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# The EU-27 Import of Selected Wood Fuels and Current Changes in Supplying

## Uvoz odabranih drvnih goriva u zemlje EU-27 i promjene u opskrbi

**ABSTRACT** • *The paper presents the results of the analysis of the supply of wood pellets, wood chips, wood briquettes, sawdust and wood waste and scrap on the EU market from non-EU countries in the period 2010-2023. The aim of the study was to identify the most important non-EU countries for the supply of selected wood fuels to the EU market and the volume of imports. In addition, the value of imports of selected fuels from non-EU countries and from individual non-EU countries that are the largest suppliers to the EU market were analyzed. The study pays particular attention to the period 2022-2023, during which the EU initially reduced and then suspended imports of wood fuels from Russia and Belarus. The EU met part of its energy needs by importing wood fuels from non-EU countries during the period under review. The analyses carried out provided an insight into the EU's energy dependence on the import of selected wood fuels from non-EU countries. Regression models were used in this paper to determine the impact of EU imports of wood pellets from non-EU countries on the consumption of wood pellets in the EU.*

**KEYWORDS:** *wood pellets; wood chips; wood briquettes; sawdust; wood waste and scrap; energy*

**SAŽETAK** • *U radu su prikazani rezultati analize opskrbe tržišta EU-a drvnim peletima, drvnom sječkom, drvnim briketima, piljevinom i drvnim ostatcima iz zemalja izvan EU-a u razdoblju 2010. – 2023. Cilj studije bio je identificirati najvažnije zemlje izvan EU-a za opskrbu tržišta Unije odabranim drvnim gorivima i odrediti količinu uvoza. Osim toga, analizirana je vrijednost uvoza odabranih goriva iz zemalja nečlanica Unije te pojedinih zemalja izvan EU-a koje su najveći opskrbljivači njezina tržišta. Posebna pozornost u ovom istraživanju pridana je razdoblju 2022. – 2023., tijekom kojega je Unija isprva smanjila, a zatim obustavila uvoz drvnih goriva iz Rusije i Bjelorusije. Tijekom promatranog razdoblja Unija je dio svojih energetskih potreba zadovoljila uvozom drvnih goriva iz zemalja koje nisu njezine članice. Provedene analize dale su uvid u energetsku ovisnost Unije o uvozu odabranih drvnih goriva iz zemalja koje nisu njezine članice. U radu su primijenjeni regresijski modeli kako bi se odredio utjecaj uvoza drvnih peleta iz zemalja nečlanica EU-a na potrošnju drvnih peleta u Uniji.*

**KLJUČNE RIJEČI:** *drvni peleti; drvna sječka; drvni briketi; piljevina; drvni otpad i ostatak, energija*

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# 1 INTRODUCTION
## 1. UVOD

The European Renewable Energy Directive (RED I) defines the targets, rules, principles and support schemes for the use of renewable energy up to 2020 (European Commission, 2009). The target originally set in RED I that the share of renewable energy in gross final energy consumption in the EU should be 20 % by 2020 was achieved within the planned timeframe (European Commission, 2009). In RED II, a share of at least 32 % of renewable energy in gross final energy consumption in the EU by 2030 was set (European Commission, 2018).

EU targets for renewable energy consumption are always closely linked to climate challenges. In this aim, in 2020 it was proposed that the share of renewable energy in gross final energy consumption in the EU should reach 40 % by 2030 in order to achieve the planned reduction in greenhouse gas emissions (European Commission, 2020). In 2021, in the Proposal of RED II it was suggested that the share of renewable energy in gross final energy consumption in the EU should be increased to 38 % - 40 % by 2030 (European Commission, 2021). The proposed increase is justified by the achievement of the EU's climate-neutrality targets by 2050 (European Commission, 2021; Parajuli et al., 2024). The REPowerEU plan was adopted in 2022, which further promotes the use of renewable energy in the EU. Due to the disruption in the European energy market caused by the war between Russia and Ukraine, the REPowerEU plan was adopted with the aim of rapidly reducing the EU's dependence on Russian fossil fuels by accelerating the green transition (European Commission, 2022). In 2023, RED III prescribes a share of 42.5 % of renewable energy in gross final energy consumption in the EU by 2030, with the members of the Union achieving a share of 45 % (European Commission, 2023). Wood fuels play an important role in achieving the planned EU target for renewable energy consumption. In 2016, "more than 60 % of the biomass supplied for energy purposes in the EU was wood-based" (Camia et al., 2021). With 45 % of the EU covered by forests and other forest land, there is a good raw material base for the production of wood fuels (European Court of Auditors, 2021). In 2018, almost half of the wood biomass used in the EU was used for energy production (European Court of Auditors, 2021). "The use of wood for energy offers a flexible way to provide renewable energy, with additional benefits for the global climate and forests" (Brack et al., 2018).

Of the selected fuel categories, wood pellets and wood chips are the most traded on the European market (U.S. Department of Agriculture, 2024a). The EU has been the largest producer and consumer of wood pellets in the world for years, producing 44 % and con-suming 50 % of global production (Petrović, 2014; Bioenergy Europe, 2024; U.S. Department of Agriculture, 2024a). In 2021, production reached 19.6 million tons, in 2022 it increased to 20.3 million tons, and in 2023 to 20.8 million tons (Voegele, 2022; U.S. Department of Agriculture, 2024a). Consumption of wood pellets in the EU reached 22.9 million tons in 2021 and 24.8 million tons in 2022 (U.S. Department of Agriculture, 2024a). In 2023, wood pellet consumption in the EU decreased by 1.2 % to 24.5 million tons, which was the first decline in consumption since 2015 (U.S. Department of Agriculture, 2024a). The total amount of wood chips available on the European market is not only used for energy production, but also for the production of wood-based panels as well as pulp and paper (Lamers et al., 2012; Jiang et al., 2017). Wood chips used for energy production generally have shorter transportation distances in terms of moisture content and heat output (Lamers et al., 2012). Wood chips and sawdust, which are by-products of wood processing, are often used for energy production in wood industry factories (Sahoo et al., 2022).

The study, whose results are presented in this paper, was carried out with the aim of determining the volume of imports of wood pellets, wood chips, wood briquettes, sawdust and wood waste and scrap from non-EU countries into the EU. The study also aimed to identify the most important non-EU countries for supplying the EU market with selected wood fuels. One more aim of the study was to determine the extent to which the EU meets its energy needs by importing selected fuels from non-EU countries. The study paid particular attention to the period 2022-2023, during which the EU suspended imports of selected wood fuels from Russia and Belarus. Accordingly, the resulting changes in the supply of the EU market were analyzed.

