The application of pellets made from wood and agricultural waste as an alternative to fossil fuels

Olga Golub[1], *Dzhemma* Shushpanova[1*], *Dmitriy* Mikhailidi[1], and *Aleksandr* Mikhrabov[2]

[1]EIPC Research Institute, 38, Stremyannyy Lane, Moscow, 115054, Russia
[2]Mendeleyev University of Chemical Technology, 9, Miusskaya Square, Moscow, 125047, Russia

Abstract. The article presents an analysis of the prospects for replacing fossil fuels with pellets produced from wood and agricultural waste. The "waste-to-energy" approach means the thermal utilization of high-flammable or combustion-supporting waste components. Organic pellets are suitable for distribution as a fuel alternative in some regions with high biomass residue from previous activities or with low availability of fossil fuels. Authors note that incineration of pellets becomes one of the essential components of the modern energy generation (both in terms of economy with rising prices for fossil fuels, and in terms of the environment) while increasing the amount of useful energy corresponding with the same (or similar) emissions. The article assesses of the main wood pellet markets, and analyzes the prospects for the development of wood and agricultural waste processing industry, as well as other areas of pellet application as a product of circular economy.

1 Introduction

Nowadays, the humanity faces so-called "triple planetary crisis", manifested in the climate change, environmental pollution and waste, and biodiversity loss, caused by the anthropogenic impacts. The worst effects of such crisis have been driven hard by the energy-intensive manufacturing and logistics together with the solid waste generation.

The obvious idea is to replace the fossil fuels by an alternative – a garbage with the significant share of combustible components – in the vast majority, the organic ones [1]. The application of environmentally preferable fuel processed from timber harvesting, wood-processing and agricultural waste (hereinafter referred to as plant biomass) will save the equivalent of fossil fuel in useful energy generation and therefore will reduce the atmospheric emissions of harmful substances, the amount of waste located on landfills. It will not mitigate the emissions of the greenhouse gases (hereinafter referred to as GHG), but make them cost-effective [2].

The application of plant biomass as energy resource corresponds to the principles of the circular economy, since it reduces the burden on ecosystems, which are affected by the activities of the fuel and energy sector [3]. It may require less useful energy (or exergy) for

* Corresponding author: d.shushpanova@eipc.center

the further production of thermal and electricity from a plant biomass compared with a fossil one, for example in an area with limited access to traditional energy resources (due to the complex logistics and high prices) [4].

As for the GHG generation, the amount of CO_2 is absorbed from the atmosphere during the growth of biomass, and the same amount would be released during the useless humification or during the effective combustion [5].

The following waste from wood processing, sawmilling and the agro-industrial complex can be used to produce a fuel from plant biomass: barks, wood chips, sawdust, logging residues, pulp and paper mill waste, bagasse, cocoa husks, corn stalks and cobs, palm fibers, wheat, cotton and rice straws and husks, olive pits, nut shells, etc.

The most popular products manufactured as the result of recycling are pellets (compressed cylindrical granules of biomass) or briquettes (bars made from dried crushed biomass compressed under high pressure with some heating) which are used as solid fuel.

Pellet production has several stages – waste sorting, grinding, drying, pressing, cooling, packaging. During pressing, granules of the required size are stamped in a pellet press at a pressure of 300 bar and a temperature of 100 °C. Under such conditions, lignin softens – a polymeric organic compound, due to which the particles of the mass stick together, and the pellets acquire a stable shape and retain their strength in the future. Thus, no additional chemicals are used in the production of pellets, and there is no wastewater that can worsen the quality of water in the natural waterbodies neighboring the production units [6].

Briquettes are more usable as a fuel because they can sustain long burning, but the technology of their manufacturing faces difficulties with providing the stable quality of the raw material: even small variations in humidity and gummosity do not allow the desired industrial output. The production of pellets is easier and more profitable, that is why they have been widespread so much, and there are many available data sources about their production and consumption.

The feasibility study of economic and ecologic justified applications of waste-to-energy products as an alternative to the traditional fossil fuels is quite relevant for the implementation of circle economic integrity.

