ones considered for this study, often deal with day-to-day operations with little to no consideration for energy efficiency or waste management. Furthermore, there is frequently no monitoring of energy or material usage at the process level in such small businesses; instead, these data are provided at the enterprise level, usually via invoicing and annual data. As a result, the preliminary energy audit approach is used to produce a rapid estimate of the amounts, types, and availability of waste from the Niš region's wood production.

It should be emphasized that, according to the author's best knowledge, Serbia has only one large-scale installation for the manufacturing of wood-based panels (low and medium density fibreboards), and it is located outside of Niš. According to the "scoring" search of the national registered firms [5], the Niš region has 185 enterprises involved in the treatment or manufacture of wood and wood products. Niš and Niška Banja are home to more than half of the region's small and medium businesses in the wood sector (54.6 percent). Furthermore, the number of pellet-producing small and medium firms is just 2.7 percent, with 40 percent of them located in Niš municipalities.

The small and medium businesses examined in this article produce furniture and carpentry for buildings. The companies in the sample can be considered typical regional examples of this category relative to size, revenues technologies applied, etc.

## 2. RESULTS

Typical representatives are chosen for the study presented in this paper based on their annual financial statistics, number of employees, type of production, and willingness to participate and submit data. This article examines the following production types: wood-based building carpentry and furniture manufacturing.

### 2.1. Production of wood-based building carpentry

In the hottest and coldest months of the year, typical wood-based carpentry manufacturing takes place in a production hall heated by local heaters, with low levels of indoor thermal comfort for the workforce. The raw materials balance of the production is as follows: Aluminium 39.5 percent, wood 22.6 percent, steel elements 16.94 percent, and PVC elements 5.65 percent. Natural ventilation is a common method of ventilation. A drilling machine, a linear wood cutting machine, an electrical saw machine, and an edge processing equipment are basic machinery used in the manufacturing process.

The production also demands the installation of a central compressed air supply system. A typical producer treats and produces not just wood-based carpentry, but also PVC, aluminum, and wood-aluminum building carpentry elements due to market demands. Carpentry elements are created to order for each customer, however, there is almost no serial production. Wood elements are first pre-cut to a specified length and then shaped to the desired cross-section shape using linear wood cutting/processing equipment. For each order, standard length PVC and aluminum elements are acquired and stored. Linear elements (wood, aluminum, or PVC) are cut to size, drilled, and joined according to the ordered element specifications. Other components of the assembly include hinges and handles, which are purchased separately. Glass packs, as well as rubber breaths, are obtained from various sources according to the order. The company's production is done in one shift. The machines are powered by electricity. The elements are painted after machine treatment and assembly. Electric heaters are used for space heating.

The machine power rating and assessed electricity consumption are given for 100t of products per year. The power and annual electricity consumption based on the machine is given in Table 1.

**Table 1** Building carpentry production power and electricity consumption

	Count	Specific power kW	Operation hours	Consumption (kWh/god)	Ratio in annual consumption (-)
PVC welder	1	2.1	4500	8977.5	0.09
Excess treatment	1	2.6	4500	11115	0.11
Borer (drill)	1	0.74	4500	3163.5	0.03
Cross cutter	2	2	4500	17100	0.17
Handle drill	1	1.9	4500	8122.5	0.08
Drill	1	0.8	4500	3420	0.03
Saw	1	6.1	4500	26077.5	0.26
Air compressors	1	4.8	4500	20520	0.21

For a small firm in the region, the machine power and anticipated annual electricity consumption are estimated for 100t of product per year production. The saw uses the most electricity, followed by the air compressor and cross-cutting machine. Annual production achieved is 65-85 percent of real machine capacity. The chosen representative produces a higher percentage of wood-based products, with 75 percent of wood products and 23 percent of PVC items produced.

Electricity usage is calculated at the enterprise level using billing information. It is difficult to specify production per product type because the organization produces a variety of products (wood, aluminum-wood, aluminum, and PVC), and some machinery are used for all product types. The production of the chosen enterprise includes 52 percent aluminum-based products, 32 percent wood products, and 16 percent PVC products.

Achieved energy efficiency indicators are presented in Table 2.

**Table 2** Building carpentry production indicators

	Indicator
Energy efficiency indicator – electricity kWh/t of product	1389.47
Wood-based waste generation indicator t/100t of products	1,58

The average waste generation rate is 6% of raw resources. Although aluminum cut waste can be sorted, collected, and recycled, in the small enterprises examined, it is frequently mixed with communal waste. Because the glass and steel components are obtained from suppliers, there is no waste generated during production. Painting is done with paint-saving sprayer guns. Waste rubber makes up a very small portion of the total mass of waste.

The majority of waste comprise cut-out wood elements, which are created when prepared wood elements are cut to the required length based on the ordered element specifications. This wood produces 1.58t per year, or 1.37 percent of the raw material mass. In a hot water wood-fired boiler or a local wood-fired heater, the waste wood elements can be utilized for space heating.

The available energy for heating for 100t of items is 6645 kWh.

## 2.2. Production of furniture

The production of furniture products is based on the local market demands and includes not just traditional wood products but mostly medium and low-density fibreboards (MDF and LDF). The surface of these boards is covered with a texture layer which could be a real wood veneer for the MDF or printed PVC-based texture. Furthermore, MDF elements can be sprayed and painted according to customer preference. Typical representative of this group from the region produces predominately MDF and LDF-based custom-made products. LDF and MDF boards are purchased from different suppliers. MDF is normally purchased without a preset surface texture or coating, whereas LDF comes with a prepared PVC coating. Production takes place in a production hall, where machines are usually operated manually.