# 2 MATERIALS AND METHODS
## 2. MATERIJALI I METODE

The study, whose results are presented in this paper, was carried out according to the methodology adopted, which is based on the following. The determination of the energy demand met by the EU-27 in the period 2013-2022 through the import of wood pellets, wood briquettes and wood chips from non-EU countries is based on the values of the net calorific value of the analyzed fuels, as defined in the European standard EN ISO 17225 (2-4): "Solid biofuels - Fuel specifications and classes". In accordance with the requirements defined in the second part of the standard, the lower calorific value of this fuel of 16.5 MJ/kg was used to determine the energy obtained from the combustion of wood pellets (Petrović, 2014). The calculation also includes sawdust imported by the EU from non-EU

countries during the period under consideration. It was assumed that the entire quantity of imported sawdust from non-EU was used for the production of wood pellets in the EU and based on the experience of manufacturers in Serbia, that 1.2 tons of sawdust can be used to produce one ton of wood pellets. The calculation of the energy obtained from the combustion of wood briquettes is based on the net calorific value of this fuel of 15.5 MJ/kg (EN ISO 17225, 2021).

International trade in wood briquettes and similar fuels used to be recorded under the same code in the Eurostat database until 2021, which is why it is not possible to determine the amount of energy obtained from the combustion of each type of fuel. When calculating the energy obtained from combustion, the net calorific value of the wood briquettes was used, as it is not known from which type of wood similar fuels were produced and what their moisture content was.

For the calculation of the energy obtained by burning wood chips, a moisture content of 35 % was assumed, whereby the net calorific value for coniferous wood chips at the specified moisture content is 11.63 MJ/kg and the net calorific value for hardwood at the same moisture content is 11.5 MJ/kg (EN ISO 17225, 2021). The adopted moisture content of wood chips is explained by the hygroscopic properties of wood, which dries at higher air temperatures. Trade in wood chips with a high moisture content is avoided (or limited to short distances) in order to save transportation costs.

The calculation of the energy demand met in the EU by the import of wood chips from non-EU countries was therefore carried out specifically for wood chips from softwood and hardwood, but the data is presented in a summarized form. To determine the maxi-

mum energy potential that could be achieved in the EU by burning wood chips imported from non-EU countries during the analyzed period, it was assumed that the total quantity of imported wood chips was used to generate energy.

The analysis of the EU-27 energy balances for the period 2013-2022 showed that wood pellets, wood chips and wood briquettes were used in the household, commercial and public services, industry and agriculture sectors. Energy balances from the Eurostat database were used to determine the energy demand that could be met in four sectors in the EU by importing selected wood fuels from non-EU countries (Eurostat, 2024a). The energy balance for 2023 was not yet available in the Eurostat database at the time of publication. The substitution of energy that could be obtained in the EU by burning wood fuels imported from non-EU countries, with the energy from natural gas was calculating using a net calorific value of this fossil fuel of 40 MJ/m$^3$ (Norwegian Petroleum, 2024).

An analysis of international trade flows of selected wood fuels was carried out on the basis of data from the Eurostat database (Eurostat, 2024b). In the Eurostat database, the data for selected wood fuels are listed in Chapter 44: Wood and articles of wood. The Eurostat database uses eight-digit codes, which are identical to customs tariffs, to record international trade in selected wood fuels (Eurostat, 2024b). For the purposes of the study, the codes for wood pellets, wood chips, wood briquettes, sawdust and wood waste and scrap were used as in Table 1 (Eurostat, 2024b).

In the period 2010-2012, trade in non-agglomerated sawdust and sawdust agglomerated into briquettes and similar forms of fuel was recorded under a com-

**Table 1** Eight-digit codes for wood fuels used in Eurostat database (Eurostat, 2024b)
**Tablica 1.** Osmeroznamenkasti kodovi za drvna goriva korišteni u bazi podataka Eurostata (Eurostat, 2024b)

| Type of wood fuel<br>*Vrsta drvnoga goriva* | Eight-digit codes and periods in which they were used<br>*Osmeroznamenkasti kodovi i razdoblja u kojima su korišteni* |
|---|---|
| Wood chips: coniferous<br>*drvna sječka: četinjače* | 44012100: „coniferous wood in chips or particles" (2010 – ) |
| Wood chips: broadleaves<br>*drvna sječka: listače* | 44012200: „wood in chips or particles" (2010 – 2020)<br>44012210: „wood in chips or particles, of eucalyptus" (2021 – )<br>44012290: „wood in chips or particles" (2021 – ) |
| Wood pellets<br>*drvni peleti* | 44013020: „sawdust and wood waste and scrap, agg. in pellets" (2010 – 2011)<br>44013100: „wood pellets" (2012 – ) |
| Sawdust<br>*piljevina* | 44013930: „sawdust of wood, not agglomerated" (2013 – 2016)<br>44014010: „sawdust not agglomerated" (2017 – 2021)<br>44014100: „sawdust not agglomerated" (2022 – ) |
| Wood waste and scrap<br>*drvni otpad i ostatak* | 44013980: „wood waste and scrap, not agg. excl sawdust" (2013 – 2016)<br>44014090: „wood waste and scrap, not agg, excl sawdust" (2017 – 2021)<br>44014900: „wood waste and scrap, not agg, excl sawdust" (2022 – ) |
| Wood briquettes<br>*drvni briketi* | 44013920 „sawdust and wood waste and scrap, agg. in logs, briquetts or similar forms, excl. pellets" (2013 – 2016)<br>44013900: „sawdust and wood waste and scrap agg. in logs, briquetts or similar forms, excl. pellets" (2017 – )<br>44013200: „wood briquettes" (2022 – ) |

mon code. Therefore, the analysis of EU imports of these fuels was performed as of 2013, when two codes were introduced to record the above-mentioned fuels. The same analysis procedure was used for wood waste and scrap. The term total imports is used in this paper to refer to the sum of EU wood fuel imports from non-EU countries and wood fuel imports between EU Member States.

Regression models were used in the paper to determine the functional dependency between EU imports of wood pellets from non-EU countries and the consumption of this fuel in the EU. Wood pellets were selected for the analysis because it is assumed that they are used entirely for energy production. The regression models were created based on data from the following sources. Data on the import of wood pellets into the EU from non-EU countries was taken from the Eurostat database, while data on the consumption of wood pellets in the EU for the period 2014-2023 was taken from the report of the U.S. Department of Agriculture (Eurostat 2024b; U.S. Department of Agriculture 2022, 2024a). To determine the impact of wood pellet imports from non-EU countries on wood pellet consumption in selected sectors in the EU, linear, power and exponential regression models were created.