2 Materials and methods

This study employs a methodological framework which systematized statistical indicators of manufacturing, consumption and trade of pellets made from wood and agricultural waste with comparative analysis and retrospective studies.

Study involved the regional specific of application that was built due to the principles of the circle economy, combining the consumer paradigm with resource efficiency both for industrial and domestic sectors. This article uses the concept of a sustainable development, which means the rational management of natural resources with the comprehension that resource efficiency can only be assumed in the combination of life cycles for products, that impact an ecosystem.

The application of pellets and briquettes instead of fossil fuel is explored as an instrument of resource efficiency improvement and mitigation of negative environmental effects within socio-economic systems. Within the scope of addressing green challenges, the results included total manufacturing capacity and its dynamics, specific raw materials, ways and sectors of application, export abilities, expansion potentials.

After systematization of indicators, the characteristics of emerging trends within specific or regions, identifying the key factors that contribute to the development of alternative energy generation were identified.

3 Results and Discussion

3.1 Retrospective of organic waste-based solid fuel recycled products

At the beginning of the XX century, the role of pellets was considered as a feed supplement, animal bedding and cat litter. During the Great Depression in the United States of America (USA), the prices for traditional fuels had raised tremendously, and customers began to look for any available material for heating. A new product was developed and named "Pres-to-Logs" – a slow-burning, low-smoke fuel made from sawdust, wood chips and shavings, which had been pressed for specified time under high pressure and temperature conditions. This product was promoted as suitable for fireplaces and stoves in residential buildings and trailers. The pellet mill industry began to develop, after World War II, the specified equipment was shipped to European and Asian countries where the energy demand had been continually increased [7]. However, in Japan, the local pellet industry was founded only since the 1980s.

Simultaneously with the onset of the scientific and technological revolution in the 1970s, the status of the fuel and energy economic sector became the most informative indicator of the national development ability. The demand exceeding supply of fossil fuels in Europe, especially in the Mediterranean, led to the interest in alternative energy generation from wood and agricultural waste, the last was abundant in the region, so biofuel pellets were applied to heat farm facilities. After the OPEC (Organization of the Petroleum Exporting Countries) oil embargo had become effective in 1973, the traditional fuel prices increased fourfold. During this period, sales of wood stoves repeated the levels of the Pre-oil era, and the manufacturing of household stoves running on pellets was launched worldwide [8].

In 1979, after the Three Mile Island power station accident in Pennsylvania (USA), the public became more concerned about the risks of nuclear energy usage and the radioactive environmental pollution as the possible result of any alarm. It became the next step for the transition to pellets. In 1980, a referendum was held in Sweden on the gradual abandonment of nuclear power. Wood pellet plant with a production capacity of 3,000 tons per year was built there to ensure national energy security by the development of the renewable energy sources. In 1991, the Swedish government introduced a tax on GHG emissions and put in place a system of tax benefits for the biofuel operating power plants [9].

In 1986, in the Soviet Union, the energy optimization program was adopted in the context of the "Main Directions of Economic and Social Development of the USSR for 1986-1990 and for the Period up to 2000". It was aimed to cause a radical change in the structure of energy supply, its further expansion was based on the including use of biofuels, but those plans were postponed for a long time.

3.2 Current status of biofuel pellets application

According to official statistics (https://www.worldbioenergy.org), the main energy sources today are formed by coal, oil and gas, summarizing 80% of the total energy supply. However, in 2022, bioenergy, including fuel pellets, accounted for 9% at the same scale (Figure 1).