To make the most of the raw materials, the production process begins with determining a cutting pattern for each of the boards. This is accomplished either via the experience and design of the responsible person (usually the owner) or through the use of plate furniture software. The cut plate elements layers are covered with a PVC layer, and more processes on other machinery are performed before the full or partial assembly of furniture elements is completed.

The elements of MDF products can be sprayed and painted after assembly, or coated with real wood veneer and sprayed and protected by a transparent paint layer. The spray nozzles are suitable for the application of optional paint. A 20kW hot water boiler is used by the representative company for space heating via a radiator system. Local heaters or a central hot water system with a boiler provide space warmth.

Typical electrical power based on the 100t of annual production capacity is given in table 3.

Table 3 Furniture production power and electricity consumption

	Count	Specific power kW	Operation hours	Consumption (kWh/god)	Ratio in annual consumption (-)
Border tape layer adding machine	1.00	5.80	0.65	4500	10440
Formatizer	1.00	6.25	0.65	4500	12656.25
Borer	4.70	0.60	0.65	4500	5710.5
Air compressor	5.50	0.75	0.65	4500	6496.875
Lighting	23.00	0.03	0.65	4500	662.4

Not only does the company produce custom-made products, but it also assembles and installs them in customers' facilities.

Based on the material product mass, the average annual production is 30 to 40% of machine capacity. The scrap generated accounts for 10-15% of the bulk of wood-based plates. Parts of plate MDF and LDF elements make up the majority of the trash, with a tiny percentage of sawdust. In order to maintain a more organized production, sawdust is physically collected at the end of each shift.

The amount of genuine wood waste is negligible because of the product nature. Due to the adhesives used in their manufacture and the plastic-based surface texture layer of the LDF, the MDF and LDF waste elements are not suitable for combustion and heating.

Table 4 Furniture production indicators

	Indicator
Energy efficiency indicator – electricity kWh/t of product	1435,29
Wood-based waste generation indicator t/t of products	0,176
Space heating indicator kWh/t of product	823,5

Based on the raw material treatment mass, the accomplished yearly output at the representative company for this type of manufacturing was 25.5-30% of the entire annual production capacity. As a result, the electricity usage indicator might be regarded as high. Furthermore, the waste generation indicator is highly linked to the frequency of faults or customer-imposed product changes after the original production, which is typical of custom-made products.

Despite the fact that it may produce heat for space heating to almost totally fulfill the heating demands, direct combustion of the aforementioned waste generated should be avoided for the above reasons. The utilization of this type of waste is a challenge for the local recycling market at this point due to its contamination with glue and adhesives [6]. However, it should be examined whether collecting such waste and producing rough recycled construction material is viable. Construction and recycling of such materials on a small business level, however, are not practical. Instead, sorting and collecting such material on a regional level could provide enough rough material mass for feasible recycling by a third specialized entity.

## CONCLUSION

In this paper, a preliminary energy audit method was used for assessment of micro, small and medium furniture and carpentry manufacturing enterprises. The study was limited to the Serbian region of Niš. The metrics for energy efficiency and waste generation were calculated.

The determination of the quantities of created wood-based waste received special attention.

The building carpentry production provides 5-6% of the total production mass of wood element waste, which can be burned directly in wood-fired boilers to provide space heating for such production facilities. However, in the studied location, a typical furniture manufacturing facility uses prefabricated medium density fibre-board and low-density fibre-board, both of which contain adhesives and wood particles, which, in case of direct combustion, will produce a negative impact on air pollution. A textured plastic-based coating is often applied to low-density fibre-board. Hence, such waste materials require development of a system of organized sorting, collecting and recycling, as they cannot be considered adequate for direct combustion.

Based on the overall mass of treated materials, the creation of furniture from prefabricated boards yields 10-15% of wood-based board mass. However, despite the higher proportion of waste components in this form of production, direct combustion cannot be used to generate heat. The search for a solution for this type of production should focus on recycling, which is heavily influenced by the region's recycling technology and, in particular, the market for recovered materials.

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## **ENERGETSKA EFIKASNOST SEKTORA PRERADE DRVETA MMSP U NIŠKOM REGIONU**

*U Niškom regionu postoji 185 preduzeća koja se bave preradom ili proizvodnjom drveta i proizvoda od drveta. Prema nacionalnom registru delatnosti preduzeća, 22,7 posto preduzeća se bavi sečom i preradom drveta, 27,03 posto proizvodnjom građevinske stolarije, 29,73 post proizvodi ambalažu od drveta, 2,7 posto se bavi proizvodnjom peleta, a 32,43 postoposluje u oblastima drugih proizvoda i usluga u vezi sa obradom drveta. Ovaj članak koristi metodu preliminarnog energetskeg pregleda kako bi na osnovu rezultata izabranih mikro, malih i srednjih preduzeća, bile identifikovane potencijalne mere za poboljšanje energetske efikasnosti a time i konkurentnosti, ali je poseban akcenat stavljen na određivanju potencijala za upotrebu otpadne drvne biomase. Pored toga, u radu su definisane referentne vrednosti indikatora energetske efikasnosti na mikro, malih i srednjih preduzeća iz Niškog regiona, na osnovu analiziranog uzorka.*

**Ključne reči:** *Energetski pregled, otpadno drvo, preduzeća za obradu drveta*