The selection of the regression model that best describes the analyzed dependencies was based on the highest value of the coefficient of determination and the smallest standard error (Glavonjić *et al.*, 2009). The power regression model is converted into a linear form and presented in Section 3.4. In determining the impact of imports from non-EU countries, which are the largest suppliers of wood pellets to the EU market, on the consumption of this fuel in the EU, regression models were created to examine the impact of imports from the USA, followed by Ukraine and Brazil. The parameters of three series of models (linear, power and exponential for each country) showed that the largest impact on the consumption of wood pellets in the EU comes from imports from Ukraine. The influence of imports from Ukraine on the consumption of wood pellets in the EU is best represented by a power regression model (largest coefficient of determination and smallest standard error). The power model is converted into a linear form and presented in Section 3.4. The regression models were created using the "Statistics 7.0" software package that combines correlation and regression in a single methodological tool (StatSoft Europe GmbH, Germany).

## 3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

This chapter presents the results of the analysis of the supply of the EU market with selected wood fuels

from non-EU countries. The main non-EU countries supplying the EU market with selected fuels were identified, as well as the value of EU imports of these fuels in the period 2010-2023. Particular attention in the analysis was paid to the period 2022-2023, during which the supply on the EU market changed due to the reduction and then suspension of imports from Russia and Belarus. The percentage share of energy demand in four sectors in the EU met by imports of selected wood fuels from non-EU countries in the period 2013-2022 was determined. Regression models demonstrated the existence of a functional dependency between EU imports of wood pellets from non-EU countries and the consumption of this fuel in the EU.

### 3.1 Supply of selected wood fuels to the EU market
3.1. Opskrba tržišta EU-a odabranim drvnim gorivima

In the period from 2010 to 2023, non-EU countries were the primary suppliers of wood chips and wood pellets to the EU market (Figure 1). A peak in EU imports of wood chips from non-EU countries was observed in 2019, reaching 7.6 million tons, followed by a steady decline in imports, which fell to 2.6 million tons by 2023 (Eurostat, 2024). Although the import of wood fuel from Russia and Belarus was significantly reduced and ultimately halted during 2022-2023, this situation did not impede the supply of wood pellets to the EU market. In response to these changes, the EU had record imports of wood pellets from non-EU countries, totaling 5.9 million tons in 2022, with a decrease to 4.9 million tons in 2023 (Eurostat, 2024). The import of wood briquettes, sawdust, and wood waste and scrap from non-EU countries remained considerably lower than that of wood chips. A record import of wood briquettes reached 1.0 million tons in 2018, followed by sawdust imports of 0.5 million tons in 2021, and wood waste and scrap imports of 1.5 million tons in 2013 (Eurostat, 2024). Following these peak values, the EU decreased the import of all three wood fuel types from non-EU countries until 2023, with wood briquette import dropping to 0.4 million tons, sawdust to 0.13 million tons, and wood waste and scrap to 1.2 million tons (Eurostat, 2024).

### 3.1.1 Major non-EU countries for the supply of wood chips to the EU market
3.1.1. Glavne zemlje izvan EU-a za opskrbu tržišta Unije drvnom sječkom

During the period under review, Belarus and Russia were the largest suppliers of wood chips to the EU market, while Uruguay, Brazil and Norway were significantly less important (Figure 2). In 2019, record imports from these countries amounted to 7.3 million tons, accounting for 96.7 % of imports from non-EU
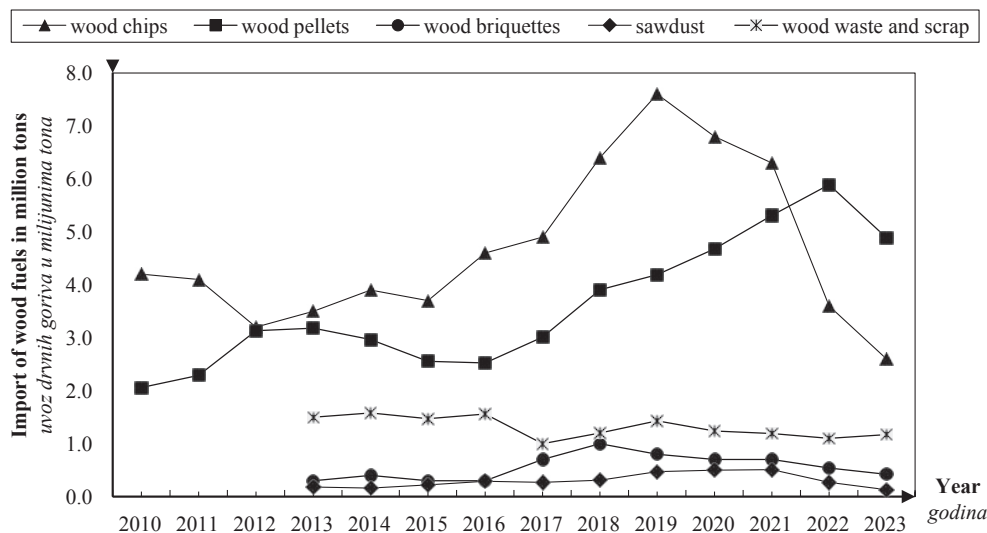
**Figure 1** Market supply in the EU-27 with wood chips, wood pellets, wood briquettes, sawdust and wood waste and scrap from non-EU countries in the period 2010-2023 (Eurostat, 2024)
**Slika 1.** Tržišna opskrba u EU-27 drvnom sječkom, drvnim peletima, drvnim briketima, piljevinom te drvnim otpadom i ostatcima iz zemalja izvan EU-a u razdoblju 2010. – 2023. (Eurostat, 2024.)

countries (Belarus 43.9 %, Russia 28.7 %, Uruguay 12.7 %, Norway 7.3 %, Brazil 4.1 %) (Eurostat, 2024). After the EU achieved record imports of wood chips from Belarus of 3.3 million tons in 2019 and from Russia of 2.5 million tons in 2020, imports from these two countries were reduced in 2022 and stopped in 2023 (Eurostat, 2024). As a result, EU imports of wood chips from non-EU countries were 42.0 % lower in 2022 than in 2021 and 28.3 % lower in 2023 than in 2022 (Eurostat, 2024).

With the exception of the period 2010-2011, imports from Uruguay did not exceed 1.0 million tons in the other years of the period under review, nor did imports from Norway and Brazil (Eurostat, 2024). Russia mainly supplied wood chips to Finland, Belarus to Poland, Lithuania and Latvia, Brazil and Uruguay to Por-

tugal and Norway to Sweden. In 2023, Russia was replaced by Latvia and Estonia on the Finnish market, Belarus was replaced by Lithuania on the Polish market, while Latvia became the largest supplier to Lithuania and Estonia to Latvia (Eurostat, 2024).