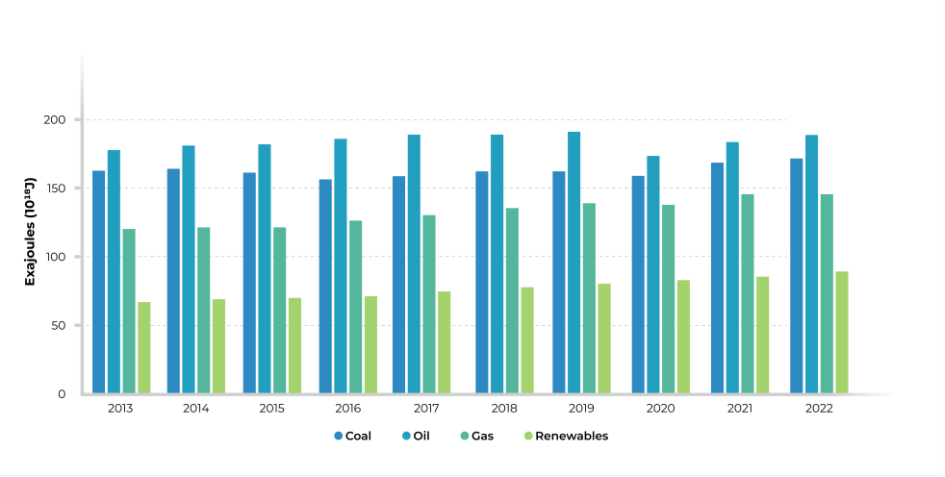

Fig. 1. The main sources of world energy supply.

In 2022, around 1.33 EJ of renewable energy was produced both at power stations and plants. Biomass provided 96% of this output. Almost 80% of the total renewable energy is generated in Europe (Figure 2).

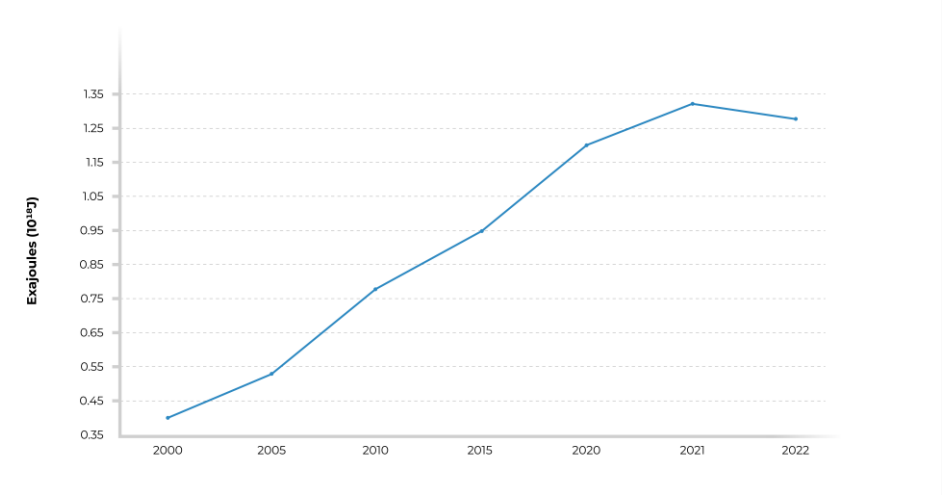

Fig. 2. World energy generation from biomass during 2000-2022. From: worldbioenergy.org

In 2022, the global domestic biomass supply reached nearly 54 EJ. At the same time, about 85% of it was generated from solid biomass waste. Asia and Africa contribute the main feedstock for biofuel manufacturing (Figure 3).

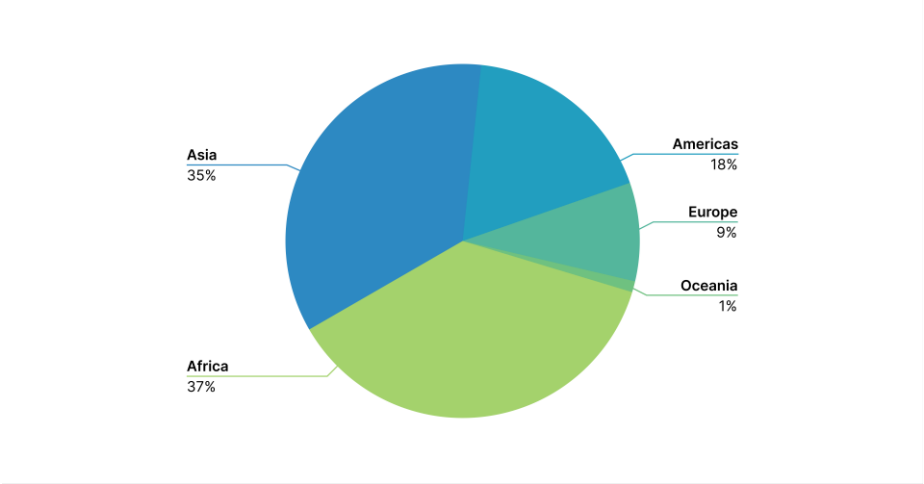

Fig. 3. World feedstock for biofuel manufacturing in 2022 (by energy).

In 2022, the global wood pellet market reached 48 million metric tons (hereinafter referred to as MMT), while Europe is contributing nearly 52%. Germany remained as the leading producer in Europe, sharing of 20% of the region's output.

The Americas shared 32% of the global market, with the USA and Canada as local dominators and the world's leading producers.

Vietnam is showing the significant growth in pellet manufacturing, its capacity is increased already for nearly 60% of Asia's pellet production to clinch second place in the world.

3.3 European pellet markets

The European pellet market has been driven by the development of renewable energy supply, particularly in the residential sector. In 2022, the municipal customers consumed 56% of total European wood pellet output, it raised for 5% within one year and before was completely stable since 2014. However, total wood pellet consumption in Europe decreased in Covid-19 era from 24.5 to 24.2 MMT. This decline contrasts with growth in manufacturing, which rose in 2022 by 3.2% to 20.4 MMT, driven by capacity expansion through the net addition of 63 new production facilities across the continent [10].

Germany produced 3.71 MMT in 2023, making it the largest producer in Europe. Its total production capacity is estimated at 4.1 MMT per year, with 90% of pellets made from timber harvesting and wood-processing waste.

France also showed a steady growth in wood pellet production, becoming the second-largest in the region, reaching 2.25 MMT in 2023. There are about 70 local pellet plants, and recent expansion has added 0.27 MMT for the specific capacity.

Combined Baltic exports fell to 2.87 MMT in 2023, from a peak of 4.69 MMT in 2021. The region is a major exporter historically, but domestic consumption has increased significantly due to the Russian gas import ban since 2022.

The Nordic region, particularly Sweden, makes the greatest contribution to the European market with 56 factories and total capacity of 2.4 MMT and there are plans to expand it by a further 0.3 MMT in the coming year to comply with increased demand from households and industry [11].

European manufacturers keep dynamic growth, but face challenges including raising self-costs and shrinking availability of wood biomass. Competition for wood waste as a

resource is intensifying, leading to growing interest in alternative biomass source such as agricultural residue. However, even with this additional feedstock, an industry is expected to be unable to keep up with growing demand, particularly from the residential heating sector.

3.4 Russian pellet market

Pellet production in Russia was founded in 2002 and was initially focused on the European market, so it was concentrated in the North-West regions due to the easy availability of raw materials and the proximity to the main sales areas and seaports. For 3 years, the number of enterprises in the Russian regions have increased by an order, reaching 0.5 MMT in 2007, 80% was exported. The domestic market for these products is gradually emerging, pellets are applied mostly in small industrial and household boilers. About 64% of cat litter in 2022 was made from wood pellets.

In March 2022, due to the introduction of restrictions against Russian industrial sector, pellets turned to the internal market, solving the import dependence problems at a time. The output of pellets in 2022 decreased by 17.5% to 2.6 MMT (Figure 4). According to Russian Statistics Agency (Rosstat), pellet export in 2023 felt by 24% compared to 2021, to 1.8 MMT. Now almost whole (95%) export is directed to South Korea, which imports large volume of wood pellets for the generation of electricity.

Russia had tried to increase the export to China, however, in accordance with the Notice of the Customs Administration of the People's Republic of China dated November 24, 2020 No. 53, wood pellets are on the list of goods prohibited from being imported to China, because they are considered as a solid waste.

Russia also exports fuel briquettes made from wood residue materials. Currently, Mongolia is considered as an export destination due to the fact that a coal-based energy generation, creates a tense environmental situation in Ulaanbaatar and coal is thought to emit more harmful substances than fuel briquette during combustion. In 2024, the Mongolian government purchased more than 0.1 MMT of briquettes for experiments in the ger areas of Ulaanbaatar.