### 3.1.2 Major non-EU countries for the supply of wood pellets to the EU market
### 3.1.2. Glavne zemlje izvan EU-a za opskrbu tržišta Unije drvnim peletima

With the exception of 2010, when Canada was the largest supplier of wood pellets to the EU market, it was the USA and Russia in the other years of the period under review. Ukraine, Brazil, Belarus and Canada were less important for supplying the EU market in the other years of the period under review (Figure 3). In 2021, the EU imported 5.1 million tons from the coun-
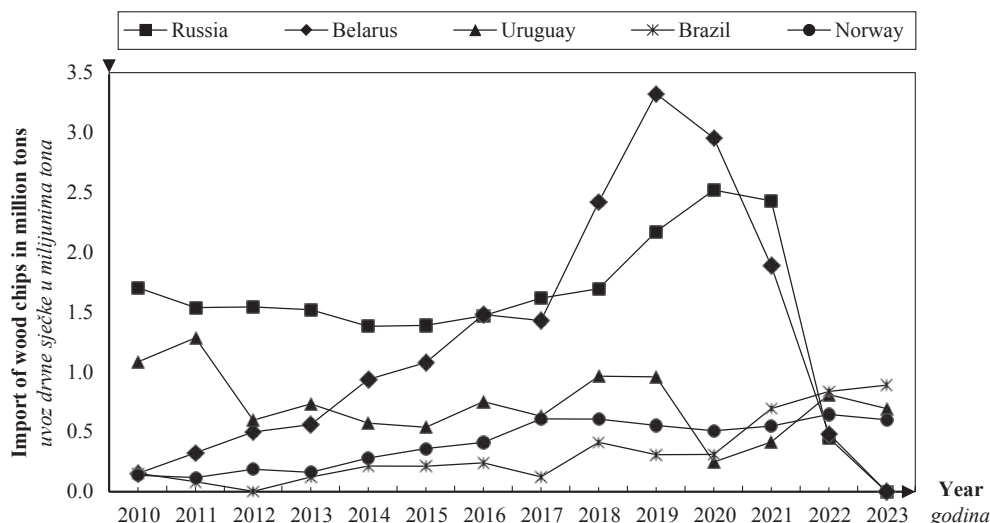


**Figure 2** Major non-EU countries for the supply of wood chips to the EU market in the period 2010-2023 (Eurostat, 2024)
**Slika 2.** Glavne zemlje izvan EU-a za opskrbu tržišta Unije drvnom sječkom u razdoblju 2010.– 2023. (Eurostat, 2024.)
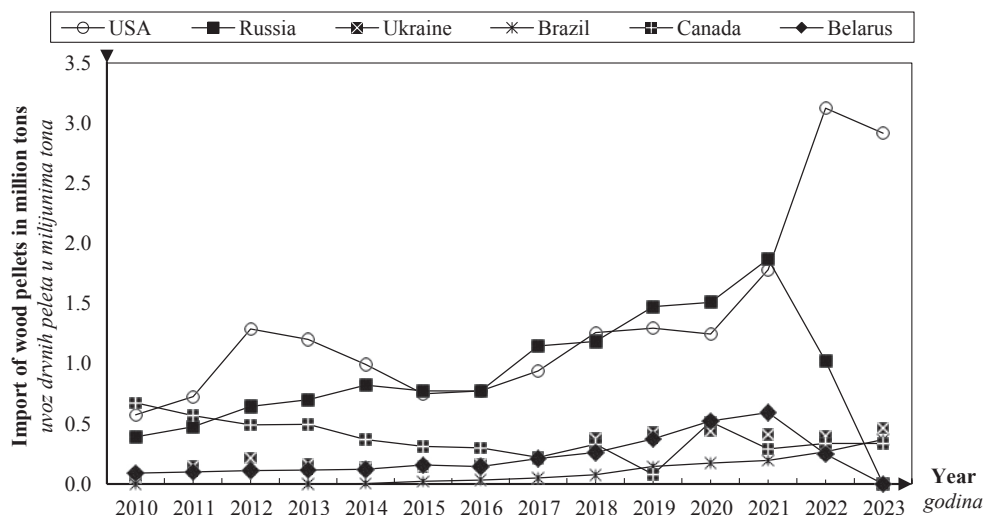
**Figure 3** Major non-EU countries for the supply of wood pellets to the EU market in the period 2010-2023 (Eurostat, 2024)
**Slika 3.** Glavne zemlje izvan EU-a za opskrbu tržišta Unije drvnim peletima u razdoblju 2010. – 2023. (Eurostat, 2024.)

tries mentioned above, which corresponded to 96.9 % of imports from non-EU countries (Russia 35.2 %, the USA 33.5 %, Belarus 11.2 %, Ukraine 7.7 %, Canada 5.5 %, and Brazil 3.8 %). Due to the decline in imports from Russia in 2022, the USA again became the largest supplier of wood pellets to the EU market. In the same year, the EU increased its wood pellet imports from the USA by 75.4 % compared to 2021. In 2022, EU wood pellet imports from the USA, Ukraine, Brazil and Canada accounted for 70.1 % of imports from non-EU countries (USA 53.0 %, Ukraine 6.8 %, Canada 5.7 %, and Brazil 4.6 %). Although imports from the USA fell by 6.7 % in 2023 compared to 2022, the share of the four largest suppliers in EU imports from non-EU countries rose to 83.2 % (USA 59.4 %, Ukraine 9.5 %, Brazil 7.5 %, and Canada 6.8 %). By 2021, Russia and the USA supplied most wood pellets to the Nether-

lands, Belgium and Denmark, Brazil to Italy, Canada to the Netherlands, Belarus to Latvia and Lithuania and Ukraine to Poland and Slovenia. In 2023, the USA, Brazil and Ukraine retained their markets, and Canada exported to Italy, Denmark and France. The new situation forced some members of the Union to work with new suppliers, with the result that Lithuania imported most of its pellets from Vietnam in 2023.