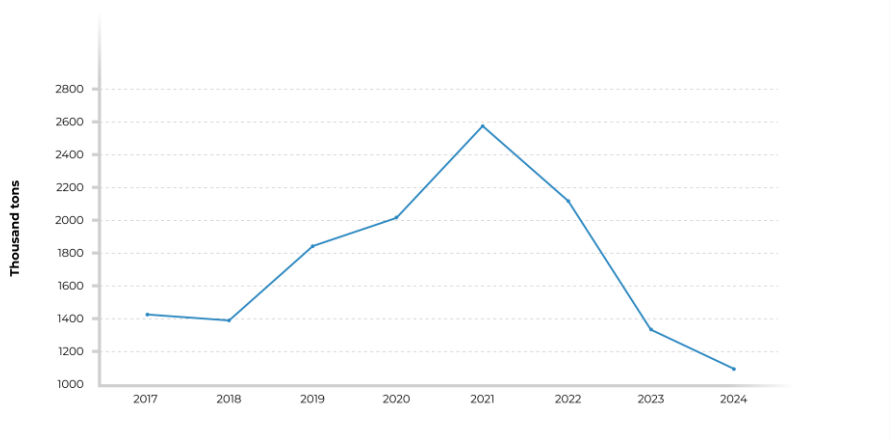

Fig. 4. Wood pellets manufacturing in Russia during 2017-2024. From: Rosstat

Currently, with the expansion of national and regional household gasification programs, pellet heating is moving to the industrial sector, but it remains relevant for the private sector in regions with limited or expensive access to natural gas pipelines. For example, some coal

thermal power plants are converted to a biofuel in the Far Eastern and Siberian regions. A number of enterprises are expressing their will to use biofuel for electricity generation. Manufacturers are turning from pellets to the production of briquettes as more suitable good for this purpose.

Russian timber complex is the biggest in the world, so waste-to-energy strategy for the circular economy is a certain way to utilize mountains of timber harvesting, sawmill and wood-processing waste.

3.5 Asian pellet markets

3.5.1 Japan

In 1982, Japan began producing wood pellets in Kochi Prefecture on the island of Shikoku, 84% of which was covered by forest.

After the Fukushima disaster in 2011, Japan shut down most of its nuclear power plants and experienced rolling blackouts, there was a surge in Japan's interest in biomass energy.

In 2012, Japan followed the European way and introduced a subsidy for application of renewable energy sources, including biofuel. However, due to the lack of its own forest resources, Japan focused on importing biofuels based on wood chips, pellets and palm kernel shells. In 2019, more than 90% of wood pellets in Japan were imported from Vietnam, USA and Canada, this amount increased to 6.4 MMT in 2024. Growing consumption in this segment may create conditions for restoring cooperation with Russia in future. Japan plans to increase the use of biomass as an energy resource to 6-7 GW by 2030 [7].

3.5.2 South Korea

South Korea also followed Europe and introduced in 2012 lucrative subsidies for the application of wood biomass for energy generation. In 2022, South Korea imported 3.8 MMT of wood pellets for 17 biofuel power plants with total consumption of 4.5 MMT. The forecast for 2026 is 6 MMT, making South Korea the world’s third-largest biofuel importer after the UK and Japan.

However, in late December 2024, South Korea made a decision to scale back government support for bioenergy, which is bound to have repercussions across Asia. The Ministry of Trade, Industry and Energy (MOTIE), together with the Korea Forest Service and the Ministry of Environment, formed an initiative called “Plans to Improve Market Structures for Biomass Fuels and Power”, which will review the biomass potential for a fuel and reduce incentives that prevent the wide development of solar and wind application. South Korea’s policy change could send a message to other countries considering and incorporating biomass into their own energy transitions and impact pellet export flows [12].

3.5.3 China

China uses wood chips as a fuel. As we noted before, pellets are prohibited for import. In 2020, the total installed capacity of biofuel energy generation in China reached 30 GW, the annual use of solid biofuel reached 50 MMT, it is mostly represented by pellets from an agricultural waste [13]. About 30 MMT are utilized to produce the pellets, and the rest is incinerated in an unprocessed form. According to FAO UN, the amount of production and consumption of wood pellets in China is low and estimated at 0.9 MMT annually.