### 3.1.3 Major non-EU countries for the supply of wood briquettes to the EU market
3.1.3. Glavne zemlje izvan EU-a za opskrbu tržišta Unije drvnim briketima

During the analyzed period, Ukraine and Russia were the largest suppliers of wood briquettes to the EU market, while the importance of Bosnia and Herzegovina, Belarus and Norway were significantly lower (Figure 4). In 2018, the EU imported a record 792,000



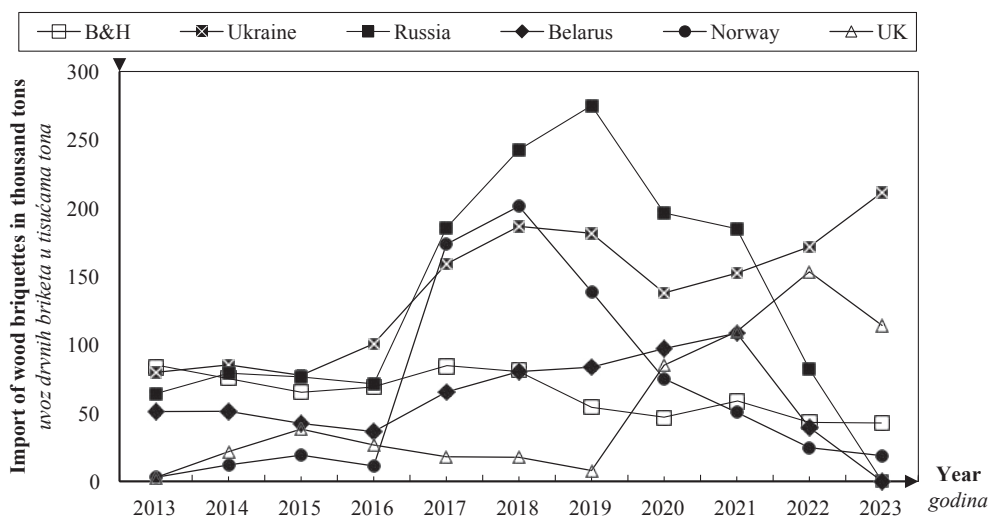**Figure 4** Major non-EU countries for the supply of wood briquettes to the EU-27 market in the period 2013-2023 (Eurostat, 2024)
**Slika 4.** Glavne zemlje izvan EU-a za opskrbu tržišta EU-27 drvnim briketima u razdoblju 2013. – 2023. (Eurostat, 2024.)

tons of wood briquettes from these countries, which accounted for 81.8 % of imports from non-EU countries (Russia 25.1 %, Norway 20.7 %, Ukraine 19.3 %, Bosnia and Herzegovina 8.4 %, and Belarus 8.3 %). In terms of supplying the EU market with wood briquettes, Russia and Belarus were replaced by Ukraine and the UK. A record EU import of wood briquettes from the UK was achieved in 2022 and from Ukraine in 2023. Imports from Bosnia and Herzegovina and Norway were reduced in the period 2022-2023. In the structure of wood briquette imports from non-EU countries to the EU in 2023, the share of the countries mentioned amounted to 91.6 % (Ukraine 50.0 %, the UK 27.0 %, Bosnia and Herzegovina 10.2 %, and Norway 4.4 %). In 2021, Russia supplied the most to Lithuania, Denmark and Germany, Belarus to Germany and Lithuania, Bosnia and Herzegovina to Slovenia, Austria, Italy and Germany, the United Kingdom to Sweden and Ireland, Norway to Sweden, Ukraine to Germany, Slovakia and Poland. In 2023, Bosnia and Herzegovina retained its markets, the United Kingdom and Norway also retained theirs, while Ukraine supplied Poland the most.

### 3.1.4 Major non-EU countries for the supply of sawdust and wood waste and scrap to the EU market
3.1.4. Glavne zemlje izvan EU-a za opskrbu tržišta Unije piljevinom te drvnim otpadom i ostatcima

During the analyzed period, Russia, Belarus and Norway were the largest suppliers of sawdust to the EU market. In 2021, the EU achieved a record import of 511,800 tons of sawdust from the mentioned countries, which corresponded to 99.5 % of imports from non-EU countries (Russia 38.9 %, Belarus 36.7 %, and Norway 23.9 %). In 2020, record imports from Russia of 219,300 tons were achieved, and from Belarus of 188,600 tons in 2021. Due to the reduction and subsequent suspension of imports from Russia and Belarus, the EU imported 46.9 % less sawdust from non-EU in 2022 than in 2021 and 53.4 % less in 2023 than in 2022. Russia and Belarus were replaced on the European market by the UK, from which the EU imported 7.8 – fold higher more sawdust in 2022 than in 2021 and 4.7 – fold higher more in 2023 than in 2022. Imports from Norway increased slightly in 2022 compared to 2021, while they decreased in 2023. Russia exported the most sawdust to Finland, and Belarus and Norway to Latvia. In 2023, Russia was replaced by Sweden on the Finnish market, while Latvia mainly imported sawdust from Lithuania, Denmark and Norway.

Norway, the UK, Switzerland, Russia and Ukraine were the largest suppliers of wood waste and scrap to the EU market in the period 2013-2021. The largest import from Russia of 221,700 tons was registered in 2016 and it did not exceed 130,000 tons until 2021 (Eurostat, 2024). In 2021, the EU imported 0.9 million tons of wood waste and scrap from the five largest suppliers, accounting for 77.1 % of imports from non-EU countries, and the share of the four countries rose to 78.6 % in 2022 and 82.2 % in 2023 (Eurostat, 2024). The suspension of imports from Russia mainly benefited the UK and Ukraine. Imports of wood waste and scrap from the UK, which were less than 1,000 tons in 2020, increased to 22,899 tons in 2022 and 102,269 tons in 2023 (Eurostat, 2024). In 2021, the EU imported 56,368 tons of wood waste and scrap from Ukraine, in 2022 the value increased to 102,015 tons, and in 2023 the import reached the level of 2021 again (Eurostat, 2024). In 2021, Russia supplied the most wood waste and scrap to Finland, Norway to Sweden, Switzerland to Germany, Austria, Italy and France, and the USA and Canada to France. In 2023, Russia was replaced on the Finnish market by Sweden and the UK, while the other countries retained their markets (Eurostat, 2024).

### 3.2 Value of EU wood fuel imports from non-EU countries
3.2. Vrijednost uvoza drvnoga goriva u EU iz zemalja nečlanica

Although imports from Russia and Belarus were reduced, the EU achieved a record level of imports of analyzed wood fuels from non-EU countries in 2022. The largest share of the record value of EU imports of all analyzed types of wood fuels of € 1.82 billion were wood pellets with a record import value of € 1.27 billion (Eurostat, 2024). In the value structure of EU imports from non-EU countries, wood pellets accounted for 69.5 % in 2022 (2021:61.4 %), while the share of wood chips was 20.3 % (2021:28.0 %), briquettes 5.5 %, wood waste and scrap 4.0 % and sawdust 0.7 %. In 2023, the value of EU imports of wood pellets decreased by 14.9 % compared to 2022, and the value of EU imports of selected wood fuels from non-EU countries decreased to € 1.59 billion (Eurostat, 2024). The trend towards growth in the value of EU imports from non-EU countries in the period 2022-2023 was also observed for wood waste and scrap, which increased from € 73.2 million (2022) to € 84.4 million (2023) (Eurostat, 2024). In contrast, the value of the import of wood chips has steadily decreased since 2019, when it reached a record value of € 400.5 million, to € 309.4 million in 2023. The same trend was recorded for sawdust, the import value of which fell continuously from a record value of € 14.4 million in 2019 to a level of € 9.9 million by 2023 (Eurostat, 2024). The record value of wood briquette EU imports of € 106.5 million was achieved in 2018 and decreased to € 99.5 million in 2022, i.e. to € 70.1 million in 2023 (Eurostat, 2024).

### 3.2.1 Value of EU imports of analyzed wood fuels from certain non-EU countries

3.2.1. Vrijednost uvoza analiziranih drvnih goriva u EU iz određenih zemalja nečlanica

In the period 2010-2021, Russia, the USA, Belarus, Ukraine, Brazil and Canada were the EU's largest foreign trade partners for the wood fuels analyzed. In 2021, the EU imported € 1.09 billion worth of wood fuels from these countries, which corresponded to 87.7 % of the value of imports from non-EU countries (Russia 33.4 %, the USA 25.3 %, Belarus 10.4 %, Brazil 7.5 %, Ukraine 7.0 %, Canada 4.1 %) (Eurostat, 2024). Although wood fuel imports from Russia and Belarus decreased in 2022, the EU recorded a record import value of € 1.45 billion from the six countries analyzed in the same year. However, the share of these countries in the value of EU imports from non-EU countries fell to 79.6 % in the same year (USA 37.4 %, Russia 12.3 %, Brazil 10.2 %, Ukraine 10.2 %, Canada 5.5 %, and Belarus 4.0 %) (Eurostat, 2024). In 2023, the value of EU imports from the fourth countries analyzed fell to € 1.11 billion, and their share in the value of imports from non-EU countries fell to 71.6 % (USA 41.9 %, Brazil 13.1 %, Ukraine 10.4 %, and Canada 6.2 %) (Eurostat, 2024).

During the period under review, Russia supplied the EU market with all types of wood fuels. In the value structure of EU imports from Russia in 2021, wood pellets had a share of 61.7 %, wood chips 31.4 %, wood briquettes 5.0 %, sawdust 1.2 % and wood waste and scrap 0.7 %. After the EU achieved a record import value of € 416.5 million from Russia in 2021, this value dropped to € 223.7 million in 2022 (Eurostat, 2024). Apart from wood waste and scrap, Belarus supplied the EU market with all other wood fuels analyzed. Wood chips and wood pellets accounted for the largest share in the value structure of EU imports from Belarus. The record value of EU imports of wood fuels from Belarus of € 156.4 million was reached in 2019 and fell to € 73 million by 2022 (Eurostat, 2024).

After the imports from Russia and Belarus were reduced and then suspended, the EU increased the import of wood fuels from other non-EU countries, which were the largest suppliers to this market. In 2022, a record level of wood fuel imports from the USA of € 681.3 million (2021: € 314.9 million) was reached, and that amount fell to € 650.7 million in 2023 (Eurostat, 2024). In 2022, wood pellets accounted for 95.8 of the value structure of EU imports from the USA (2021: 92.9 %) and wood waste and scrap for 4.2 %, while the share of pellets rose to 97.7 % in 2023 (Eurostat, 2024). During the analyzed period, Ukraine supplied the EU market with all types of wood fuels. The value of EU imports from Ukraine increased to € 186.1 million in 2022 (2021: € 87.5 million), falling to € 160.8 million in 2023 (Eurostat, 2024). In 2022, compared to 2021, the value of EU imports of wood pellets from Ukraine increased by € 62.2 million, wood briquettes by € 26.9 million, wood waste and scrap by € 7.3 million, wood chips by almost € 2.3 million, and only the value of sawdust imports decreased by € 90,334 (Eurostat, 2024). In 2023, only the value of the import of wood chips increased, while the value of the import of other fuels decreased.

Brazil supplied the EU market with wood chips and wood pellets. The value of EU imports of these fuels from Brazil amounted to € 185.5 million in 2022 (2021: € 93.8 million) and reached a record value of € 203 million in 2023 (Eurostat, 2024). In 2022, wood pellets accounted for 46.0 % of the value structure of EU imports from Brazil (2021: 35.2 %), and in 2023 it fell to 45.3 %. In 2022, the EU imported € 99.6 million worth of wood pellets and wood waste and scrap from Canada (2021: € 50.8 million), and the import value fell to € 95.9 million in 2023 (Eurostat, 2024). In 2022, the share of wood pellets in the value structure of EU imports from this country was 82.5 % (2021: 87.6 %), and in 2023 it fell to 73.3 %.

### 3.3 Meeting the EU's energy needs by importing wood fuels from non-EU countries

3.3. Zadovoljavanje energetskih potreba EU-a uvozom drvnih goriva iz zemalja nečlanica

In the period 2013-2022, the EU could meet less than 1.0 % of its energy needs in the household, commercial and public services, industry and agriculture

**Table 2** Meeting energy demand (%) by imports of selected wood fuels from non-EU countries in the commercial and public services, households, industry and agriculture sectors in the EU-27
**Tablica 2.** Zadovoljavanje potražnje energije (%) uvozom odabranih drvnih goriva iz zemalja izvan EU-a u sektorima komercijalnih i javnih usluga, kućanstava, industrije i poljoprivrede u EU-27

| Year / Godina* | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| Share / Udio, % | 0.36 | 0.39 | 0.35 | 0.38 | 0.45 | 0.58 | 0.65 | 0.66 | 0.64 | 0.58 |

\* The calculation is based on the assumption that the total amount of sawdust imported from non-EU countries was used for the production of wood pellets in the EU-27 countries and on the assumption that the total amount of wood pellets, wood chips and wood briquettes imported from non-EU countries was used for energy production.

*\* Izračun se temelji na pretpostavci da je ukupna količina piljevine uvezene iz zemalja izvan EU-a iskorištena za proizvodnju drvnih peleta u zemljama EU-27 te na pretpostavci da je ukupna količina drvnih peleta, drvne sječke i drvnih briketa uvezenih iz zemalja izvan EU-a korištena za proizvodnju energije.*

**Table 3** Meeting energy demand (%) by imports of selected wood fuels from non-EU countries in the commercial and public services, households, industry and agriculture sectors in the EU-27
**Tablica 3.** Zadovoljavanje potražnje energije (%) uvozom odabranih drvnih goriva iz zemalja izvan EU-a u sektorima komercijalnih i javnih usluga, kućanstava, industrije i poljoprivrede u EU-27

| **Year** / *Godina* | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Billions of m³** *Milijarde* m³ | 2.5 | 2.5 | 2.3 | 2.6 | 3.1 | 3.9 | 4.4 | 4.3 | 4.4 | 3.8 |

sectors by importing wood chips, wood pellets and wood briquettes from non-EU countries (Table 2). Due to a lack of knowledge about the structure, type of wood, moisture content and the type of wood fuel for whose production it could have been used, wood waste and scrap were not included in the calculation, which is why the data in Table 2 is lower than the actual values.