Specific technical requirements in China for wood fuel pellets and briquettes are quite low. The country was aimed to of modern industrial technologies, such as gas-air mixture combustion. Sales markets belong to private customers.

China is the world's largest manufacturer of composite panels from wood waste, and has rapidly growing pulp and paper industry, which predetermines the use of all types of wood waste in the manufacturing of product with high added value. Wood waste granulation for subsequent combustion does not have wide support in China, as it finds in Europe and North America.

Chinese climatic and economic conditions differ significantly from the conditions of the boreal forests of Europe, Russia and North America, which predetermines a different paradigm for the use of biomass. In local conditions, the combustion of agro-waste in agglomerated and non-agglomerated form has greater potential, which is determined by:

- the large volume and low price of agro-waste. China is the largest producer of agricultural products. According to Chinese estimates, about 700 MMT of straw are formed in rural areas annually as well as 200 MMT of wood waste, which is equivalent to 500 MMT of coal. Biofuels can replace not only coal, but also natural gas and oil;
- low humidity and high calorific value of agro-waste, which is a consequence of the warm climate in China and there are gigantic amount of rice and other grain crops. For example, rice husk has a fairly high calorific value (12-13.5 kJ/kg) and is applied in Southeast Asian countries on an industrial scale as a fuel without additional agglomeration.

3.5.4 Thailand, Vietnam, Malaysia, and Indonesia

The main producers and exporters of wood pellets in Asia are Thailand, Vietnam, Malaysia and Indonesia. In 2012, favor to the high demand from Japan and South Korea, Vietnam launched pellet manufacturing facilities with the capacity of 2.75 MMT annually. The composition of wood used for Vietnam's wood chip exports is formed by acacia (98% by weight). The additive is made up of eucalyptus, pine, rubber and other wood species. Acacia dominates the raw material composition due to its superior productivity and quality compared to other trees and is currently used to produce wood chips, paper pulp, wood pellets, plywood, construction furniture, etc.

The Vietnam Timber and Forest Products Association (https://vietnam.vnanet.vn) reported that pellet export totals 4.67 MMT in 2023, with turnover of US$ 679.59 million, accounting for 5.2% of the wood processing industry. Vietnam exported wood chips to 13 different markets, with South Korea, Japan, China and Taiwan being the largest.

Wood pellets are widely used in both domestic and industrial energy generation, serving as fuel for thermal power plants, bedding for livestock farms, and a source of comparatively cheap energy that can replace electricity or coal.

According to the VIIIth National Energy Development Plan, Vietnam aims to refuse coal for generating electricity by 2050, and to use biofuels and ammonia instead. Thus, there is a high probability that domestic consumption for wood pellets will increase sharply in the near future.

In Indonesia, pellet production started earlier than in Thailand, Vietnam and Malaysia, but developed more slowly. After overcoming effects of 1998 Asian financial crisis, the energy consumption in Indonesia began to raise steadily. Indonesia also adopted an energy program aimed at reducing oil consumption and developing renewable energy sources. In 2008, the pellet production began and 95% of it is sold overseas [14]. The pellet export has grown so much that it has caused concerns among environmentalists. Companies from Japan and South Korea finance the biofuel production segment and this business leads to cut down large forest areas.

In 2021-2023, Indonesian domestic consumption market has also become more active, and there are conversion projects for the coal power plants to biofuel. Thus, the state-owned Perusahaan Listrik Negara (PLN) includes the utility of 10% biomass together with coal at 52 power plants across the country.

It is estimated that this will require 8 MMT of pellets annually compared with 1 MMT in present. The Indonesian authorities plan to achieve this output by increasing the deforestation area by 66%. Since 2020, about 10 million hectares of unique forest have been cut down in areas where biofuel manufacturing was permitted [15].