If the energy produced in the EU by importing wood fuels from non-EU countries in the period 2013-2022 were to be replaced by energy from natural gas, the required quantities of natural gas would be as shown in Table 3.

### 3.4 Regression models
### 3.4. Regresijski modeli

By developing regression models, it was found that EU imports of wood pellets from non-EU countries have a strong influence ($R^2 = 0.91$) on the consumption of wood pellets in the EU. The dependence studied is best described by a power model with an Eq. 1 of the form:

$$y = 8.639606 \cdot x_1^{0.611892} \qquad (1)$$

Where:

$y$ – Consumption of wood pellets in the EU (million tons);

$x_1$ – EU import of wood pellets from non-EU countries (million tons).

The power regression model exhibited a higher coefficient of determination and a lower standard error compared to the linear and exponential models. The parameters of the equation show that if EU imports of pellets from non-EU countries increase by 1.0 %, the consumption of wood pellets in the EU is expected to increase by 0.61 %. From the values of the t-statistics and the F-test, it can be concluded that parameters a and b are statistically significant, as is the correlation coefficient (Tables 4 and 5). The model is not loaded with autocorrelation (DW test).

Regression models were created to determine the impact of EU wood pellet imports from Ukraine on wood pellet consumption in the EU. It was found that the dependence analyzed is best described by the power regression model, whose Eq. 2 has the following form:

$$y = 7.1207 \cdot x_2^{0.270515} \qquad (2)$$

Where:

$y$ – Consumption of wood pellets in the EU (million tons);

**Table 4** Results of power regression of wood pellet consumption in the EU ($y$) as a function of EU imports of wood pellets from non-EU countries ($x_1$)
**Tablica 4.** Rezultati potencijske regresije potrošnje drvnih peleta u EU-u ($y$) kao funkcije uvoza drvnih peleta u Uniju iz zemalja nečlanica ($x_1$)

| **Model** | **Constant – a, millions of tons** | **Constant – b** |
|---|---|---|
| | 8.639606 | 0.611892 |
| St. error | 0.091512 | 0.066601 |
| *t*-test (model) | 23.56368 | 9.18749 |
| *t*-test (table) | 2.262 | 2.262 |
| \|*t*-test\| | $\|t_a\| > t_{0.05}$ | $\|t_a\| > t_{0.05}$ |

Designations in the table have the following meaning: $y$ – consumption of wood pellets in the EU-27, $x_1$ – EU import of wood pellets from non-EU countries, St. error – standard error, *t*-test (model) – *t*-test value obtained in the power regression model, *t*-test (table) – *t*-test value from Student`s Table.
*Značenje oznaka u tablici: y – potrošnja drvnih peleta u EU-27, x₁ – EU uvoz drvnih peleta iz zemalja izvan EU-a, St. error – standardna pogreška, t-test (model) – vrijednost t-testa dobivena u modelu potencijske regresije, t-test (tablica) – vrijednost t-testa iz Studentove tablice.*

**Table 5** Statistical characteristics of the regression model
**Tablica 5.** Statistički pokazatelji regresijskog modela

| **Statistical characteristic** *Statistički pokazatelji* | **Values** / *Vrijednosti* |
|---|---|
| $R$ | 0.95573494 |
| $R^2$ | 0.91342927 |
| $R^2_{cor}$ | 0.90260793 |
| $F_{(1.8)}$ | 84.410 ($F_{test\,(0.05)}$: +) |
| $SE$ | 0.06182 |
| $DW$ | 1.792520 ($DW_{test\,(0.05)}$: +) |

Designations in the table have the following meaning: $R$ – coefficient of correlation, $R^2$ – coefficient of determination, $R^2_{cor}$ – corrected coefficient of correlation, $F$ – F-statistic, $SE$ – standard error, $DW$ – the Durbin-Watson statistic, 0.05 – significance level.
*Značenje oznaka u tablici: R – koeficijent korelacije, R² – koeficijent determinacije, R²cor – korigirani koeficijent korelacije, F – F-statistika, SE – standardna pogreška, DW – Durbin-Watsonova statistika, 0,05 – razina značajnosti.*

$x_2$ – EU value of wood pellet imports from Ukraine (€ million).

The power regression model exhibited a higher coefficient of determination and a lower standard error compared to the linear and exponential models. The high value of the correlation coefficient and its statistical significance (F-test) show that there is a strong correlation between the phenomena analyzed. The value of the coefficient of determination shows that 94 % of the changes in the consumption of wood pellets in the EU can be explained by changes in the

**Table 6** Results of power regression of wood pellet consumption in the EU ($y$) as a function of wood pellet imports from Ukraine ($x_2$)
**Tablica 6.** Rezultati potencijske regresije potrošnje drvnih peleta u EU-u ($y$) kao funkcije uvoza drvnih peleta u Uniju iz Ukrajine ($x_2$)

| Model | Constant – $a$, $10^6$ t | Constant – $b$ |
|---|---|---|
| | 7.1206997 | 0.270515 |
| St. error | 0.094521 | 0.024803 |
| $t$-test (model) | 20.76805 | 10.90645 |
| $t$-test (table) | 2.262 | 2.262 |
| $|t$-test$|$ | $|t_a| > t_{0.05}$ | $|t_a| > t_{0.05}$ |

Designations in the table have the following meaning: $y$ – consumption of wood pellets in the EU-27, $x_2$ – EU import of wood pellets from Ukraine, St. error – standard error, $t$-test (model) – $t$-test value obtained in the power regression model, $t$-test (table) - $t$-test value from Student`s Table.
*Značenje oznaka u tablici: $y$ – potrošnja drvnih peleta u EU-27, $x_2$ – EU uvoz drvnih peleta iz Ukrajine, St. error – standardna pogreška, t-test (model) – vrijednost t-testa dobivena u modelu potencijske regresije, t-test (tablica) – vrijednost t-testa iz Studentove tablice.*

**Table 7** Statistical characteristics of the regression model
**Tablica 7.** Statistički pokazatelji regresijskog modela

| Statistical characteristic / *Statistički pokazatelji* | Values / *Vrijednosti* |
|---|---|
| R | 0.96797905 |
| $R^2$ | 0.93698344 |
| $R^2_{cor}$ | 0.92910637 |
| $F_{(1.8)}$ | 118.95 ($F_{test (0.05)}$: +) |
| SE | 0.05274 |
| DW | 2.28266 (DW$_{test (0.05)}$: +) |

Designations in the table have the following meaning: $R$ – coefficient of correlation, $R^2$ – coefficient of determination, $R^2_{cor}$ – corrected coefficient of correlation, $F$ – $F$-statistic, $SE$ – standard error, $DW$ – the Durbin-Watson statistic, 0.05 – significance level.
*Značenje oznaka u tablici: $R$ – koeficijent korelacije, $R^2$ – koeficijent determinacije, $R^2_{cor}$ – korigirani koeficijent korelacije, $F$ – F-statistika, SE – standardna pogreška, DW – Durbin-Watsonova statistika, 0,05 – razina značajnosti.*

value of pellet imports from Ukraine (Tables 6 and 7). Parameters a and b are statistically significant, and the model is not loaded with autocorrelation (DW test). The parameters of the equation show that if EU import of wood pellets from Ukraine increases by 1.0 %, the consumption of wood pellets in the EU is expected to increase by 0.27 %.