In Thailand, the government adopted the Renewable Energy Development Plans (REDP 2008-2022). Wood pellet manufacturing began in 2011-2012. Since 2015, the government has been subsidizing 30-50% of the costs for replacing coal with pellets for combustion in boilers. Even diesel or natural gas boilers were projected to transfer to wood pellets. In Thailand, this approach has been met at industrial sector. A biofuel mainly consists of palm kernels, wood chips, sawdust and other wood waste. The consumption of wood pellets is increasing every year with high trend.

Malaysia has abundant natural biomass resources, which is conducive to the development of the specific industry. Wood pellet manufacturing in Malaysia began in 2011 and by 2016 reached 16.8 MMT annually. Malaysia is the largest producer of palm oil in the world, so bio-waste is widely applied for the granulated fuel for generation of electricity, industrial boilers and heating furnaces.

3.6 The impact of waste-origin pellets for the circle economy and environment

Studies of the environmental impact of the fuel pellets give controversial results, with raising, but not accounted concerns about deforestation, air and water pollution, and other negative roles which may lead to the destruction of ecosystems.

Pellets can be applied also for the manufacturing of bioplastics, packaging, fertilizers, chemicals for the production of vinegar and industrial sugar.

Pellets can provide a positive effect for the soil cover. They can be used as an organic fertilizer, enriching the soil with useful substances and balancing the acid-base balance of the soil. Mulching with pellets improves the structure of the soil, makes it loose, saturated with oxygen, which significantly increases crop yields. Ash from incinerated pellets can also be used as a fertilizer and a means for deoxidizing soils instead of lime. It enriches the soil with nutrients, which is especially effective for poor soils.

This renewable fuel significantly reduces CO_2 emissions by saving the combustion of the fossil fuel. The burning of pellets also raises concerns about the carbon-intense energy. Some researchers assure that despite the absorption of CO_2 by trees during their growth, the emissions generated during the production and combustion of pellets may exceed the benefits of carbon absorption.

However, the environmental and economic assessments have been conducted many times of the cost of reduced emissions for energy facilities when converting to biofuel (wood pellets/briquettes) from fuel oil/coal. A team of authors from the Melentyev Energy Systems Institute has presented the results of research that show a significant environmental potential for reducing pollutant emissions (by 90%), GHG emissions (by 99.9%) and the formation of ash and slag waste (by 92%).

It should be noted that sawmilling and wood processing generates a significant amount of wood waste, the storage of which is accompanied with costs, cautions and other problems for the economy and environment. Wood waste is prone to spontaneous combustion, and also entails the fatal harm to flora and fauna. For example, the storage of 13 million m^3 of wood waste occupies an area of 700-1000 hectares. In this case, the

manufacturing of pellets will be the most optimal way to utilize waste from timber and wood-processing industrial enterprises.

Deforestation has led to the loss of diversity of some animal species living in this ecosystem. However, in most countries of the world, including Russia, China, and in Europe pellets are produced from sawmill and wood-processing waste as a method of utilization and providing energy in required areas.

4 Conclusion

An analysis of pellet manufacturing and application show that solid biofuel from wood and agricultural plant waste can become an alternative to traditional energy resources at the regional level. In particular, wood or agro-waste origin pellets can be used for industrial and domestic heating.

Although 80% of energy resources are fossil (coal, oil and gas), the global energy supply from renewable sources, including biofuel, is increasing every year. In 2022, bioenergy shared 9% of the total energy supply. The growth of energy generation from renewable sources, including biofuels, accounted to 89 EJ of a total of 622 EJ, which is 30% more than in the last decade.

80% of heat from renewable sources generates in Europe, 95% of it comes from biofuel. The top five producers of wood pellets are USA, Vietnam, Germany, Canada and Sweden.

The main exporter of pellets in Asia is Vietnam, which supplies them to the markets of Japan and South Korea. China buys wood chips from Vietnam, since pellets are considered as solid waste and are prohibited from being imported into the country. Pellets are also supplied to Japan and South Korea from Indonesia, Malaysia and Thailand.

The pellet industry in Russia was export-oriented. Pellet production was organized in connection with the emerging issues of recycling sawmill and wood processing waste, as well as the high demand of European countries for this kind of fuel. Now there is a transfer to Asian market and domestic use.

Solid biofuel is considered as an environmentally friendly product, since its production mainly uses waste from the forestry or agro-industrial complex. The absence of wastewater during its production, as well as a positive agro-technical impact when using pellets as a fertilizer form other favorable aspects for its wide application.

References

1. P. Pradhan, P. Gadkari, A. Arora A, S. M. Mahajani, Economic Feasibility of Agro Waste Pelletization as an Energy Option In Rural India, Energy for Sust. Dev., **43**, 1–14 (2018)
2. Z. Vincevica-Gaile, M. Zhylina, A. Shishkin, L. Ansone-Bertina, L. Klavins, L. Arbidans, L. Dobkevica, I. Zekker, M. Klavins, Selected Residual Biomass Valorization into Pellets as a Circular Economy-Supported End-of-Waste, Clean. Mat., **15**, 100295 (2025)
3. H. Unyay Rostocki,, K. Ławińska, A. Obraniak, Granulates Based on Bio and Industrial Waste and Biochar in a Sustainable Economy, Energies, **16(1)**, 56-67 (2022)
4. V. K. Lyubov, A.N. Popov, E.I. Popova, Study of the energy efficiency of wood pellets and poplar chips, J Phys.: Conf. Ser., **1683**, 4 (2020)
5. B. Mola-Yudego, M. Selkimäki, J. R. González-Olabarria, Spatial Analysis of the Wood Pellet Production for Energy in Europe, Ren. Energy., **63**, 76-93 (2014)

6. C. Longjian, X. Li, H. Lujia, Renewable Energy from Agro-Residues in China: Solid Biofuels and Biomass Briquetting Technology, Ren. Sust. Energy Rev., **13**, 9, 2689-2695 (2009)
7. U. Stulpinaite, V. Tilvikiene, E. Zvicevicius, Co-pelletization of Hemp Residues and Agricultural Biomass: Effect on Pellet Quality and Stability, Energies, **16(16)**, 5900 (2023)
8. L.J.R. Nunes, J.C.O. Matias, J.P.S. Catalão, Wood Pellets as a Sustainable Energy Alternative in Portugal, Search for Alternative Raw Materials for Pellet Production – a Preliminary Study, Ren. Energy, **85**, 1011-1016 (2016)
9. V. Priedniece, A. Sturmane, R. Eglitis, G. Krigers, V. Kirsanovs, Search for Alternative Raw Materials for Pellet Production – a Preliminary Study, Env. Clim. Tech., **28**, 1, 652–669 (2024)
10. A.d.C.O. Carneiro, A.J.V. Zanuncio, A.G. Carvalho, J.A.C.G. Jorge, R.J.C. dos Santos, I.F. Demuner, L.C. Peres, S.G. Winter, V.R. de Castro, M. Branco-Vieira et al., Resources, **14**, 26 (2025)
11. G. Gramauskas, A. Jasinskas, V. Kleiza, R. Mieldažys, E. Blažauskas, J. Souček, Sustainable Production of Coffee Husk Pellets: Applying Circular Economy in Waste Management and Renewable Energy Production, Processes, **11(7)**, 2097 (2023)
12. S-R. Lee, S. B. Kang, G-S. Han, Reducing particulates and gaseous emissions through fuel switching from coal to wood pellets at power plants in South Korea during 2005 to 2022, Bio Res., **18**, 4, 8458 (2023)
13. W. Chuan, Y. Jinyue, Feasibility Analysis of Potential Benefits by Using Wood Pellets to Substitute Fossil Fuels in China, Int. J. Green Energy, **2(1)**, 91-107 (2005)
14. M. C. Barbu, E. M. Tudor, State of the art of the Chinese forestry, wood industry and its market Wood Mat. Sci. Eng., **17.6**, 1030-1039 (2022)
15. D. Rimantho, N.Y. Hidayah, V.A. Pratomo, A. Saputra, I. Akbar, A.S. Sundari, The strategy for developing wood pellets as sustainable renewable energy in Indonesia, Heliyon, **9**, 3, e14217 (2023)