### 3.5 Interpretation of analysis results
### 3.5. Interpretacija rezultata analize

Until 2021, non-EU countries were the major suppliers of the EU market with wood chips and from 2022 with wood pellets. The importance of non-EU countries for supplying the EU market with wood briquettes, sawdust, wood waste and scrap is significantly lower compared to wood chips and wood pellets. EU imports of wood chips from non-EU countries began to decline in 2020 and were further reduced by the cessation of imports from Russia and Belarus. In 2022-2023, the EU increased its imports of wood chips from other major non-EU supplier countries such as Brazil, Uruguay and Norway. However, imports of wood chips in 2023 were the lowest imports from non-EU countries in the period 2010-2023.

In contrast to wood chips, EU imports of wood pellets from non-EU countries reached a record level in 2022, only to fall slightly in 2023. It is assumed that the decline in imports is due to a mild winter in the 2023/2024 heating period and that there are still stocks on the market from the 2022 imports. In 2022-2023, the EU was able to maintain the stability of the wood briquette market thanks to the increase in imports from its members, as imports from non-EU countries decreased. The EU market would have been even more destabilized by the interruption of imports of wood briquettes from Russia and Belarus if imports from the Ukraine had not increased in the period 2022-2023. The suspension of imports of sawdust from Russia and Belarus has seriously affected the supply of the EU market, as these two countries, together with Norway, were the three largest suppliers to this market. Imports of wood waste and scrap into the EU decreased in 2022 compared to 2021 and increased again in 2023. Russia was less important for the supply of the EU market, which is why it did not destabilize it. The supply of wood chips, wood briquettes, and sawdust to the EU market was destabilized due to disruptions in imports from Russia and Belarus, in contrast to wood pellets and wood waste and scrap. In the period 2022-2023, the EU did not find new non-EU trading partners that could replace Russia and Belarus in supplying its market with woodchips, briquettes and sawdust. EU imports of the aforementioned fuels from non-EU countries therefore show a negative trend in the period 2022-2023. In contrast, Russia and Belarus were replaced by the USA in the supply of pellets to the EU market. As a result, the EU reached a record level of pellet imports from non-EU countries in 2022.

Until 2021, the EU paid the most for imports of analyzed wood fuels to Russia, the USA, Belarus, Ukraine, Brazil and Canada. Due to the decline and subsequent suspension of imports from Russia and Belarus, the value of EU wood fuel imports from all other major non-EU supplier countries increased. In 2022, the value of EU imports of wood fuels from the USA, Brazil, Ukraine, Canada and the United Kingdom doubled, while in 2023 the value of imports from Brazil and the United Kingdom increased and the value of imports from the USA, Canada and Ukraine decreased (Eurostat, 2024).

Given the results obtained in meeting energy needs in the EU sectors of households, commercial and public services, industry and agriculture by importing analyzed wood fuels, it is clear that the suspension of imports from Russia and Belarus will not cause important changes in the supply of energy to the EU market.

The impact of Ukraine on the EU wood pellet market should be highlighted in particular, given the values of the parameters obtained in the regression model. Given the current situation in Europe, it is difficult to predict Ukraine's role in supplying wood pellet to the EU market in the coming years.

## 4 CONCLUSIONS
## 4. ZAKLJUČAK

The study whose results are presented in this paper, was carried out using official statistical data taken from two sections of the Eurostat database, one relating to international trade in goods and the other to energy trade. In the period 2010-2023, the EU imported mainly wood chips and wood pellets from non-EU countries and significantly less wood briquettes, sawdust and wood waste and scrap. In all years of the analyzed period, EU members were the largest suppliers of selected wood fuels to their own market, except for the period 2018-2021, when non-EU countries dominated the supply of wood chips to the EU market. The EU achieved record imports of wood briquettes from non-EU countries in 2018, wood chips in 2019, sawdust in 2021 and wood pellets and wood waste and scrap in 2022.

The suspension of imports from Russia and Belarus in 2022-2023 has hit the EU wood chip market the hardest. The decline in EU imports of wood chips in that period continued the negative trend in imports of this fuel from non-EU countries that began in 2020. The EU market of wood pellets was stable in the period 2022-2023, mainly thanks to the USA. Imports of other analyzed wood fuels from non-EU countries are significantly lower compared to wood chips and wood pellets, which is why they have a smaller impact on the functioning of the EU market. Depending on the type of wood fuel, Russia and Belarus have been replaced in the supply of the EU market by other non-EU countries, most frequently by the USA, Ukraine and the United Kingdom. In the period 2022-2023, an increase in wood fuel imports was also recorded from other major non-EU countries.

Until 2021, Russia was the major supplier of wood pellets to the EU market and Belarus of wood chips and wood pellets. In 2021, the EU recorded a record value of wood fuel imports from Russia of € 416.5 million and from Belarus of € 126.9 million, which in total represented 30.0 % of the value of wood fuel imports from non-EU countries. In the period 2013-2022, by importing analyzed wood fuels from non-EU countries, the EU could meet 0.35 % (2015) and 0.66 % (2020) of energy needs in the commercial and public services sector, households, industry and agriculture. According to the values determined, the suspension of wood fuel imports from Russia and Belarus is not ex-

pected to result in any significant changes in final energy consumption in the selected sectors on the EU market. Regression models have shown that EU imports of wood pellets from non-EU countries have impact on the consumption of this fuel in the EU. Imports of wood pellets from Ukraine were also found to have influence on the consumption of this fuel in the EU. Further research in this area should focus on the factors of price and non-price competitiveness of wood pellets supplied to the EU market from non-EU countries. The suspension of imports from Russia and Belarus could be an opportunity for non-EU countries in south-eastern Europe to strengthen their role in supplying the EU market with wood pellets.

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